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VOLUME I

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THE ROLE OF GULLY POTS IN DETERMINING URBAN STORMWATER QUALITY.

Gareth Andrew Fulcher.

Thesis submitted to the Council for National Academic Awards (CNAA) in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

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February 1989.

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DECLARATION.

1. Whilst registered as a candidate for the award of Doctor of Philosophy for the CNAA, the author was not registered as a candidate for any other award of the CNAA. The author was not registered at any other academic or professional institution.

2. Advanced studies undertaken in connection with the programme of research were:

i) attendance at the Third International Conference on "Urban Storm Drainage" held in Goteburg, Sweden in June 1984.

ii) attendance at the Second International Conference on "Highway Pollution" held at Middlesex Polytechnic, London in July 1986.

iii) visit to the "Ijsselmeer Polders Development Authority" in Lelystad, The Netherlands in June 1984.

In addition, a number of National and Local Branch Meetings were attended of the following organisations:

i) British Hydrological Society.

ii) The Institute of Water Pollution Control.

iii) The Institution of Water and Environmental Management.

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I would also like to thank all the staff in the Departments of Civil Engineering and Physical Sciences at the Trent Polytechnic for their advice and assistance and particular thanks go to the Technical Staff in the Analytical Chemistry Section and to Mr. Colin Chambers from the Public Health Engineering Laboratory at the Trent Polytechnic.

I also wish to thank all my colleagues in the Storm Drainage Research Group in the Department of Civil Engineering and special thanks to Dr. M. A. Parkar for his help and advice. I also wish to thank Mr. M. Wallis for his assistance in translating one of the references.

Finally, I would like to thank all my family and friends who have supported and encouraged me over the past few years and I am very grateful for all the help and assistance that they have given me.

ERRATA:

1. The units expressed in the text have not been superscripted and the numerical values within the unit expression should be superscripted. The units used in the thesis text can be described as follows:

UNIT	DESCRIPTION
mg1-1	milligrams per litre
ls-1	litres per second
mmhr-1	millimetres per hour
µgg-1	micrograms per gram etc.

2. The unit expressed in the text as µscm-1 should have read as µScm-1 (microsiemens per centimetre).

3. The temperature unit used is expressed as 'C which is in degrees centigrade.

Abstract:

THE ROLE OF GULLY POTS IN DETERMINING URBAN STORMWATER QUALITY.

by Gareth Andrew Fulcher

A three year research project was carried out in order to investigate the role of the gully pot in determining urban stormwater quality from a separately-sewered residential catchment area. The field work was carried out on selected catchment areas on the Clifton Grove Housing Estate in Nottingham, England.

An extensive hydrometric programme was run over the three year period to measure rainfall in real-time over the catchment areas. A series of "Linear Reservoir" Rainfall-Runoff Models were established for the micro-catchment areas under study so that the overland flow characteristics could be simulated.

A comprehensive dataset of twenty-six physio-chemical determinands over a twenty-two week period within a calendar year was obtained for the gully pot standing liquor quality from twelve gully pots on the Clifton Grove Estate. The trends within the data have been fully described.

Fifteen storm events were analysed on three gully pots over an eighteen month period and a comprehensive dataset of chemical and hydrological data was established. The Linear Reservoir Rainfall-Runoff Models were used to simulate the storm hydrographs from each event for each rainstorm measurement. A series of deterministic and probabilistic models of the BOD and SS quality in stormwater outflows from a gully pot were established.

An extensive urban sediments sampling programme was conducted over a six month period and the nature and pollutant characteristics of these sediments were established. A number of experiments were set up to investigate the relationship between the pot liquor quality and the gully pot basal sediments and the results showed the importance of the sediments in influencing the resultant stormwater quality.

Abstract:

THE ROLE OF GULLY POTS IN DETERMINING URBAN STORMWATER QUALITY.

by Gareth Andrew Fulcher.

A three year research project was carried out in order to investigate the role of the gully pot in determining urban stormwater quality from a separately-sewered residential catchment area. The fieldwork was carried out on selected catchment areas on the Clifton Grove Housing Estate in Nottingham, England between May 1984 and July 1986. The quality of urban stormwater has been identified as an important component within water resources studies and its impact upon surface water quality in urban areas has received much attention in recent years. The quality of the stormwater can be influenced by an above-ground (overland) phase and by a below-ground (within the storm sewer) phase and the gully pot is the point at which the two phases meet. The research programme looked at the quality of the gully pot standing liquor and also the changes in the pot liquor quality during a storm event in order to model these processes in relation to the hydrological conditions.

An extensive hydrometric programme was run over the three year period to measure rainfall in real-time over the catchment areas. A series of 'Linear Reservoir' Rainfall-Runoff Models were established for the micro-catchment areas under study and so the flow volumes and inflow intensities into the gully pots could be simulated.

A comprehensive dataset of twenty-six physio-chemical determinands over a twenty-two week period within a calendar year was obtained for the gully pot standing liquor quality from twelve gully pots on the Clifton Grove Estate. The trends within the data have been fully described. A series of deterministic models was established using a step-wise multiple regression analysis in order to model the quality within the pot liquor with the hydrological conditions within the micro-catchment, draining to the individual gully pot. The data for the BOD and SS determinations were found to conform to a log-normal distribution and so a series of probabilistic models were also established in order to model the BOD and SS concentrations in the gully pot standing liquor against a known level of probability.

Fifteen storm events were analysed on three gully pots over an eighteen month period and a comprehensive dataset of chemical and hydrological data was established. The Linear Reservoir Rainfall-Runoff Models were used to simulate the storm hydrographs for each event from the rainfall measurement. A series of deterministic and probabilistic models of the BOD and SS quality in stormwater outflows from a gully pot were established. The models were shown to perform well and one stormwater quality model was used against some data collected from a gully pot in Sweden from another study and this quality model was shown to perform very well.

An extensive urban sediments sampling programme was conducted over a six month period and the nature and pollutant characteristics of these sediments were established. A number of experiments were set up to investigate the relationship between the pot liquor quality and the gully pot basal sediments and the results showed the importance of the sediments in influencing the resultant stormwater quality.

An extensive dataset of chemical and hydrological data has been established in order to investigate the role of gully pots in determining stormwater quality. A series of both deterministic and probabilistic models are presented to describe the state of the standing gully pot liquor and the quality of the outflow waters from the pot during a storm event.

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CHAPTER 1 : An Introduction to Urban Stormwater Quality.

1.1 Introduction.

In recent years, there has been a growing awareness of the need to maintain and improve surface water quality in the United Kingdom. Surface water quality is an indicator of the activities within a given catchment area and both short term and long term changes in quality may result from natural variations or from anthropogenic sources. Pollutants entering a watercourse may come from a 'point source' (eg. an industrial discharge point or a water reclamation work's final effluent point) or from a 'non-point source' (eg. such as agricultural runoff and urban runoff). Traditionally, water pollution control measures have concentrated upon the control of point sources through a legislative programme requiring the issue of consents for discharge to surface waters. These consents are usually defined in terms of both the quantity of flow permitted into the watercourse over a given time period and the maximum allowable concentration of a particular water quality determinand sampled at the discharge point. There has been little attention paid to establishing the role and importance of non-point source discharges and uncontrolled point source discharges in determining surface water quality trends due to the difficulty in assessing both the magnitude and quality of such flows and the impact of a spasmodic discharge upon a receiving watercourse. Traditionally, all domestic wastewater and industrial effluents were transported by a combined sewer system to a water reclamation works for treatment before discharge to a watercourse. The combined sewer systems were designed to accommodate stormwater draining to it from the roof, road and paved surfaces to a design

criteria of six dry weather flows. Storm overflows within a combined sewerage network and at the inlet to a water reclamation works were able to accommodate flows in excess of the six dry weather flow condition. The unpredictability of storm events both in terms of duration, frequency and magnitude often resulted in an overloading of the combined sewers and the combined sewer overflows discharged highly polluting industrial and sewage effluents direct to a watercourse. Rapid urbanisation into many areas of the United Kingdom in the 20th. Century resulted in an overloading of some of the combined systems constructed during the Victorian Period and this is one of the factors which has led to a deteriorating surface water quality standard in many urban areas during the last fifty years. Problems with combined sewer systems resulted in a major policy rethink of the drainage of stormwater in the urban environment. The main aim of providing an urban stormwater drainage system is to drain excess rainwater from an urban surface to a suitable watercourse, in a safe and economical way. The drainage of excess rainwater should alleviate flooding and subsequent damage and cost to the urban fabric. During the last 30 years, .most newly constructed urban areas have adopted separate storm sewer systems to accommodate the stormwater flows. The major advantage of such a system was that the stormwater could be discharged direct to a nearby watercourse thus negating the need to treat this volume at a water reclamation works. One important, underlying assumption in this argument was that urban stormwater (which is comprised of the urban runoff water from road, roof and paved surfaces within a given urban catchment) was not considered to be of a particularly polluting nature. The urban environment was considered to be relatively free from major sources of pollution and the quick response time of the rainfall-runoff processes at work during a storm

event meant that there was only a short residence time for the water within the urban hydrological cycle. The stormwater would therefore be returned more quickly to urban watercourses and this may be desirable in order to sustain base flows in the river at a time when abstraction and demands for water within the urban areas was increasing. However, recent concern over the long term surface water quality objectives has led to a growing awareness of the need to investigate more thoroughly those discharges from both unmeasured and uncontrolled point sources of pollution such as separate storm sewer outfall discharges and from non-point sources areas. The widespread adoption of separate storm-sewered systems soon raised doubts in some areas as to the validity of the argument that urban stormwater runoff was relatively clean and non-polluting and that it did not pose a threat to a receiving watercourse.

1.2 Urban Stormwater Quality Studies.

In recent years, the introduction of further Government legislation and Directives from the European Commission have focussed attention upon the need to assess the impact of all discharges to surface waters and the stormwater component of the urban hydrological cycle has been viewed with much interest and concern within river quality studies. This has led to a number of research projects being set up within the last ten years to investigate the nature of urban stormwater quality. A large number of studies have been carried out in nearly all the major industrialised and urbanised countries including the United States, Japan and many countries in Western Europe. The urban runoff drains from the road, roof and paved areas of the urban catchment through a series of gully pots and connecting pipework to a storm

sewer network which conveys the stormwater to an outfall which discharges to the nearest watercourse. The dependence upon a storm event of a certain magnitude and duration to provide any discharge at the outfall means that the outfall will only discharge intermittently and some studies have shown that such discharges are on average only apparent for some three percent of a given time period (Ellis in Hollis 1979). This figure is for temperate climates and is likely to change radically for other prevailing climatic conditions (Desbordes and Servat 1984). The results of these research studies generally indicate that stormwater quality does constitute a "problem" and may be an important ingredient to surface water quality deterioration and the cause of water pollution incidents in some areas. The nature and extent of the "problem" depends upon the catchment conditions and the storm event at any given time but urban stormwater has been considered to be responsible for sudden changes in river quality and even fish kills. It is the current inability to quantify the impact of the discharge that has led to a need to be able to clarify and confirm the influence that an urban stormwater discharge may have upon a receiving watercourse. Urban stormwater quality has been recognised in recent years as a separate area of study and it is still in its infancy as far as results from long-term projects is concerned. Some of the earlier studies into urban stormwater quality concentrated upon an assessment of the pollutant loads at the outfall in order to quantify the pollutant load going to a river for a given storm event (Ellis in Hollis 1979; Fletcher 1981; Sartor, Boyd and Agardy 1974; Whipple, Hunter and Yu 1974). More recent approaches have been adopted to try to measure the pollutant sources within a catchment area, the transport mechanisms responsible for the mobilisation and/or deposition of both soluble and sediment associated pollutants and the

eventual removal of pollutants by the stormwater runoff. A better appreciation of these phases could lead to a more substantive understanding of the urban stormwater quality problem. The aim of these studies has been to provide a data set of the processes operating within the catchment areas with a view to modelling the storm sewer processes and to provide a predictive model for urban stormwater outfall discharges for a given storm event. Urban stormwater quality modelling techniques could be incorporated into wider river quality models and would thus accommodate an urban stormwater component which may improve the forecasting of both short term and long term changes in surface water quality. The development of such modelling techniques is in progress (Moys and Henderson 1987).

1.3 Urban Stormwater Quality - the processes at work.

The quality of the stormwater discharge at the outfall is the result of a number of factors operating within the urban catchment. Some pollutants are almost exclusively found in the soluble form whilst others are more readily associated with sediments. The build up of pollutants within the catchment is a function of size, topography, slope, aspect, climatic conditions, type of construction and human activity and the removal of the pollutants is again related to these factors along with the storm characteristics and the hydrological and hydraulic response of the urban surfaces to a given meteorological event. The build up of pollutants within the catchment, their passage to the storm drainage system and their eventual removal via the outfall can be described by a series of important factors which are as follows:-

1.4 The Urban Fabric.

The 'urban fabric' is a term used to describe the constitution of the urban catchment area and is described in terms of the construction materials, type of road and paved surface, the housing type and age and the nature of the vegetated and grassed areas. The building materials used and the quality and age of the road surfaces, pavements, kerbsides and roof materials also influence the quality of the resultant storm sewer discharges. The nature of the urban surface is particularly important in respect to the rates of sediment supply and the size of the particulates involved. Some heavy metals show a particular association with smaller particles (<250 μm) and the ability of zinc and lead to attach themselves to these smaller particles and the greater ease of mobilisation of these particles means that close attention should be made to the sediment fractionation within the urban environment. The housing density and degree of impermeability will influence the flow and quality conditions of the stormwater discharges. Most materials used in urban areas are considered to be highly impermeable and non-polluting and a catchment area can be described as X% impermeable with areas such as gardens, grassed areas, grass verges etc. all being classed as hydrologically permeable areas. The sources of metals within the urban catchment are greatly influenced by the the extent of metal surfaces (particularly galvanised surfaces) and the paintwork found within the area.

1.5 Catchment Activity.

The type of activity within the catchment area and the housing density

can be used to describe the character of the catchment. The type of housing, housing density, age of the properties, type of gardens, traffic density, presence of parking areas, general upkeep of the gardens and properties, whether or not it is a through-road or a cul-de-sac, whether the roads are tree-lined or have grass verges, the frequency of car washing etc. - are all important factors which can influence the build up of pollutants within a given urban catchment.

1.6 Catchment Characteristics.

The size and geometrical configuration of the catchment will also influence the quantity of flow available for a given storm event. The catchment areas will individually produce their own hydraulic and hydrological reponse to a given storm event and the pollutographs will be influenced in a similar fashion.

The conventional means by which a road surface is drained is by a series of gully pots. The gully pot is a cylindrical-shaped chamber which is entrenched adjacent to the kerbside and it acts as a sediment trap for the runoff from the road and paved areas. Each pot can hold about 100 litres before discharging to the storm sewer pipe and the incoming flow is mixed with the standing gully pot liquor before discharging takes place. The ability of the gully pot to trap sediment and the quality of the standing liquor can influence the resultant stormwater quality. The gully pot is really an intermediate device used to trap sediments before discharge to the storm sewer pipe in order to prevent blockage and to alleviate the solids loading at the outfall. Municipal authorities maintain the gully pots by cleaning them out and the frequency of such action can vary

considerably although a twice yearly gully pot clearance is generally found within the United Kingdom. A common problem encountered with such a maintenance programme is that the gully pot grating often becomes trapped on its frame and this is usually caused by small stones which become wedged between the grating and the frame or when the road is resurfaced, the gully pot gratings may become tarred in place. This makes the gratings impossible to lift and the gully pots are therefore unlikely to be cleaned. The number of gully pots found within a catchment area depends upon the catchment characteristics such as the width of paved area and the road gradient, but in general one gully pot is provided for every 200m^2. of impervious area. Gully pots are generally spaced at not more than 40 to 50 metres apart but a commonly used formula takes into account the gradient of the road surface and the width of the paved area. For example the recommended area to drain to one gully pot is 160 m^2. for a 1 in 200 gradient carriageway and is 330 m^2. for a 1 in 15 gradient carriageway, and so on. The positioning of the gully pots is influenced by the local conditions and may be at the discretion of the site engineer during highway construction.

1.7 Aerial Deposition.

The passage of pollutants in the soluble and in the sediemnt associated form from the atmosphere to the urban surface is another source by which pollutants may enter the urban environment. Aerial deposition is the deposition of chemical constituents from the atmosphere to the urban surface. This can be by wet deposition during a rainfall event (which can be an important source of nitrate into the urban environment) or by dry deposition which involves aerosols being

deposited by the wind and the generally prevailing climatic conditions as well as the aspect of the catchment can have an important bearing on the significance of these factors. Some workers have ignored the influence of dry depositional processes because it may be assumed that the input and output of aerosols through an urban area will be equal and that the urban surface acts as only a temporary storage of such particles.

1.8 Pollutant Loads.

Many of the urban stormwater quality research studies have concentrated upon the assessment of pollutant loads from the outfall to the receiving watercourse (Ellis in Hollis 1979; Fletcher 1981). This approach has been in direct response to the need to provide data to describe the nature of stormwater discharges. A valuable series of results have been established to confirm recent fears that stormwater discharges can be highly polluting but these studies have only been concerned with the measurement of discharges at the outfall and have not been able to accommodate any appreciation of the processes occurring within the catchment area (Fletcher, Pratt and Elliott 1978; Van de Ven 1983; Wada and Miura 1984; Ellis, Harrop and Revitt 1986). The determination of pollutant loads to a watercourse involves an accurate measurement of the volume of discharge as well as determinations of the concentrations of salient pollutants in the discharge water. The product of the flow volume and the mean pollutant concentration is the "load" upon the receiving watercourse for a given storm event. Therefore one of the inherent needs for both storm sewer design and stormwater quality studies, has been the need to accurately measure or predict stormwater volumes and flow

characteristics.

The need to accurately measure runoff volumes and flow characteristics from urban surfaces has led to the development of a new subject area, termed 'urban hydrology' which is the study of the hydrological cycle within urban or predominantly urban catchments. Urban hydrology has grown rapidly in recent years and there is now a much greater level of understanding of the hydrologic and hydraulic responses of urban surfaces to a given storm event. A number of urban hydrological studies have now been carried out to assess the influence of surface configuration, catchment characteristics, degree of impermeability and the nature of the urban fabric used on the response of the flow conditions from a given meteorological input (Kidd and Lowing 1979; Kidd and Packman 1980; Hall 1984; Parkar 1987). Field instrumentation has now been developed to measure urban runoff into gully pots, within the storm sewer pipe network and at the storm sewer outfall and these field studies have provided a valuable dataset of the flow conditions within the urban catchments under study (Blyth and Kidd 1977; Gunst and Kidd 1980). Such data have been used to calibrate a series of Rainfall-Runoff Models to predict stormwater volumes and flow conditions for specific catchment areas. These models have been widely used to enhance storm sewer design. The STORM Model (developed by the EPA in the USA) and the WASSP Model (developed by the Hydraulics Research Station in the UK) have received widespread use in the design of urban drainage systems (US Army Corps of Engineers 1974; National Water Council (listed as "The Wallingford Procedure") 1981; Price 1984).

1.9 Stormwater Modelling.

Measurements of the quality of urban stormwater outfall discharges have shown that such stormwater does constitute a pollution problem in many areas but the main area of concern at present, is the need to develop a reliable stormwater quality discharge model which could bring together the quality and quantity components of stormwater discharges into one unified model which could be used to predict the input of such discharges upon receiving watercourse in both the short and the long-term. There is also a need to develop good Rainfall-Runoff models applicable to small catchment areas (ie. several km^2.) and to model the quality of resultant discharges from such catchments. A greater appreciation of the within-catchment processes, the sources of pollutants and their spatial and temporal variablility and the way in which the urban runoff flows can influence the resultant quality of the discharges are all factors requiring further investigation. Many river quality modellers have long recognised the need to incorporate a stormwater component into general river quality models and there is a great potential use awaiting the development of a good and reliable stormwater quality discharge model (or models) which can be widely applied.

There is an increasing degree of environmental awareness in modern day society and the development of the understanding of stormwater processes in terms of both the quality and the quantity is a vital ingredient in the increasing concern over the quality of surface waters and groundwaters in the UK, especially in the long-term. A better appreciation of the extent of the problem can certainly be accommodated in the overall strategy and coordination of any

environmental pollution abatement programme for the aquatic environment.

CHAPTER 2: The Aims of the Research Programme.

2.1 Areas of Study in the Research Programme.

A number of studies have been carried out in recent years to investigate the impact of separately-sewered stormwater discharges upon receiving watercourses. Stormwater has traditionally been considered to be non-polluting or uncontaminated surface water runoff and therefore little attention has been paid to its influence upon surface water quality in terms of both the quantity and the quality of the stormwater discharges. Some studies carried out during the 1950's and 1960's provided enough evidence to suggest that some stormwaters may be highly polluting and these findings initiated a growth in the amount of stormwater quality investigations (Akerlinch 1950; Wilkinson 1956; Gameson and Davidson 1963; Pravishinsky and Gattillo 1968). Many of the earlier stormwater studies concentrated upon the measurement of the quality of the stormwater at the outfall in order to assess the exact nature of the discharge into the receiving watercourse. These studies were closely followed by work to measure the volume and the flow characteristics of stormwater discharges. The development of urban hydrology as a separate area of hydrology, and the greater understanding of the hydrologic and hydraulic processes operating with the urban catchments, has enhanced the understanding of the water quality results. The measurements of flow and of water quality in urban areas have grown together in the last ten to fifteen years and many researchers are now adopting a more integrated approach to the study of stormwater quality in urban areas.

Early attempts to model the quality of discharge waters at the outfall failed to appreciate the influence of the processes operating and

fluctuating within the catchments. Some discharge quality models were based purely upon hydrological conditions but these models failed to produce good predictions of quality at the outfall. A number of these studies carried out in Europe and the United States of America are reviewed in Chapter 3. During the last few years, many researchers into stormwater quality analyses have recognised the need to find out more about the within-catchment processes with respect to the supply, depletion, transmission, transport and deposition of both soluble and sediment-related pollutants. This involves a better appreciation of both the above-ground and the below-ground phases in the transmission of runoff water from the urban surface draining to the outfall.

The above-ground phase is concerned with the passage of water from its point of contact with the urban surface to the storm sewer pipe. Nearly all urban surfaces are drained by a series of gully pots which act as sediment traps to prevent larger-sized debris from entering the storm sewer pipe network. The gully pots also act as sedimentation chambers whereby an improvement in the quality would be anticipated if the gully pot liquor was allowed to stand. In fact, the quality condition of the pot liquor may worsen if septic or anaerobic conditions develop in the basal sediments of the gully pot. The gully pot is the link between the above-ground and the below-ground phase. The below-ground phase consists of a network of storm sewers which gravitate to an outfall or a series of outfall pipes which discharge the stormwater to the receiving watercourse. Some outfalls may be submerged. The gully pot supplies water to the below-ground phase at the beginning of the storm event (once runoff has commenced) and it exerts an influence over the water flowing into it due to the degree of mixing or by-passing of the standing pot liquor. The quality of the gully pot standing liquor can be considered to be representative

of the sources of pollutants and processes operating within the catchment area at any one time. An analysis of the changes in the quality of the standing pot liquor can result in a better appreciation of the sources of pollutants, their temporal and spatial variability and can be indicative of the potential pollutional strength of the stormwater discharge.

2.2 Research Aims and Investigations.

The aim of this research programme was to concentrate upon the influence the gully pot may exert upon the stormwater quality during both dry periods and storm events. The research programme set out to conduct a series of field investigations, field and laboratory simulations and laboratory experiments in order to investigate the role of gully pots in determining stormwater quality on a separately-sewered urban catchment area. A three year research programme has been undertaken to investigate the influence of gully pots on the quality of stormwaters entering a separate stormwater sewer system. The study has been based on three highway sub-catchments in a well-maintained, residential housing estate at Clifton Grove on the southern outskirts of Nottingham, England.

The research was conducted in two parts:

The first part involved a one year survey of the quality of gully pot standing liquor in order to detect spatial and temporal variability. Some analyses were also carried out on their associated basal sediments at this time. The study set out to build up a dataset of twenty-six water quality determinands (including twelve metals) over a

one year period through a systematic weekly sampling programme. Some statistical analysis (including correlation techniques) would be used to help identify important associations between parameters in the stormwater system and to identify some pollutant sources within the catchment areas.

The second half of the research programme involved the analysis of a number of storm events to measure the quality of the inflow waters into the gully pot and the quality of the waters which are then discharged from the gully pot to the storm sewer pipe. A number of storm events need to be monitored in order to identify the changes in water quality as the flow passes through the gully pot system and to relate such changes to the hydrological conditions. An extensive hydrometric data collection programme was therefore an essential requirement in this part of the programme.

The research programme set out to establish what influence (if any) the gully pot has on stormwater quality and how effective the gully pots were in improving the quality of the outflow waters after some sedimentation in the pot chamber, during storm conditions. The data obtained in the study could be used to illustrate the importance of urban stormwaters which are now considered to be more polluting than had previously been believed. A further application of the data is its inclusion in a review of the engineering design of urban drainage structures since alternative methods of urban drainage design such as infiltration pavements etc. have received increasing attention in the last few years. The gully pot system was conceived as a most acceptable (and economically acceptable) means of draining urban areas and roadways with little direct attention being given to the quality

aspects of the stormwater flows.

One of the most urgent needs in stormwater research is to develop an accurate and reliable "Stormwater Quality Discharge Model", which would receive widespread application in water pollution control studies and the analysis of changes in surface water quality. Such a model would be a water quality equivalent to the Runoff Model such as the "STORM" or the "WASSP" models (see Chapter 4). It has been long recognised that such a quality discharge model should include modelled processes in both the above-ground and the below-ground phases. The importance of being able to model the flow characteristics, variable pollutant source areas both temporally and spatially, pollutant seasonality factors, sediment transport processes, the influence of gully pots, in-pipe deposition and resuspension, the first-flush phenomenon etc. are all variables which should be incorporated (or at least taken account of) in such a "Stormwater Quality Discharge Model". The modelling of relationships between the water flows and their associated water quality will help to establish a better estimate of pollutant concentrations and loadings from stormwater discharges. The research programme set out to develop both deterministic and probabilistic models incorporating both water quality and hydrological data and the development of such a model can be seen as a very important contribution to stormwater quality research studies. The derived models would have a value within their own right to help explain the processes occurring within the above-ground phase of the stormwater discharge, but perhaps more importantly they can act as an "intermediate component" within a larger "Stormwater Quality Discharge Model", based on both the above and below-ground components and calibrated from a far wider water

quality and hydrological dataset.

2.3 Summary of the Research Aims.

The main aims of the research programme were:

1. to study a number of important water quality parameters in urban stormwaters and to identify the nature and quantities of sediment and pollutant input, retained and released from the gully pots.

2. to measure the quality of the gully pot standing liquor and assess its spatial and temporal variations.

3. to study the physical and chemical processes occurring within the gully pots, both between and during storm events.

4. to measure the solids loadings to roadside gully pots and to measure the sediment-related heavy metal pollution in the gully pot systems.

5. to conduct an extensive hydrometric data collection programme and to provide simulated flow figures using Rainfall-Runoff Models calibrated for the micro-catchments under study, such that a joint study of the water quality and the water quantity may be carried out.

6. to enhance the results obtained from the field investigations with those from laboratory-based experiments.

7. to derive a series of deterministic and probabilistic models to be used to predict gully pot liquor quality both under quiescent conditions and under storm conditions. The results from these model simulations could be routed through a below-ground model phase to

enhance the accuracy of the stormwater quality discharge results at the outfall.

Chapter 3 : Literature Review.

3.1 Introduction.

It is now widely acknowledged that nonpoint sources of water pollution can influence greatly the quality of surface waters. Urban runoff has long been recognised as an important component of the urban hydrological cycle and in the last twenty years, a large number of studies have been conducted to investigate the quantity and quality of runoff waters from urban areas. Separate storm sewer systems convey runoff water to a nearby receiving watercourse and the lack of water quality data for such stormwater discharges has led to many countries initiating comprehensive research programmes through their Technical Institutions, Government Agencies and Universities. Investigations into stormwater runoff quality have been made on separate sewer systems and on combined systems, together with more specific studies into associated problems of highway drainage and runoff quality, parking areas and road and roof surface studies. A number of such studies are detailed in Helliwell (1978), Yen (1981) and Balmer, Malmquist and Sjoberg (1984).

This Chapter outlines the results and findings of some of the more important studies into stormwater quality which have been conducted in recent years. A collection of recently published papers is also reviewed which are particularly relevent to the aims of the research programme as set out in Chapter 2. The literature review sets out to illustrate the diversity between many studies in terms of catchment scale and climate and to highlight specific work which has been conducted on gully pot liquors in separate storm sewer sytems which

relate to the aims as outlined in Chapter 2. The majority of stormwater research has been conducted in the United States of America and in West European Countries, but increasingly widespread concern over the role of urban runoff in water pollution has led to a significant research contribution from the Soviet Union, Japan and some East European countries in more recent years. This has led some countries to adopt large-scale pollution abatement programmes which are now in progress.

3.2 Urban Water Quality Problems.

Hall and Ellis (1985) provided an account of the overall problems of water quality in urban areas. The hydrological aspects of urbanisation were highlighted through a treatise of the changes to the hydrological cycle in urban areas. The two aspects of urbanistaion that were considered to have the most impact, were the rise in the population density and the increase in building activity within the catchment areas. This results in a larger runoff volume discharging from a given urban area. Hall and Ellis (1985) stated that the effect of stormwater discharges on receiving water bodies was one of the most critical aspects of stormwater management. The pollutants in stormwater runoff can severely deplete the oxygen regime of a river or lake and can exert toxic effects on the stream biota as well as stimulate the development of microorganisms and macrophytes. The authors reviewed the various complex factors which could determine the quality of the final stormwater discharges at the outfall by consideration of both the above-ground and the below-ground phases of the runoff. Hall and Ellis (1985) stated that dilution-exhaustion was the most common discharge-pollutant response in urban catchments.

This reflected the supply-limited conditions and in-pipe and downstream reductions in pollutant concentrations which were brought about by sedimentation rather than by dilution. Hall and Ellis (1985) defined "Stormwater Management" as ..."a group of techniques and procedures the purpose of which is the mitigation of undesirable effects produced by the quantity and quality of urban runoff".... Brief mention was made of the various models which have been developed such as the "STORM" model : Storage, Treatment and Overland Runoff Model (US Army Corps of Engineers 1974) and the "SWMM" model : Stormwater Management Model (Lager et al 1971).

A similar treatise of the overall subject of water quality problems in urban areas was provided by Jalal (1977), who stated that urbanisation invariably leads to an increase in the imperviousness of a natural watershed but the overall hydrologic and water quality effects of this change were not always immediately evident. The need to quantify the effects of urbanisation on the quantity and quality of runoff have been partially satisfied by the development of general catchment-based models such as the "STORM" model. The "STORM" model can provide a set of hydrographs and pollutographs (a plot of a chemical concentration against time) at the outlet of a drainage basin. Jalal (1977) concluded that the "STORM" model could be used to determine the optimum storage-treatment combination that would meet a given water quality objective at a minimal cost. Ischinger (1979) reviewed the overall, associated problem of nonpoint source pollution. This article stated that the magnitude and cumulative effects of nonpoint source pollutants could produce a profound impact on the aquatic resources of any area. The regulation of land use and associated land management practices were identified as the only effective means of

controlling nonpoint source pollution problems. Most recent studies into stormwater quality have focussed upon the problem of heavy metals in urban watercourses. Stormwater runoff is cited as a major contributor of heavy metals by many observers and it is the heavy metal loadings together with an appreciation of the metal speciation which has received much attention in recent years. Problems associated with heavy metals have been reviewed by Dissanayake (1983), who emphasised the importance of organic matter in the aquatic systems and its interrelation with heavy metals. The importance of organic matter in complexing heavy metals is now being increasingly recognised. Trace metals can exist in a number of physicochemical forms which are determined by the Redox Potential, the pH and the concentration of inorganic ligands and colloidal materials in solution. This is called the 'Metal Speciation' whereby certain complexed forms are considered to be considerably less toxic than the free metal ions. A fuller discussion on metal speciation has been presented by Morrison (1983). Dissanayke (1983) has shown that in order for organic carbons to trap metals in the aquatic environment, certain conditions for Redox Potential and pH should be at an optimum. Such conditions may exist within the storm sewer pipe network and in the receiving waters when the stormwater discharges contain sufficient quantities of both heavy metals and organics. Further evidence of the importance of heavy metal concentrations in stormwaters was provided by Florence and Batley (1977). They reported that environmental scientists were becoming increasingly aware of the need for reliable methods which could differentiate and determine the chemical forms of trace metals in natural waters and drainage waters. Their argument was that it was important to determine the extent and rate to which the foreign (ie. the discharged) metal species equilibrate with the

dissolved metal species in the receiving waters but this was a very difficult problem and a great deal more research needed to be carried out before a full evaluation of the environmental impact of a given stormwater discharge could be made. Florence and Batley (1977) stated that more attention should be given to the 'bound' and 'labile' (weakly complexed) metal states in water pollution studies.

3.3 Stormwater Quality Studies in the USA.

One important study which initiated a great deal of research, was conducted by Sartor, Boyd and Agardy (1974). This study set out to define the stormwater problem after a period of years when separate storm sewer systems were adopted as a standard by many countries and the polluting strength of urban runoff water was considered to be insignificant. The study was conducted in twelve cities throughout the USA and it set out to investigate the amount of pollutants, their sources, significance and possible means of control. A further objective of the study was to determine the effectiveness of street cleaning in urban pollution abatement and to evaluate how stormwater compared to other types of wastewaters. Sartor, Boyd and Agardy (1974) found significant amounts of heavy metals in street surface contaminants but the inorganic material was thought not to constitute a threat to receiving watercourses. One of the most important findings of this study was that a great proportion of the overall pollution potential was associated with the fine solids fraction of the street surface sediments. The length of time of accumulation of the material on the street surface was also deemed to be an important factor as was the rate at which the rainfall washes loose particulates off the urban surfaces, which was found to be a function of the

rainfall intensity, the particle size and the street surface configuration. Sartor, Boyd and Agardy (1974) concluded that more studies were essential in order to provide a greater understanding of the urban runoff pollution problem and that measures to control such pollution should incorporate street and gully pot cleaning practices together with means of control and possible treatment (partial) of the polluting stormwater discharges. The results of the study carried out by Sartor, Boyd and Agardy (1974) prompted an increased interest in urban runoff pollution problems and led to the implementation of many other research projects in the USA and in Western Europe throughout the 1970's and 1980's.

The American approach to investigate stormwater pollution problems has been based predominantly on large catchment areas with a view to developing land management directives and programmes of pollution abatement. A large number of studies have been carried out in the USA in various cities and towns under differing climatic regimes. Field (1985) presented a review of the most important findings in the American research and he called for methods to be developed for controlling pollution from both urban stormwater discharges and combined sewer overflows. Field (1985) reported that the Environmental Protection Agency had supported an Urban Rainfall-Runoff Quality Database since 1974 for two important data requirements.

i) characterisation of urban storm runoff.

ii) calibration and verification of stormwater models.

Field (1985) also discussed the management alternatives to the

stormwater pollution problem by suggesting that there were four options available, either singly or in combination.

i) better land management.
ii) in the collection system.
iii) off-line storage.
iv) treatment facilities.

Field (1985) concluded that the relationships between water quality and storm flow discharges must be more clearly established but it was recognised that this was a difficult problem and one that could only be tackled by a number of studies on different catchment areas. The value in obtaining this information through a clearer understanding of the processes at work has led Field (1985) to conclude that the control of runoff pollution could be viable for maintaining the receiving water quality standards. It was suggested that an integrated management approach was the only way which would be feasible and economical.

Reckhow, Butcher and Marin (1985) presented a review of the different 'Pollutant Runoff Models' which were available with particular emphasis on their selection and use in decision making. They stressed that due to data limitations and lack of experience in applying the models, it was often only possible to provide annual pollutant runoff loading estimates. The 'Pollutant Runoff Simulation Models' could be used to predict the discharge of a variety of pollutants including nutrients (eg. nitrates and phosphates), pesticides and specified sediment attached pollutants. The authors did, however, emphasise that there was a great deal of room for improvement in the methods

used to model pollutant runoff and the models were calibrated on relatively small databases, even though they were receiving widespread application. Reckhow, Butcher and Marin (1985) identified certain specifications which should be included in a Stormwater Runoff Model and these were:

a) low cost;

b) seasonal resolution;

c) a minimum number of site specific parameters;

d) greater degree of regionalisation of predictive models.

The results from many of the studies carried out in the USA during the 1970's led to the formulation of the "Nationwide Urban Runoff Program (NURP)", which was a large-scale project conducted in the USA to investigate urban stormwater pollution problems on a nationwide scale. NURP was initiated to evaluate the significance of priority pollutants in urban stormwater runoff and to implement the program various urban authorities received grants and technical assistance for urban water sampling and analysis. Nineteen cities in the USA were involved in the program and altogether fifty-one catchment areas were chosen for study and these varied enormously in both size (from 1 acre to 33544 acres) and geographical location. Torno (1984) presented a review of the setting up of the NURP project. A review of the early findings of the NURP project was given by Cole, Frederick, Healy and Rolan (1984) and they reported that 129 priority pollutants were identified at the start of the program and the initial stages of the analysis sought to identify how many of these priority pollutants were found in stormwater runoff and if so in what concentrations. The list of 129 parameters was drawn up to provide a comprehensive suite of pollutants

which posed the greatest threat to surface water quality and whose presence was anticipated in urban stormwater runoff and in urban watercourses. This evaluation was really a screening procedure to identify urban runoff pollutants which warranted further investigation. From the original list of 129 parameters, only 24 pollutants in stormwaters were regarded as potentially important sources of pollution and this was defined by the fact that they appeared in at least ten percent of all samples taken in the NURP analysis. Cole et al (1984) reported that the concentrations of copper, cadmium, lead and zinc exceeded the freshwater acute limit for aquatic life in between 9% and 50% of all samples taken. About 40% of all copper and zinc was found to be in the dissolved form which was generally regarded as its most toxic form. One important counter-argument to this point was that additional dilution during storm events was likely to reduce the concentrations from the levels measured. Cole et al (1984) concluded their review of the preliminary findings of the NURP by stating that the accumulation of some of the priority pollutants (eg. lead) may have detrimental long term effects which were largely unknown.

3.4 Pollution Abatement Programmes in the USSR.

Nechaev (1985) has provided a review of recent studies into stormwater pollution problems in the Soviet Union. He stated that the damage to receiving water bodies by periodic, momentary discharges of great amounts of contaminants in stormwater could often exceed the self-purifying ability of the receiving water. Nechaev (1985) calculated that in the first half hour of a rainfall event, the following contaminants would be likely to be discharged from a one

hectare urban area:

i) 200 kg. undissolved impurities;

ii) 20 kg. oil products;

iii) 50 kg. organics.

A review was also provided of the differing types of treatment facilities which have been tested in the Soviet Union. Nechaev (1985) reported that various types of settling tanks have been installed at certain locations and these were generally designed to withold a three day retention period. These tanks had a low capital and maintenance cost but they did require a relatively large area for installation. Nechaev (1985) also reviewed the use of filter media for stormwater treatment, whereby the treated runoff water could meet a strict analytical requirement before the final effluent was discharged. It was generally considered that the final effluent should meet a standard of about 3 mgl-1 for oils and a maximum of 5 mgl-1 for SS. Nechaev (1985) concluded that a number of projects were currently being conducted in the Soviet Union into stormwater problems and the approach was very much towards that of treatment of the runoff water, rather than the change in land management practices, so often postulated in the USA.

3.5 Pollution Abatement Programmes in Japan.

One study from Japan which clearly illustrated the pollution potential of road surfaces during a runoff event has been presented by Wada and Miura (1984). They collected together data from a number of related studies in Japan to show that the accumulated loads on road surfaces

showed large variations between different types of area. The pollutants could be flushed out in great quantities at comparatively early stages in the rainfall event. Various different types of land use were analysed - residential, light industrial, industrial and commercial in the Kyoto-Osaka area of Japan and it was found that considerable loads of pollutants were flushed off the road surfaces within the first fifteen minutes of a rainstorm event. The runoff pollutant loading was heavily influenced by the rainfall intensity and the smaller particles on the road surfaces were found to be very susceptible to movement. Wada and Miura (1984) developed an empirically derived equation to describe the runoff of accumulated loads. The equations of motion and continuity were represented in the empirical equation which were as follows:

$$Q = C \cdot S^{x} \cdot R$$

where:

- Q = runoff load per unit time.
- C = runoff coefficient.
- S^{x} = accumulated load on the surface.
- R = rainfall intensity.

The study showed that $0.20 \leq C \leq 0.55$
and $1.00 \leq X \leq 2.00$
The accumulated load on the surface S was derived as follows:

$$S^{x} = A \cdot P(n) - \int Q \, dt.$$

where:

- A = road surface area.
- $P(n)$ = initial accumulated load on roads after n days.

It was shown that the calculation of the accumulated load on road surfaces was easily estimated using the above equation. Wada and Miura (1984) concluded that the runoff load increased with low

rainfall when the accumulated loads were high (ie. after a long antecedent dry period), but overall the total runoff pollutant loading was directly related to the rainfall intensity.

3.6 West European Studies into Stormwater Quality Problems.

There has been a substantial increase in the number of research projects carried out in West European countries in the past few years. These studies have set out to investigate the common problems of stormwater discharge quality from separate storm sewer systems, but they have all been conducted in catchment areas having their own individual character and uniqueness. There have been more specialised studies into stormwater quality from certain parts of the urban environment eg. road surfaces, motorways, airport runways, paved parking areas etc. rather than an overall study looking at runoff from a larger urbanised catchment area. These specialised studies have homed in on a number of contributing components within the urban area which overall could be grouped together as an urban runoff stormwater quality effect. Some Scandinavian studies have reviewed the difficulties of measuring snowmelt runoff from urban areas and the problems encountered in quantifying the pollutional effect of stormwater in such a climatic regime.

Table 3.1 summarises the findings of a number of studies which investigated the quality of stormwater outfall discharges from a number of different urban surfaces (including highways) within different West European countries during the 1970's and the 1980's.

Average Concentrations of Some Pollutants in Urban Stormwater Outfall Discharges from Various West European Studies.

(All values are expressed in mgl-1 unless otherwise stated).

Parameter	Study Area				
	A	B	C	D	E
SS	17	-	65	-	100
pH (pH units)	7.0	-	6.5	-	-
Pb	0.18	0.42	0.07	0.11	0.34
Cu	0.08	0.10	0.05	0.01	0.04
Zn	0.31	0.34	0.49	0.13	0.25
Fe	1.2	6.2	-	-	-
P	0.08	-	-	1.6	0.28

Study Areas:

A Residential Catchment in Goteborg, Sweden. (Malmquist and Svensson 1978)

B Highway Runoff Study in Goteborg, Sweden. (Lisper 1974)

C Light Industrial Estate in Goteborg, Sweden. (Malmquist 1983)

D Residential Area in Munich, West Germany. (Goettle 1978)

E Motorway Runoff Study in Zurich, Switzerland. (Dauber and Novak 1978)

Table: 3.1

3.7 The Finnish Urban Stormwater Project.

Melanen (1984) reviewed the findings of the "Finnish Urban Storm Water Project 1977-1980", which was an extensive three year research programme based on seven experimental urban catchment areas in four cities in Finland. The catchment areas differed with respect to area (13.2-40.5 ha.); slope (1.0%-3.0%); and the degree of imperviousness of the urban area (29%-67%). The programme set out to measure 30 physiochemical parameters, and between 70 and 160 rainfall-runoff events were measured for each catchment area. A summary of the results from the Finnish study is presented in Table 3.2. The parameter n is the number of storm events analysed.

The conclusions of the three year study were that stormwater was found to constitute a water quality problem in all the catchments under study for a large proportion of the storm events analysed. There was considerable interest aroused from the study by the local municipal authorities, whereby the infiltration of stormwater by urban fabric design was considered to be a favourable alternative and one which could help eradicate the quality problems found in many urban streams which were receiving stormwater discharges. A further conclusion drawn from the national study carried out in Finland was the need to further examine the concentration of micropollutants in urban stormwaters and to assess their impact upon receiving watercourses.

Stormwater Quality: Combined Observations from Six Catchment Areas Studied in the "Finnish Urban Storm Water Project".

(All values are in mgl-1 unless otherwise stated)

	n	Min	Max	Mean
BOD	92	<2	130	19
COD	199	15	620	150
TOC	27	4	150	18
Cl	112	0.4	30	4.8
pH (pH units)	184	5.9	8.1	6.8
Zn	92	0.04	1.7	0.36
Cu	91	0.01	0.7	0.08
Pb	225	0.01	1.5	0.22

Table: 3.2 Melanen (1984)

3.8 The Lelystad Studies in the Netherlands.

A very intensive research project has been conducted in the Netherlands over the past twenty years or so into the hydrology and associated water quality effects on the reclaimed polderlands in the Ijsselmeer.

The Ijsselmeer Polders Development Authority (IPDA) is the organisation responsible for the scientific and socio-economic study of the polderlands which have been reclaimed from the sea. The IPDA is based in Lelystad which is the regional capital of the Flevoland polder. Lelystad has developed as a new town since the late 1960's and many of its rapidly growing population have come from the city of Amsterdam which lies some 60 km. to the west. Lelystad has a separate storm sewer system and the IPDA have conducted an on-going hydrological research programme since 1968, to assess water budgets for the surrounding area and to monitor the environment during the development of the new town. The town is drained by a system of urban canals which are between 5 and 10 metres wide and whose average depth is no more than 0.6m. These canals have an ecological and recreational purpose as well as a hydrological one. The canals are fed by three different hydrological components:

i) stormwater
ii) direct seepage
iii) water from sub-surface drains

Since 1982, a series of water quality studies have been carried out. There was a need for water quality data to be collected in-situ in

order to make a proper choice between separate and combined sewer systems for the urban areas. The results of these studies have been reported in recent years (Van de Ven 1983). The main aim of the project was to study the effect of storm sewer discharges on small, slowly flowing receiving watecourses such as the urban canals. The area chosen for study was the Bastion Housing area, which is a 4.5 ha. catchment comprised of 60 houses per ha. which lies adjacent to the town centre. The area is a relatively clean, residential area that is estimated to be approximately 66% impermeable. The separate sewer system led to a submerged outfall which discharged to the urban canal. A Venturi Flume was used to measure the discharge volume and a sophisticated, computer controlled sampling strategy was used to collect the samples at the outfall. Three automatic, water quality monitors were installed in the middle of the urban canal receiving water, to study the impact of the stormwater discharges. The study concentrated upon the measurement of Temperature, pH, Dissolved Oxygen, Chloride, Suspended Solids and Heavy Metals, although some measurements of mineral oils and bacteriological counts were also made. Stormwater samples were collected every $12m^3$. of discharge, just up-pipe of the outfall. The results of the study have showed that the zinc concentrations in the stormwater discharge were generally high due to the large number of galvanised railings found in the catchment. Lead was only found to be present during discharges from larger storm events and Van de Ven (1983) has attributed this to the attachment of the lead to particulates which were only mobilised by the larger flow intensities which exceeded the "threshold velocity" for sediment transport.

Tables 3.3 and 3.4 show a summary of the Water Quality studies carried

out in Lelystad.

The Lelystad studies are still in progress but the results obtained so far have illustrated that stormwater was highly variable due to the variabilities in rainfall both in terms of volumes and intensities and the pollutant sources found at any given time within the catchment area. Traffic, corrosion of the urban fabric and faecal deposition by domestic animals were all thought to be significant sources. The receiving canal water was generally considered to be in an acceptable state, although pollutant concentrations were found to be enhanced at and just downstream of the storm sewer outfall, and the quality of the storm discharge was on average worse than the receiving watercourse (see Tables 3.3 and 3.4).

The Lelystad study also included some biological monitoring of the receiving watercourses to detect changes due to the impact of stormwater. Biological Monitoring is an alternative approach to the purely physicochemical measurement of water quality. This type of approach is concerned with the measurement of the establishment of a stable and diverse ecosystem. The structure of the ecosystem is used as a pollution indicator. The Lelystad urban canals were shown to be @ - mesosaprobic which is defined as ".... moderately polluted with organic matter ...." . The species composition in the urban canals was shown to be influenced by the presence of the storm sewer outfalls and the biological water quality assessment is a useful and somewhat more sensitive means of assessing the impact of stormwater runoff (Roos 1983).

The Bastion Housing Areas in Lelystad.

Figure 3.1

Water Quality Monitoring in an Urban Canal in Lelystad.

Figure 3.2

Stormwater Quality from the Bastion Housing Area, Lelystad.

(all values are expressed in mgl-1 unless otherwise stated)

Averaged Results over a two year period.

Parameter	Stormwater Discharge at the Outfall	Canal Water (Receiving Water)
SS	34	-
BOD	3.2	3.1
COD	23	24
P	0.4	0.27
Oil	1.5	0.4
Pb	0.053	0.016
Zn	0.390	0.069
Cu	0.017	0.005
Faecal Coliform (No/100 ml)	< 95	< 95

Table: 3.3 (Van de Ven 1983,1986)

The Impact of the Stormwater Discharge on the Urban Canal in Lelystad in the Netherlands.

Averaged results over 19 storm events
(all values are expressed in mgl-1 unless otherwise stated)

Parameter	Upstream of Outfall	At the Outfall	Just Downstream of the Outfall	Downstream of Outfall
Water Quality				
COD	27	21	22	25
P	0.32	0.31	0.43	0.36
Pb	0.019	0.035	0.033	0.022
Sediment Quality				
COD	45	95	72	47
P	0.5	1.1	1.0	0.7
Pb	0.027	0.167	0.064	0.026

Table: 3.4 (Van de Ven 1983,1986)

3.9 Quality Problems from Motorway Runoff.

The quality of motorway runoff waters has recently come into focus as a cause of concern within the urban environment. A number of studies recently conducted in France and in the United Kingdom have confirmed the polluting nature of motorway drainage and the problem is undergoing serious consideration and has been heightened by the proposals to rapidly expand the motorway network throughout Europe, with massive investment planned from both public and private sources. A series of studies into runoff quality from road surfaces have recently been conducted in France. The results of this work has prompted renewed interest in the quality of motorway runoff, where little consideration has historically been given to the impact of runoff waters from these very highly trafficked catchment areas. Ellis (1988) has stated that in the United Kingdom, this problem has been compounded by a lack of co-ordination among those public authorities responsible for the planning, provision and maintenance of highways. In the UK, the responsibilities fall between national, county and local government departments and the interests of the environmental impact of highway development may not be best served under this present structure.

3.10 French Studies into the Quality of Highway Drainage.

Astruc, Astruc, Beguinand and Mericam (1979) carried out a study of the chemical quality of stormwater runoff from the town of Pau in France and they concluded that specific treatment of some runoff waters was desirable in order to protect some receiving waters. They studied a number of organic pollutants including many hydrocarbons as

well as metals in runoff waters. They concluded that a number of "accidental pollution events" occurred on highway surfaces (due to accidents, crashes, spillage etc.) and it would be desirable to consider the effects of these types of event against the pollutional strength of some discharge waters from storm events. The authors felt that it was important to put the stormwater quality in perspective in relation to other potential events which could occur in and around a highway environment.

Balades et al (1985) stated that previous work into stormwater quality had consistently concluded that urban runoff could provide discharges whose quality was directly comparable with foul sewerage wastewaters. Highways were also very important sources of pollutants and formed a major component of any urban runoff water. Highways were known to be a source of chronic, seasonal and accidental pollution and so the French Highways Department set up a research project to investigate the polluting effects of highway surfaces as a component of stormwater runoff. Two study sites were selected and these were:

1. A4 Motorway (Paris to Strasbourg), 27 km. east of Metz. The catchment area was 1470 m^2 and the slope was 2.1%.

2. A61 Motorway, 20 km. south-east of Bordeaux with a catchment area of 6300 m^2.

Altogether 86 rainfall-runoff events were measured over the two year study period from March 1980 to March 1982. One of the basic aims of the study was to find relationships which would make it possible to explain and perhaps estimate the pollution loads on the basis of other parameters. It was therefore assumed that the correlations between

the pollution loads and the other parameters were linear and multiparametric. The overall study hoped to formulate relationships between pollution loads, traffic density, traffic flow rates, rainfall, runoff rates etc. in order to gain and quantify a better understanding of the pollution loads from highway surfaces.

The results showed that for the A4 Site, about 80% of the COD and Pb (Lead) were removed from the highway by the initial 52% of the runoff, but it took about 60% of the runoff volume to remove 80% of the zinc from the surface. The study concluded that the site characteristics and climate could be more important in determining the pollution loading than the traffic conditions, since no meaningful relationships were found between the traffic level and the pollution load. Balades et al (1985) concluded that the manner in which the pollution loads were entrained and the form (or species) in which they reached the environment were very important. The significance of high intensity rainfall-runoff events should not be underestimated since it was calculated that 6% of the total number of rainfall-runoff events accounted for the removal of about 30% of the total COD removal.

Jacques (1985) presented the findings of another French study into the problems of stormwater runoff quality from highway surfaces. He studied a stretch of motorway 120 km. south-east of Paris over a period from 1973 to 1980. This study was more interested in the effects the highway pollution was having upon areas adjacent to the road surface. Analysis was conducted on soil samples and water samples from ponds adjacent to the roadway in order to ascertain whether, or not, the road surface was having an important influence upon the quality of the nearby environment. The study showed that

soils adjacent to the road had high levels of sodium chloride and the heavy metals content in the surface sediments was also found to be high. A similar result was also found for some pond waters which were analysed and the effect was seen up to about 50m. from the road. Jacques (1985) adopted a more ecological approach to the study of urban runoff from highway surfaces but the conclusion drawn was that it may be necessary to take into account the potential pollution risk from a highly trafficked road if the road crosses an environmentally vulnerable area.

3.11 The Quality of Highway Drainage Waters in the UK.

The studies by Jacques (1985) and Balades et al (1985) have been complemented by work carried out in the United Kingdom dealing exclusively with motorway runoff quality and the options available to treat these runoff waters so as to deplete their pollutional strength. Some studies have been carried out by the Department of Public Health Engineering at the Imperial College, University of London. The results of this work have been presented by Pope, Young and Perry (1978); Pope, Young, Graham and Perry (1978) and Perry and McIntyre (1986).

Pope, Young and Perry (1978) set out to determine the correlation relationships between hydrological conditions and water quality in motorway runoff from a study site on the M1 motorway in the UK at a point 3 km. south of the Toddington Service area. Three 55 m. lengths of roadway were under study. The motorway sections had relatively simple drainage systems and they were therefore relatively easy to monitor. Sampling stations were established to enable the

collection of individual samples during the course of a storm event. The emphasis of the data collection programme was to collect the maximum amount of water quality data for a limited number of storm events rather than a detailed study of the individual storm events. The study included a determination of the relative amounts of metal in the soluble and the sediment-associated form, since the mechanisms of removal of these metal compounds from the road surfaces could be dependent upon many factors including storm characteristics; the metal speciation at the time of the discharge; pH variations within the storm event; and the mineralogy and size distribution of the sediment fractions. Pope, Young and Perry (1978) found that the length of time between the storm events and the weather conditions during that period determine the nature, distribution and amount of contaminants present on the road surfaces. Further conclusions drawn from the work on the M1 Motorway experimental site have been presented by Perry and McIntyre (1986).

Johnston and Harrison (1984) carried out a study on an area adjacent to the M6 Motorway in North-West England, to investigate the deposition of metallic and organic pollutants alongside a heavily trafficked roadway. This was used as a test site since the study arose out of a concern about the potential pollution of the Audenshaw Reservoir in South-East Manchester. Lead, cadmium and some organic pollutants emitted from vehicle exhausts would be discharged from the proposed M66 Motorway which was under consideration for construction. It was found that the rates of metal deposition near the motorway reach the background levels at a distance of approximately 200m. from the carriageway. The soil samples taken within a 10m. distance of the highway showed the highest metal concentrations. This study used

deposition gauges whereas most previous studies (of which there are few) tended to concentrate on the analysis of soils and plant material. Soil sample analysis can only really be used for accumulated deposition rates over a time period and not a specific deposition over a given time period. The results of the study were that there did not appear to be any clear relationship between the water soluble cadmium and the distance from the main carriageway and the relationship of the total cadmium decaying with distance from the carriageway was more erratic than that observed for total lead concentrations. The majority of motorway-derived polyaromatic hydrocarbons (PAHs) appeared to be deposited within 3.8m. of the carriageway and these concentrations were shown to have a marked seasonal effect and this was partly explained by the burning of fossil fuels in the neighbouring housing estates. This study showed that there were a number of important organic pollutants as well as metals which were found on and near motorway surfaces and attention should be drawn to the relative importance of these substances within the whole concept of highway pollution.

Early work into the pollution problems associated with highway drainage in the United Kingdom included the well documented and referenced works by Bellinger, Jones and Tinker (1982) and Hedley and Lockley (1975). Hedley and Lockley (1975) carried out some work on a stretch of the Aston Expressway (A38(M)) and in the Haunch Valley near Birmingham. They showed that certain storm events can give a pollution loading considerably greater than that derived from domestic sewage. A flow proportional sampler was used and the samples were taken over a twelve month period. All parameters (apart from temperature) showed higher levels during the winter period and this

was particularly marked for zinc and lead concentrations in the stormwater runoff. The application of rock salt to the road surfaces for de-icing purposes was considered to constitute a major influence over the resultant stormwater quality, and so some samples of rock salt used, were analysed and the results were used to calculate the total loading to the road surfaces. The Department of the Environment recommended to the County Council Highway Departments (who are responsible for the maintenance of roadways) that the rock salt should be applied at a rate between 14 to 56 $gm.^{-2}$. The results from these calculations showed that nearly all the sodium, chloride, nickel and chromium found in the stormwater runoff was due to the addition of rock salt. Variations were found in the other metal concentrations and these were related to more variable sources operating within the urban motorway environment. The vehicles were known to be the cause of most of the metal pollution due to wear and tear on the vehicles themselves, corrosion of the structure and tyres and emissions from the combustion processes or vehicle exhausts. Hedley and Lockley (1975) concluded that the runoff quality was unlikely to improve over time and so the impact upon any receiving watercourse should be fully assessed and, if possible, quantified such that a better appreciation of the impact that a stormwater runoff from a highway surface could be made.

Bellinger, Jones and Tinker (1982) highlighted the growing awareness of the pollution threat posed by highway drainage in its many forms from small residential roads to motorways. They recognised that the removal of accumulated materials on the highway surfaces was a complex problem and one which was not easy to analyse. They carried out a study on a 680m. length section of the M55 Motorway near Junction 1 from January 1976 to December 1977. Particle size analysis showed the

sediments to be well graded with a concentration of grain sizes between 0.1 to 2.0 mm. which is in the medium to coarse sand range. The authors also highlighted the influence of road salting upon the stormwater runoff and they made a specific reference to sodium, chloride, sulphate and nitrate values in the runoff waters (see Table 3.5).

Averaged Pollutant Concentrations from the M55 Motorway Study.

(All values are given in mgl-1 unless otherwise stated)

	Salting Period	Non-Salting Period.
Na	2 x 10	12 - 37
Cl	3.75 x 10	22 - 75
SO	540	6 - 100
NO	1.95 - 73.5	same as for salting period.

Table: 3.5 Bellinger, Jones and Tinker (1982)

Some very high sediment loadings were observed from the motorway drainage catchment area during the winter months but the authors noted that this could be advantageous, since they tended to remove any calcareous deposits which had built up in the concrete drain during the summer months, and this removal was either physical or chemical (possibly due to the low pH values of rainfall received in larger quantities during the winter months or the even lower pH values of snowmelt runoff which was observed over the two year study period), or even a combination of both. Some removal of sediments from the road surface was made by vehicular displacement as well as the runoff mechanisms. Bellinger, Jones and Tinker (1982) recognised the threat posed by stormwater runoff from highway surfaces and they recommended the use of less rock salt for de-icing purposes and the possibility of some runoff water treatment before the discharge to a receiving watercourse. A series of reviews of the quality of motorway runoff in the UK has been presented by Bickmore and Dutton (1984) who provided some practical examples of the extent of motorway runoff. They highlighted the effects of road runoff pollution in areas adjacent to the road surface and they concluded that more attention should be given to such potential problems in motorway design and construction.

3.12 Stormwater Runoff at Airports.

Gay, Jeffcoate, Dunn and Hawkins (1987) provided an excellent review of a relatively little known aspect of stormwater runoff quality but one which is now receiving its deserved attention within the general study of urban runoff quality, and that is the runoff from airport runways. This particular type of storm drainage problem only occurs in a limited number of locations and so its effects are very

localised. The sources of stormwater at such sites were given as runway de-icing, aircraft de-icing, aircraft washing, oil and fuel spillage, aircraft maintenance, fire training, some trade effluents etc., all or some of which may find their way into the storm sewer system. The authors carried out a very detailed study at Stansted Airport in England and they concluded that in winter the concentrations of glycol and urea in stormwater could be well in excess of those permitted for discharge by the Regional Water Authorities. In summer, the major problems were found to relate to the contamination from oils, greases and detergent and chemical spillages. Gay et al (1987) stated that there were practical alternatives to the treatment of airport stormwater runoff through either hydraulic means or biological treatment (both aerobic or anaerobic), or a combination of both. It may prove economically viable to recover glycol and this would then prompt the airport authorities to carry out some type of treatment on the stormwater, which can only be of benefit to the surrounding environment. Gay et al (1987) concluded that:

....."when designing airport developments in cold, wet climates, the problem of stormwater contamination in winter is no longer one which can be given only passing consideration, particularly in inland areas. In the UK, the implementation of the COPA II has meant that stormwater discharges have come under increased scrutiny. It is important therefore, that the problem is addressed at an early stage in airport design development such that an economic, practical and reliable solution can be achieved" ....

3.13 Stormwater Studies on Residential Catchments in the UK.

During the 1970's and 1980's, the Storm Drainage Research Group (SDRG) at the Trent Polytechnic in Nottingham and the Urban Pollution Research Centre (UPRC) based at the Middlesex Polytechnic, have both conducted extensive research programmes into the quantity and quality of stormwater runoff in residential catchment areas. Early studies produced results which quantified the magnitude of the stormwater quality problem from such catchment types and led to the recognition that stormwater was a serious threat to the quality of inland waterways in the United Kingdom (Fletcher, Pratt and Elliott (1978); Fletcher (1981); Fletcher and Pratt (1981); Ellis (1975) and Ellis (1979)). More recent studies by the SDRG and the UPRC have involved the modelling of stormwater quality and a more in-depth analysis of the processes operating within the catchment areas (Adams (1983); Pratt and Adams (1981); Pratt, Harrison and Adams (1984); Pratt, Elliott and Fulcher (1987); Ellis, Harrop and Revitt (1985); Morrison et al (1984) and Revitt et al (1987)).

3.14 Trent Polytechnic: Storm Drainage Research Group (SDRG).

For the past ten years, studies have been carried out by the SDRG to assess the quality and quantity of stormwater runoff on the Clifton Grove Housing Estate on the south-western outskirts of Nottingham. This was also the site used in the present research programme and the site is more fully described in Chapter 7. A number of studies have been conducted on the overland flow regimes of the urban surfaces (Pratt and Harrison 1984); the Rainfall-Runoff Modelling of the urban catchments (Parkar 1987); the water quality found both within and

discharged from the catchment (Fletcher 1981 and Adams 1983); and Modelling of Stormwater Discharge Quality (Adams 1983 and Mofazzali 1987).

Fletcher, Pratt and Elliott (1978) presented an assessment of the importance of roadside gully pots in determining the quality of stormwater runoff. They stated that the degree of pollutional strength within the discharge waters was related to the intensity and duration of the rainfall, the length of the antecedent dry period, the degree of street cleaning and seasonal variations such as leaf fall, snowmelt etc. The nature and intensity of human activity in the sub-catchment residential areas was thought to be a significant factor in determining the nature and composition of the roadside gully pot liquors. These liquors were found to be highly polluted at times, and anaerobic or septic conditions were observed within the basal sediments of the pots on some occasions. A series of gully pot liquors were sampled regularly on a fortnightly basis and the results showed a large variation in the parameter concentrations over a one year period (see Table 3.6).

The concentrations of BOD, COD, nitrate, ammonia and dissolved solids were found to rise dramatically during the dry summer periods and the authors concluded that a large number of variables determined the quality of the water stored within the gully pot systems.

Average Concentrations in the Clifton Grove Gully Pot Liquors.

(all values are in mgl-1 unless stated)

SS	21
BOD	7
COD	39
DO	6.1
Ammonia	0.96
Nitrate	7.8
Chloride	142.3
pH (pH units)	8.3

Table: 3.6 Fletcher, Pratt and Elliott (1978)

Fletcher and Pratt (1981) reported that water stored in gully pots may become highly polluting in nature after periods of dry weather due to the anaerobic degradation processes in the basal sediments. This was illustrated by increases in the BOD and COD values through the release of soluble organic compounds, ammonia and volatile acids. A series of laboratory studies were set up to investigate the removal of dissolved solids and settled, basal sediments under different flow regimes of the inflow waters into the gully pot chamber. The removal of the dissolved material was analysed using a dosing procedure of a salt solution of known concentration and then monitoring the level with a conductivity probe in the pot liquor. Fletcher and Pratt (1981) reported that the pot liquor was fully mixed when the inflow rates exceeded 0.12 ls-1. Inflow rates below this value exhibited a short-circuiting effect, whereby the inflow waters by-passed the gully pot liquor and were partially discharged down into the storm sewer network. Fletcher and Pratt (1981) conducted a very interesting experiment to determine the rate of removal of basal sediments within

the gully pot liquor. Two kilogrammes of solids were added to the experimental gully pot and water was gradually added to the pot. A series of experiments were conducted using inflow water rates within the range 0.1 to 1.0 ls-1. An empirically derived relationship was established to determine the rate of release of material from the basal sediments (mgs-1), using a linear regression analysis.

K = rate of release of basal sediments (mgs-1)

Q = inflow rate (ls-1)

$$K = 278Q + 25.9 \qquad (r=0.85)$$

The experiments showed that the gully pot was very efficient in retaining trapped, basal sediments since a maximum of only 0.2% of the bottom sediments were removed by the highest inflow rate (ie. 1.0 ls-1). Fletcher and Pratt (1981) argued that the solids found in stormwater discharges were primarily from material already suspended in the pot liquors, as well as that entrained within the storm runoff waters. The contribution of solids from basal sediments into stormwater discharges was considered to be very small since inflow rates into gully pots rarely exceeded 0.2 ls-1. The removal of dissolved and suspended solids was readily achieved but the removal of significant quantities of basal sediments was likely to be only an extremely infrequent event. This provided further evidence of the need to provide an effective gully pot cleaning programme on a regular basis so that the state of the pot liquor could not be influenced by the build up of basal sediments. The performance of the pot chamber as a sediment trap would be severely reduced by the build up of basal

sediments.

Fletcher (1981) sampled a number of stormwater discharges at the outfall to the Clifton Grove Estate and he concluded that the relationships between the discharge water pollutographs and the storm hydrographs were not easy to establish. A wide variation in response was noted between storm events and some chemical parameters did not show any meaningful relationships with the hydrological conditions of the storm. Fletcher (1981) highlighted the difficulties involved in sampling stormwater discharges at storm outfalls but the data collected was combined and used in a multiple regression analysis to investigate the relationships between pollutant loads and the mean storm concentrations with the hydrometeorological parameters. The regression models produced were calibrated on a limited dataset and Fletcher (1981) stressed that the use of such equations was limited to the catchment areas from which they were derived.

Pratt and Adams (1981) presented the results of a series of studies to determine the sediment washoff rates of solids into roadside gully pots. Five gully pots on the Clifton Grove Estate were analysed during the period August 1979 to October 1980. The material input (in terms of a 14 day sediment washoff) was found to be a function of the micro-catchment characteristics (ie. the nature of the area draining to one gully pot) and the stormwater flow. A moderately good correlation was found between the 14 day sediment washoff and the storm volumes and this was particularly evident when the soil moisture deficit was seen to fall to zero. The material input was found to be well correlated with the catchment conditions (ie. micro-catchment conditions) such as the impervious area, the maximum drainage path

length, the slope of the maximum drainage path length and the number of houses served by the individual gully pot under analysis. The solids material was collected in a series of meshes hung below the gully pot grating. A seasonality factor was also evident in the data obtained but Pratt and Adams (1981) derived a series of empirically-derived regression equations relating the 14 day sediment washoff loads to the catchment characteristics. This series of experiments was further discussed by Adams (1983), who extended the scope of the analysis to investigate the contributions of solids from the road surface and from roof surfaces. Adams (1983) confirmed that the removal of gully pot, anoxic, basal sediments would do little to decrease the annual solids loadings at the outfall, but would serve only to improve the sedimentation performance of the chamber and this would reduce the likelihood of blockage within the storm sewer pipe network. Adams (1983) discussed the alternative means of urban drainage whereby roof runoff waters could be conveniently discharged via soakaways and other types of infiltration-based methods. These alternative methods of stormwater disposal are currently under investigation by the SDRG and the preliminary findings of some field experiments have been presented by Pratt, Mantle and Schofield (1988).

3.15 Middlesex Polytechnic: Urban Pollution Research Centre (UPRC).

The Urban Pollution Research Centre (UPRC) based at Middlesex Polytechnic in London, has become one of the most active research groups in the field of stormwater quality problems in the United Kingdom. During the 1970's, the Urban Pollution Research Centre conducted a study on the Graham Park Catchment in Hendon, North London. The 3.5 km^2 catchment is on the site of the former Hendon Aerodrome and the area is separately sewered to an outfall on the Silk Stream which is a tributary of the River Brent. This urban area is of mixed land use and is not exclusively residential. The land use can be defined as follows:

Residential	30.5	as % of land area
Open Space	26.1	
Ministry of Defence Land and RAF Museum	22.7	
Shops and Warehouses	5.9	
Light Industrial	1.9	
Highways	12.9	

Ellis (in Hollis 1979).

A number of storm events were analysed and samples were taken at the catchment outfall. The results showed that there was a high degree of variability in the pollutant concentrations between storms and the relatively high concentrations of suspended solids and COD were thought to be conclusive evidence that urban stormwater can constitute a problem to the receiving watercourse. Ellis (in Hollis 1979)

concluded that the sudden hydraulic impact of a stormwater discharge and its associated pollutants could have a severe effect on the ecological balance of the receiving stream. The results of the Graham Park studies have been presented by Ellis (in Hollis 1979) and have been summarised in Table 3.7.

Stormwater Discharge Pollutant Concentrations for Nine Storm Events Measured on the Graham Park Catchment in North London.

(All values are expressed in mgl-1 unless otherwise stated)

Parameter	Mean	Standard Deviation	Range
SS	546.5	426.3	20 - 2688
BOD	22.2	13.8	3 - 672
COD	342.8	231.3	31 - 2105
pH (pH units)	7.4	1.3	6.6 - 7.9
Alkalinity	174.1	151.7	20 - 806

Table: 3.7 Ellis (in Hollis 1979)

The Urban Pollution Research Group have conducted an on-going series of research experiments into stormwater quality and associated problems. Revitt and Ellis (1980) carried out a study to investigate rainwater leachates of heavy metals in road surface sediments. They found that there was no obvious dependence of metal concentrations with grain size and the largest variation in metal level concentration in both time and in grain size was for lead. The study found that peak leachate levels occurred within about ten days and so weekly gully pot cleaning would be required to control metal toxicity levels during the first flush of a storm flow. Revitt and Ellis (1980) concluded that total metal levels in some storm runoff could be toxic to benthal organisms.

Ellis and Harrop (1984) studied two gully pots with a total catchment area of $533m^2$., in order to investigate the variations in solids loadings to the gully pots. The gully pot acted as a settling tank for solids washed in from the road surfaces. Ellis and Harrop (1984) stated that it was the nature and character of the gully pot particulates which effectively controlled the form and strength of any ensuing pollutant flush from the pot chamber into the storm sewer. The study showed there to be a seasonal fluctuation in sediment loadings which corresponded with the seasonal variation in rainfall and associated flow characteristics. The total solids and the organic solids measurements both correlated highly with the total rainfall volume measured for given storm events. It was also suggested that there was an effective relationship between the load of particulate removed and the duration of the surface runoff. Ellis and Harrop (1984) concluded that a log-normal distribution was found in the sediment grading in pot sediments and about 66% of all sediment input

to the pots was between 400 and 3000 μm. in size. This was a similar finding to that made by Pratt and Adams (1981). The study showed that the nature, condition and gradient of the contributing road surface appeared to be significant factors in explaining the total solids loadings and particle size distributions removed from roadside gully pots.

The Urban Pollution Research Centre carried out a number of studies on the sediment characteristics and quality of roadside and gully pot sediments over a period of years (Revitt and Ellis 1980; Ellis, Hamilton and Roberts 1981; Ellis and Harrop 1984). A further extension to this work involved the study of gully pot liquor and associated sediments under storm conditions to investigate the hydrological and quality interrelationships. Some of this work was carried out in a collaborative project with the Department of Sanitary Engineering at the Chalmers University of Technology in Goteborg, Sweden. Morrison et al (1984) showed that the dissolved and sediment associated heavy metals both showed similar distributions to the flow hydrograph, but it was observed that in some cases, secondary peaks and deviations appeared and these were thought to have been caused by the scavenging of the dissolved species. The runoff volume, land use and length of antecedent dry period all influenced the pulse of heavy metals and the dilution-exhaustion effect was only observed where the supply of metals was limited (such as through a short antecedent dry period). The experiments were conducted on a stormwater outfall from a 214 hectare housing estate in NW London. The concentrations of zinc, lead and copper, in both the dissolved and the sediment associated phases, all showed similar concentrations which led Morrison et al (1984) to conclude that a similar or common source was

responsible for the input of these metals to the storm sewer system. This led Hamilton, Revitt and Warren (1984) to look more closely at the concentrations and physico-chemical associations of cadmium, copper, lead and zinc in the roadside sediments. It was known that the transport pathways and the effects of the metals depended upon their concentration, the size spectrum of the heavy metal containing particles and the chemical form (or species) in which the metals occurred. An eight month study was conducted at three sites in NW London. The results showed that 50% of the mass of cadmium, copper, lead and zinc was associated with particles less than 500 μm. in diameter and standard street cleaning operations only removed particles with diameters greater than 250 μm. The maximum heavy metal concentrations on roadside sediments were found to be:

Cadmium	670	all values in μgg-1.
Copper	1660	
Lead	8500	
Zinc	8000	

The main conclusion drawn from the study was that the chemical associations of the heavy metals in the highway sediments indicated that the overall availability to the soluble phase of stormwater runoff was governed by changes in the pH and the oxidising and reducing conditions of the runoff waters, and these were likely to be highly variable in any given storm event.

One of the inherent difficulties in any water quality monitoring programme is that of representative sampling. Storm events are often spasmodic and it is sometimes difficult to adjust the frequency of sampling to compensate for the flow conditions and the runoff duration of any given storm event. The difficulties of obtaining

representative sediment samples from road surfaces are mentioned in some of the papers reviewed above.

In order to provide a better overall picture of stormwater quality changes throughout a storm event, an experiment was set up by the UPRC at the Middlesex Polytechnic in collaboration with the Chalmers University of Technology in Goteborg, to provide continuous on-line monitoring of environmental pollutants in stormwater (Morrison, Sjolander and Svensson 1985). The experiment was conducted on a 15.4 hectare residential catchment site in the NE of the City of Goteborg, called Bergsjon. The monitoring equipment was set up to continuously measure pH, conductivity, DO, temperature and redox potential. During the winter months, the gully pots acted as a reservoir of warmer water (when compared to the runoff water flowing over a very cold urban surface) and the flushing of the pot liquors at the start of the storm event could be seen through an initial temperature rise in the in-pipe waters. This study showed that during periods of heavy rainfall, basal sediments could be remobilised and then become suspended in the runoff flows. This caused a drop in the redox potential and DO, and an increase in the pH of the outflow waters due to the reducing nature of the basal sediments. The DO levels tended to be quite high since the incoming rainwater was likely to be saturated on its descent through the atmosphere. A limited number of storm events were analysed by the continuous on-line monitoring programme but the results provided a useful summary of the events occurring within the pot liquors, and they also highlighted the variation in performance of the gully pots under different runoff flow regimes.

Ellis, Revitt and Gavens (1985) presented the results of a study into

sediment-associated polyaromatic hydrocarbons (PAHs) which was conducted in the 5.3 km^2. Silk Stream catchment area in NW London. Six PAHs were under study : anthracene, fluoranthrene, pyrene, benzo(b)and(k)fluroanthenes, benza(a)pyrene and benzo(ghi)perylene. It was thought that the PAH distribution was essentially hydraulically controlled through the discontinuous resuspension of the mobile surface sediment layers during the turbulent flow conditions found during a storm event. The study showed that between 80%-95% of all hydrocarbons in urban runoff were particulate-associated. Revitt et al (1987) reviewed the findings of a study into the distribution and fate of toxic pollutants in urban runoff. They concluded that the distribution of these pollutants was controlled by the biochemical processes which activated the transformation and mobilisation of the toxic compounds during a stormflow event.

As an extension to the research conducted into stormwater quality over the last ten years, the Urban Pollution Research Centre are currently involved in some studies into the biological monitoring of watercourses in urban areas. The chemical quality and the often high storm discharge intensity of urban stormwater runoff is known to have a profound effect upon the biological populations of receiving watercourses. The current research project is being conducted on the Salmon's Brook which is a tributary of the River Lee in North London. Such a study of the macroinvertebrate population of a receiving water can provide a more meaningful approach to ascertaining the influence of urban runoff waters on receiving watercourses. The advantage of biological monitoring is that it provides a time-integrated approach to water quality management. The preliminary findings of the biological monitoring of the Salmon's Brook have been presented by Bascombe, Ellis, Revitt and Shutes (1988).

3.16 The Deterministic Modelling of Stormwater Quality.

There are two types of statistical models:

1. Deterministic: whereby causal relationships are derived between variables which control the process being modelled. One or more independent variables are said to influence the dependent variable.

2. Stochastic or Probability Models: whereby relationships between probability levels of the variables involved in the process are established.

Hemain (1986).

Hemain (1986) has provided a comprehensive review of the use of different types of models in stormwater studies. The most common type of deterministic model involves the use of simple or multiple regression in either a linear or a non-linear form. Hemain (1986) stated that ..."no single formulation of a regression equation adequately predicts stormwater quality for all pollutants and basin conditions"... and that ..."no particular model is consistently better than others in predicting stormwater pollutant runoff"...

The need to be able to predict the resultant stormwater quality from a given rainfall event has led to the development of some deterministic models based on empirically-derived data. Some studies have adopted simple step-wise regression models to predict pollutant loading rates for stormwater discharges (Ellis, Harrop and Revitt 1986), whilst others have modelled pollutant mean concentration values (Desbordes and Servat 1984). It is possible to use these derived relationships to determine a predicted, effective pollutant concentration in the discharge waters, whereby the volume of the stormwater discharge (if

not measued directly) can be estimated using an established Rainfall-Runoff relationship.

Further examination is now made of the regression models developed by Ellis, Harrop and Revitt (1986) and by Servat and Desbordes (1984).

3.17 The UPRC Stormwater Quality Discharge Models.

The Urban Pollution Research Centre at the Middlesex Polytechnic in England conducted a study of the hydrological controls upon pollutant removal from highway surfaces on the Oxhey residential catchment in Hertfordshire, England. Ellis, Harrop and Revitt (1986) set out to model pollutant removal from highway surfaces through the use of regression models using hydrological data. The study also concentrated on the hydrological controls which were known to influence the rates of pollutant removal from the highway surfaces. A step-wise linear regression analysis was carried out using five selected hydrological parameters against the various pollutant loadings. Athayde et al (1982) had previously suggested that the runoff volume was the most significant, predictive loading factor for regulating pollutant concentrations. Ellis, Harrop and Revitt (1986) showed that the total runoff volume and the storm duration together explained about 90% of the observed variance in the lead, cadmium, manganese and solids loadings. The study was conducted on a 0.05 hectare highway surface in NW London. There is a considerable contradiction in the literature with regard to the importance of the antecedent weather conditions in controlling the pollutant runoff levels. The results of the Middlesex Polytechnic study clearly showed that the antecedent dry period and the rainfall intensity were not

significant factors in controlling the removal of particulate pollutants from the catchment area. The five hydrological parameters used in the step-wise regression analysis were:

i) rainfall volume (mm);

ii) maximum 5 minute rainfall intensity (mmhr-1);

iii) storm duration (min);

iv) antecedent dry period (hr); and

v) total surface discharge (litres).

Ellis, Harrop and Revitt (1986) reported that the predicted runoff metal loading rates were generally comparable with values quoted for typical storm events. The metal loadings were shown to be primarily controlled by storm flow and storm duration characteristics. The antecedent dry period was not found to be an important factor. The metal loading rates were found to be similar in terms of magnitude to the aerial rates of deposition of these metals which led the authors to the conclusion that most of the metals found in the stormwater runoff were derived from the atmosphere. Ellis, Harrop and Revitt (1986) did, however, stress that certain other factors should be considered when applying the regression model equations developed in their study. They highlighted the need to incorporate factors such as a wetness index, pollutant and sediment accumulation rates, the state of the road surface etc. into future stormwater quality predictive models. The prediction equations for pollutant loadings from the highway surface developed in the study were as follows:

where	TS	=	Total Solids Loading	(g ha-1)
	Q	=	Total Surface Runoff	(litres)
	ADP	=	Antecedent Dry Period	(days)

RV = Total Rainfall (mm)
RINT= Maximum 5 Minute Rainfall Intensity (mmhr-1)
SDUR= Storm Duration (min)

TS = 114.86 + 3.589 Q + 0.346 ADP + 4.257 RV
(r=0.99)

Pb = 77.07 + 3.533 SDUR - 0.613 ADP - 2.799 Q
(r=0.99)

Cd = - 0.0139 + 0.033 SDUR - 0.032 Q - 0.003 ADP
(r=0.96)

Fe = - 900.997 + 87.113 RV + 18.381 Q + 4.212 SDUR
(r=0.99)

Zn = 78.322 + 3.257 SDUR - 2.914 Q - 0.499 ADP
(r=0.93)

Mn = 0.140 + 0.495 Q + 1.340 SDUR - 0.175 ADP
(r=0.99)

Cu = 103.218 - 2.942 RV - 1.231 Q - 0.433 ADP + 1.876 SDUR
- 0.369 RINT
(r=0.86)

All metal loadings are in mg.

Ellis, Harrop and Revitt (1986) stated that there were difficulties in disassociating the hydrological controls upon stormwater discharge quality from the local factors relating to urban conditions such as traffic conditions, road surface type, human activity etc. These conclusions reflected those of Hemain (1986), who stated that no one model could be developed for widespread use in determining stormwater quality. The authors found that the predicted metal loading rates were of the same order as those values often quoted for typical atmospheric deposition rates and the authors stressed that this was further evidence of the importance of the atmospheric input in contributing directly to the stormwater runoff load. The main conclusions drawn from this work at the Middlesex Polytechnic were

that the metal loadings were primarily dependent upon stormflow and duration, and that the antecedent dry period did not appear to be significant in determining the variations in pollutant loadings.

3.18 The French National Urban Runoff Programme Models.

The second study reviewed here was concerned with the deterministic modelling of urban water quality data obtained in France. Desbordes and Servat (1984) carried out a series of studies on four catchment areas in different regions of France. The data collection programme formed part of a wider research programme which involved the collection, collation and analysis of water quantity and water quality data from various urban areas as part of the "French National Programme of Urban Runoff Quality Measurement". This has been reviewed by Deutsch and Hemain (1984). The data obtained by Desbordes and Servat (1984) was used to develop a series of simple regression models for use to predict the mean suspended solids concentration in stormwater discharges from separately-sewered urban catchment areas. They recognised suspended solids as the most significant pollutant in stormwater discharges due to the following three factors:

1. effects upon the turbidity in the receiving watercourses;
2. solid organics exert an oxygen demand upon the waters; and,
3. the ability of the suspended solids to transport various toxic pollutants, such as heavy metals, pesticides etc.

The four catchment areas under study varied considerably in size, slope, imperviousness and geographical location (see Table 3.8). Two of the sites were in Paris and the other two were in the South of

France in an area near Aix-en-Provence (see Table 3.8). A number of storm events were studied on all four catchment areas and the SS concentrations were analysed on stormwater outfall discharge waters. A step-wise regression analysis was performed between the mean SS concentrations and nine explanatory hydrological variables. The regression analysis showed that the variables IMAX5 (mean maximum rainfall intensity during a 5 minute time interval in mm/hr) and DTS (duration of the dry weather period preceding the storm event in days) were the most highly correlated with the mean SS concentration, and they explained more than 50% of the variance. One other interesting observation related to the fact that the DTS was more highly correlated with the mean SS concentration for the two Paris catchment areas, whereas the same was true for the IMAX5 variable in the two catchment sites in the South of France.

Table 3.9 shows the step-wise regression relationships found for the four catchment areas under study. The regional (or climatic) differences, as outlined above, were also illustrated in the regression equations presented in Table 3.9. Desbordes and Servat (1984) stated that ..."in the South of France, the dry weather periods are much longer (almost twice) than those in the north of France, on an average basis. Therefore dusts become more consolidated and their removal should necessitate higher rainfall intensities"... Desbordes and Servat (1984) did, conclude however that more measurements needed to be made to confirm these findings and other physical phenomena should be included in future studies such as mean wind speeds, wetness indices etc.

The French studies found that the rainfall intensities were more

important than the rainfall volume in determining the mean SS concentrations, and this was contrary to the findings of the Urban Pollution Research Centre studies carried out in Oxhey, England. The Climatic Regime of the Mediterranean area may well have biased the results in favour of this conclusion, whereby the rainfall intensity was seen as a very important parameter in the modelling of SS concentrations in stormwater discharges. There was, however, a certain amount of agreement in the conclusions drawn by both studies as presented by Ellis, Harrop and Revitt (1986) and by Desbordes and Servat (1984). The inclusion of a parameter describing the antecedent dry period in both models was an important feature common to both studies.

The Catchment Characteristics and Observed SS Concentrations in the French Study carried out by Desbordes and Servat (1984).

Catchment	Maurepas Paris	Les Ulis Paris	Aix Zup (South)	Aix Nord (South)
Area (ha)	26.7	43.1	25.6	92.0
Slope(%)	0.5	0.55	2.9	6.5
Impervious Area (%)	60.0	42.0	78.0	35.0
Popn Density (per/ha)	100.0	350.0	210.0	40.0
Mean SS Conc (mgl-1)	185.0	512.0	288.0	471.0
No. of Storm Events	89	62	48	44

Table: 3.8 Desbordes and Servat (1984)

Table to Show the Step-wise Regression Models for each Site in the French Study as carried out by Desbordes and Servat.

Catchment	Model	Correlation Coefficient
Aix Zup	SS = 302 + 4.51IMAX5 - 3.37H7	0.516
Aix Nord	SS = -15.14 + 35.37IMAX5	0.916
Les Ulis	SS = 125.32 + 58.7DTS + 13.49IMAX5	0.691
Maurepas	SS = 68.22 + 22.94DTS + 3.42IMAX5	0.701

where SS=mean suspended solids concentration and H7 is the rainfall depth during the seven days before the storm (mm).

Table: 3.9 Desbordes and Servat (1984)

3.19 The Analysis of Gully Pot Liquor Quality.

A previous reference has been made to the work of Fletcher (1981) and Adams (1983) who studied the quality of gully pot liquor over time on the Clifton Grove Estate in Nottingham, England. Very few studies have been carried out worldwide into the quality of pot liquors and the influence that the gully pot exerts during a storm event. The outflow waters from a gully pot chamber can exert a considerable influence upon the final discharge waters which are also influenced by their passage through the storm sewer pipes before they reach the stormwater outfall. The aim of the present research programme was to investigate the role in which gully pots may determine the quality of stormwater (see Chapter 2). Two studies which have been conducted in recent years into an assessment of the contribution of gully pots to the stormwater runoff quality problem, have been carried out in West Germany and in England.

The West German study has been conducted by a research group based at the University of Hannover. Grottker (1986) carried out a study into stormwater runoff quality from a street with a medium traffic loading in the town of Hildesheim near Hannover. The main objective of the study was to identify and estimate the physical and chemical characteristics of road dusts and stormwater, with a view to describing the processes of accumulation, removal and transport on the road surface. This study was conducted over a one year period and the roadway under analysis was made of an asphalt roadway with a block-paved stone gutter. The results showed that the storm runoff removed the smaller sized fractions much more than the larger sized particles and this was the reverse effect to the action of street

cleaning, whereby the apparatus tends to pick up only the larger sized particles. Surface sediment samples were taken both before and after a rainfall event from the road surface. The two samples were then analysed for heavy metals, having been sieved into eight particle size fractions. It was found that the bigger sized particles were removed better than the smaller ones and, therefore, the heavy metal concentrations were higher after a storm event. These results were not very conclusive since only a few samples were collected over the one year study period. Further research work is currently in progress on the Hildesheim catchment areas, but Grottker (1986) concluded that a full understanding of the accumulation/removal processes at work on the road and paved surfaces, within the gully pot systems and within the storm sewer pipe network was needed before the successful modelling of runoff quality from street surfaces could be achieved. A number of gully pot liquor samples were also collected and the data collected could be used in the development of a model of gully pot performance during a storm event. This work is currently in progress (Grottker 1986).

There is only a very limited amount of data collected for outfall discharges and even less has been collected for the outflow waters from a gully pot during a storm event. Such data could be used to model the performance of the gully pot during a runoff event and the role of the gully pot in determining the quality of the stormwater discharge would then be better appreciated. This was the aim of the research programme (see Chapter 2).

The English study has been presented by Revitt et al (1987) and this was one of the very few studies carried out on gully pot discharge

quality. The paper presented by Revitt et al (1987) was part of a collaborative project between the Urban Pollution Research Centre at the Middlesex Polytechnic in England and the Department of Sanitary Engineering at the University of Chalmers in Goteborg in Sweden. This paper discussed the variability of some water quality parameters during individual storm events and the data was collected from a separate study gully pot on a car park site and from two diverse, separately-sewered catchment areas in the UK and in Sweden. The individual gully pot was located in a car park at the University of Chalmers in Goteborg in Sweden and it served an area of 390 m^2 of asphalt surface. The two separately-sewered catchment areas were both residential in nature and the first was a 247 hectare area at Oxhey in NW London where 18% of the surface was considered to be impervious. The second catchment area was at Bergsjon which is a 15.6 hectare housing area in Goteborg with a 42% impervious area. Revitt et al (1987) presented the results of five individual storm events when the gully pot outflow waters were analysed and this data is presented in Table 3.10. The gully pot loadings of SS were found to be dependent primarily upon the intensity of the storm event and the overall runoff volume although these relationships would be controlled by the amount of material within the gully pot itself. Revitt et al (1987) reported that an important process which occurred within the gully pot during storm conditions was the mobilisation of interstitial sediment waters, and the rate at which this happened was related to the incoming overland flow rates.

Revitt et al (1987) also presented some results of analysis of stormwater outfall discharges from the two residential catchment areas under study. The stormwater solids appeared to be organically

enriched at the outfalls and this indicated that there was a clear enhancement between the gully pot outflow and the catchment area outfall waters. Revitt et al (1987) concluded that this was probably due to the hydraulic release and transport of highly organic material from within the in-pipe system and these re-entrained particles were able to absorb organics released from the microbial action in the below-ground phase of the storm sewer network. The data for the nine storm events selected for analysis are presented in Table 3.11. The analysis of the storm pollutographs showed that the SS concentrations followed a very similar pattern to the storm hydrograph and in most cases, the SS peak coincided with the peak flow. This feature was also observed in the gully pot outflow water study. Revitt et al (1987) suggested that the 'first flush' of solids from the road runoff was delayed through the gully pot settling, but the contents of the pot chamber could be remobilised by the increasing turbulence and unstable flow conditions associated with the rising limb of the storm hydrograph.

Table to Show the Hydrological Characteristics and SS Loadings from Gully Pot Outflow Waters for Selected Storm Events Measured by the UPRC at the Middlesex Polytechnic.

Study Site: Gully Pot in the Chalmers University Car Park, Sweden.

STORM	RAINFALL mm	VOLUME litres	DURATION Hours	ADP Days	SS LOADING g
A	18.5	6932	5.8	10	467
B	2.9	1667	8.7	3	23
C	4.6	2155	4.3	1	28
D	9.7	3951	1.0	10	314
E	6.5	3992	2.5	1	48

Table: 3.10 Revitt et al (1987)

Table to Show the Hydrological Characteristics and Mean SS Concentrations for the Outfall Discharge Waters for Nine Storm Events Studied by the UPRC at the Middlesex Polytechnic.

Study Sites: Oxhey, NW London (O) and Bergsjon, Sweden (B).

STORM NUMBER	SITE	DURATION Hours	RUNOFF VOLUME m^3.	MEAN SS CONCENTRATION mgl-1
1	O	2.2	1058.3	161
2	O	2.7	1362.3	52
3	O	0.8	320.3	132
4	B	0.7	33.4	123
5	B	1.7	63.1	70
6	B	0.4	79.9	65
7	B	4.4	281.3	34
8	B	6.6	111.7	243
9	B	9.0	77.1	39

Table: 3.11 Revitt et al (1987)

3.20 Summary.

The aim of the literature review was to present some of the findings of the major work carried out in the field of stormwater quality and to review some of the more recent work carried out in the UK and the rest of Europe. Recent work has been developed in the fields of highway drainage and airport drainage problems which are themselves an integral part of the overall problem of urban stormwater runoff quality. A great deal of research has been carried out in the last fifteen years and some other important references not referred to in Chapter 3, are listed in the Bibliography.

Chapter 4: Urban Hydrological Measurement.

4.1 Introduction.

It has already been stated that the hydrology of a particular urban catchment area has an important bearing upon the resultant water quality in the urban runoff. A description of the hydrology of an urban area involves an appreciation of various components of the hydrological cycle which are seen to be important. The Rainfall-Runoff process provides the runoff water which may dissolve, precipitate, enhance the pollutant load or concentration and mobilise sediments. The process therefore exerts an influence upon the stormwater quality. The Rainfall-Runoff process can best be explained through a simplified version of the hydrological cycle comprising of three distinct phases :

i) meteorological
ii) hydrological
iii) hydraulic

Comparatively few studies have been carried out on fully instrumented separately storm-sewered catchments and difficulties have been experienced over the measurement of flows in storm sewer pipes and at the stormwater outfalls. A number of studies have been carried out on instrumented catchments in order to investigate and quantify the Rainfall-Runoff processes at work. This has led to some work also being done on water budgets for urban catchments. The aim of such studies was to give a better appreciation of the Rainfall-Runoff process, to measure the flow characteristics and to assemble data in

order to develop models which can be used to simulate flow conditions which would enhance the provision and design of separate storm sewer networks (Kidd and Packman 1979).

4.2 Stormwater Quantity: The Use of Rainfall-Runoff Models.

Equations to determine overland flow are quite complex and are fraught with difficulties for real-time application. During the last twenty years, a series of Rainfall-Runoff models have been developed to assist in the quantification of storm volumes and flow characteristics. Rainfall-Runoff models have been developed in recent years to provide simulated flow conditions from a given meteorological event input for varying catchment conditions in urban areas. These are empirically derived models whose derivation is based upon the measurement of rainfall and discharge volume from a given catchment. Relationships can be found between these two parameters for a given number of storm events and such a model can then be used to predict the discharge volume for a given rainfall input. Recent advances in computer processing power and the wider availablity of the asssociated hardware (especially the increase in the number of powerful micro and mini-computer systems used in offices) has led to an increasing use of computer modelling techniques in urban storm drainage studies and design. There are a number of different approaches to the modelling process. The modelling of the Rainfall-Runoff interaction is essentially an estimation of the water available for runoff after losses have been taken into account. This volume is then hydraulically routed with respect to area and time so that an inlet hydrograph is produced from an 'effective hyetograph'. The different approaches vary with regard to the assumptions made concerning the

losses be it in a proportional loss model or a non-linear model. Some factors may be neglected altogether and a compromise has to be arrived at, with respect to the sophistication of the model required, the data input requirements and the complexity of the data processing. Rainfall-Runoff models recognise three distinct phases - i) meteorological ii) hydrological and iii) hydraulic

i) Meteorological

The rainfall measurement can be made with a standard raingauge (which should conform to the Meteorological Office Siting Specifications) and a tipping bucket raingauge can be used to produce rainfall depths in real time, so that rainfall intensities can be calculated. The rainfall is assumed to fall evenly over the entire catchment. Urban climatological studies have shown that urban areas experience different rainfall regimes to rural areas with urban areas generally having a greater number of high intensity/short duration storm events. It is now widely recognised that the relative warmth of urban areas (through the generation of artifical heat and the heat capacities of materials used in the urban fabric), the higher absolute humidities, the greater concentration of atmospheric pollutants (especially aerosols) and the mechanical influence of the air and heat fluxes over the urban surfaces, all contribute to urban areas experiencing higher than average rainfall. This effect was observed in the detailed climatological studies of London by Chandler (1965) and Atkinson (1979). Similar conclusions were drawn from the METROMEX experiments carried out in the USA (Landsberg 1981).

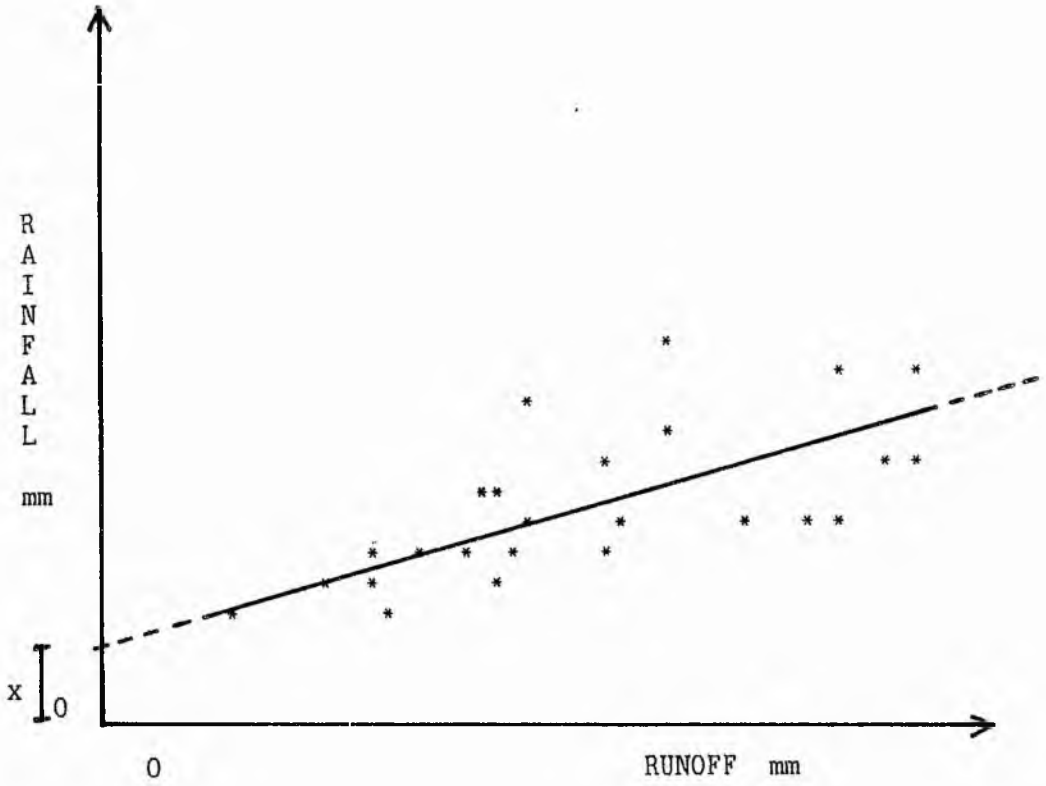
ii) Hydrological

This phase assesses the actual volume of rainfall which is available as runoff. The evaporation, interception and storage components of the urban hydrological cycle are not thought to be significant in the rainfall-runoff modelling approach. Evaporation is considered to be negligible in the argument and this assumption is acceptable in a temperate climate when the rainfall-runoff response time will be quick. The short residence time of the water on the urban surface means that the rate of evaporation will be very small and can therefore be regarded as a negligible flux of water within the urban hydrological cycle. Interception is not thought to be important due to the absence or low spatial density of trees and vegetation in the urban catchments. The Rainfall-Runoff process is therefore simply regarded as a direct rainfall impact upon the surface with subsequent runoff. Losses will occur and therefore the total volume of runoff will always be less than the total volume of rainfall over the catchment. A certain volume will be held as surface storage and this water is held in small cracks and depressions within the surface structure. This is known as 'depression storage'. Losses will also occur through cracks and the kerbside jointing leading to the gully pot drainage system. Losses through infiltration are not considered to be great since most urban asphalt and concrete surfaces are considered to be highly impermeable although some studies have refuted this claim (Davies and Hollis 1981). The measurement of the total rainfall falling over the catchment and the discharge volume at the outfall can be used to estimate these losses. The standard approach is to plot the rainfall depth against the runoff depth in an equivalent unit of depth, usually expressed in mm., (which is

equivalent to the volumes concerned since the catchment area is constant in each case) for a number of rainfall events (see Figure 4.1). The points on such a plot generally conform to a straight line relationship and a least squares regression analysis can be performed on the data to provide the line of best fit for the data. This line will always cut the rainfall axis at a value greater than zero by virtue of the fact that some rainfall will occur before the runoff process commences and it is this depth of rainfall which is equivalent to the 'depression storage'. The depression storage can be defined as the quantity of water which is retained on the urban surface as storage water in depressions within the surface configuration. This depth (or volume) of water is equivalent to that depth of rainfall required before urban runoff commences. The gradient of the regression line is called the 'runoff coefficient' and this takes account of the losses that occur during the runoff process. The Runoff Coefficient takes account of the losses after the depression storage has been filled, such that the total rainfall depth is equal to the runoff depth plus the total rainfall losses for a particular urban surface.

Rainfall-Runoff Depth Plot Showing Depression Storage

Figure 4.1



where RAINFALL = M (RUNOFF) + X

when M = Runoff Coefficient

X = Depression Storage

iii) Hydraulic:

The hydraulic component of the model involves the surface routing of the available runoff volume over the urban surfaces producing a hydrograph from an "effective hyetograph" (ie. the rainfall available for runoff after all the losses have been accounted for). A number of complex physical approaches can be simplified whereby the hydrological processes are expressed as inputs (rainfall) and outputs (runoff) with storage as a "lumped parameter". This "storage routing" concept is based on the continuity and dynamic equations, which describe the storage-discharge relationships for a storage element and a kinematic wave approximation to the full momentum equation. The basic principles of Rainfall-Runoff Modelling have been briefly outlined above. A number of simple and more highly complex Rainfall-Runoff Models have been developed in recent years and these have been used to enhance storm sewer design (eg. through the development of the WASSP Procedure, as developed by the Hydraulics Research Station) and the models have been used to enhance the development of stormwater quality models by providing good estimates of storm flow characteristics and flow conditions. The overland flow characteristics should be seen as the important driving force by which a number of physical mechanisms are set in force whereby the within-catchment pollutants may be mobilised, transported, deposited and discharged in the stormwater from the catchment area.

The WASSP (Wallingford Storm Sewer Package) procedure was published in 1981 as a result of a joint study by the Meteorlogical Office, the Institute of Hydrology and the Hydraulics Research Station (National Water Council 1981; Price 1984). The Wallingford Procedure was

designed as a package to be used to provide an efficient and cost-effective scheme for the drainage of urban areas. The model was originally designed for use on a mainframe computer but micro versions are now available and are in widespread use throughout the UK. The WASSP procedure recognised the importance that should be attached to the provision of a good urban storm drainage system and defined the need for such a system in terms of:

1) to maintain public health;
2) to provide protection from physical damage and flooding;
3) to create an environment acceptable to the community; and
4) to make land available for development.

4.3 The Field Measurement of Hydrological Components.

Hydrological measurement is an essential factor in the appreciation of water quality and it is therefore an important component within stormwater quality analysis. One of the most important difficulties experienced in the measurement and analysis of stormwater runoff is the spasmodic nature of the event. Stormwater analysis differs from other areas of hydrological investigation such as river flows, groundwater analysis, reservoir and lake studies etc. because the presence of water is discontinuous. This makes the measurement and sampling of stormwater flows more difficult due to the unpredictable nature of the event and the unpredictable resultant flow and quality conditions. This means that it is often necessary to conduct field investigations for a long period of time in order to derive a good dataset of urban rainfall and associated runoff measurements. There are also considerable difficulties encountered in instrumenting some urban areas with raingauges and flow measuring equipment due to

accessibility, interference from outside sources, safety, access to the public highway and footpaths, vandalism etc. There are also problems associated with the instruments themselves which may be measuring only a small fraction of the time eg. perhaps a few hours per week. Both mechanical and electrical/electronic devices tend to perform better with continuous use and are designed in many cases for such conditions. The intermittent nature of rainfall and stormflow measurement means that such instruments are not being utilised to their full effect. Such problems have limited the number of field investigations in urban hydrology but an interest started in the early 1970's has led to a number of valuable datasets being derived, some of which have been used to develop Rainfall-Runoff models. These models require a meteorological input which can be easily measured with a raingauge and this flux of water is translated via a series of assumptions and calculations based upon the catchment characteristics, into a flow regime for both the above-ground and the below-ground phases. Some models now involve some very complicated mathematical modelling techniques.

4.4 The Different Types of Rainfall-Runoff Model.

Kidd (1978) has presented a review of the different types of Rainfall-Runoff models available for overland flow and they fall into three broad categories.

1) Constant Proportional Loss Model:

The depression storage is filled by the rainfall and once this quantity (or depth) has been satisfied, the rainfall losses are proportional. The remaining losses (as described by the runoff coefficient) are deducted as a fixed proportion of the remaining rainfall event.

2) Phi-Index Model:

This approach is concerned with the depression storage being subtracted at the start of the event and the rainfall losses occur at a constant rate for the remainder of the storm.

3) The Variable Proportional Loss Model:

This can be simply defined as a model which allows for a higher rate of loss of rainwater available to runoff at the start of the storm, incorporating both the depression storage and the runoff losses as function of the storm duration.

The model used in this research programme was a 'Linear Reservoir

Model' (LRM) which is based upon the unit hydrograph theory and has been described by Kidd (1976,1978), Pratt and Henderson (1981) and Parkar (1987). The LRM consists of two parts:

i) a constant proportional loss rainfall model gives the net hyetograph

ii) a surface routing procedure which is a standard procedure used to route the available runoff over the catchment surface into an inlet hydrograph for an individual gully pot.

Surface routing is used in urban runoff modelling to describe the hydrological processes operating on the urban surface which are considered as a series of inputs and outputs (ie. Rainfall-Runoff) whereby the storage term is a 'lumped parameter'. The LRM has been noted for its "goodness of fit" and this is particularly true for the estimation of the peak flow. The LRM for the Clifton Grove Housing Estate sub-catchment and micro-catchment areas has been developed and calibrated by Pratt and Henderson (1981); Pratt and Harrison (1982); and Parkar (1987). The LRM was adapted and calibrated to provide a simulation of flow conditions into the gully pot in the form of an inlet hydrograph. The catchment characteristics were derived from previous work on the Clifton Grove Estate (Pratt and Henderson 1981; Pratt and Harrison 1982; Adams 1983). In this research programme, three versions of the LRM were developed for the three micro-catchments being studied, called Tame 2 (T2), Churnet 2 (C2) and Twyford 2 (TW2) micro-catchments, which were used in the storm analysis studies (see Chapter 8). A micro-catchment is defined as the area which drains to an individual gully pot. The Computer Program developed by Parkar (1987) was edited and amended to provide a means

of simulating the runoff conditions in the T2, C2 and TW2 micro-catchments by the means of providing an inlet hydrograph for the gully pot on each micro-catchment. The three catchment characteristics required by the LRM were depression storage, runoff coefficient and the micro-catchment area and these can be seen in Table 4.1.

Table of the Micro-catchment Characteristics Used in the LRM Rainfall-Runoff Model to Simulate Flow Conditions into the Gully Pots.

Micro-catchment Name	Depression Storage	Runoff Coefficient	Micro-catchment Area
	mm		m
T2	0.76	0.90	228
C2	0.66	0.81	241
TW2	1.22	0.83	382

Table: 4.1 (Fletcher, Pratt and Elliott 1978)

4.5 Hydrological Measurement in the Research Programme.

The research programme was chiefly concerned with the collection and analysis of water quality data to study the influence of the highway gully pot on resultant stormwater quality. It was therefore necessary to conduct an extensive hydrometric data collection programme for the sub-catchment and micro-catchment areas under study in order to describe the hydrological conditions experienced on the urban sub-catchments during the period of study, and to add a hydrometic dimension to the analysis of the water quality data. A rainfall measurement programme was conducted throughout the two year period from May 1984 to April 1986. A tipping bucket raingauge was installed adjacent to the Tame Close sub-catchment and the gauge was installed at a height of approximately 1.5 m. above ground level in the corner of a grassed area. The gauge was well away from any buildings and the position chosen was the optimum location for the gauge within the study area since it was away from public thoroughfares and the roadways and there was adequate room to install an instrument box adjacent to the gauge (see Figure 4.2). This gauge was defined as the 'primary' gauge and the results from the Tame Close raingauge would be used in the research programme. The possibility of instrumental breakdown and associated environmental hazards, meant that it was necessary to have back-up gauges which could provide rainfall data during the periods of 'downtime' of the Tame Close raingauge. Two other tipping bucket raingauges were installed at nearby locations (see Figure 7.1) and these gauges were used as a back-up facility. These two gauges were located on the Campus of the Trent Polytechnic (Clifton Site) and in a secluded garden on Pieris Drive which is a residential location on the Barton Green Housing Estate. The site

locations for the Pieris Drive and the Trent Polytechnic Clifton Campus raingauges have been described by Parkar (1987). A continuous rainfall record was kept for the two year period.

The Tame Close (TC) raingauge was a 0.1 mm (nominal), 8 inch diameter Rimco tipping bucket raingauge and it was used to continuously measure the rainfall. The Pieris Drive (PD) and the Trent Polytechnic Clifton Campus (RR) gauges were of an identical type. The raingauge was connected to a data logging system designed by 'Microdata Digital Logging Systems' (Microdata M200L Handbook 1978) and the logger system was installed in an instrument box adjacent to the TC raingauge (see Figure 4.2). The logger system was housed in a robust, sealed casing to maximise operational reliability when exposed to varying and, at times, extreme contrasts in the environmental conditions such as temperature and humidity. The logger could be set up and left on-site and a rechargeable battery supply meant that the logger did not require a mains power supply which would have further limited the location of the gauge and its instrument box. The multi-channel logger could accommodate several instruments at once and real-time input cards were available to be able to log the results in real-time. The logging interval (ie. the time interval between which the data are logged) could be manually set using a switch within the range of two seconds to one hour. The data were logged and recorded onto a C90 magnetic, audio cassette tape and four channels were used on the logger. The four channels were for:

1	Battery Check		
2	Raingauge Logger Count		
3	Hours)	REAL TIME	
4	Minutes)	APPLICATION	(see Table 4.2)

Photograph of Raingauge Site at Tame Close

Figure 4.2

An Example of the Raw Input Datafile to the Rainfall Data Processing Program.

A	B	C	D
240	002	012	057
240	002	012	057
240	002	012	058
240	002	012	058
240	002	012	059
240	002	012	059
240	003	013	000
240	003	013	000
240	003	013	001
240	003	013	001
240	003	013	002
240	003	013	002
240	003	013	003
240	003	013	003
240	003	013	004
240	003	013	004
240	003	013	005
240	003	013	005
240	003	013	006
240	003	013	006
240	003	013	007
240	003	013	007
240	003	013	008
241	003	013	008
240	003	013	009
240	003	013	009
240	003	013	010
240	004	013	010
240	004	013	011
240	004	013	011
240	004	013	012
240	004	013	012
240	004	013	013
240	004	013	013
240	004	013	014
240	004	013	014
240	004	013	015
240	004	013	015
240	004	013	016
240	004	013	016
240	004	013	017
240	004	013	017
240	004	013	018
240	005	013	018
240	005	013	019
240	005	013	019
240	005	013	020

A = BATTERY CHECK
B = NUMBER OF TIPS (CUMULATIVE)
C = TIME IN HOURS
D = TIME IN MINUTES

Table 4.2

It is well known that urban catchment surfaces respond quite quickly to a rainfall input and so it is therefore necessary to select a logging interval which adequately reflects the physical changes likely to develop in the hydrological regime. The impending use of the rainfall data as an input to a Rainfall-Runoff Model (ie. the LRM) necessitated the use of a small time interval because the rainfall intensity was under study and not just the total rainfall depth for a given storm event. It was decided to adopt a 30 second logging interval which provided adequate definition for subsequent rainfall intensity analysis and this logging interval was also consistent with that used for the Pieris Drive (PD) and Trent Polytechnic Clifton Campus (RR) tipping bucket raingauges. The raingauge tip data were therefore logged every 30 seconds onto the C90 magnetic tape. This size of tape was able to hold about 8 to 9 days of data on a four channel log dimension and so in the hydrometric data collection programme, the tape and the battery were changed every week to ensure full data capture. Much effort was expended in looking after all the raingauges and in monitoring their performance. A high level of maintenance and cleaning was required in order to safeguard a continuous and reliable data capture. Some problems were encountered and these included obstruction of the rainfall inlet by leaves, twigs and other wind-blown material; the occasional battery failure; problems with the electrical contacts leading to the battery supply and the unreliability of some tapes to record properly and problems with the tape spools whereby the tapes jammed around the head. All tapes were replaced after three months use in order to alleviate this problem in the data logging. The analogue signals were sent from the raingauge to the interface unit, from where the digital signals were sent to the logger unit, where they were recorded onto the magnetic

tape (see Figure 4.3). The tape is removed from the logger unit (this was only done during dry periods so that no rainfall data were lost during a tape change) and on return to the laboratory, the tape is put into a 'Microdata Tape Reader' where the digitised data can be read directly to the DEC 20 Mainframe Computer where the raw data can be held as a standard datafile.

It is evident that with a 30 second logging interval, a great deal of data are held in the raw datafile for a time period of one week. The raw datafiles held on the DEC 20 were therefore edited on a regular basis to remove the periods of no rainfall (ie. the dry periods). The raw data were scanned visibly on the screen and on a hard copy printout and changes were noted in the logger rainfall tip count which was the indication of a rainfall event. Each raw datafile was split up into a series of storm datafiles using a powerful mainframe editing facility and so each rainstorm event was held in its own file and the periods of dry weather were expunged from the system. Each rainstorm event file was given its own individual identifier name in a standard format. The format for naming each storm datafile was as follows:

Each name is made up of a two letter prefix, a six figure number, a single letter storm identifier and a file extension string.

Example of a filename for a rainstorm file = TC841205A.DAT

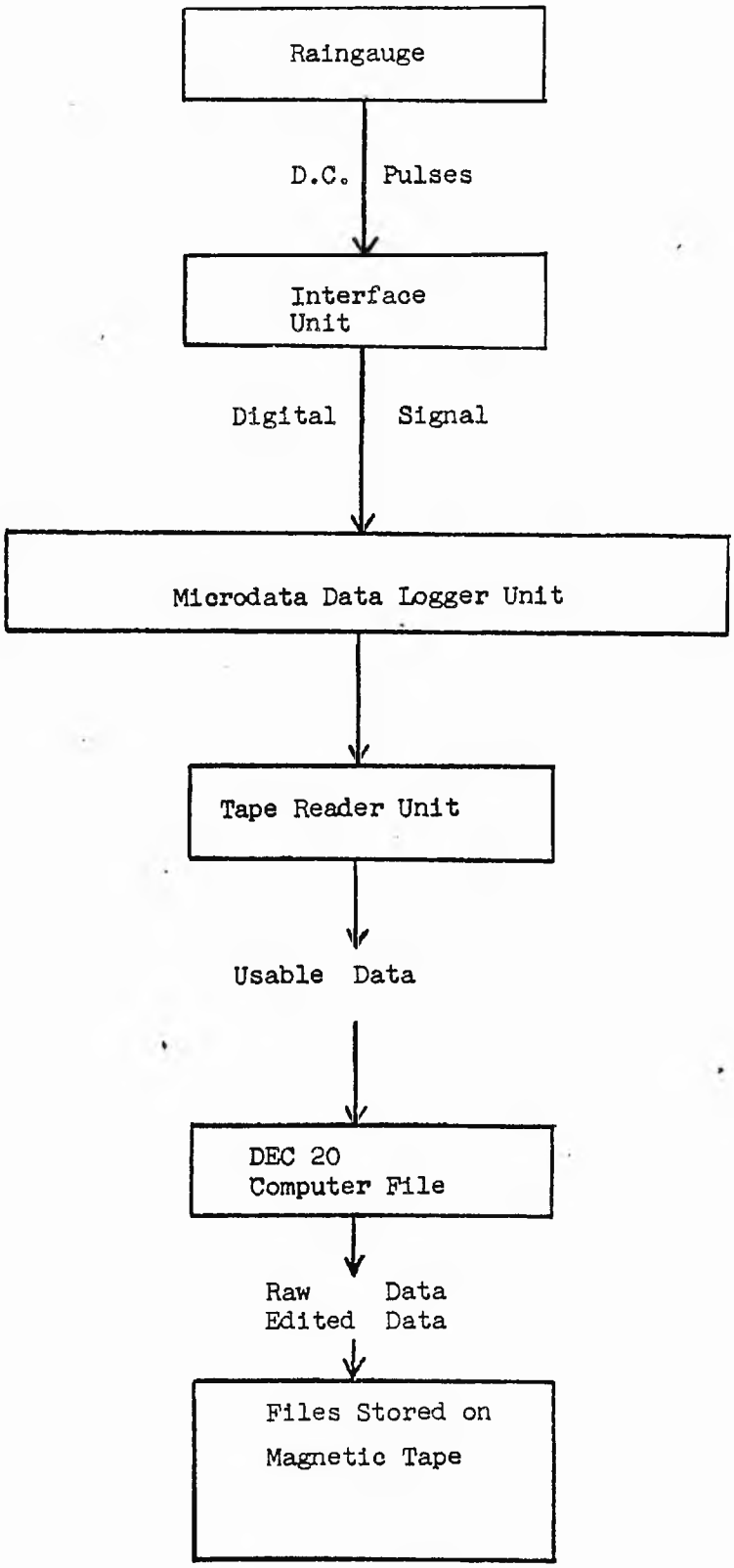
The first two letters describe the raingauge where the data were measured. The prefixes used were TC (Tame Close), PD (Pieris Drive) and RR (Trent Polytechnic).

The six figure number is the date of the storm in the American notation (ie. in reverse) as YYMMDD (ie. as Year,Month and Day each in a two digit form).

The single letter is a storm identifier. The first storm in each day is given the letter A, the second storm B, the third storm C and so on, so individual storms in any one day can easily be identified.

The Rainfall Data Processing System.

Figure 4.3



The file extension is a requirement for the DEC 20 Mainfame system and all files had the extension .DAT

For example, the storm datafile called PD860203B.DAT contains the raw rainfall data collected from the Pieris Drive raingauge for the second storm on the 3rd. February 1986.

The raw datafiles contained four values for each logger registration and so one line of data was written to the magnetic tape every 30 seconds (see Table 4.2). On scanning through the raw datafiles, there were some problems encountered with the recording of some of the values, especially the real time channels. The files were edited to provide a continuous and correct raw datafile. The occasional rogue value was found in the datafile and these were corrected or deleted. A log book was kept of all the rainfall raw datafiles and this provided a daily rainfall summary for the whole two year study period on the Clifton Grove Estate. This record could easily provide a summary of the number of days of rain per month and also the raingauge usage figures. The two letter prefix of the filename describes the raingauge from which the rainfall data were obtained for that particular event. There were however, certain periods during the study period when all three tipping bucket raingauges were out of action. This was particularly surprising due to the close attention and maintenance given to all three gauges on a regular basis. In order to complete the rainfall records, it was decided to supplement the records from the tipping bucket raingauges with data collected by the Meteorological Office. The nearest Meteorological Office Standard Raingauge to the study site was situated at Wilford Hill in Nottingham which lies about one and a half miles north-east of Clifton Grove.

The Wilford Hill gauge also suffered some operational problems and was itself out of action for some periods of time and so rainfall records were also taken from the Watnall Meteorological Station in Nottinghamshire (East Midlands Weather Centre) in order to complete the records. The Wilford Hill and Watnall records were only rainfall depths since they were standard gauges and not of the tipping bucket variety, as used in the study programme. Altogether five raingauges were used to provide the rainfall records for the Clifton Grove area over the two year period and a summary of the raingauge usage can be seen in Tables 4.3 and 4.4.

Table to Show the Number of Days of Raingauge Usage throughout the Two Year Study Period.

The standard abbreviations for each raingauge are used in the table.

YEAR / MONTH	Raingauge Location: TC	PD	RR	WT	WL	TOTAL
	(All values are expressed in Days)					
1984						
May	12	10		9		31
June	27			3		30
July	31					31
August	31					31
September	30					30
October	28	1		2		31
November	21	4		5		30
December	27	4				31
1985						
January	30				1	31
February	23			5		28
March	15				16	31
April	26	4				30
May	19	11		1		31
June	29	1				30
July	29			2		31
August	8			23		31

September	16			14		30
October	27				4	31
November	30					30
December	18		13			31
1986						
January	3		28			31
February	15		11	2		28
March	29		2			31
April	30					30
Total	554	35	54	66	21	730

Table 4.3 cont'd

Table to Show the Raingauge Usage During the Two Year Study Period.

The Two Year Period was from 010584 to 300486

Raingauge Used	Total Number of Days	% of Total Time Period
TC	554	75.9
PD	35	4.8
RR	54	7.4
WT	66	9.0
WL	21	2.9
Total	730	100.0

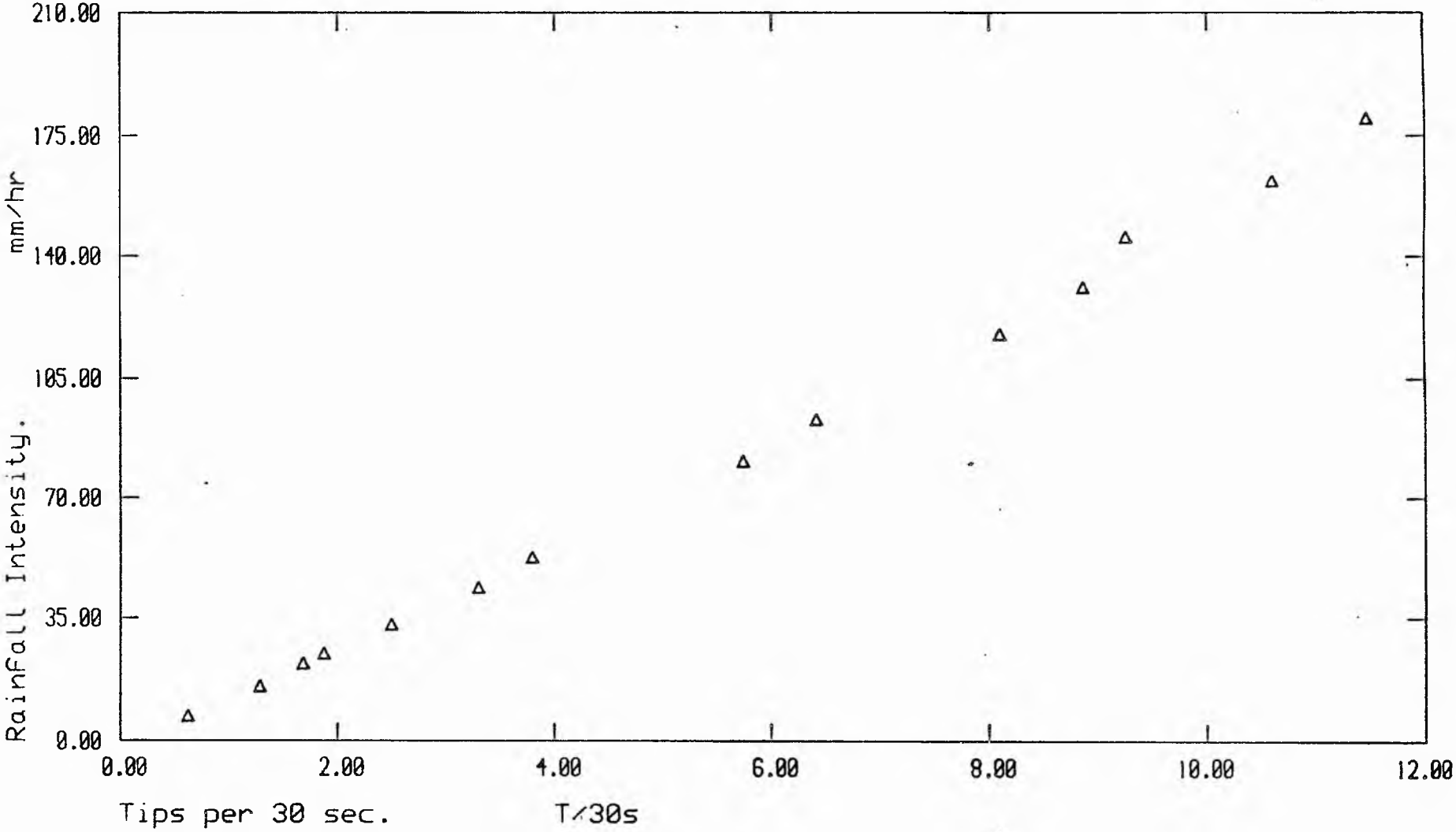
Key: Raingauges used in the Study Period.

TC	Tame Close, Clifton Grove Housing Estate
PD	Pieris Drive, Barton Green Housing Estate
RR	Trent Polytechnic Clifton Campus
WT	Watnall Meteorological Station, Nottingham
WL	Wilford Hill Meteorological Station, Wilford, Nottingham

Table to Show the Values Used in the Calibration of the Tame Close Raingauge.

Table 4.5

Rainfall Intensity (mm/hr)	Number of Tips per 30 seconds.
7.22	0.63
15.53	1.29
22.10	1.69
24.87	1.88
33.16	2.50
43.94	3.30
52.70	3.80
80.86	5.74
92.91	6.41
117.77	8.10
131.18	8.86
145.58	9.25
161.90	10.60
180.19	11.47



TAME CLOSE TIPPING BUCKET RAINGAUGE CALIBRATION.

Figure 4.4

4.6 Raingauge Calibration.

All three tipping bucket raingauges (TC, PD and RR) were thoroughly checked and accurately calibrated in the laboratory before installation. The procedure used for calibrating the gauges has been described by Parkar (1987) and it involved both a static and a dynamic calibration method. The static determination is basically a simple procedure to determine the exact volume of water needed to tip each of the two buckets (which was 2.80 ml for the TC raingauge). Calder and Kidd (1978) stressed the need to use a dynamic calibration whereby in conditions of heavy rainfall, splashout from the buckets and the rainfall lost during the time taken for the bucket to actually tip, may be important. The dynamic calibration procedure as described by Parkar (1987) was followed, in order to standardise all three tipping bucket raingauges used in the study. The calibration involved the determination of the rainfall intensity for a given number of tips within the 30 second logging interval. A number of laboratory simulations were run under carefully controlled conditions. Fourteen different rainfall intensities were run through the raingauge and the number of tips were recorded on the tape unit. The values for the calibration procedure can be seen in Table 4.5 and in Figure 4.4. The upper limit for calibration was set at a rainfall intensity of about 180 mm/hr. A Statistical Package called 'GLIM' (General Linearised Model) was used to produce a second order equation to fit the line of the calibration graph (see Figure 4.4) and the equation derived was used in the calibration computer programme (see the Appendices).

The second order equation used for the Tame Close Raingauge (TC) was:

$$I = -0.6024 + 12.86N + 0.2515N^2$$

where I = rainfall intensity in mm/hr.

and N = number of tips per 30 seconds.

The calibration procedure also revealed that for the TC raingauge the tipping bucket system recorded an averaged value of 0.086 mm/tip. This figure is derived from the fact that the bucket capacity was determined to be 2.80 ml (or 2800 $mm.^3$). The Rimco raingauge had a collecting diameter of 8 inches and the area of the collecting surface can be calculated, assuming that it is a circle.

The area of the collecting surface is $= \pi R^2$

$= \pi (4 * 25.4)^2 \quad mm^2$

$= 32429 \quad mm.^2$ (as a whole number)

Therefore the depth of rainfall required to fill the bucket is:

$$\frac{2800}{32429} = \underline{\underline{0.086 \quad mm/tip.}}$$

(see Table 4.6).

By using the second order calibration equation, we can say that:

Number of Tips per 30 seconds	Rainfall Intensity mm/hr
1	12.51
2	26.12
3	40.24
4	54.80
5	70.00
10	153.15

Table : 4.6

4.7 The Processing of the Rainfall Data.

A computer program was developed by Parkar (1987) to process the raw rainfall data into a rainfall depth and rainfall intensities in real time. This program was edited and amended into three separate programs so that the data from the TC, PD and RR gauges could all be processed (see Appendices). The model used was a 'constant proportional loss rainfall model' (Parkar 1987). The three programs were similar except that differing calibration factors and second order equations were put in for each raingauge. The raw datafile is used as an input file to the rainfall data processing programs. An example of a raw datafile can be seen in Table 4.2. The program produced a hard copy output direct to a fast linewriter of the

rainfall event (see Table 4.7) showing the time, the rainfall depth and the rainfall intensity. A second program was developed to provide graphic output and a hyetograph (plot of rainfall against time) was plotted in real time for each rainstorm event. The two program listings for each of the three tipping bucket raingauges used can be seen in the Appendices.

The rainfall processing program was run for each rainstorm and it is important to note that the choice of program run, depended upon the source of the rainfall raw datafile. The output was analysed and the rainfall depth and peak rainfall intensity were recorded for each rainstorm event over the two year period. This provided a complete rainfall record over the study period. Two important assumptions were made in the rainfall data processing programme. The first is that the rainfall event is recognised by a change in the number of tips on the raingauge. It was assumed that if the number of tips count (since the logger count was a cumulative total) did not change for at least half an hour then the storm had finished. This problem of deciding when one storm has finished and another storm has started or whether the event is all part of the same storm event, is often encountered in rainstorm analysis. This was taken into account by defining that if it does not rain for half an hour, then that particular event has finished irrespective of what happens after that. The second assumption was that if a rainstorm starts on one day and finishes the next day (ie. it occurs through the midnight hour), then the storm event and its characteristics are recorded for the day that the storm started and not when it finished.

Table 4.4 shows the raingauge usage during the two year period and the TC Primary raingauge operated for 75.9% of the total time (or 554 days

Table to Show the Hard Copy Output from the Rainfall Data Processing Computer Programme.

Table 4.7 (see Appendices for a listing of the programme).

REAL TIME		RAINFALL INTENSITY	ELAPSED	RAINFALL
HRS	MINS	(MM./HOUR)	TIME(M)	DEPTH(MM.)
16	45	7.98	0.0	0.00
16	45	5.89	0.5	0.05
16	46	59.06	1.0	0.51
16	46	26.12	1.5	0.72
16	47	42.24	2.0	1.06
16	47	25.12	2.5	1.28
16	48	42.24	3.0	1.61
16	48	25.12	3.5	1.83
16	48	25.12	4.0	2.05
16	49	5.18	4.5	2.09
16	49	5.18	5.0	2.13
16	50	12.51	5.5	2.24
16	50	3.45	6.0	2.27
16	51	3.45	6.5	2.30
16	51	3.45	7.0	2.32
16	52	26.12	7.5	2.54
16	52	25.12	8.0	2.76
16	53	25.12	8.5	2.98
16	53	12.51	9.0	3.08
16	54	25.12	9.5	3.30
16	54	12.51	10.0	3.41
16	55	12.51	10.5	3.51
16	55	5.18	11.0	3.55
16	56	5.18	11.5	3.59
16	56	3.45	12.0	3.62
16	57	3.45	12.5	3.65
16	57	3.45	13.0	3.68
16	58	26.12	13.5	3.90
16	58	42.24	14.0	4.23
16	59	12.51	14.5	4.34
17	0	25.12	15.0	4.56
17	0	12.51	15.5	4.66
17	1	12.51	16.0	4.76
17	1	12.51	16.5	4.87
17	2	12.51	17.0	4.97
17	2	26.12	17.5	5.19
17	3	25.12	18.0	5.41
17	3	12.51	18.5	5.51
17	4	3.18	19.0	5.55
17	4	5.18	19.5	5.61

MONTHLY RAINFALL RECORD FOR THE COMPLETE TWO YEAR STUDY PERIOD.

(All rainfall values expressed are in mm and the average figures quoted are for the period 1941-1970).

Table 4.8

YEAR MONTH	NUMBER OF DAYS WITH RAINFALL	TOTAL RAINFALL	% OF AVERAGE MONTHLY VALUE
1984			
May	7	41.4	73.9
June	10	50.9	96.0
July	6	26.2	42.3
August	9	74.5	94.3
September	11	43.5	72.5
October	13	40.0	71.4
November	16	75.1	105.8
December	18	24.7	39.8
1985			
January	14	30.8	46.6
February	9	7.5	14.2
March	18	47.5	95.0
April	14	29.2	60.8
May	13	67.0	119.6
June	16	82.5	155.7
July	12	35.5	57.3

August	24	77.1	97.6
September	8	14.9	24.8
October	3	29.4	52.5
November	13	40.0	56.3
December	18	70.1	113.1

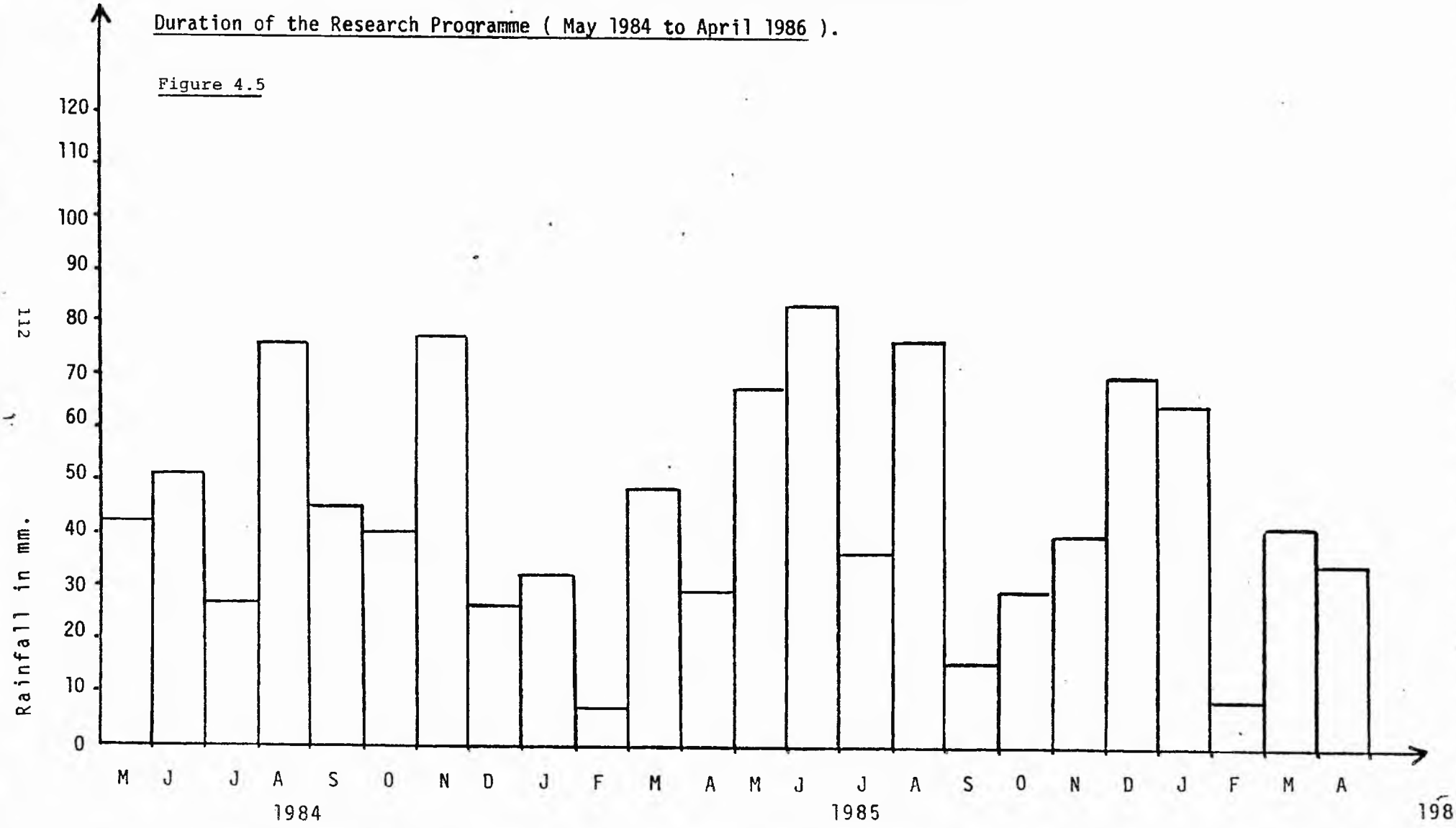
1986

January	22	63.5	96.2
February	6	8.9	16.8
March	16	41.2	82.4
April	13	34.9	72.7

Table 4.8 cont'd

Graph of the Monthly Rainfall Record at Clifton Grove, Nottingham for the Duration of the Research Programme (May 1984 to April 1986).

Figure 4.5



Average Monthly Rainfall Totals for Watnall Meteorological Station, Nottingham.

The average figures quoted are for the period 1941-1970 and were obtained from the Meteorological Office, Bracknell, Berkshire, England.

MONTH	RAINFALL (in mm)
January	66
February	53
March	50
April	48
May	56
June	53
July	62
August	79
September	60
October	56
November	71
December	62

The Annual Average Rainfall is (1941-1970) 716 mm

Table 4.9

Table to Show the Hard Copy Output from the Linear Reservoir Rainfall-Runoff Model Computer Programme.

Table 4.10 (see Appendices for a listing of the programme).

LINEAR RESERVOIR MODEL SIMULATION. Tame Close Catchment No. 304.104

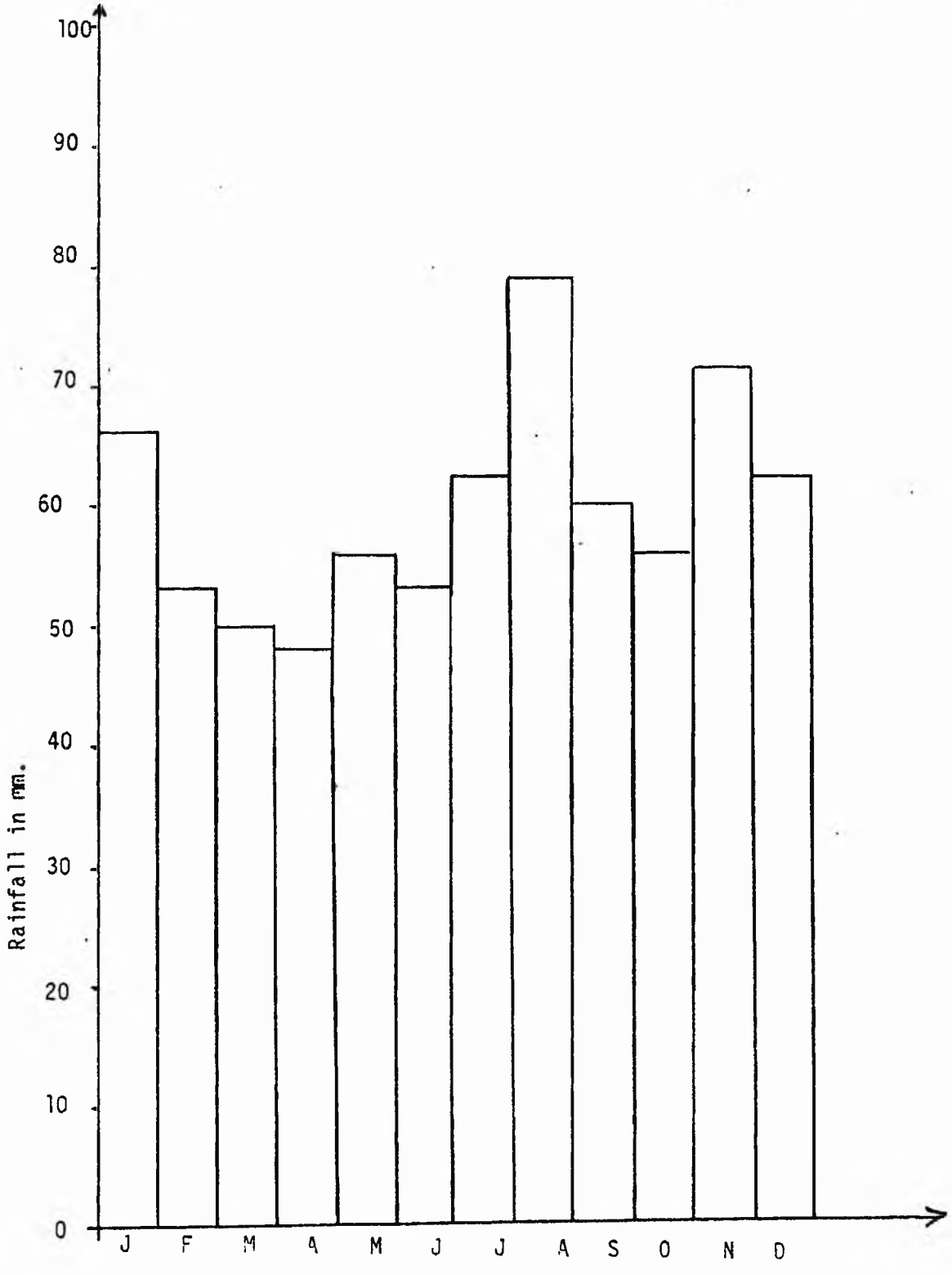
CATCHMENT CHARACTERISTICS. Date Of Event: 20-06-84

Depression Storage = 2.76 mm.
Runoff Coefficient = 98.0 %.
Area = 229.0 km2.
Catch = 11.5 .

TIME		RAINFALL INTENSITY (mm/h)		SIMULATED RUNOFF (l/s)
HRS	Min	Total	Effective	TAME No. 304.104
16	45	[illegible]	2.30	2.30
16	45	5.69	3.87	3.30
16	46	54.86	2.62	2.30
16	46	26.17	2.72	2.80
16	47	40.24	32.33	2.45
16	47	26.12	23.51	3.64
16	48	40.24	36.22	1.84
16	48	26.12	23.51	1.39
16	49	26.12	23.51	1.15
16	49	5.17	1.66	3.94
16	50	5.17	1.66	2.79
16	50	12.51	11.26	2.72
16	51	3.45	3.11	2.66
16	51	3.45	3.11	2.50
16	52	3.45	3.11	2.43
16	52	26.12	23.51	2.54
16	53	26.12	23.51	2.51
16	53	26.12	23.51	2.95
16	54	12.51	11.26	2.87
16	54	26.12	23.51	1.80
16	55	12.51	11.26	2.92
16	55	12.51	11.26	2.86
16	56	5.17	1.66	2.74
16	56	5.17	1.66	2.64
16	57	3.45	3.11	2.55
16	57	3.45	3.11	2.18
16	58	3.45	3.11	2.42
16	58	26.12	23.51	2.51
16	59	5.21	36.22	1.77
16	59	12.51	11.26	2.95
17	0	26.12	23.51	1.76
17	0	12.51	11.26	2.95
17	1	12.51	11.26	2.88
17	1	12.51	11.26	2.83
17	2	12.51	11.26	2.78
17	2	26.12	23.51	2.91
17	3	26.12	23.51	1.77
17	3	12.51	11.26	2.98
17	4	5.17	1.66	2.84
17	4	5.17	1.66	2.73

Graph of Monthly Rainfall (1941-1970) at Watnall Meteorological Station, Nottingham.

Figure 4.6



out of 730 days). The other four gauges each contributed to the records in a small way. A breakdown of the raingauge usage on a monthly basis can be seen in Table 4.3. The monthly rainfall record for the two year period can be seen in Table 4.8. This table shows the number of days in each month with rainfall, the total monthly rainfall and the rainfall total expressed as a % (percentage) of the average monthly value measured at the Watnall Meteorological Station (average figures are for the period 1941-1970), all on a monthly basis. These records are summarised in Figure 4.5 which is a plot of the monthly rainfall totals measured during the two year period. The values in Table 4.8 can be used to describe how representative the meteorological conditions were during the two year period of study, as compared to the average conditions experienced in the area. In 1984, July and December had well below average rainfall. In 1985, the winter months of January and February were particularly cold and a lot of snow fell at this time (see Figure 4.5). The values of 46.6% (Jan.1985),14.2% (Feb.1985) and 16.8% Feb.1986) of the average monthly precipitation, all reflect the difficulty in measuring snowfall and the rainfall figures are really unrepresentative for these three months. The month of June 1985 had one and a half times the average rainfall but it was followed by a much drier than average July. September 1985 was also a relatively dry month with only 14.9 mm. of rainfall. Table 4.8 shows the fluctuations away from the average rainfall values. Table 4.9 and Figure 4.6 show that there is no real seasonal influence over the rainfall regime experienced over the City of Nottingham. This can be partially explained by its location within the United Kingdom away from major orographic influences, the influence of the distinctive climatology of the Trent Basin and also the effect of the number of coal-fired power stations in the region

and the close proximity of some of them to the city. Some observers have noted that the influence of power station emmisions on local rainfall regimes should not be underestimated. The rainfall pattern measured at Clifton Grove over the two year period is well illustrated in Figure 4.5 whereby the dry months of February 1985, September 1985 and February 1986 are well marked.

The collection of a comprehensive dataset for the rainfall depth, rainfall intensity and the time of the event provided an extremely useful guide to the hydrological conditions prevailing in the Clifton Grove sub-catchment areas throughout the duration of the Gully Liquor Monitoring Programme. The rainfall data were also invaluable in the analysis of the behaviour of the gully pots under storm conditions (see Chapter 8). The data provide a valuable indicator in the variablity of storm events in both frequency, duration and magnitude and the deviation away from the monthly averages should also be noted with much interest for some months. This is particularly true if averaged results are to be incorporated in future water quality modelling routines. The rainfall records are a valuable account and can be used to interpret the gully pot liquor quality on a more meaningful basis. This is particularly true for the more conservative parameters such as chloride concentrations whose variability in the pot liquor can often be explained by changes in dilution due to a rainfall event, rather than any physiobiochemical change within the pot liquor itself. The measurement of rainfall (precipitation) was in itself important, but it is only one component of the urban hydrological cycle and an essential ingredient to the research programme was the ability to predict runoff flows from rainfall records through the use of a Rainfall-Runoff Model Simulation. The rainfall records (held as raw datafiles) can be seen more importantly

as a means of providing a comprehensive and reliable in-situ rainfall measurement as an input to an urban Rainfall-Runoff Model.

4.8 The Linear Reservoir Rainfall-Runoff Model (LRM).

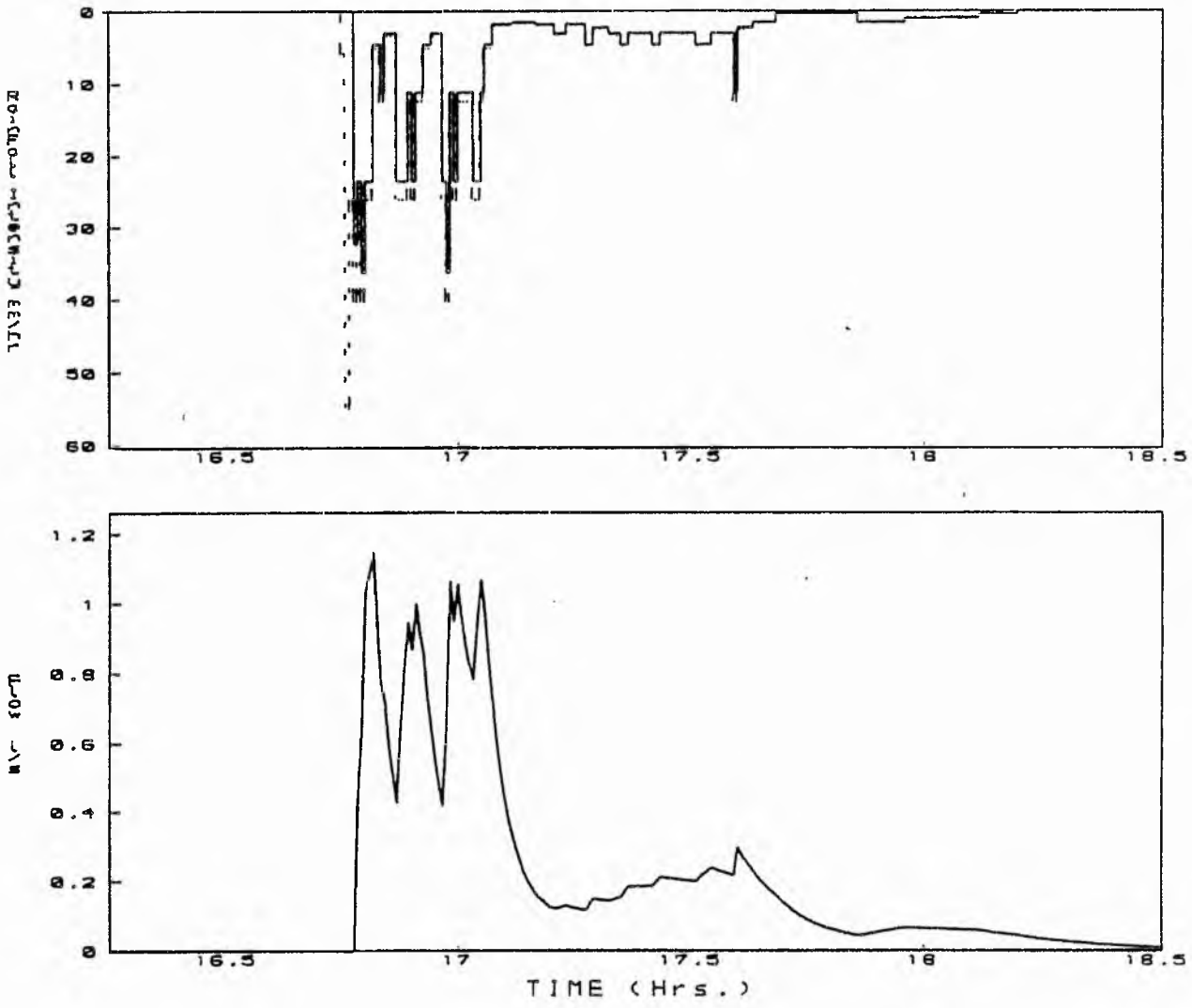
A linear reservoir Rainfall-Runoff Model (LRM) was developed for each of the Number 2 micro-catchment areas (ie. T2, C2 and TW2) on the three sub-catchments under study on the Clifton Grove Estate. The basis of this model has been described above but it consists of a constant proportional loss rainfall model and the effective hyetograph is then surface routed to give an inlet hydrograph to the gully pot. The computer program for the LRM was developed by Parkar (1987) and this version was amended and edited for use in the three micro-catchment areas. Two programs were written for the runoff simulations using the LRM, in much the same manner as those developed for the rainfall data processing. The first program calculated the flow conditions based on a raw datafile rainfall record and the results were sent direct to a linewriter for a hard copy printout (see Table 4.10). This was done so that a hard copy record could be kept and to reduce the amount of data held on the DEC 20 such that only the raw data were held since the processed data could easily be obtained by running the program. A second program was devised to provide graphic output and an inverted hyetograph was plotted above the inlet hydrograph for a particular storm event. An example of this type of output can be seen in Figure 4.7. Three versions of each of the two programs were written (giving six in all) so that each micro-catchment had its own Rainfall-Runoff Model or LRM (see Appendices). Each model had its own individual catchment characteristics as defined by previous work on the Clifton Grove Estate (see Table 4.1) (Pratt and

Henderson 1981; Pratt and Harrison 1982; Adams 1983).

Both programs were run for each of the three micro-catchments for all the rainstorms measured over the whole of the two year study period (except for those rainstorm events measured by the Wilford Hill and Watnall gauges which did not provide the rainfall measurement in terms of rainfall intensities). These flow simulations were run in order to provide a detailed record of all flows into each of the three gully pots under study, so that a better understanding of the relationship between the pot liquor quality and the hydrological conditions prevailing at the time and in the time between sampling, could be achieved. A daily log of all rainfall and associated runoff flow conditions was kept so that a complete hydrological history was known and could be presented with the water quality data. The LRM for each micro-catchment was run again and used more fully in the pot liquor analysis during individual storm events when the LRM provided simulated flow conditions for each of the storm events analysed.

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TAME CLOSE MICROCATCHMENT

Date of Event : 20-06-84



. . . . . Total Hyetograph
_____ Net Hyetograph
_____ Simulated Flow

Depression Storage= 0.76 mm.
RunoFF CoeFFicient= 90.0 %.
CATCH= 11.5
Simulated Peak Flow= 1.15 l/s.
Simulated Total Volume=1468.6 litre

Figure 4.7

(See Appendices)

4.9 The Importance of Urban Hydrology.

During the last twenty years, urban hydrology has grown into a single, identifiable subject and a number of studies have concentrated upon the need to measure various components of the urban hydrological cycle more accurately within an urban environment. The collection of rainfall and both surface and below-ground flow data has led to the formulation and calibration of a number of Rainfall-Runoff Models. These models are now receiving more widespread use through their ability to predict surface runoff for given storm events and they have been successfully incorporated into a number of computer packages used in urban drainage systems design throughout the world. The Rainfall-Runoff Models have also become important within urban water quality studies whereby a better appreciation of the flow conditions in urban areas both over the surface and below-ground can be obtained.

The development and running of the Rainfall Processing programmes and the Rainfall-Runoff Models used in the research programme took a great deal of time to formulate and to administer but the information derived from these urban hydrological studies was extremely valuable in supplementing the water quality data and adding to the interpretation of the quality data. Comparatively few studies have been carried out which combine both the hydrological and the water quality components of urban stormwater runoff.

Chapter 5 : LABORATORY ANALYTICAL METHODS.

5.1 Introduction.

Twenty-six chemical parameters were studied as part of the research programme (see Table 5.1) including twelve metals. The laboratory analysis was conducted according to standard methods as outlined by the Department of the Environment (UK) and the American Public Health Association. All analyses were carried out in the Analytical Laboratory in the Department of Physical Sciences at the Trent Polytechnic in Nottingham.

All analyses were carried out as soon after the samples were taken as was possible. However when a delay occurred, all the samples were kept cool at a constant temperature. The sampling procedure and the analytical practice were kept consistent throughout the whole of the study period and the utmost care was given to all sample collection, storage and analysis. The Water Research Centre Technical Report TR214 (1984) states that:

"....the control of sources of error relating to sampling practice or sample storage is an important factor in achieving the required accuracy and comparability of analytical results in any monitoring programme...."

Throughout the study, the washing of sample bottles with detergents, mild acids and distilled water were all employed at various times to ensure the best possible conditions for sample collection and storage. All sample preservation recommendations of the Standard Methods were adopted in so far as it was possible to do so.

List of the Twenty-Six Parameters Analysed in the Gully Pot Standing Liquor Sampling Programme.

Table 5.1

Water Quality Parameter (Determinand)	Unit of Measurement	Abbreviation used in the Report
Temperature	' C	Temp
Dissolved Oxygen	mgl-1	DO
Biochemical Oxygen Demand (BOD)	mgl-1 as BOD	BOD
Chemical Oxygen Demand (COD)	mgl-1 as COD	COD
Conductivity	µscm-1	Cond
Suspended Solids (SS)	mgl-1	SS
Alkalinity	mgl-1 as CaCO3	Alk
Total Hardness	mgl-1 as CaCO3	TH
Phosphate	mgl-1 as P	Phos
Sulphate	mgl-1 as SO_4^{2-}	Sul
Chloride	mgl-1 as Cl^-	Cl
Nitrate	mgl-1 as N	Nit
Ammonia	mgl-1 as N	Amm
Sodium	mgl-1	Na
Potassium	mgl-1	K
Iron	mgl-1	Fe
Lead	mgl-1	Pb
Calcium	mgl-1	Ca
Magnesium	mgl-1	Mg
Zinc	mgl-1	Zn
Manganese	mgl-1	Mn
Copper	mgl-1	Cu
Cadmium	mgl-1	Cd
Nickel	mgl-1	Ni
Chromium	mgl-1	Cr

5.2 SUSPENDED SOLIDS: (SS).

The determination of SS is an important test in assessing water quality and it is one of the most commonly analysed determinands in all studies of surface waters, wastewaters, potable supplies and drainage waters. All SS are considered to be settleable over time and the SS analysis is an important value to determine with regard to the pollutional strength of a particular water. It figures prominantly in nearly all river classifications thoughout the world.

The experimental procedure used in the research programme was the Standard Method as defined by the American Standard Methods and the Department of the Environment (UK). The standard Whatman GF/C (1.2 μm pore diameter and 5.5 mm paper diameter) filter paper was used in convention with the International Standards. The paper was dried in an oven and stored in a dessicator before use. It was then weighed just prior to the analysis. A known volume of the sample water was thoroughly shaken and then filtered through a Buchner Funnel containing the filter paper under suction. The volume of the sample solution to be filtered was chosen so as to obtain a significant quantity of solids to enable accurate measurement of the suspended mass on the filter paper (WRC TR127 (1980)). The filtrate was collected and used in subsequent analysis when a filtered sample was necessary eg. atomic absorption spectrophotometry, the TOC test etc. The filter paper was then dried at a temperature of 105'C in an oven and it is dried until it reaches a consistent or constant weight. This process normally takes about two hours. The mass of suspended solids found on the paper was calculated by subtracting the two weights of the papers taken before and after filtration and the concentration is usually expressed as mgl^{-1}.

The Water Research Centre TR127 Report (1980) states that there is no statistically significant proof that the rate of filtration influences the SS determination. Vacuum pumps are often used to speed up the analysis. The GF/C Whatman filter paper (glass fibre paper) has one rough and one smooth side. A harmonised monitoring programme conducted by the Water Research Centre showed that using standard Kaolin based solutions. There was no significant difference between the two sides of the filter paper at the 95% confidence level. The Water Research Centre (WRC) TR127 Report (1980) presents a table as recommended by the Department of the Environment which states the desired sample volumes to be used in the SS determinations based on the expected SS value.

Expected SS Value	Recommended Sample Volume
mgl-1	ml.
< 20	500
20 - 100	250
> 100	100

The WRC Monitoring Programme results also showed that a relative standard deviation of 5% or 0.5 mgl-1 (whichever is the greater) can be achieved in the SS determination, if care is taken in the procedure. One source of error highlighted in the report was that the sample in a measuring cylinder should be sufficiently agitated to ensure that all the solid material leaves the cylinder to be filtered out on the paper.

Preliminary tests showed that most SS determinations in gully pot

liquor were above 80 mgl-1, with a large number in excess of 100 mgl-1. It was therefore decided to adopt a 100.0 ml sample volume as a standard volume to be used throughout the research programme. One of the main difficulties in the SS test on pot liquor is to ensure that all the SS material is transferred to the filter paper and this is a particular problem if some of the material is coated with oil or other hydrocarbons which make the solids stick to a glass surface. A similar problem is also encountered in the taking of the sample from any body of water eg. a river water, gully pot liquor etc. All the samples were agitated sufficiently to ensure that all the solids were filtered and that the analyses complied with the recommendations in the Standard Methods.

5.3 VOLATILE MATTER ANALYSIS.

It is possible to obtain a measurement of the amount of organic matter present in the solids material. This is known as a "volatiles" analysis whereby a combustion procedure is used to convert all the organic matter to carbon dioxide and water, whilst at the same time sustaining a temperature that will not decompose or volatilise inorganic salts which are present. The standard procedure is to conduct the ignition at 550'C in a muffle furnace, where the decomposition of the inorganic salts is minimised (see Figure 5.1). Exceptions include magnesium carbonate which decomposes at 350'C and certain ammonium salts are known to break down or sublime at temperatures less than 550'C. One advantage of using a glass fibre filter paper in the SS test, is that it is unaffected by an ambient temperature of 550'C. A normal paper filter will ash at temperatures well below this, and its value as a stable medium to support the SS during ignition is lost. The volatile analysis exposes the SS to the combustion process for about 15 minutes which is sufficient time to allow the volatile matter to be combusted. The loss in weight after ignition can then be directly attributed to the amount of organic matter present in the solids and the result is usually expressed as a % of the original mass. The volatile fraction is not a precise measurement but it is a useful indicator in describing the type of solid particle present in the water sample. In urban drainage systems, the results from the volatile analysis can be used to describe the source of the solid material. The organic matter present in the solid particle is most likely to have originated from vegetable or soil particles rather than the inorganic materials used in the building fabric eg. asphalt, concrete, road grit. One would expect

the percentage volatile matter to vary seasonally, which would reflect the changing importance of the various sources of solid particles with time in an urban catchment area.

In terms of controlling pollution, the removal of SS is usually considered to be of at least equal importance to the removal or decrease of BOD and one of the most important considerations is the level of SS (and associated volatile matter) entering a watercourse. Turbidity of the water will be greatly influenced with consequent detrimental effects on the fishery and other recreational usage, and large masses of solids entering a watercourse over time may seriously influence the flow regime of a channel. The solids loadings from stormwater discharges may be more important than a particular SS discharge concentration from a given storm event. It is often the build up of solids over time which exerts the most influence on the flow regime and the quality of the receiving watercourse. Sudden influxes of solids through high SS concentrations in stormwater discharges will have a more local and short term influence upon the quality of the receiving water.

Photograph of the Muffle Furnace used in the Volatiles Analysis.

Figure 5.1

5.4 BIOCHEMICAL OXYGEN DEMAND : (BOD).

The BOD test is used widely to determine the pollutional strength of natural waters and wastewaters. The BOD determination is essentially a bioassay procedure involving the measurement of oxygen consumed by living organisms (microbes) in their breaking down of organic matter. The Royal Commisssion on Sewage Disposal set the determination as measuring the oxygen absorbed by a sample of water held at 20'C for 5 days. The BOD is based on a quantitative relationship which exists between the amount of oxygen required to convert a given quantity of any organic compound to carbon dioxide and water during the reaction. The BOD test seeks to simulate the conditions that the water will experience naturally, and this involves sealing a given volume of the sample solution so that it is no longer in contact with the air. Most natural waters contain enough salts and minerals to support the metabolic processes of the living organisms and an initial dissolved oxygen level within the liquor to support the oxidation process over a 5 day period. Aeration and the addition of salts (mainly calcium and magnesium based) in the form of a dilution solution is often necessary for the more heavily polluted waters and this addition is almost obligatory for most industrial, sewage and trade effluents.

The BOD test was one of the first parameter tests to be defined and regularly used within public health engineering and water quality analysis and it has long been interpreted as an important determinand in the analysis of natural watercourses and effluents. Nearly all river classifications found throughout the world include some reference to the BOD. Indeed, much of the pollution control legislation around the world and water quality classifications are based upon the BOD which is normally expressed in units of mgl^{-1} as

BOD.

The Experimental Procedure:

The basis of the BOD test involves the accurate measurement of levels of dissolved oxygen (DO) in the sample solution. The test can be carried out directly on some samples (normally only river samples) where the BOD is expected to be less than 6 mgl^{-1} as BOD. Sample dilution is required in nearly all other cases. This is carried out by making up a dilution water whose pH should be in the range pH 6.5 to pH 8.5. Salts are added in small quantities (mainly sodium, calcium, magnesium and potassium in the form of sulphates, phosphates and chlorides) and these provide a buffering capacity to the solution as well as being elements vital to the biological metabolism and growth. In some cases, it may also be necessary to add some microorganisms to the dilution feed water which is usually in the form of adding a small quantity of domestic wastewater, collected rainwater or river water (about 2 ml per litre is adequate for this purpose). The dilution water and the sample solution should also be devoid of any significant concentrations of heavy metals and high ammonia levels since these substances can be toxic to the microbial population that should be sustained over the 5 day period.

A preliminary review of previous studies, revealed that most urban drainage waters supported a good microbial population that could be utilised in the BOD test without the need to seed the dilution water with microorganisms. A series of experiments was carried out in the Spring 1984 just prior to the start of the data collection in the research programme, to measure the BOD on some gully pot liquor samples and river samples, which were taken from the River Trent at

the Beeston Weir, at Clifton Grove adjacent to the study area and from Wilford Bridge just downstream of the study area. This work was carried out to derive a suitable working volume for the BOD test for gully pot liquor samples and it was tested against river samples for comparison. This preparatory work proved to be very valuable in providing a working range. For the urban stormwater samples collected from the gully pots, a 9:1 dilution of feed water to sample solution was found to be adequate and this dilution was used in nearly all determinations carried out in the research data collection programme. In the research programme, the BOD test was carried out in a 300 ml BOD flask with 30 ml of the sample solution being fully mixed with 270 ml of the aerated feed dilution water. The Dissolved Oxygen (DO) electrode was used to measure the initial DO level of the solution. A glass stopper sealed the top of the flask and any excess air bubbles trapped under the neck of the flask were removed by gently tapping the neck of the flask. A blank sample was set up as part of the BOD analysis and this consisted entirely of dilution water. A blank sample was set up for every 12 samples on a batch basis. The sample bottles (including the blank) were then placed in an incubator at 20'C for 5 days. At the end of the 5 days (to within plus or minus one hour), the samples were removed and the DO measured. This critical time factor was achieved for 82% of all samples taken throughout the research programme with 94% of all samples being analysed within plus or minus three hours. The remaining 6% of all the samples were analysed outside the three hour time limit due to unforeseen logistical reasons. Samples left for a time greater than plus eight hours were discarded. The difference in the DO level for the blank sample over the 5 day period should not be greater than 2.0 mgl-1 and breaches of this limit on some occasions meant that some samples had

to be discarded. This explains some gaps found in the dataset for the BOD analysis in the presentation of the results.

The BOD value is calculated in the following way:

$$BOD = D\left[(Xi - Xv) - (Bi - Bv) \right]$$

where BOD = Biochemical Oxygen Demand in mgl^{-1} as BOD.
D = The dilution factor eg. D = 9 in most cases.
Xi = The DO concentration at the start of the test.
Xv = The DO concentration at the end of the test.
Bi = The DO concentration of the blank at the start of the test.
Bv = The DO concentration of the blank at the end of the test.
i signifies the start of the 5 day period.
v signifies the end of the 5 day period.

NOTE: The test is only valid if $(Bi - Bv) \leq 2.0\ mgl^{-1}$.

In this programme, all the BOD determinations carried out were for BOD (Total) or uninhibited samples. The alternative test which is now being more widely adopted throughout the world as an accepted norm for river and industrial/trade effluent samples is for BOD(ATU). This test involved the addition of alkylthiourea (ATU) which suppresses the nitrification process over the 5 day incubation period. There is no standard against which the accuracy of the BOD data can be tested and an estimated figure of 5% is often quoted as a level of accuracy if the test is carried out under a strictly controlled procedure. The BOD results should really be viewed more as an index of pollutional strength (or potential pollution strength) rather than a precise analytical measurement, even though it can be fully quantified.

5.5 CHEMICAL OXYGEN DEMAND : (COD).

The COD test is used as a means of measuring the pollutional strength of waters and the test is based upon the fact that nearly all organic compounds can be oxidised by strong oxidising agents under acidic conditions. The COD value is a measure of the total quantity of oxygen required for the complete oxidation of all the carbonaceous matter to carbon dioxide and water and it is expressed as a unit of mgl-1 as COD. One of the major advantages of the COD test is the relatively short analysis time since the result can be obtained in a few hours rather than the 5 day test for the BOD. An important limitation of the COD test is its failure to differentiate between biologically oxidisable and inert organic matter. In many types of sample, a definite relationship can be seen to exist between the BOD and the COD (particularly in the case of industrial effluents eg. dye wastewaters, distillery wastes) and so one can be predicted from the other in certain situations.

The experimental procedure to determine the COD is based upon the fact that most (in fact very nearly all) types of organic matter are fully oxidised by a mixture of boiling chromic and sulphuric acids. The sample is refluxed with known amounts of potassium dichromate and sulphuric acid and at the end of the experiment, the excess dichromate is titrated with ferrous ammonium sulphate. The dichromate ion is a very strong oxidising agent in the presence of a strongly acidic solution and the quantity of oxidisable organic matter (used as an indicator of the pollutional strength of a water) is proportional to the amount of potassium dichromate consumed in the reaction at a given temperature and for a predetermined duration. Interference from chloride ions is known to cause problems with this particular test and

so a small quantity of mercuric sulphate is added to the sample to fix the chloride ions in solution. The mercuric ions form a poorly ionised mercuric chloride complex.

The Experimental Procedure:

A Hach Chemical Company COD reactor was used in the COD analysis. This conducts the experiment on a scale using only small quantities of both sample solution and reagents. The COD digestion occurs in a small vial (culture tube). The procedure was to place 2.0 ml of the sample solution in the tube and to add 1.0 ml of 0.25N potassium dichromate solution ($K_2Cr_2O_7$). About 0.1 g of mercuric sulphate (this quantity need only be estimated) was added to the tube and then 2.0 ml of concentrated sulphuric acid (which contains 2% by weight of silver sulphate as a catalyst for the oxidation reaction) was added and the whole mixture was thoroughly shaken. An exothermic reaction takes place with the result that the tube becomes very hot. The tube was then sealed with a screw top before being placed in the reactor tray set at 150'C for two hours. The liquid in the base of the tube was heated in the tray and kept at the required temperature through a thermostatically controlled heating mechanism for the two hour duration. The top of the tube sits above the heater tray and is exposed to the air. Therefore the evaporate condenses at the top of the tube and falls back into the base of the tube to give a reflux reaction. A blank sample was set up (in an equivalent form to the BOD test) using distilled water as the sample solution. This blank contained no organic matter. At the end of the two hour period, the tube was removed from the reactor and was left to cool. Once cool, the contents of the tube were transferred to a small flask and a drop

of ferroin indicator (1,10-phenantholine ferrous sulphate) complex was added to the solution. A titration with ammonium ferrous sulphate was then used to determine the amount of dichromate used up in the reaction. (The ferroin indicator is used in the titration to indicate when all the dichromate has been reduced by the ferrous ion). The end point of the titration was marked by a distinct change in the colour of the solution from a pale green to a bright, vivid, red colour.

The reaction between the ferrous ammonium sulphate and the dichromate ion can be represented by the following equation:

$$6\,Fe^{2+} + Cr_2O_7^{2-} + 14\,H^{+} \longrightarrow 6\,Fe^{3+} + 2\,Cr^{3+} + 7\,H_2O$$

A 0.0125N solution of ferrous ammonium sulphate (FAS) was used in nearly all the COD determinations because this concentration gave the best working range for the COD values expected in gully pot liquor. It was also the concentration recommended for natural drainage waters in the Hach Chemical Company COD Reactor User Guide.

The calculation for the COD value is as follows:

$$\text{COD (in mgl-1 as COD)} = \frac{\text{(Blank - Sample) x Normality of FAS x 8000}}{\text{ml of sample}}$$

where (Blank - Sample) is the difference between the two titration values.

The sample volume was always kept at 2.0 ml.

The normality of the ferrous ammonium sulphate (FAS) was nearly always 0.0125N.

Therefore:

$$COD = (Blank - Sample) \times 0.0125 \times 4000$$

So that:

$$COD = (Blank - Sample) \times 50$$

(in mgl^{-1} as COD)

5.6 TOTAL ORGANIC CARBON : (TOC).

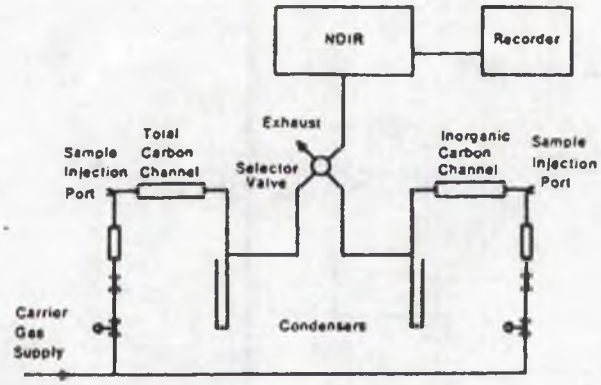
The analysis of Total Organic Carbon (TOC) has become more widespread in water pollution control work in recent years due to its quick results and sensitivity. The development of TOC measurements has sought to replace and enhance the more time-consuming BOD and to a lesser extent COD analyses, which have traditionally formed the basis of much of the analysis of wastewaters. The development of reliable TOC instrumentation during the last fifteen years has now made possible the rapid and accurate determination of carbon in wastewaters and surface waters and TOC has now acquired a widespread application in water pollution control work. The analysis of TOC is a quick and effective method of expressing the amount of organic or carbonaceous matter in a water sample and it involves measuring the carbon dioxide evolved from the combustion of a quantity of organic matter in solution. This is really an opposite approach to the measurement of the amount of oxygen consumed during an oxidation reaction which is the basis of the BOD and COD tests. It is recognised that the efficiency of the carbon dioxide release from the organic matter depends upon the type of oxidation procedure employed. Organic carbonaceous matter is a major oxygen-demanding pollutant in surface waters. The TOC Analyser measures the amount of organic matter in a sample by injecting a quantity of the sample into a combustion chamber at 900'C and an oxygen carrier gas is fed through the system to ensure the total oxidation of the carbon to carbon dioxide gas, which in turn is measured by an infra-red analyser. The organic carbon is catalytically oxidised to carbon dioxide. The carbon analyser measures the total carbon involved in the oxidation process which is made up of both an organic and an inorganic (mainly in the form of

carbonates and bicarbonates) component. An effective measurement of TOC is obtained by sample acidification prior to the test, whereby the inorganic carbon is removed. Inorganic carbonate and bicarbonate may be decomposed with acid to produce carbon dioxide and this pre-treatment means that when the sample is analysed for total carbon, it is really equivalent to a measure of the total organic carbon (TOC). The acidification is usually achieved by adding one drop of concentrated hydrochloric acid or nitric acid to every 10 ml of sample solution analysed. This reduces the pH to about pH 2.0. One of the problems associated with the analysis is that the samples have to be filtered prior to analysis. This prevents solids from blocking the pathway to the combustion chamber. A microlitre, hypodermic syringe is used to inject the samples into the analyser and there is a selectivity or screening of the particles in solution. Such losses on sample injection result in an accuracy of around plus or minus 1 mgl-1, for most TOC analysers. The sample has its organic matter combusted to carbon dioxide and the resultant gas flows through a heated catalyst-packed cobalt-oxide impregnated column, via a four way valve to a non-dispersive infra-red analyser where the carbon dioxide selectively absorbs the infra-red energy. The absorption peak is obtained on the chart for each sample analysis and this is compared to the values obtained from standard solutions which are used to calibrate the instrument at the start of the analysis.

The Beckman Model 915A Total Organic Carbon Analyser and the Beckman Model 865 Non-Dispersive Infra-red Analyser were used in the research programme analyses (see Figures 5.2 and 5.3).

Diagram to Show the Model 915 Total Organic Carbon Analyser.

Figure 5.2



Photograph of the Model 915 Total Organic Carbon Analyser.

Figure 5.3

TOTAL CARBON = ORGANIC CARBON + INORGANIC CARBON

A preliminary investigation on some samples taken from roadside gully pots showed that a very small percentage of the total carbon found in the gully pot liquors was in the inorganic form. A number of gully pot liquor samples and river water samples taken from the River Trent were analysed and the results showed that the gully pot liquors had an insufficient concentration of inorganic carbon to make the determination of this concentration valuable. It was therefore decided to eliminate the inorganic fraction from the sample before the TOC analysis took place and the value obtained for the Total Carbon could be taken as being equal to the Total Organic Carbon. The inorganic carbon was removed by sample acidification, just prior to sample injection. Some volatile acids may also be lost in this way but these are found in very small concentrations in surface waters. The carbon dioxide gas produced is directly proportional to the concentration of the total carbon (which is equivalent to the TOC). The TOC values are expressed as a concentration in mgl^{-1} as C. The TOC analyser used in the research programme was found to have a sensitivity of around 1 to 5 mgl^{-1} as C, and the analysis time was generally around two to three minutes per sample.

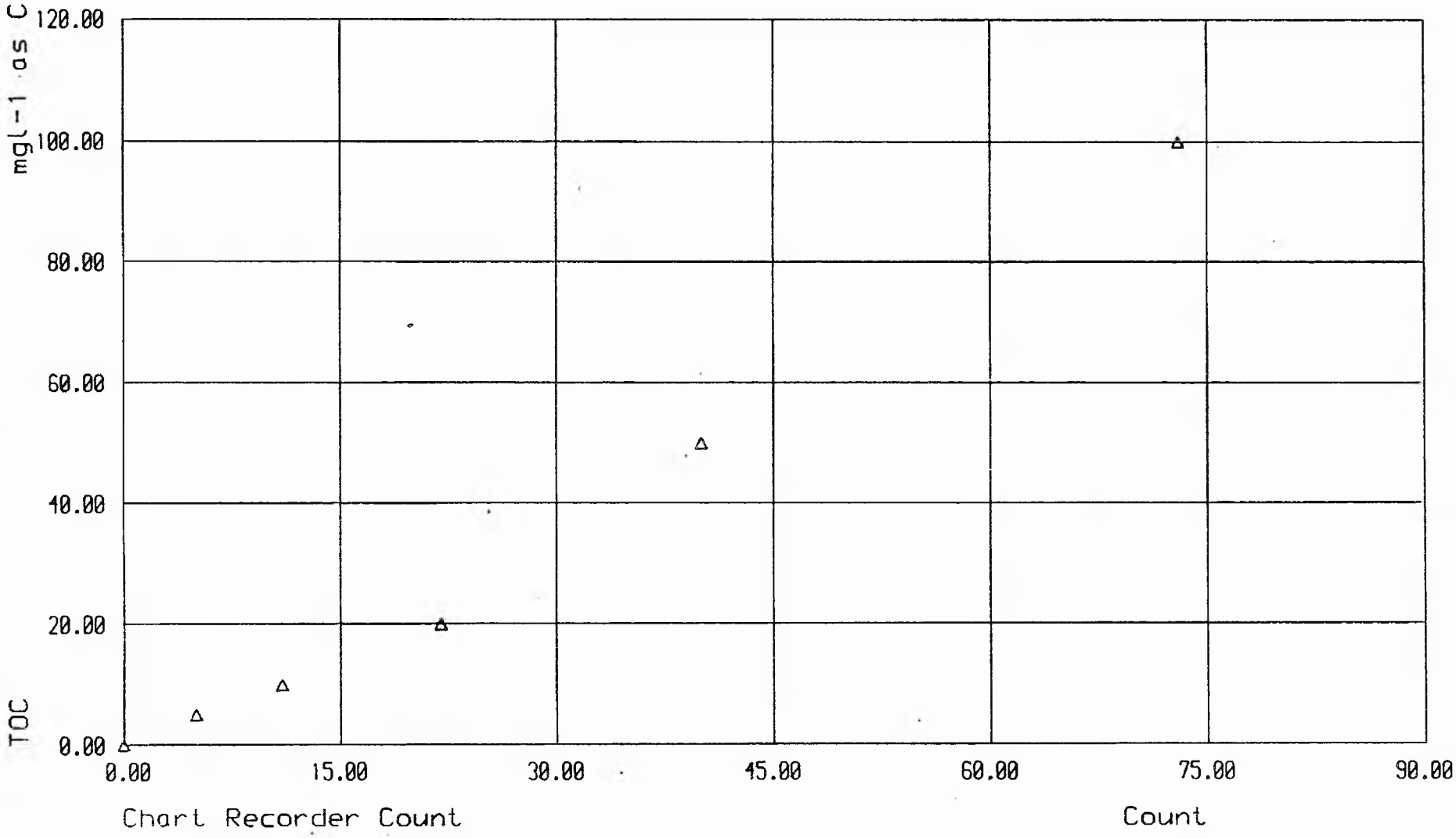
The Experimental Procedure:

The TOC analyser was calibrated using a series of standard solutions and the scale was set to zero using a blank solution. Distilled water was used to provide the blank (ie. organic free) sample solution and the standard solutions were made up with potassium hydrogen phthalate. A standard solution of 1000 mgl^{-1} as C was made up as a stock solution

and then a series of serial dilutions was conducted to provide standard solutions of the required concentration for a good working range. The standards used in the analysis were 10,20,30,50 and 100 mgl-1 as C. The distilled water or blank solution was used to zero the instrument and the carbon dioxide measurement was relayed to a chart recorder. The charts were read at a later date. The standard solutions were renewed every two weeks and were kept refridgerated when in store. Distilled water was flushed through the injection chamber between sample injections to ensure that there was no contamination of samples. The peak heights were measured on the chart recorder and a calibration graph was plotted for each set of analyses of the chart count against the solution concentration and this was used to determine the TOC concentrations (see Figure 5.4).

The preparation of the standard solutions was conducted in accordance to the methods as outlined by Croll (1976). The method involved adding 0.212 g of potassium hydrogen phthalate ($KHC_8H_7O_4$) to a 200 ml flask and this solution contained 500 mgl-1 as C of organic carbon and was stable for about one month.

The TOC analysis proved to be a very quick method of analysis and the results were used to enhance the results from the BOD and COD analyses. Nearly all the samples analysed fell into the predicted working range of 0 to 150 mgl-1 as C, which was derived from a series of preliminary studies carried out in Spring 1984 and so very few sample dilutions had to be carried out in order to adjust to the working range of the TOC analyser.



Calibration Curve For Total Organic Carbon using the Beckman TOC Analyser.

Figure 5.4

5.7 pH.

pH is defined as the negative logarithm to the base 10 of the hydrogen ion activity which in dilute solutions is interchangable with the concentration. The pH of 'neutral' solutions at 25'C is pH 7 while 'acidic' solutions are those with a pH of less than 7 and those above pH 7 are termed 'alkaline'.

$$pH = - \log (H^{+})$$

The pH of most natural waters falls within the range of pH 4 to 9 and it is controlled by the chemical interactions and equilibria among the ions in solution. A buffer solution shows no change in its pH if it subjected to increased or decreased concentrations of hydrogen ions or hydroxyl groups when in solution. The 'buffering capacity' is its ability to resist a pH change when small amounts of acid or alkali base are added and this is due to the presence of an acid or base which is weakly dissociated and one of its salts.

The most common method of measuring the pH is to use the glass electrode in combination with a reference potential provided by a saturated calomel electrode (see Figures 5.5 and 5.6). The electrode system is calibrated against known buffer solutions which should be freshly made up for each series of pH determinations. Here, the instrument used was a PHILIPS PW9418 pH Meter (Digital Ion Activity Meter) and this was calibrated using standard buffer solutions of pH 4.0, 7.0 and 9.2. The electrodes were placed in the buffer pH 7.0 and the scale was set to 7.0. The electrodes were then removed and were thoroughly washed in distilled water and dried before being immersed

Diagram of a Glass Electrode with an Internal Reference Electrode.

Figure 5.5

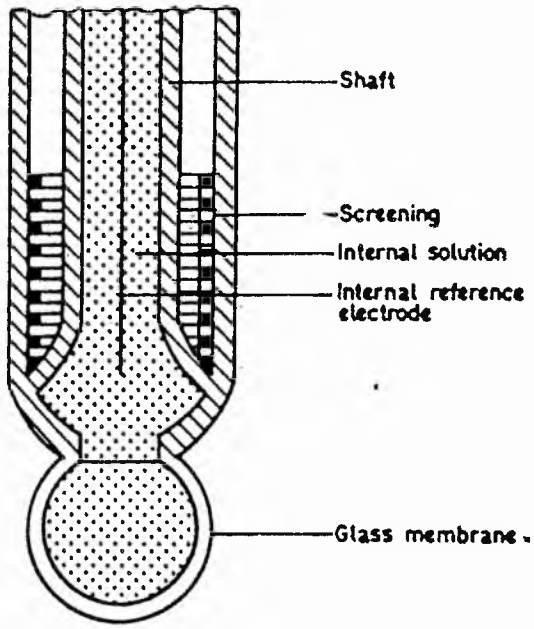
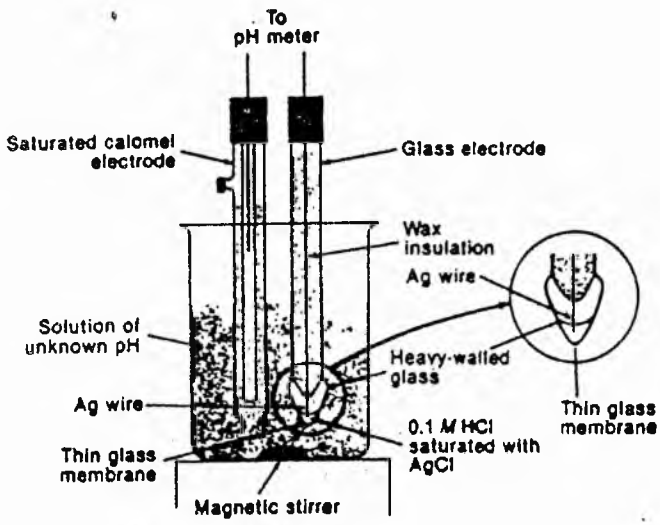


Diagram to Show the Typical Electrode System for Measuring pH.

Figure 5.6



in either the pH 4.0 or the pH 9.2 buffer solutions, depending upon whether an acid or alkaline working range was required. Any discrepancy in the reading was adjusted using the slope control on the meter and this procedure was repeated several times if necessary, until a consistent calibration was derived. All samples were analysed at room temperature and the meter was therefore set to a 20'C setting. Once the instrument had been standardised, the pH meter was ready to use for analysis. The sample solution was stirred throughout the measurement. The solution was left for a few minutes until a stable reading was found and the pH values were read directly off the meter to one decimal place. For most samples analysed, the pH meter was calibrated on the pH 7.0 to pH 9.2 range. The instrument calibration was checked with the buffer solutions every twenty samples or so, in order to eradicate any drift in the meter and the electrodes were thoroughly rinsed with distilled water and dried between each sample pH determination. Most pH determinations using various types of electrodes and meters can provide the level of accuracy of the determination to within plus or minus 0.1 pH units.

5.8 CONDUCTIVITY OR SPECIFIC CONDUCTANCE.

The conductivity of a solution is a measure of its ability to carry an electric current and is related to the number and type of ions present in any given solution. Conductance is the reciprocal of electrical resistance and the unit is the siemen per centimetre. The conductivity of a natural water is usually quite low, generally less than 50 μscm^{-1}. It is used as a measure of the total concentration of dissolved ions. The nature of the various dissolved substances and the ionic strength of the water as well as the temperature influence the conductivity. The amount of dissolved inorganic matter can be estimated by multiplying the specific conductance by an empirical factor which varies from 0.5 to 0.9, but these types of relationships are often difficult to establish.

The conductivity analysis in the research programme was carried out using a Corning Conductivity Meter 220. The instrument is made up of two parts. The conductivity cell consists of a pair of rigidly mounted platinum electrodes and each cell has its own 'cell constant', depending upon the position and the size of the electrodes. The electrical conductance is measured by the meter which consists of a low voltage source, connected to a Wheatstone Bridge circuit. The conductivity varies sharply with the temperature and it is important to standardise the temperature setting on the meter during the calibration procedure. The meter was set to zero using a sample of distilled water and so the zero point was fixed on the calibration scale. An upper calibration point was derived by using a solution of known specific conductance at a given temperature. The meter was calibrated using a known standard solution of 0.1M potassium chloride

(KCl) and the meter was set manually with the cell immersed in a well mixed sample of the standard solution (see Table 5.2). Once this procedure had been repeated a few times, a consistent value of conductivity was obtained for the standard solutions and the meter was then ready for use in the analysis (see Figure 5.7). The conductivity cell was rinsed thoroughly in distilled water before being immersed in the sample solution. A stable reading was usually obtained on the meter within about 30 seconds and the value in μscm^{-1} was recorded, as a direct reading. It is considered that an accuracy to within 5% (plus or minus) was achieved with this conductivity cell and the associated meter.

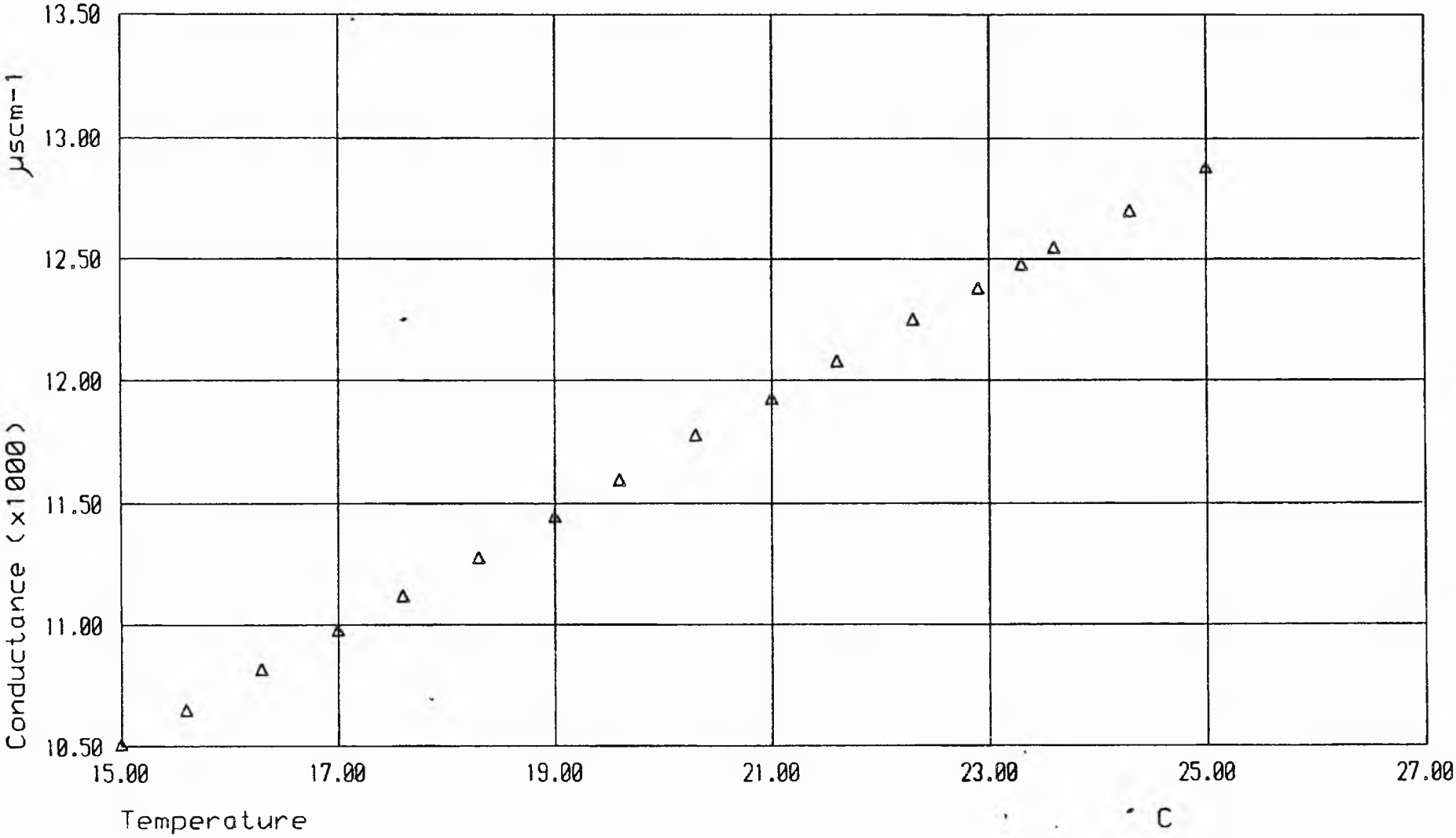
Table to Show the Specific Conductance of Potassium Chloride Solutions at 25°C.

Table 5.2

SPECIFIC CONDUCTANCE OF POTASSIUM CHLORIDE SOLUTIONS AT 25°C

Concentration	Specific conductance
moles	µmho/cm
0.0001	14.94
0.0005	73.9
0.001	147.0
0.005	717.8
0.01	1,413
0.1	12,900
1.0	111,900

0.1 mole KCl = 7.455 g/l



Graph to Show the Specific Conductance of 0.1M KCl against Temperature.

Figure 5.7

5.9 The Use of Electrodes in Environmental Analysis.

The development and use of electrodes in water quality studies is still a relatively new idea but this field has developed enormously over the past few years and has added a new dimension to water analysis methodology. Electrodes have been installed in monitoring stations on many watercourses in the United Kingdom (Lester and Woodward 1972) and many electrodes are now specifically designed for wastewater analysis and are becoming more common on water reclamation works and private wastewater treatment plants.

Petch et al (1975) stated that ...

"In any study of the environment, scientists are faced with problems of experimental complexity and logistical limitations which make it desirable to minimise analytical effort"...

It is for this reason that electrode instrumentation has become more popular in environmental studies. This approach is favoured because the procedures are quick and simple to use and very little preparatory work needs to be carried out before an electrode can be used.

Electrodes fall broadly into three different types:

i) ion selective electrodes which measure the activity of ions.

ii) specific conductivity electrodes which measure the ability of a solution to conduct electricity which is related to the ionic concentration of the solution.

iii) electrodes which can directly determine the concentration of gases or other molecular species.

An ion selective electrode (ISE) consists of a membrane mounted in a suitable body filled with an electrolyte and the membrane determines the particular ionic species to which the electrode responds thus making it selective to particular ions. When placed in a solution, an electric potential is set up across the membrane and the effective concentration of the species can be determined using a calibration against a fixed potential of a reference electrode.

5.10 THE DETERMINATION OF DISSOLVED OXYGEN : (DO).

All forms of life are dependent upon oxygen for their metabolic processes and so the concentration or indeed absence of dissolved oxygen (DO) in water is of vital consequence to all forms of life, both flora and fauna. The solubility of oxygen in water is temperature dependent and the colder the water, the more oxygen can be dissolved in it at a given atmospheric pressure (see Table 5.3 and Figure 5.8). The solubility of oxygen can also be influenced by salinity and the solubility is always less in saline waters. DO levels in natural waters are therefore dependent upon the physical, chemical and biological activities prevailing within the water at any given time. The depletion of oxygen within a water body results from the oxidation of carbonaceous or nitrogenous material and the respiratory mechanisms of aquatic fauna and flora.

The DO electrode used to directly measure DO levels, differs from ion selective electrodes since it responds to the partial pressure of a dissolved gas and not to ionic activity. These electrodes are very sensitive to temperature and so a thermistor is usually included within the electrode, so that a temperature correction can be accommodated into the calibration procedure. It is important to note that the DO value must be determined as soon after the sample is taken, as is possible and it is also important to remember that the sample bottle must be completely filled so that there is no interference from an air layer at the top of the bottle. The electrode is really a cell and consists of an anode in the form of a lead rod which is surrounded by three hollow cylinders of porous polyvinyl chloride, perforated silver and a polythene membrane. A

conducting path is provided between the anode and the cathode by a suitable electrolyte usually in the form of a gel. A constant potential is applied to the oxygen cell so that oxygen is preferentially discharged at the cathode and the oxygen partial pressure is estimated from the current flowing through the cell. The membrane acts as a semi-permeable barrier preventing the reduction of other electroactive substances at the cathode. The oxygen is then allowed to diffuse through the membrane at a rate proportional to the oxygen partial pressure in the water sample. Most modern DO membrane electrode systems can obtain an accuracy to within plus or minus 0.1 mgl-1.

The DO electrode used in the research programme was an ORION Model 97-08-00 which was connected to either a PHILIPS PW9414 Digital Ion Activity Meter or an EIL 7030 pH Meter. There are several ways that a DO electrode can be calibrated but the following standard procedure was adopted. The zero point on the meter was set and the top of the scale was adjusted to read the appropriate % Saturation under the prevailing atmospheric conditions. The barometric pressure was set on the instrument. A small volume (about 150 ml) of distilled water was placed in a vessel whereby when the probe was immersed in the solution, a sealed unit was obtained. A magnetic stirrer fixed to the bottom of the electrode housing was set at such a level that it skims the surface of the water. This agitation of the surface of the water over a period of time, saturated the air layer above the solution. The electrode was then left for several minutes before a stable reading was obtained and the value on the DO meter scale equalled the DO concentration in mgl-1, for a given temperature (which was always set at a room temperature of 20°C). Once the electrode had been

calibrated, it was used for DO concentration measurement by immersing the electrode in the sample solution such that the membrane and the stirrer unit were fully immersed in the solution. A constant value on the scale was obtained after a few minutes and this figure was quoted as the DO concentration of the sample.

The ORION Model 97-08-00 DO Electrode :

This electrode consists of a pair of polarised silver electrodes and an electrolyte separated from the sample by a gas-membrane. The oxygen diffuses across the electrode membrane and is reduced to hydroxyl ions at the silver cathode (see Figure 5.9).

The current produced between the cathode and the anode is proportional to the concentration of the oxygen at the membrane. The electrode uses a membrane which has a low oxygen permeability to reduce the consumption of oxygen from the sample and the stirring rate is therefore less significant. Oxygen electrodes do not directly measure the oxygen concentration. They measure the partial pressure of oxygen but the relationship between the two can be easily worked out to a constant and predictable relationship between oxygen solubility, temperature and the total atmospheric pressure. It is important to note that under equilibrium conditions that at any given temperature, the partial pressure of oxygen in water-saturated air is exactly the same in air-saturated water and so an electrode standardised in terms of the partial pressure in water-saturated air will correctly read the partial pressure of dissolved oxygen (DO) in a water sample.

No adjustments were made to the readings obtained in the analysis with

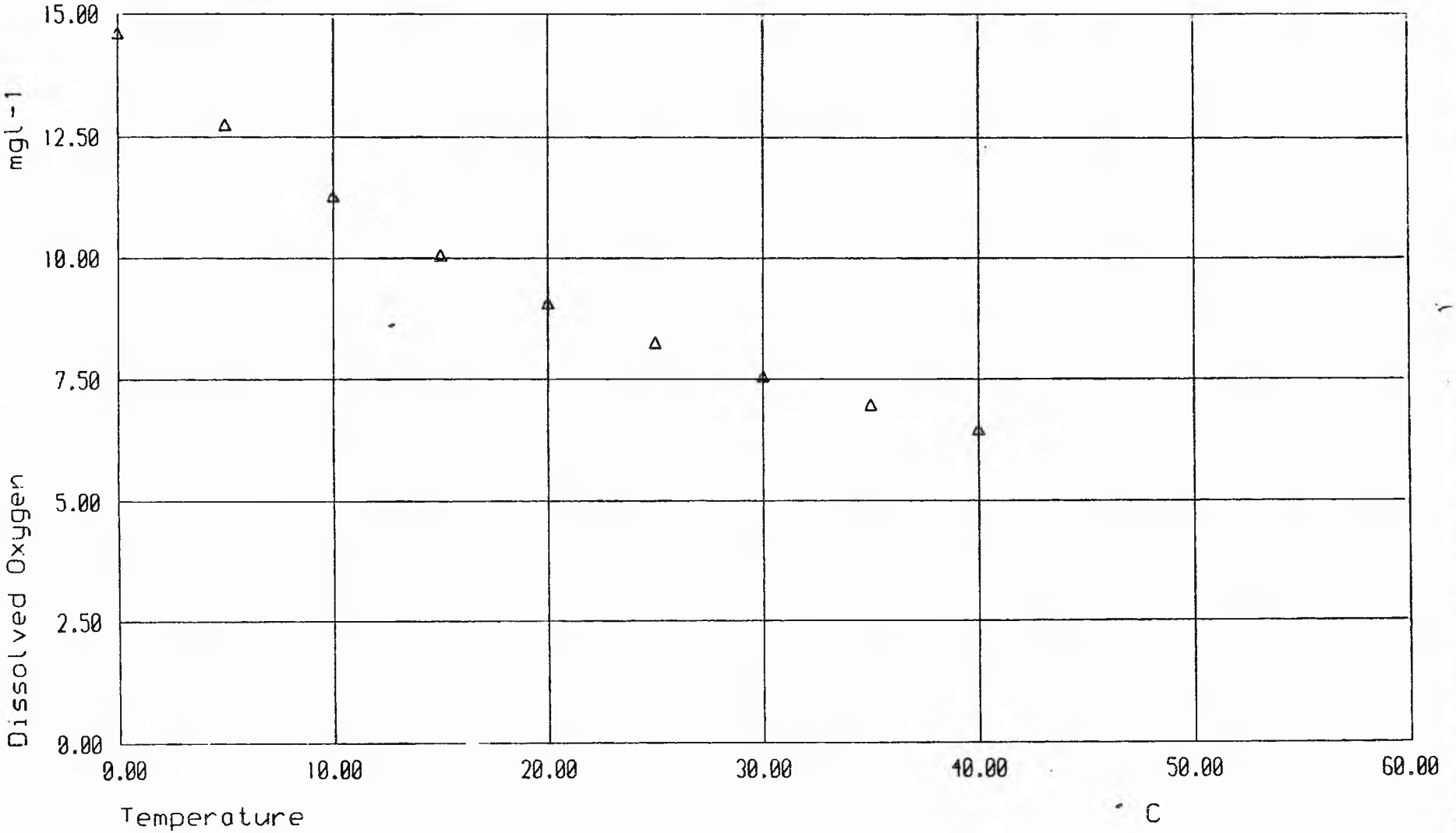
regard to the salinity of the solution or the elevation above sea level when the barometric pressure was set on the meter during the initial calibration stage. These factors were not deemed to be important in the analysis of dissolved oxygen levels in this context. All values for DO are quoted as DO concentrations in mgl^{-1} and this unit of measurement is most commonly used when discussing the effect of the water quality upon aquatic life. Most freshwater fish can only survive in waters where the DO concentration is in excess of 5 mgl^{-1}. An alternate unit of measurement to express the oxygen level in a water, is the % Saturation (Percentage Saturation), which takes into account the influence of the temperature on the dissolved oxygen levels. The concentration of DO divided by the maximum possible (saturated) concentration at any given temperature is expressed as a % Saturation and this index is also used in many water quality studies and classifications.

Table to Show the Solubility of Oxygen in Water.

Table 5.3

SOLUBILITY OF OXYGEN IN WATER

Temperature °C	Solubility of oxygen in water (mg/l) in equilibrium with air at 760 mm Hg	Correction to be subtracted for each degree of salinity (expressed as g total salts per 1000 g water)
0	14.63	0.0925
1	14.23	0.0890
2	13.84	0.0857
3	13.46	0.0827
4	13.11	0.0798
5	12.77	0.0771
6	12.45	0.0745
7	12.13	0.0720
8	11.84	0.0697
9	11.55	0.0675
10	11.28	0.0653
11	11.02	0.0633
12	10.77	0.0614
13	10.53	0.0595
14	10.29	0.0577
15	10.07	0.0559
16	9.86	0.0543
17	9.65	0.0527
18	9.46	0.0511
19	9.27	0.0496
20	9.08	0.0481
21	8.91	0.0467
22	8.74	0.0453
23	8.57	0.0440
24	8.42	0.0427
25	8.26	0.0415
26	8.12	0.0404
27	7.97	0.0393
28	7.84	0.0382
29	7.70	0.0372
30	7.57	0.0362

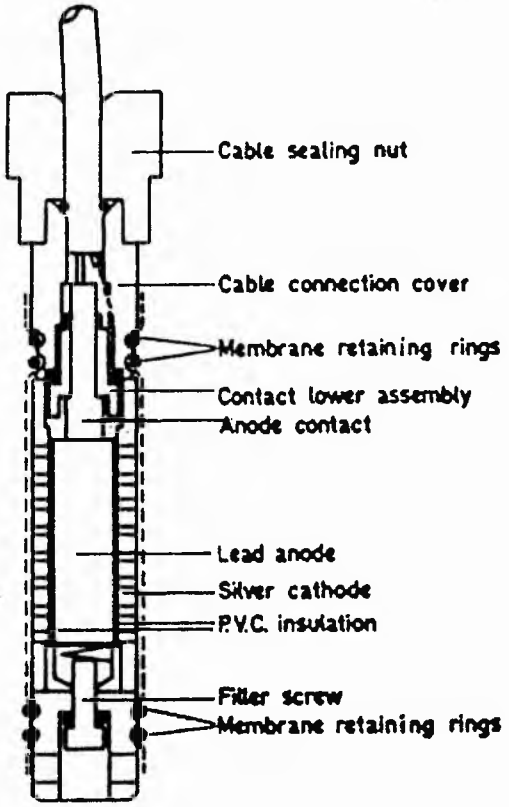


The Solubility of Oxygen in Pure Water at Standard Atmospheric Pressure.

Figure 5.8

Diagram of a Modified Mackereth Type Dissolved Oxygen Electrode.

Figure 5.9



5.11 THE DETERMINATION OF AMMONIA.

Nitrogen in the environment can exist in four recognisable forms :

i	Organic Nitrogen:	as amino acids, urea, proteins etc.
ii	Ammonia Nitrogen:	as ammonium salts or as free, unionised ammonia.
iii	Nitrates :	product of nitrification (oxidation processes).
iv	Nitrites :	intermediate stage in nitrification, usually in small concentrations.

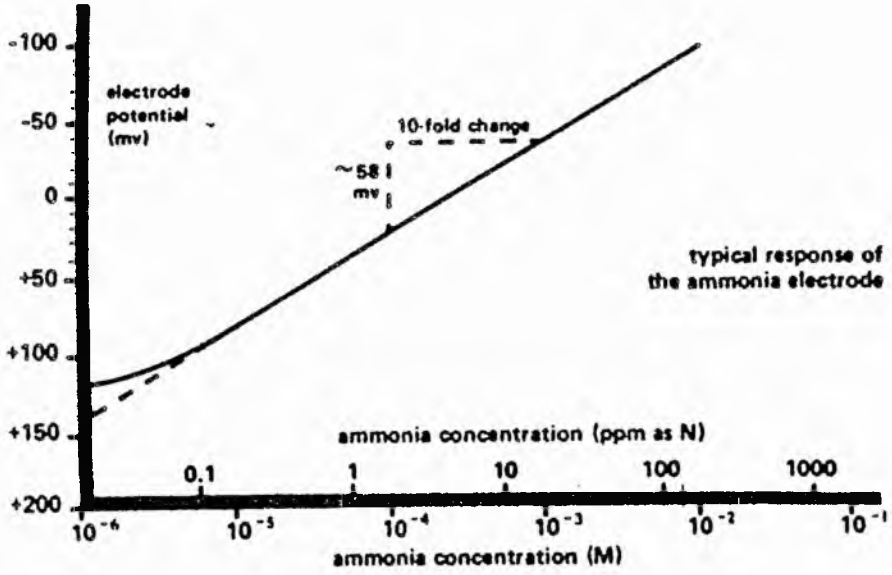
Unionised ammonia is the toxic form while the ammonium species (ionised form) is much less toxic and is more prevalent at lower pH values (see Figure 5.11). Nitrates and nitrites are also toxic to varying degrees.

The ammonia electrode provides a fast, simple and accurate measurement of dissolved ammonia in aqueous solutions and the technique is not influenced by colour or the turbidity of the samples. There are no interference problems from most commonly found ions and dissolved species except from volatile amines.

The ammonia electrode uses a hydrophobic gas-permeable membrane which separates the sample solution from the internal filling solution. The ammonia gas dissolved in the sample solution diffuses through the membrane until the partial pressure of ammonia is equal on both sides of the membrane and this partial pressure is directly proportional to its concentration. When the electrode is immersed in the sample solution, ammonia gas in the solution diffuses through the membrane and dissolves in the internal filling solution and often reacts with water in the filling solution in the reversible ammonia/water reaction:

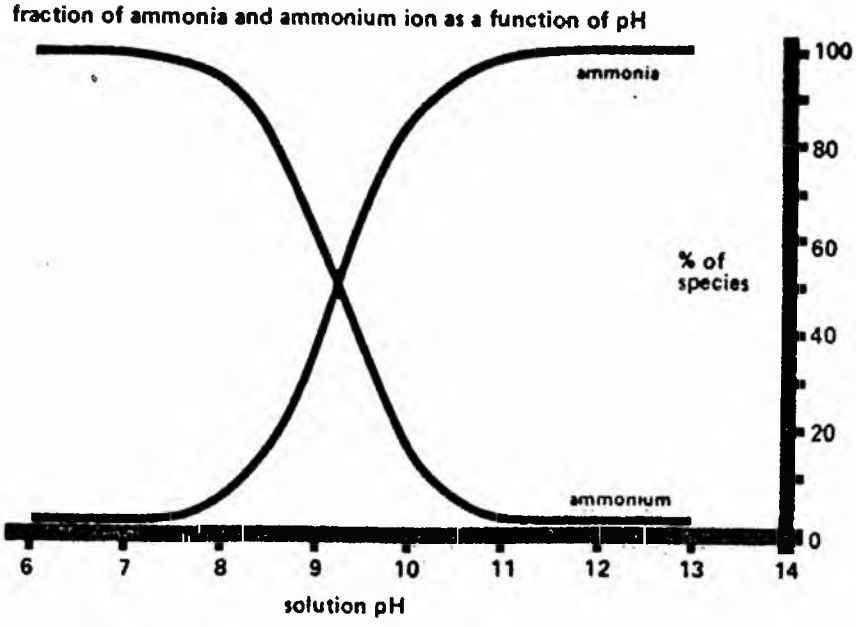
Graph to Show the Typical Response of the Ammonia Electrode.

Figure 5.10



Graph to Show the Fraction of Ammonia and Ammonium Ion as a Function of pH.

Figure 5.11



$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

Total ammonia was measured with an ORION Ammonia Electrode Model 95-10 and this was connected to a PHILIPS PW9414 Digital Ion Activity Meter. The electrode was standardised using standard solutions of ammonium nitrate (NH_4NO_3) corrected to the pH operating range (ie. pH 11 to pH 14). Standard solutions of 10^{-4} M, 10^{-3} M, 10^{-2} M and 10^{-1} M ammonium nitrate were made up and 1 ml of 10M NaOH (Sodium Hydroxide) was added to every 100 ml of standard. A 50 ml sample volume was used in all the analyses. The internal filling solution used was that recommended for the electrode (Code: ORION 95-10-02). All samples, standards and electrodes were at the same temperature and all determinations were carried out on well mixed sample solutions and standards. A direct measurement of ammonia concentration can be obtained using the ammonia electrode. The standard solutions were prepared by serial dilution from a 0.1M stock solution of ammonium nitrate. The electrode was placed in the standard solution with the 10^{-3} M ammonia standard, reserved as an absolute standard, and the millvolt meter set to zero when a stable reading was obtained. The other standard solutions (10^{-4} M and 10^{-2} M, and in some cases a 10^{-1} M solution) are then measured using the same procedure. The electrode was rinsed thoroughly with distilled water between determinations and the millivolt readings were allowed time to stabilise in all cases. The millivolt readings taken were then plotted on a calibration curve when a ten fold change in concentration (as a molar concentration) should be accompanied by a 59 mv electrode potential change, according to the Nernst Equation (see Figures 5.10 and 5.11 and Table 5.4). The measurement of ammonia in concentrations less than 0.01 mgl-1 as N are subject to significant errors and the ammonia electrode is not suited to this level of

concentration.

AMMONIA CONCENTRATION UNIT CONVERSION TABLE:

Moles per litre	mgl-1 as N	mgl-1 as NH_3
10^{-4}	1.4	1.7
10^{-3}	14.0	17.0
10^{-2}	140.0	170.0

Table: 5.4

Diagram of an Ammonia Electrode.

Figure 5.12

construction of the ammonia electrode

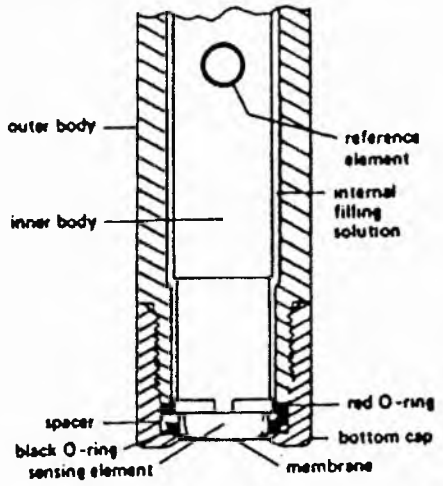
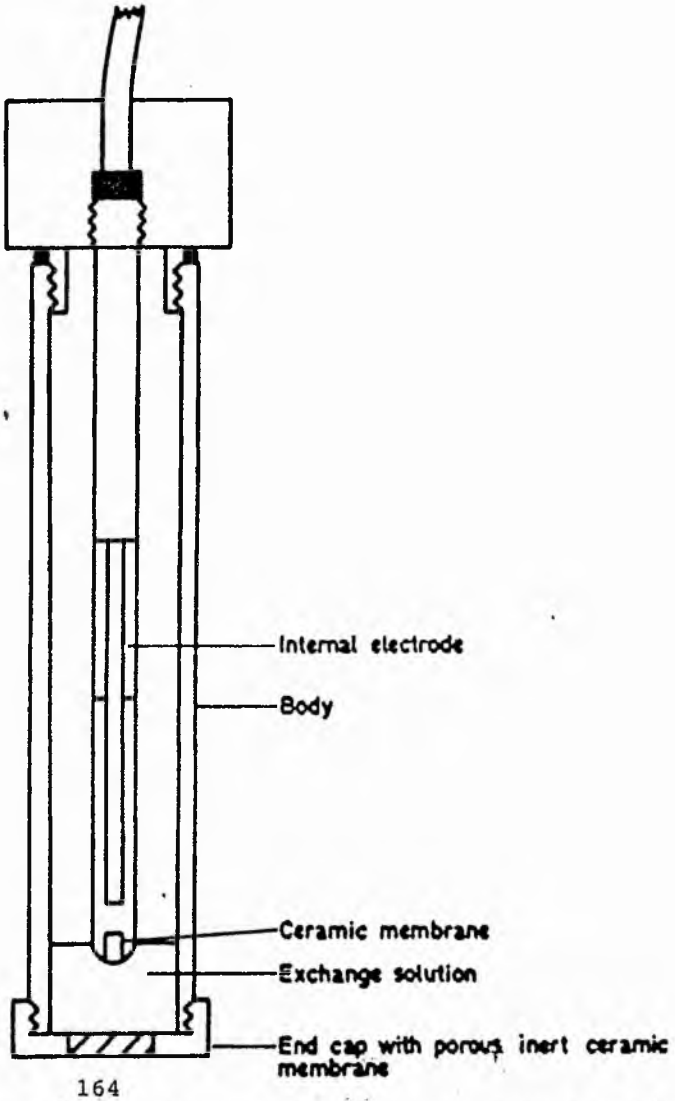


Diagram of a Nitrate Electrode.

Figure 5.13



5.12 THE DETERMINATION OF NITRATE.

Nitrogen can exist in several forms in the aquatic environment, as nitrogen gas, organic nitrogen, nitrates and nitrites. The determination of nitrate is probably one of the most difficult in analytical chemistry but recent advances in electrode technology have helped to alleviate some of the cumbersome laboratory procedures. The nitrate electrode is a liquid membrane electrode and it can detect nitrate concentrations of about 1.0 mgl-1 as N. Nitrates are receiving increasing attention in many water quality studies because their concentrations in watercourses have been seen to be increasing over the last few years mainly due to more intensive agricultural methods adopted and the enhancement of nitrate levels in land drainage waters from artificial fertilisers. Nitrogen is leached from the soil as nitrates which are highly soluble and the concentration of nitrates in drainage waters can often be found to be within the range 10 mgl-1 to 100 mgl-1 as N. Nitrate levels found in some boreholes in the UK have been seen to be increasing by 1 mgl-1 as N per year for the last ten years or so. Particular attention is currently being paid to watercourses with potable supply abstraction points since the World Health Organisation (WHO) Drinking Water Recommended Limit is 11.3 mgl-1 as N.

The calibration of the nitrate electrode is based upon the principle that nitrates dissociate very easily and there is a linear relationship between the activity and concentration except at very high or very low concentrations, which are rarely encountered in natural waters. This means that laboratory standards can be used for calibration and the electrode system can be directly calibrated against known standard solutions. Nitrate levels will generally be

found witin the range 1 to 100 mgl-1 as N and a linear response within this range should be achieved during the calibration. The nitrate electrode is known not to be as stable as other electrodes and the values obtained for the standards during the calibration, must be repeatedly checked to ensure that there is no drift in the readings. Oily deposits and other organic compounds in water are known to upset the operation of the membrane. Interference to the analysis may be caused by iodide, perchlorate and chloride ions but these are not normally encountered in sufficient concentrations to influence the results of the nitrate analyses. Another important factor in nitrate analysis is the presence of aquatic organisms in the water samples. These may deplete the nitrate concentrations and so it is recommended that the samples are analysed as soon as possible after sample collection. The influence of anaerobic microorganisms can be apparent in such cases. These may be derived from basal sediments found within the gully pots.

A CORNING Nitrate Electrode connected to a PHILIPS PW9414 Digital Ion Activity Meter was used for the determination (see Figure 5.13). This electrode was found to respond well to the range of 10^{-5} M to 10^{-2} M nitrate ion and its calibration followed Nernstian principles within this range (ie. a near linear relationship between electrical response and concentration). At the lower end of the detectable concentration limits, a slight curvature was often observed on the calibration graph and this was due to the solubility of the liquid ion-exchanger leached from the electrode membrane. This contributes a tiny fraction of nitrate through to the solution and the electrode can only operate effectively with the pH range of pH 2 to pH 11.

The nitrate electrode was calibrated using three standard solutions of 10^{-4} M, 10^{-3} M and 10^{-2} M nitrate as N. A 50.0 ml solution was used in all

the determinations and this was made up of 25.0 ml of the standard solution or the sample solution and 25.0 ml of 0.1M K_2HPO_4 (di-potassium hydrogen phosphate). The response time of the electrode was about 30 seconds although it sometimes took a couple of minutes to achieve a stable reading. The electrode was calibrated sequentially for the 10^{-4} M, 10^{-3} M and 10^{-2} M solutions with the electrode tip being thoroughly washed and dried between readings. A ten fold change in the molar concentration should result in a 59 mv electrode potential response (according to the Nernst Equation) and this can be seen in Figure 5.10. A calibration graph was plotted of the electrical response in millivolts against the molar concentration of nitrate for each batch of samples.

5.13 TOTAL HARDNESS.

Hardness is caused by divalent metallic cations, chiefly Calcium (Ca^{2+}), Magnesium (Mg^{2+}) and to a lesser extent Iron (Fe^{2+}) and Strontium (Sr^{2+}). The hardness of a particular water is closely related to the bedrock or surface rock outcrop that it has been in contact with. The hardness causing metals are most often associated with the following anions: bicarbonates (hydrogen carbonates), sulphates, chlorides and nitrates. Therefore an appreciation of the hardness value can give a valuable insight into the chemistry of a particular water. Hard waters are not a threat from a public health viewpoint but hard waters are unsuitable for certain water usage and if a hard water forms a significant source or input to a watercourse, then water softening may be required to produce a suitable water in an industrial process eg. in the chemical industries, printing or laundries. The presence of large concreted areas in the urban environment has alerted the need to investigate the hardness of runoff waters due to the potential influence of calcium in the concrete. This process may be of some importance due to the acidic rainwater falling onto a concrete surface, which may give a hard, surface runoff water.

Total Hardness is normally expressed as mgl-1 as $CaCO_3$ and the value is derived by using an EDTA Titrimetric Method (EDTA is Ethylenediaminetetraacetic acid). The EDTA compound forms a highly stable complex with divalent metal ions (eg. Ca^{2+} and Mg^{2+}) and a known quantity of EDTA is titrated against a known volume of sample solution. Eriochrome Black T is used as an indicator to show when all the hardness ions have been complexed (or when the EDTA is in excess).

For example:

M^{2+} is a divalent ion

$$M^{2+} + EDTA \longrightarrow [M.EDTA] \text{ Complex}$$

Initially the Eriochrome Black T indicator forms a complex with the deivalent ions but at the endpoint of the titration when the EDTA is in excess, the EDTA disturbs the divalent ion/indicator red complex and the EDTA forms a very stable complex with the hardness ions.

$$M^{2+} + \text{Eriochrome Black} \longrightarrow [\text{M.Eriochrome Black (Complex)}]$$

The end of the titration is therefore marked by a distinct change from a deep, wine red colour to a pale blue coloured solution.

This method for determining the Total Hardness of a water is obviously influenced by highly turbid or colloidal solutions. This is a problem common to all colourimetric determinations in analytical chemistry.

In the research programme, a 10.0 ml volume of the sample solution was used in all the titrations and this was made up to a 50.0 ml volume using distilled water. The Total Hardness Value was calculated in the following way:

$$\text{TOTAL HARDNESS (in mgl}^{-1}\text{ as } CaCO_3) = \frac{A \times B \times 1000}{C}$$

where:
A = ml of EDTA titrated.
B = mg of $CaCO_3$ equivalent to 1.0 ml of EDTA titrant.
C = sample volume in ml.

A 10.0 ml sample volume was used in all the Total Hardness analyses carried out in the research programme and a 0.01M EDTA solution was used in all cases.

Therefore:

$$\text{TOTAL HARDNESS (in mgl-1 as } CaCO_3\text{)} = A \times 100$$

The concentration of the EDTA was chosen so as to give a realistic and workable volume to be titrated, based upon the anticipated result. Some preliminary analyses of gully pot liquor and river waters carried out in Spring 1984, assisted with the choice of the 0.01M EDTA concentration used in the Total Hardness determinations.

5.14 ALKALINITY.

The alkalinity of a water is a measure of its ability to neutralise acids, in other words to be able to accept protons and this is due to the presence of bicarbonates (or hydrogen carbonates), carbonates and hydroxides. These anions are most commonly associated with salts with calcium, magnesium, sodium and potassium. The alkalinity is a measure of the buffering capacity and it is a useful indicator to describe the state of a particular water. The alkalinity is determined using a titrimetric method and the alkalinity value is usually expressed by a titration to a value of pH 4.5 as an equivalent weight of calcium carbonate (ie. in mgl-1 as $CaCO_3$). The pH 4.5 endpoint is used since it is the equivalence point for the conversion of bicarbonate (hydrogen carbonate) to carbonic acid.

$$HCO_3^- + H^+ \longrightarrow H_2CO_3$$

The alkalinity is measured volumetrically by titration with sulphuric acid and methyl orange indicator, the endpoint at pH 4.5 is when the indicator turns red from its original orange colour.

In the research programme, a 0.1N sulphuric acid solution was used as the titrant and a 50.0 ml sample was used in the analysis. The alkalinity value was calculated as follows:

$$\text{ALKALINITY (in mgl-1 as } CaCO_3) = \frac{\text{ml. titrant (A)} \times \text{Titrant Normality (C)} \times 50000}{\text{ml. sample (B)}}$$

where B = 50.0 ml and C = 0.1N.

Therefore:

$$\text{ALKALINITY} = A \times 100 \quad \text{(in mgl-1 as } CaCO_3).$$

5.15 SULPHATE.

The sulphate ion (SO_4^{2-}) is one of the commonest anions to be found in natural waters and they form an important component in the sulphur cycle which can be operative at the air-water and the sediment-water interfaces. Sulphates are important ingredients of wastewaters due to their ability to be reduced to sulphides (namely hydrogen sulphide) under anaerobic conditions. The consequence of this is an odour problem with often corrosion caused by the production of sulphuric and sulphurous acids. The sulphates act as source of oxygen for anaerobic microbes and they may be biochemically broken down in this way. Soluble sulphates are usually in the form of calcium sulphate and magnesium sulphate but the contribution from the atmosphere into any aquatic system should not be underestimated.

$$SO_4^{2-} + \text{Organic Matter} \longrightarrow S^{2-} + H_2O + CO_2$$

$$S^{2-} + 2H^{+} \rightleftharpoons H_2S$$

$$H_2S + 2O_2 \longrightarrow H_2SO_4$$

Under aerobic conditions, the hydrogen sulphide can be oxidised to sulphuric acid and this corrosive reagent can be very damaging to concrete and can lead to major problems with sewers and associated pipework.

The Experimental Procedure for Soluble Sulphate Determination:

The sulphate concentration in a solution was determined by titration and the basis of the determination is that the soluble sulphate is

precipitated with barium ions as barium sulphate.

$$Ba^{2+} + SO_4^{2-} \longrightarrow BaSO_4$$

This precipitation is achieved by adding barium ions in the form of barium chloride to the sample which had previously been acidified with hydrochloric acid at a temperature close to boiling point. There are a number of ways in which the quantity of the barium sulphate can be measured using gravimetric or turbidimetric techniques. However in this study, a volumetric determination was carried out and this method is deemed suitable for the measurement of sulphates in natural drainage waters and wastewaters but the method is not sensitive enough for potable supply waters. The determination of Total Hardness is a prerequisite for the sulphate test. The procedure adopted was to pipette 10.0 ml of sample into a 25.0 ml conical flask and dilute it to approximately 100.0 ml using 90.0 ml of distilled water. About 1.0 ml of 5M hydrochloric acid was added to this solution to acidify it and the sample was then brought to the boil on a hot plate. At this stage, 20.0 ml of 0.01M barium chloride was pipetted into the solution and was allowed to boil for about 15 minutes before being left to cool. Once cool, 3.2 ml of total hardness buffer was added to the flask, followed by one drop of Eriochrome (Solochrome) Black T indicator and the solution was then titrated with 0.01M EDTA to determine the residual barium ions. The endpoint of the titration is clearly defined by a sharp change from a red wine colour to a sky blue coloured solution. This method provided a convenient and quick method of sulphate evaluation whereas the more traditional methods for determining the barium sulphate levels by weighing the precipitate are very time-consuming and are difficult to perform.

The sulphate concentration was calculated as follows:

$$\text{Sulphate (in mgl}^{-1}\text{ as } SO_4^{2-}) = \frac{961 \times (V_2 + V_3 - V_4)}{V_1}$$

where:

V_1 = volume of the sample.
V_2 = volume of EDTA equivalent to the Total Hardness of V.
V_3 = volume of barium chloride added.
V_4 = volume of EDTA equivalent to the Total Hardness plus barium ion in V .

It is widely recognised in analytical chemistry that the determination of sulphate is not an easy analysis to perform to any good level of accuracy. There are a number of interference factors which can adversely influence the outcome of the determination and these are primarily caused by the tendency of barium sulphate to occlude foreign anions and cations. Co-precipitation may occur yielding barium nitrate and barium chlorate salts. Skoog and West (1982) suggest that the excellent agreement often observed between theoretical and experimental results in sulphate determinations is due in a considerable part to the cancellation of errors caused by the interference factors.

5.16 CHLORIDE.

Chlorides are one of the commonest anions to be found in natural waters and there are a number of sources responsible for their presence in watercourses. Animal excretion (including human wastes) contain levels of chloride roughly equal to the levels found in the food and water consumed. It is therefore often regarded as a conservative parameter in wastewater treatment analyses. Man produces about 6 g of chloride per day giving raw domestic sewage an average concentration of about 30 mgl^{-1} as Cl^-. Sewage effluents and industrial discharges therefore contribute significant quantities of chloride to watercourses. One of the most important examples of which is the pumping of minewaters from collieries where concentrations in excess of 1000 mgl^{-1} as Cl^- are not unusual. Chlorides in excess of 250 mgl^{-1} as Cl^- give waters a salty taste and so sources for potable supply should have concentrations well below this specified level even though such concentrations would not be harmful, if consumed.

Chlorides can be measured easily using volumetric analysis with internal indicators and the 'Mohr' Method uses silver nitrate as the titrant with potassium chromate as an indicator. The Standard Method was used in the research programme. The silver nitrate solution can be standardised against standard sodium chloride solutions but it was found to be quite stable when kept in total darkness at a constant temperature in a sealed vessel. In the analysis a 50.0 ml neutralised sample was taken and 1.0 ml of potassium chromate was added to it. This solution was then titrated with 0.05N silver nitrate ($AgNO_3$).

The result of the titration is based upon the premise that there is a finite amount of silver nitrate titrated to produce a detectable (ie. visible) quantity of the silver chromate precipitate. The endpoint of

the chloride determination is one of the most difficult to realise and a certain degree of subjectivity by the analyst enters the final result. The analysis must be carried out on a neutral (or as near neutral as possible) sample because the silver ions (Ag^{+}) are precipitated as silver hydroxide (AgOH) at high pH levels and the chromate ion (CrO_4^{2-}) is converted to the dichromate ion ($Cr_2O_7^{2-}$) at low pH values.

It is generally considered that a pH value between 7.0 and 9.0 is adequate to conduct the Mohr Method and sample solutions can be neutralised by titrating sodium hydroxide using phenolpthalein as an indicator. Most river waters would lie within the desired pH specifications anyway, but for urban runoff a pH range outside these recommended limits would not be unusual.

The chloride ion concentration was calculated in the following way:

$$Cl^{-} \text{ (in mgl-1 as } Cl^{-}) = \frac{A \times B \times 35.45 \times 1000}{C}$$

where:

A = ml of the titrant (silver nitrate).
B = normality of the silver nitrate.
C = volume of the sample used in ml.

In the research programme, B= 0.05N; C= 50.0 ml.

Therefore:

$$Cl^{-} = A \times 35.45 \quad (\text{in mgl-1 as } Cl^{-}).$$

The normality of the silver nitrate can be varied in order to provide

a suitable volume of titrant used and to simplify the calculation, as illustrated above. The Mohr Titrimetric Method is a suitable method for chloride ion analysis in most natural waters and industrial wastewaters but there are a number of interference factors which should be considered. Significant concentrations of bromide and iodide ions can interfere with the determination while orthophosphate concentrations in excess of 25 mgl-1 as P, can interfere by precipitating the silver ions as silver phosphate. The endpoint of the titration can be upset by iron concentrations in excess of 20.0 mgl-1. Chlorides themselves interfere with the determination of the Chemical Oxygen Demand (COD) and this particular interference factor may cause problems in road drainage waters that are heavily salted due to the winter road salting programme, whereby drainage waters often have chloride concentrations well in excess of 2000 mgl-1 as Cl^-.

5.17 PHOSPHATE.

Phosphorus compounds are commonly encountered in many forms in environmental monitoring and phosphorus occurs in natural waters almost entirely in the form of phosphates. Phosphates can exist in several different forms and are generally grouped as 'orthophosphates', 'polyphosphates' and 'organically bound phosphates' (see Table 5.5). These particular phosphate forms can occur in the soluble form, in particulate matter or in the bodies of aquatic organisms and plants, since phosphorus is an essential nutrient for both plant and animal life. Orthophosphates are commonly used as fertilisers and these are washed out of soils by surface runoff and throughflow and are carried away to receiving watercourses. Organic phosphates are primarily found in biological processes and can form an important species of phosphorus in benthic sediment deposits in river systems and in deposited sediments in drainage systems.

Phosphorus Compounds Commonly Found in Environmental Analysis.

Orthophosphates:

Trisodium Phosphate	Na_3PO_4
Disodium Phosphate	Na_2HPO_4
Monosodium Phosphate	NaH_2PO_4
Diammonium Phosphate	$(NH_4)_2HPO_4$

Polyphosphates:

Sodium Hexametaphosphate	$Na_3(PO_3)_6$
Sodium Tripolyphosphate	$Na_5P_3O_{10}$
Tetrasodium Pyrophosphate	$Na_4P_2O_7$

(Sawyer and McCarty 1978)

Table: 5.5

In the chemical analysis, all polyphosphate and organic forms of phosphorus must be converted to the orthophosphate form for measurement. It is possible to measure orthophosphates with little interference from polyphosphates due to their relative stability at the pH and temperature conditions prevalent in the analytical procedure.

Orthophosphates (mainly in the form of $H_2PO_4^-$, HPO_4^- and PO_4^{3-}) can be determined gravimetrically, volumetrically or by colourimetry. The first two methods of determination are best suited to large concentrations of phosphate (usually well in excess of 100 mgl-1 as P) which are seldom found in natural surface waters. The colourimetric method involves combining the phosphate ions with ammonium molybdate under acidic conditions to form a complex known as ammonium phosphomolybdate. If vanadium is added, the vanadomolybdophosphoric acid complex is formed which yields a bright yellow colour and the intensity of the yellow colour is directly proportional to the phosphate concentration in the sample solution. This colourimetric technique is best suited to low phosphate concentrations and it allows analysis to be carried out to within an accuracy of about 1.0 mgl-1 as P. The minimum detectable level is generally considered to be 0.2 mgl-1 as P.

$$PO_4^{3-} + 12\,(NH_4)_2MoO_4 + 24\,H^+ \longrightarrow (NH_4)_3PO_4 \cdot 12\,MoO_3 + 21\,NH_4^+ + 12\,H_2O$$

The vanadomolybdophosphoric acid colourimetric method for the determination of phosphate is a technique widely used and does not suffer from any major interference factors. The only serious problem encountered is with highly turbid solutions. Nearly all the most

common ions found in natural drainage waters do not influence the determination when in concentrations of less than 1000 mgl-1, and the only positive interference is caused by silica and arsenic and even then at only very high temperatures, which will not be encountered in environmental samples.

The colourimetric method was used to determine the phosphate concentration in the sample solutions. The pH of the sample must lie between pH 4 and pH 10 and the samples collected were found to fall well within this range in the vast majority of cases. No sample pH adjustment was therefore necessary. All the glassware used in the analysis was washed thoroughly with a mild acid and rinsed well with distilled water. Commercial cleaning detergents contain high levels of phosphate and should be avoided in the cleaning of glassware.
In the analysis, two solutions have to be prepared and these are later combined to add as a reagent to the sample solution. Solution A provides the ammonium molybdate source and it is prepared by dissolving 25.0 g of ammonium molybdate $(NH_4)_6Mo_7O_{24}$ 4 H_2O in 400.0 ml of distilled water. Solution B provides the vanadium and this is prepared by dissolving 1.25 g of ammonium metavandate (NH_4VO_3) in 300.0 ml of distilled water and this is heated to boiling point. Once cool, 330.0 ml of concentrated hydrochloric acid is added to solution B. At this point, solutions A and B are combined and are diluted to a one litre volume. This is then known as the 'vanadate-molybdate reagent'. A standard phosphate solution has to be prepared for calibration purposes and 0.2195 g of anhydrous potassium dihydrogen phosphate (KH_2PO_4) is dissolved in distilled water and diluted to a one litre volume. The following unit is then obtained for the standard phosphate solution:

1.0 ml is equivalent to 50.0 µg phosphate as P.

Colour in the sample solution is an obvious interference factor in any colourimetric determination and colour removal is an essential prerequisite in such a case. Excessive colour can be removed by filtering the sample through a filter bed of activated carbon. This procedure was adopted several times to deal with highly coloured sample solutions.

A 35.0 ml volume of the sample was put into a 50.0 ml volumetric flask and 10.0 ml of the vanadate-molybdate reagent was added to it. The solution was then diluted to the 50.0 ml volumetric level with distilled water and was well shaken. Standard phosphate solutions were prepared containing 100, 200, 300 and 400 µgl-1 as P respectively. A blank solution was also prepared whereby 35.0 ml of distilled water was used instead of the sample solution. The bright yellow colour formed in the solutions is highly stable and is not influenced by fluctuations in the ambient temperature. A Perkin Elmer 550 Spectrophotometer was used to measure the absorbance of the sample against the blank at a wavelength of 470 nanometres (470 nm). A calibration curve was plotted using the values obtained with the standard phosphate solutions and the phosphate concentration was calculated in the following way (see Figure 5.14 and Table 5.6).

$$\text{Phosphate (in mgl-1 as P)} = \frac{\text{mg P} \times 1000}{\text{ml sample}} = \frac{\text{µg P}}{\text{ml sample}}$$

The value µg P was read directly off the calibration curve because the standards were set up in this way and a 35.0 ml sample volume was used in all cases.

Therefore:

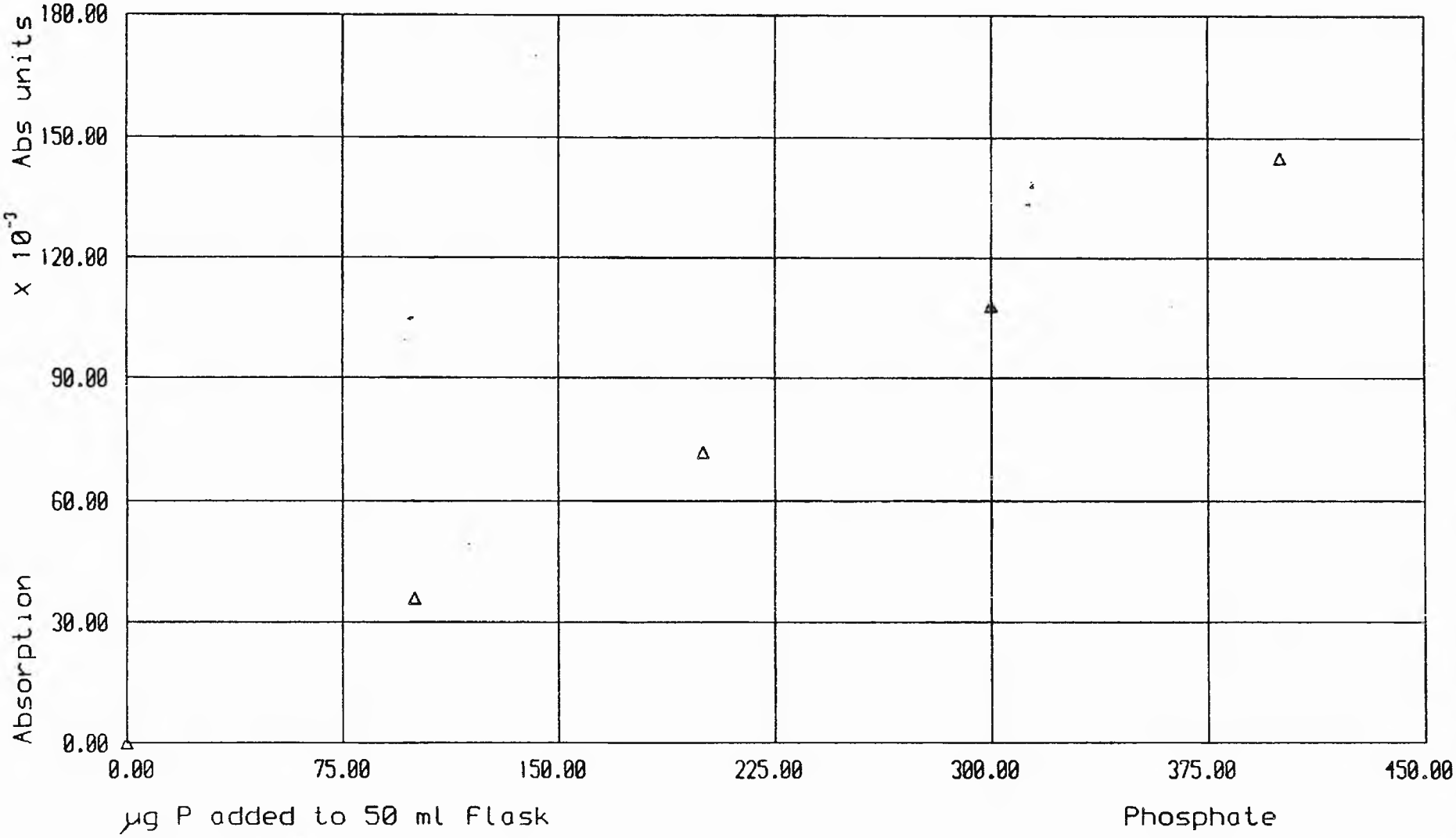
$$\text{Phosphate (in mgl}^{-1}\text{ as P)} = \frac{\mu g\ P}{35.0}$$

Table to Show Typical Absorbance Values Obtained in the Calibration.

Absorbance Units	Standard Solution µg Phosphate as P
0.036	100
0.072	200
0.108	300
0.145	400

Table: 5.6 (see Figure 5.14).

The analytical determination of phosphorus as orthophosphate is becoming an increasingly important aspect of environmental monitoring. Such determinations are vital in order to appreciate the biological productivity of natural waters and to quantify the influence of sewage and other domestic wastewaters in surface water quality studies. Phosphates are also known to cause problems in some water treatment processes because of their inhibiting effect on coagulation processes and high phosphate levels in some surface waters may therefore deter their use in abstractions for water supply purposes. Phosphates are also being increasingly studied with regard to reservoir management strategies whereby algal blooms may often appear during periods of dry, warm weather with their associated detrimental effects.



Calibration Curve For Phosphate Analysis using the Colourimetric Method.

Figure 5.14

5.18 METALS - AN INTRODUCTION.

The character, form and pathways of heavy metals under natural conditions is still understood poorly and a great deal of research is currently being directed towards the understanding and prediction of heavy metal pollution in the aquatic environment. Heavy metals in solution are found to be highly reactive and their concentration may be enhanced or depleted by a number of physiochemical and biochemical processes. It is against this background that a number of models have been developed to predict the behaviour of metals in solution and their relationship with biotic and inorganic particulate phases. The natural concentrations of heavy metals are extremely low in the aquatic environment and in most environments, the oxide, hydroxide and carbonate forms are in the solid phase. Exchange reactions with inorganic ligands are generally considered to be unimportant whereas organic chelating ligands can form highly stable, soluble complexes with a range of heavy metals but such groups are usually present in very small concentrations.

Aquatic organisms and plants are able to accumulate certain heavy metals and this type of process may form an important sink for some heavy metals in certain environments. All solid particles in natural waters, have electrically charged surfaces and these can exhibit an important influence on the heavy metals and there is an uptake selectivity for particular ions onto certain types of surface.. Many studies have shown that trace metals can be scavenged from the aquatic environment by suspended solids but precise details of how these reactions take place are still relatively ill-defined. The natural pathways of heavy metals are largely controlled by two major processes, which are:

i) capture of various solid phases.

ii) chemical complexation in solution.

It is theoretically possible to predict from 'equilibrium theory', the distribution of any specific metal within a known pH/redox potential environment, but the heavy metal concentrations in all natural waters always tends to be less than the theoretically-derived figures and this is almost certainly due to the action of solids which can act as sinks for some of the heavy metals present in the solutions. Little is known about the processes involved and the rates of remobilisation of the metals from the solid phases.

5.19 ATOMIC ABSORPTION SPECTROPHOTOMETRY : (AAS).

AAS is a technique for the determination of metals in solution and it is therefore most suited to samples that are liquid in their natural state or when pre-analysis can yield a final liquid-phase. AAS works on a similar principle to flame photometry but the fundamental difference is that AAS measures the amount of light absorbed instead of the amount emitted. A light beam is directed through the flame into a monochromator and onto a detector that measures the amount of light absorbed. The measurement of light absorption is generally considered to be more sensitive because it depends upon the presence of free unexcited atoms. Each individual element has characteristic wavelengths which it will readily absorb and a source lamp made up of that particular element is used so that there is little spectral or radiation interference. A measure is made of the light intensity having passed through the flame and this is then compared to the measurement once the sample has been aspirated into the flame. The decrease in light intensity observed is a measure of the concentration of the element and a linear relationship generally holds for the amount of light absorbed and the concentration of the element in the sample. AAS is a relatively quick and sensitive means of measuring metal concentrations and it is specific for many elements.

One of the major interference factors found in AAS occurs when the flame is unable to dissociate the molecule and magnesium phosphate is a good example of this. High phosphate concentrations interfere with the determination of magnesium and other metals, but this can be overcome by adding lanthanum (usually in the form of lanthanum chloride or lanthanum nitrate) to complex with the phosphate. These interference factors cause deviations from the theoretical AAS

relationships. Measurement of the metals by AAS produces the results as a total value and there is no indication of the chemical species present unless some pre-treatment of the sample takes place. A comprehensive review of such pre-treatment methods is given in Morrison (1985). It is usual practice to filter the samples before AAS analysis and the determination of the trace metals in the solid phase can be quantified by an extraction technique. In the absence of real time analysis, water samples must inevitably be stored between collection and analysis. All samples were kept at a cool temperature and stored in plastic bottles with a sealed top. Adsorption of some metal atoms onto the sides of sample containers can produce serious errors in the analysis with a negative resultant effect. Such effects depend greatly upon the chemistry of the solution especially with respect to its pH but the nature of the surfaces involved are equally as important. This is particularly true of glass surfaces which should not be used to store any sample to be analysed for metals.

The analytical results from an AAS analysis are obtained by plotting a calibration curve of the absorption intensity against the standard solution concentrations. The accuracy of the analytical results depends greatly upon the correct selection, preparation and use of the standard calibration curve solutions (see Table 5.7).

Flame photometry was used to analyse for sodium and potassium whilst the following metals were analysed using AAS; lead, iron, calcium, magnesium, zinc, manganese, copper, cadmium, nickel and chromium. All the metals results reported in the research programme (unless otherwise stated) are quoted as total soluble metals since all the samples were filtered prior to the AAS analysis and no pre-treatment took place.

Heavy Metals: Atomic Absorption Spectrophotometry Calibration Curves.

Metal	Wavelength nm	Concentration mgl-1	Absorption Value AA units
Fe	595.0	0.0	0.000
		1.0	0.032
		2.0	0.068
		5.0	0.140
		10.0	0.270
Pb	217.0	0.0	0.000
		1.0	0.038
		2.0	0.075
		3.0	0.113
		5.0	0.172
Ca	422.7	0.0	0.000
		1.0	0.042
		2.0	0.088
		4.0	0.170
Mg	285.2	0.0	0.000
		1.0	0.100
		2.0	0.235
		4.0	0.420
		5.0	0.590
Zn	213.9	0.0	0.000
		0.5	0.110
		1.0	0.210
		1.5	0.310
		2.0	0.390
Mn	280.0	0.0	0.000
		0.5	0.045
		1.0	0.092
		1.5	0.132
		2.0	0.178
Cu	324.8	0.0	0.000
		0.5	0.040
		1.0	0.082
		1.5	0.125
		2.0	0.162
Cd	228.8	0.0	0.000
		0.1	0.010
		0.2	0.025
		0.5	0.060
		1.0	0.145
Ni	232.0	0.0	0.000
		1.0	0.028
		2.0	0.050
		4.0	0.088
Cr	357.8	0.0	0.000
		1.0	0.022
		5.0	0.102
		10.0	0.190

Table 5.7

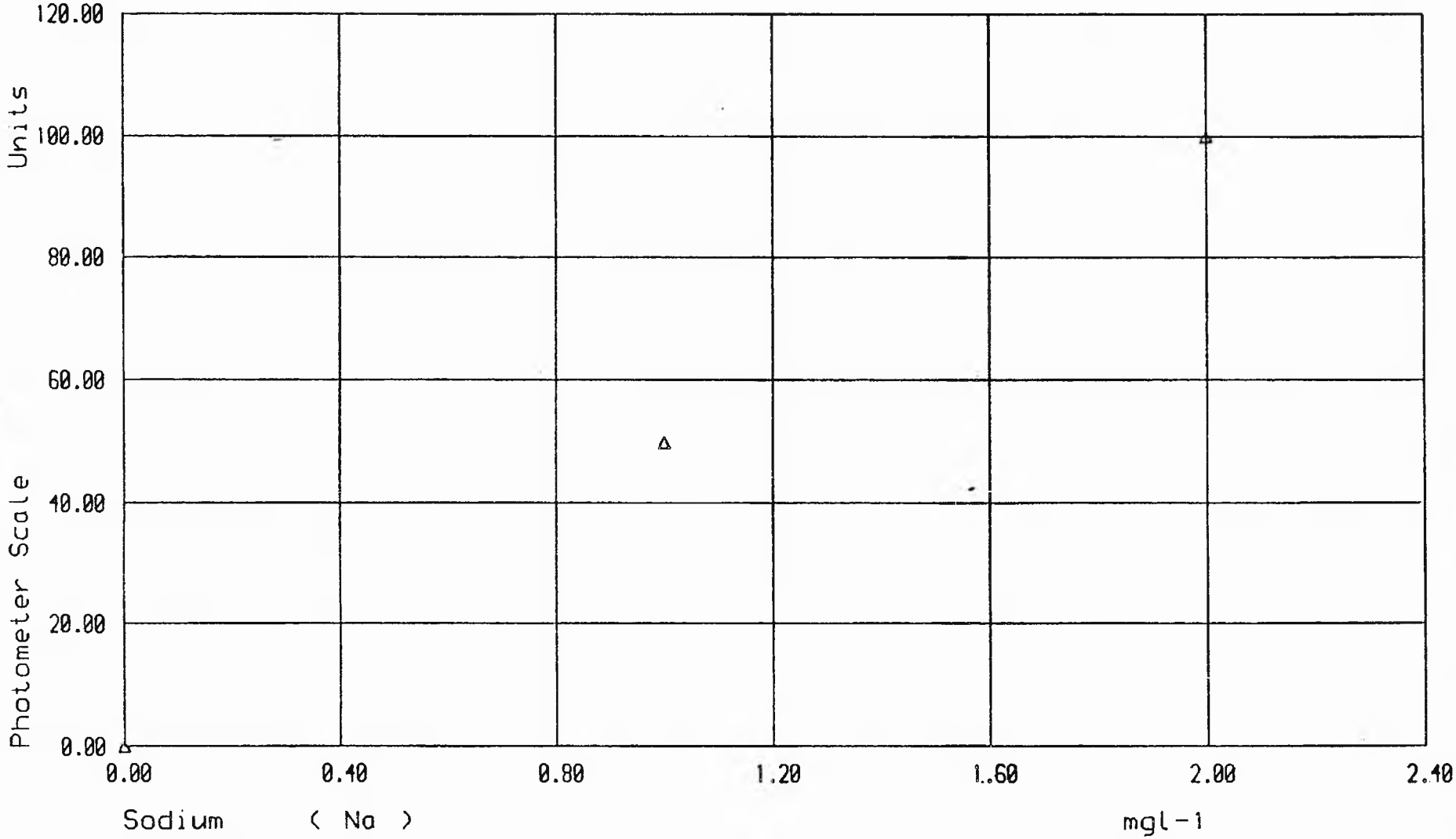
5.20 SODIUM : (Na).

Sodium is present in most natural drainage waters and its concentration may vary considerably from a negligible level to an appreciable concentration. The most common sodium salts in waters are sodium chloride and sodium bicarbonate. Sodium chloride is often used as an indicator of seawater intrusion or sewage pollution (especially in this case for groundwater analysis) in freshwater systems since such influences would provide concentrations well in excess of 50 mgl-1 which is generally regarded as an upper limit for sodium in freshwater systems.

The Flame Photometric Method for the determination of soluble sodium is a quick, yet sensitive method which is widely used in water analysis laboratories throughout the world. An EEL Flame Photometer was used for the determination of sodium by a direct reading using a wavelength of 589 nm. The principle of the test is that a sample is sprayed or aspirated into a gas flame and the atoms become 'excited'. The spectral line (individual to each element) is selected by use of a series of filters and the light emitted on return to the 'ground' state is measured by phototube potentiometer. The intensity of light emitted is directly proportional to the concentration (except at very high concentrations whereby the linearity in the relationship is seen to breakdown) of the metal. Standard solutions were used to calibrate the photometer before use and the instrument was first set to zero using a sample of distilled water. A 1.0 mgl-1 and a 2.0 mgl-1 standard solution were prepared from a freshly made-up stock solution and these were used to set the instrument up to measure units 50 and 100 respectively on the graduated scale. The standards were measured several times to ensure stability in the readings. The Flame

Photometer is best suited to a working range of up to 2.0 mgl-1 as sodium and so it was therefore necessary to dilute a number of the samples used in the research programme analyses. Magnesium is known to be a potentially important interference factor in the sodium determination but it is only significant when the magnesium/sodium ratio exceeds 100, which is a fairly rare occurrence for any natural water. Relatively large concentrations of chloride, sulphate and bicarbonate (or hydrogen carbonate) can also influence the analysis but large concentrations relative to the sodium concentration need to be prevalent before any significant interference occurs. A 20.0 ml sample of the unknown solution was put into a beaker and the solution was then aspirated into the photometer. Once the instrument had stabilised, a reading was taken and the sodium concentration was then determined using the calibration curve which was established at the beginning of each batch of samples analysed. The dilution correction was then made to this figure to provide the sodium concentration of the sample solution (see Figure 5.15).

The Flame Photometric procedure proved to be a quick and reliable method for determining sodium and the narrow sodium concentration operating range allowed for good sensitivity and accuracy in the measurement.

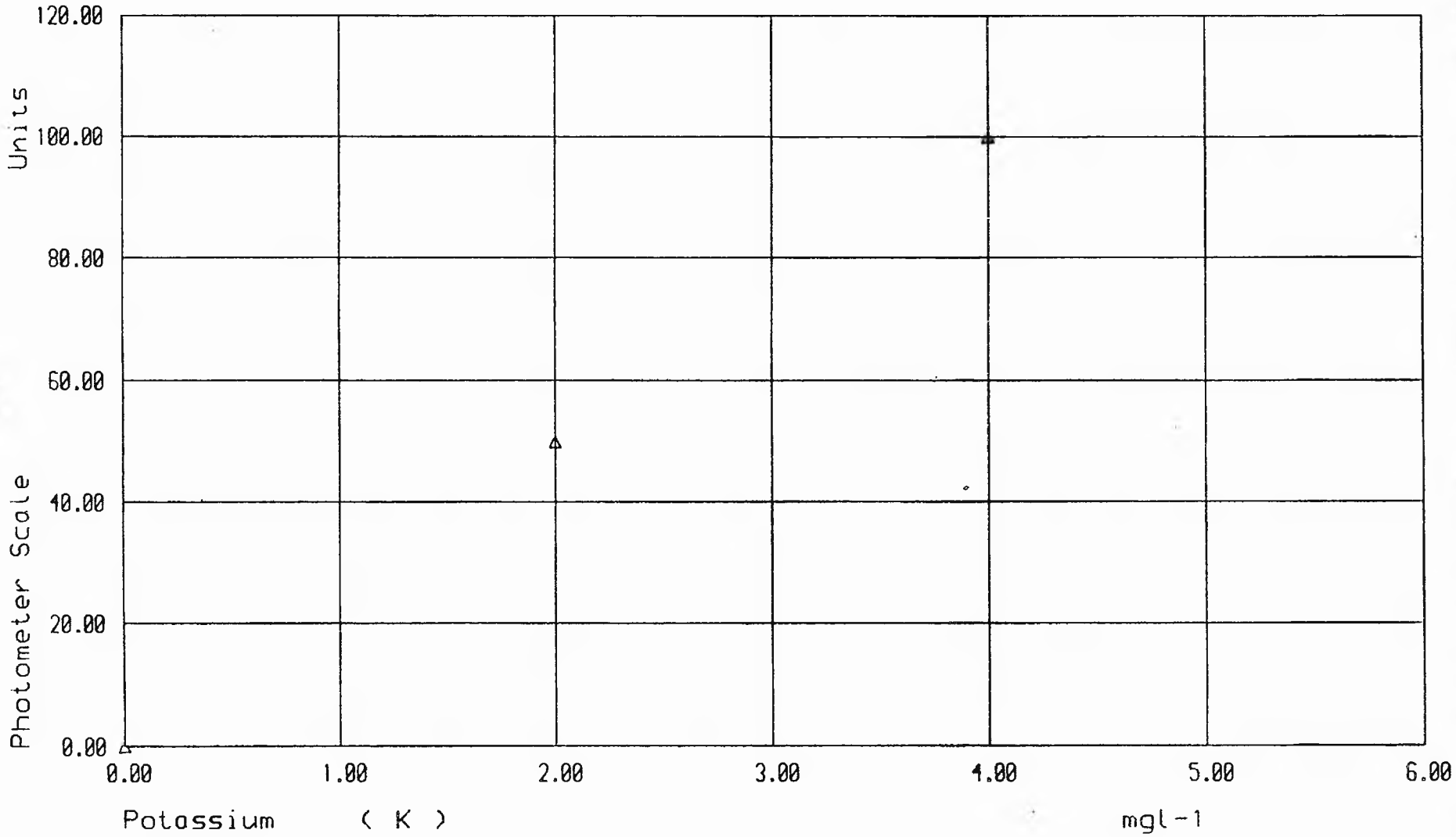


Flame Photometer Calibration Curve For Sodium.

Figure 5.15

5.21 POTASSIUM : (K).

Potassium is quite abundant as an earth-metal but usually has a low concentration in natural waters, being generally less than 30 mgl-1. Sewage effluents contain about 20 mgl-1 and so potassium can be used as an indicator of sewage pollution in some instances. In the research programme, the Flame Photometric Method was adopted to analyse the potassium in water samples and this provided a quick and accurate means of analysis. The principles of Flame Photometry have been outlined above (see under Sodium). The only difference in approach was to use a filter for a wavelength of 768 nm and the standard solutions used were 2.0 mgl-1 and 4.0 mgl-1 to set the instrument to units 50 and 100 respectively, on the graduated scale. The Flame Photometric Method can be used to measure potassium levels to within 0.1 mgl-1 (plus or minus). The interference factors are the same as those given for sodium (see above) with magnesium exerting an important influence on the result if the magnesium to potassium ratio is in excess of 100. It was often necessary to dilute the samples and the results were calculated using a calibration curve (see Figure 5.16) in exactly the same way as for sodium. Dilution factors had to be taken into account where necessary. The experimental procedure for the analysis of potassium was the same as that outlined above, for sodium.



Flame Photometer Calibration Curve For Potassium.

Figure 5.16

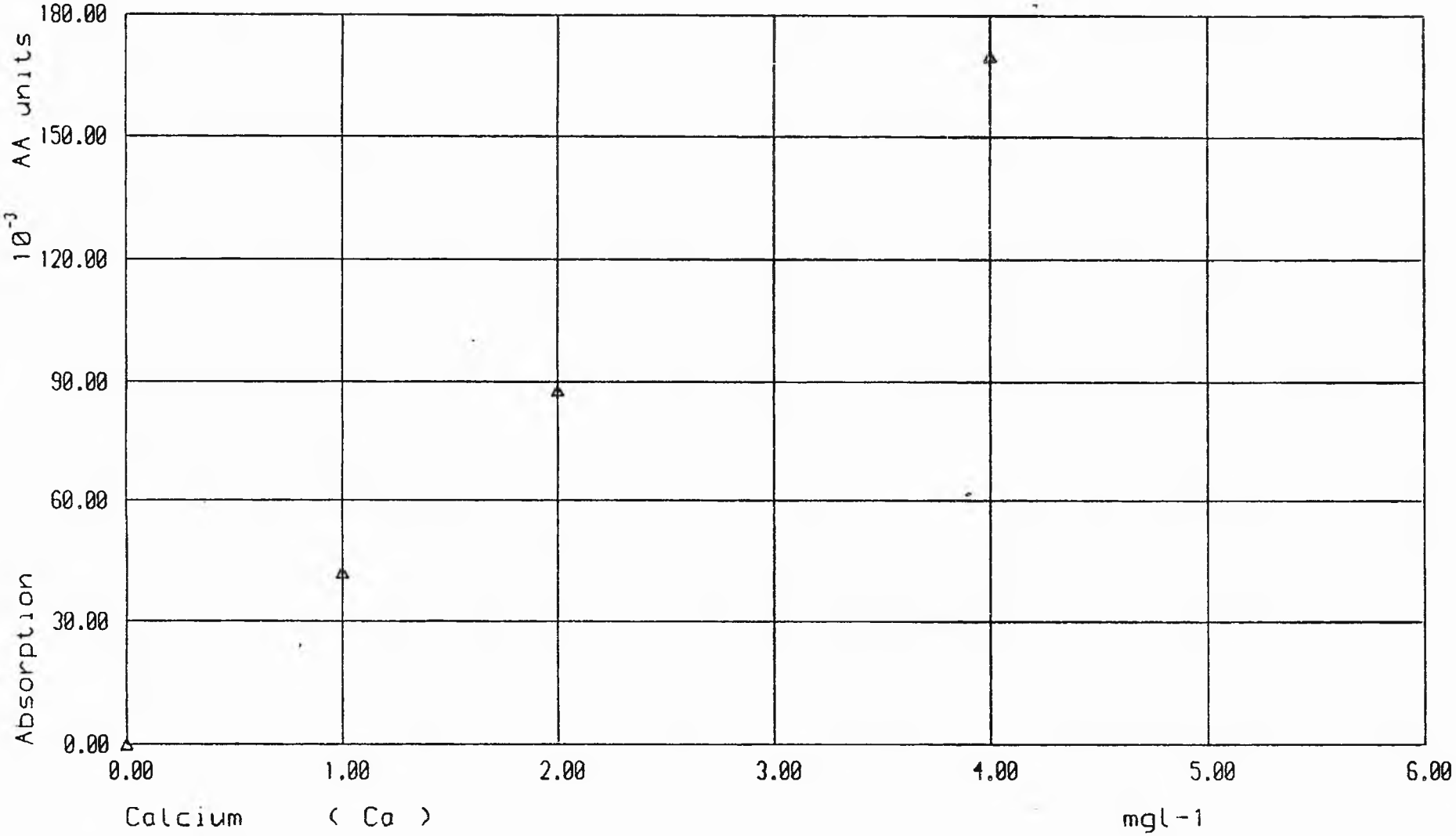
5.22 CALCIUM AND MAGNESIUM : (Ca and Mg).

These metals are known as earth-alkali metals and their concentrations in natural watercourses are greatly influenced by the natural geology of the area or the type of artificial surface. The composition of the urban fabric will also influence the quality of the urban surface runoff waters in a similar way and the dominance of concreted surfaces in urban areas will enhance the calcium concentrations in such runoff waters. The importance of calcium and magnesium in natural waters is related to their influence upon the Total Hardness of a water (see under Total Hardness) for which these two metals are the dominant cause of water hardness. Both metals are not harmful unless in very high concentrations (above 200 mgl-1) and their effect upon aquatic life is small when compared to the toxic effects of the heavy metals. Both metals were analysed using AAS for this study (see Figures 5.17 and 5.18, and see Table 5.7).

5.23 IRON : (Fe).

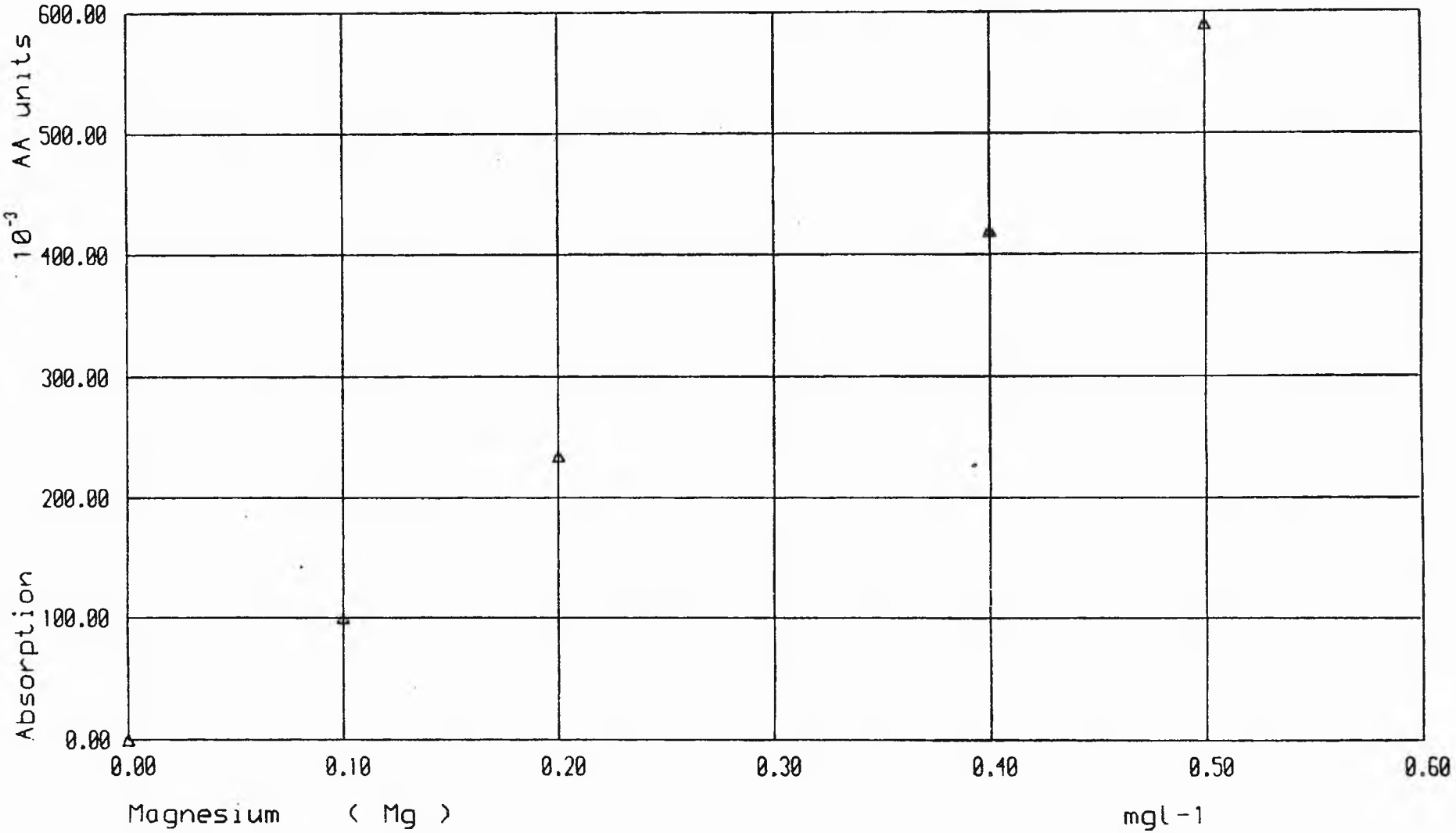
Iron is also an earth-alkali metal whose concentrations in natural waters is greatly influenced by the local geology and the nature of the surface over which the runoff has occurred. In the urban environment, there are many man-made sources of iron most notably from steel structures and iron pipework and so iron can influence the quality of the resultant stormwater runoff. Iron can be particularly troublesome in natural waters due to problems with colouration whereby the waters will frequently appear a reddy/brown colour due to the

oxidation of Fe^{2+} to Fe^{3+} and the subsequent precipitation of the hydroxide. Iron is not harmful to man (unless in very high concentrations) but its presence in stormwaters is indicative of the influence of catchment characteristics upon stormwater quality (see Figure 5.19).



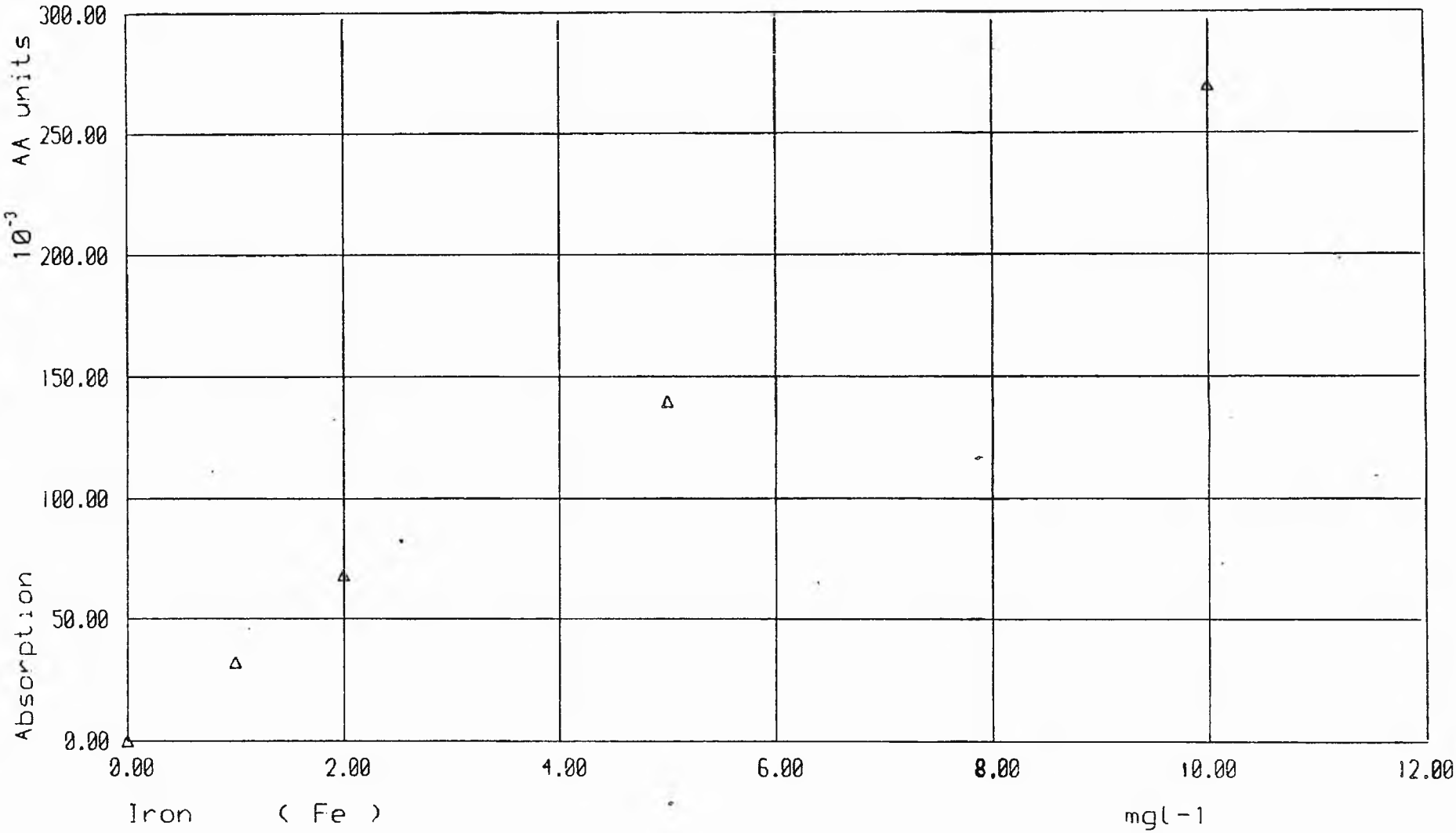
Atomic Absorption Spectrophotometry Calibration Curve For Calcium.

Figure 5.17



Atomic Absorption Spectrophotometry Calibration Curve For Magnesium.

Figure 5.18



Atomic Absorption Spectrophotometry Calibration Curve for Iron.

Figure 5.19

5.24 THE HEAVY METALS.

LEAD, ZINC, MANGANESE, COPPER, CADMIUM, NICKEL AND CHROMIUM.

(Pb, Zn, Mn, Cu, Cd, Ni and Cr)

(See Figures 5.20 to 5.26 inclusive).

Heavy metals are defined as those with an atomic number greater than 20. Heavy metals are known to be highly toxic in the aquatic environment and a great deal of research has been carried out worldwide during the last thirty years or so, into the effects of heavy metals on aquatic life and the importance of these metals in studies into water pollution. It is important to note that when predicting metal solubilities, all the contributing species should be taken into account. Urban stormwater samples usually contain metal concentrations which vary greatly with regard to the locality and the time of sampling. The importance of heavy metals as contributors to water pollution has now spread to the recognition of the influence of urban stormwaters upon the surface water quality of a given area.

It has been known for some time that trace quantities of certain metallic elements can exert a positive and a negative influence on plant, animal and human life. Some major ions such as sodium (Na^{+}), potassium (K^{+}), calcium (Ca^{2+}) and magnesium (Mg^{2+}) are indeed essential for nearly all living organisms but trace metals can become highly toxic if their concentrations exceed the amount necessary to sustain the normal metabolic processes. This toxic level is generally around 200 times the normal level. Wood in Waite (1974) defined sodium, potassium, calcium, magnesium and iron as "non-critical" elements whereas zinc, lead, cadmium, chromium and copper were defined as being

"very toxic" elements, which are also highly available within the environment. There is an increasing danger of chronic illnesses being caused by a higher intake of metals and the effects of bioaccumulation can take many years to monitor and resolve. It is now well established that heavy metal concentrations in natural waters, the oceans, the biosphere and the atmosphere are all increasing from a variety of man-made and natural sources.

There are five major sources of metal pollution :

1. Geologic Weathering;
2. Industrial Processes;
3. The Use of Metals;
4. Leaching of Waste Materials and Direct Discharging; and
5. Animal and Human Excretions.

Metal concentrations can vary within a short space of time and such fluctuations can be attributed to variations in flow, local discharges and influences, changing pH conditions, salinity, the presence of solids and the temperature. It is for this reason that biological monitoring is becoming more common because of the value of the bioaccumulation study on toxicity levels.

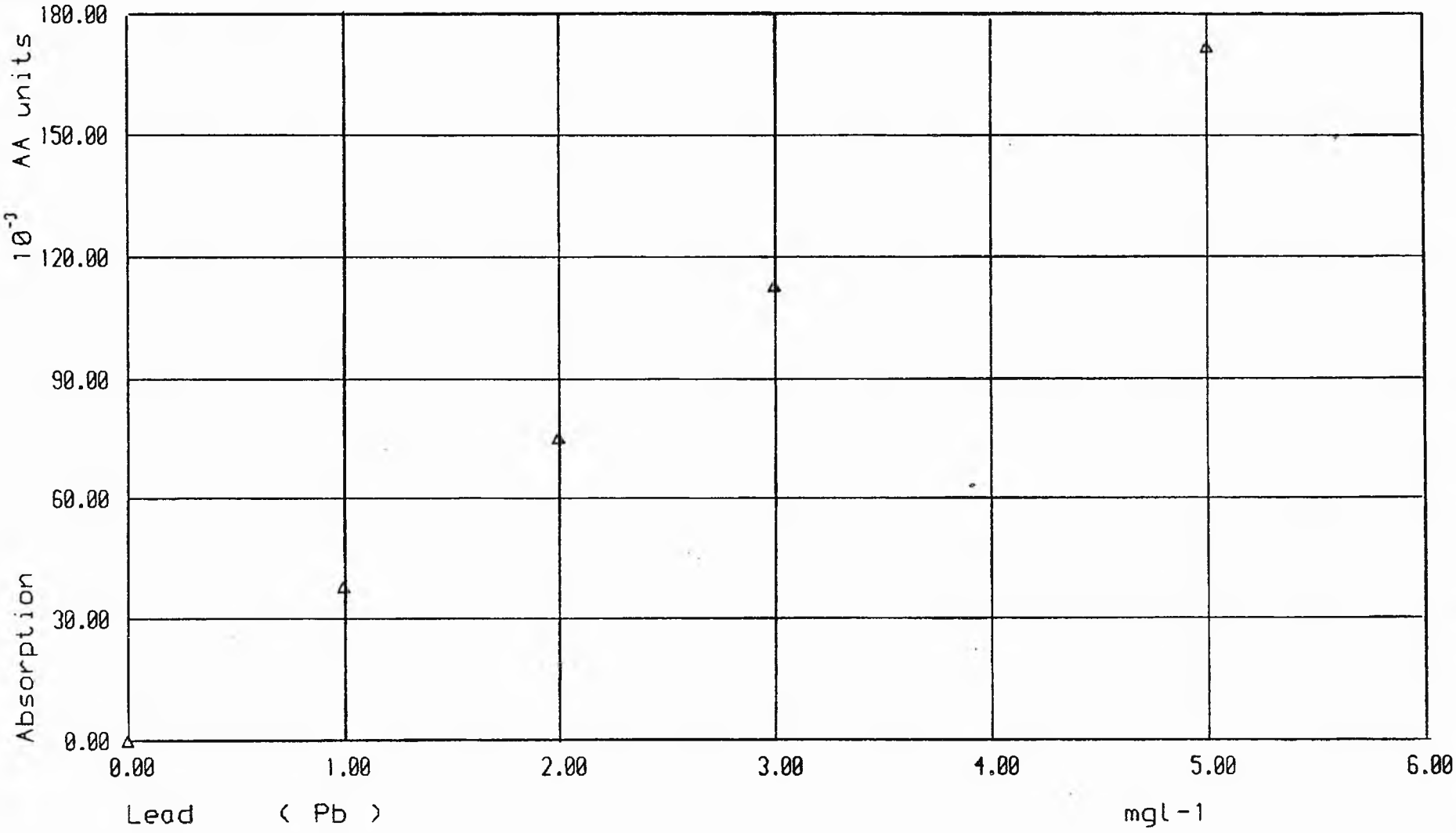
The increasingly widespread use of heavy metals in a number of industrial processes has led to serious consideration being given to this group of pollutants within water pollution studies.

Lead is a widely used, naturally occurring element and the major sources of lead pollution in the environment are from petroleum emissions, pesticides, fertilisers and smelting. Tetraethyl lead additives in petrol form a very important component in atmospheric pollution studies and the atmospheric lead is associated with aerosol particles with a size range of $< 1\ \mu m$ diameter. Larger particles tend

to be deposited close to the source but the finer aerosols can travel vast distances by aeolian processes and can greatly influence non-urbanised areas (away from the source).

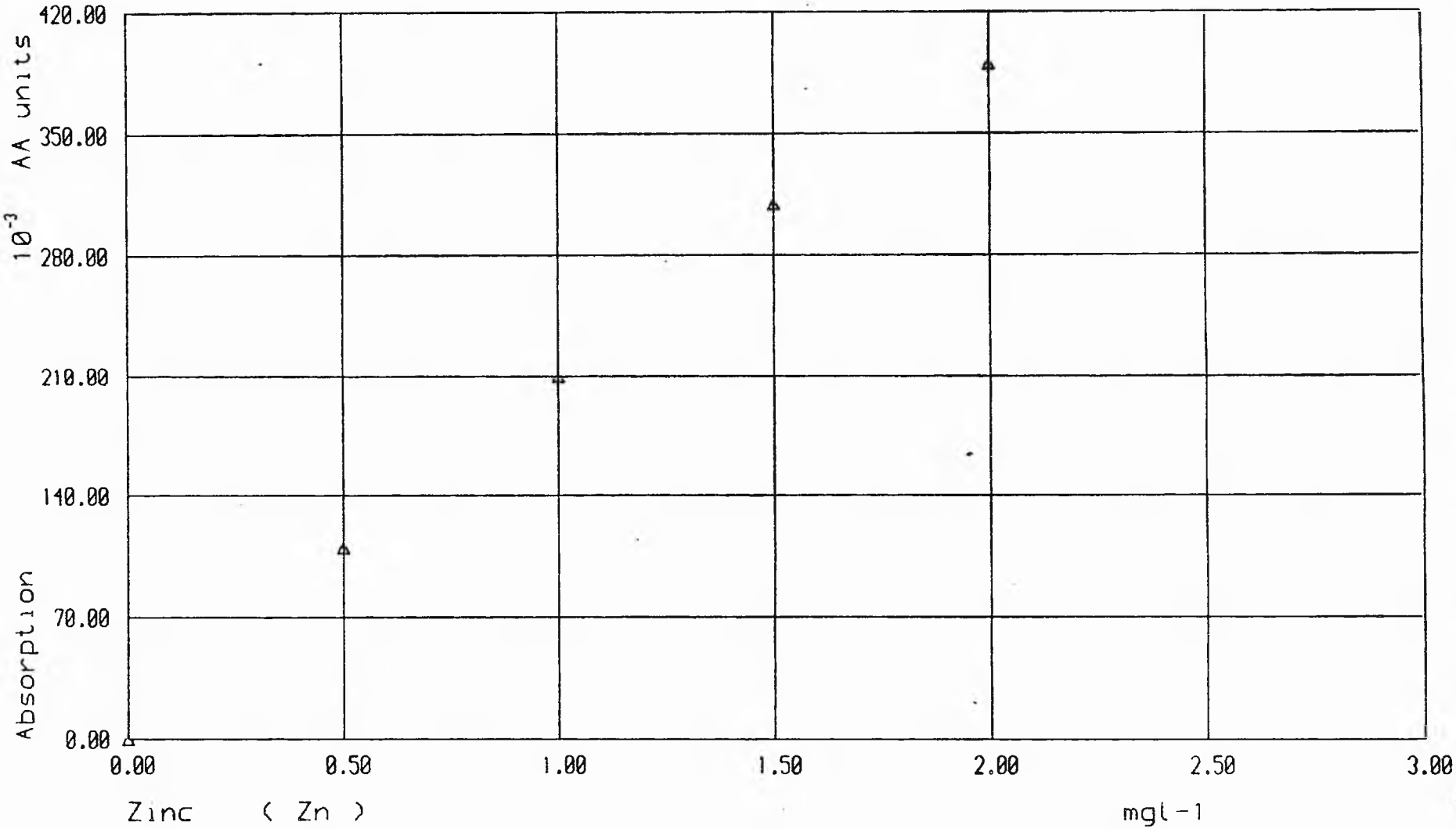
Cadmium is an extremely toxic metal to man and one of its major transportation pathways is by atmospheric deposition. It has one of the highest concentrations of all heavy metals in urban air. Salomons and Forstner (1984) showed that cadmium may be less susceptible to abiotic removal than other heavy metals and this may help to explain enhanced concentrations in the soluble and the inorganic particulate form in most natural surface waters.

The two metals quoted above are examples of the widespread use and application of heavy metals in the modern world and attention has been focussed on stormwater discharges as an important source of these heavy metals to river systems. In sewage treatment processes, a high proportion of the heavy metals are retained within the sewage sludge which is either put onto the land, dumped out at sea or is incinerated. Most sludge is put onto the land in the UK and there are strict European Directives controlling the application of these heavy metals to an acreage of land for arable farming. Similar concern is now in practice to control the heavy metal concentrations in surface waters through the implementaion of European Directives for Surface Waters and so the importance of heavy metals in surface runoff waters (ie. stormwater discharges) should not be underestimated. An increase in the number of metal consents for all types of surface water discharges under the COPA legislation (Control of Pollution Act 1984) is further evidence of the importance now being attached to heavy metals within water pollution control practice.



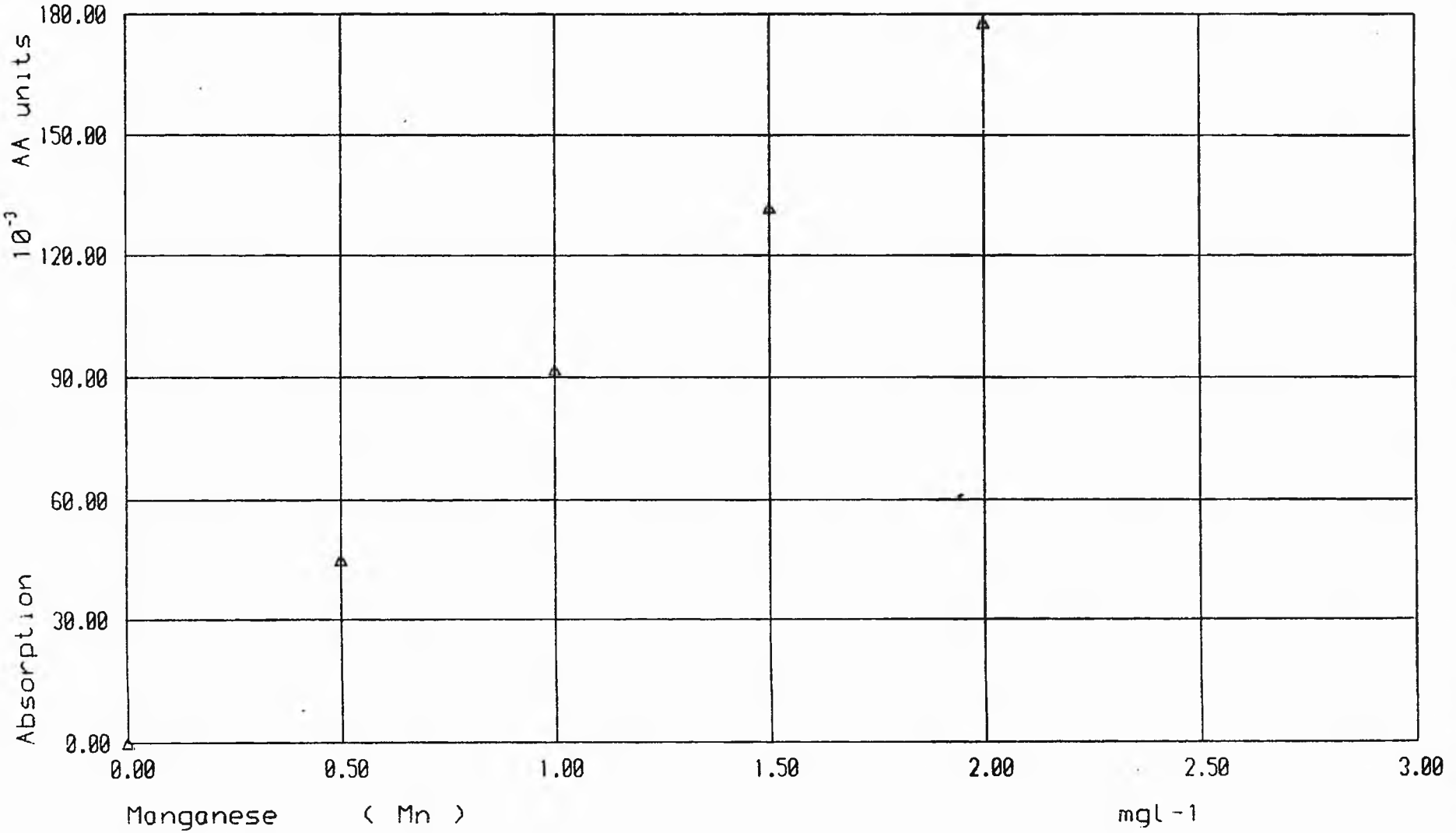
Atomic Absorption Spectrophotometry Calibration Curve for Lead.

Figure 5.20



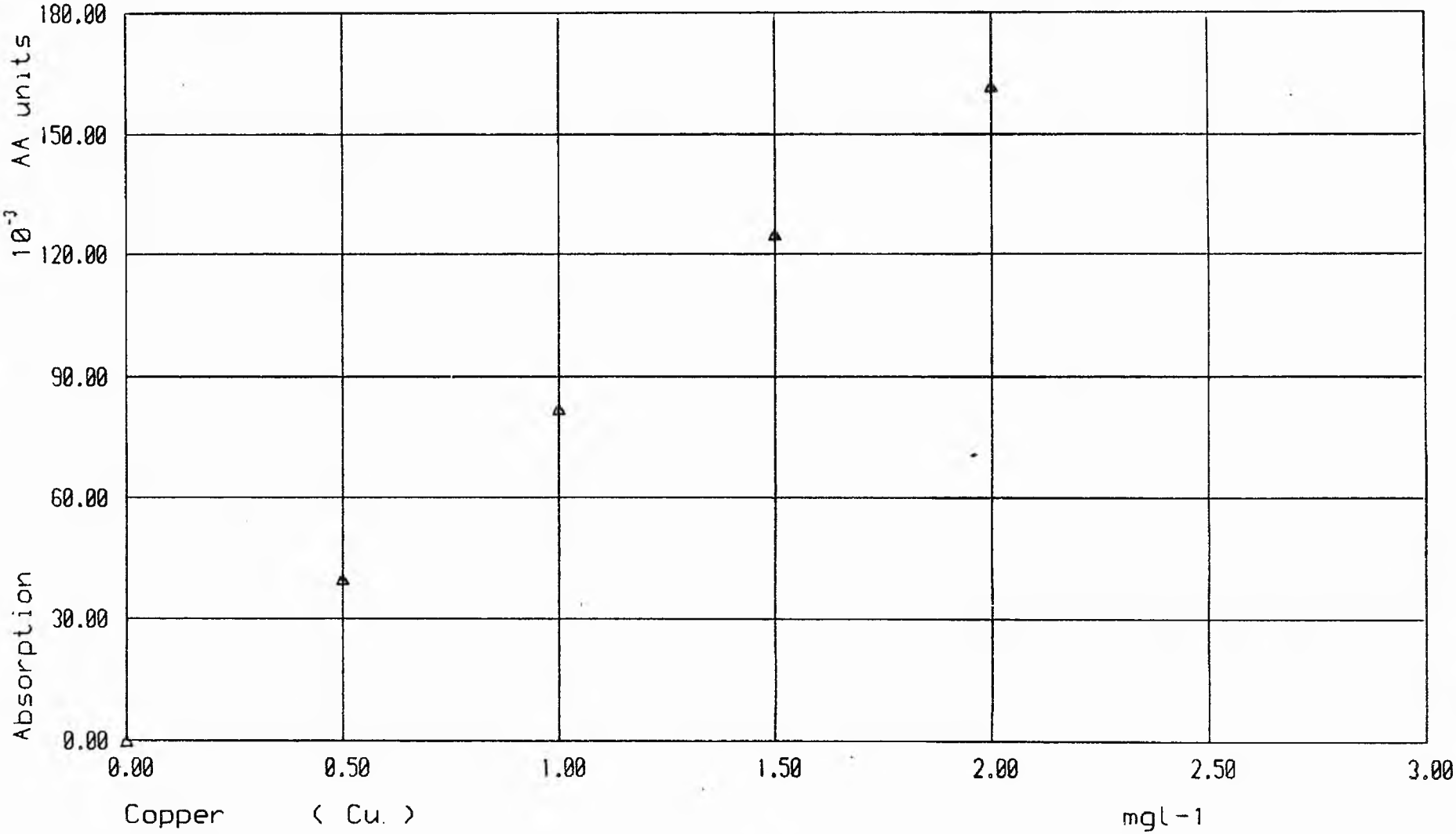
Atomic Absorption Spectrophotometry Calibration Curve for Zinc.

Figure 5.21



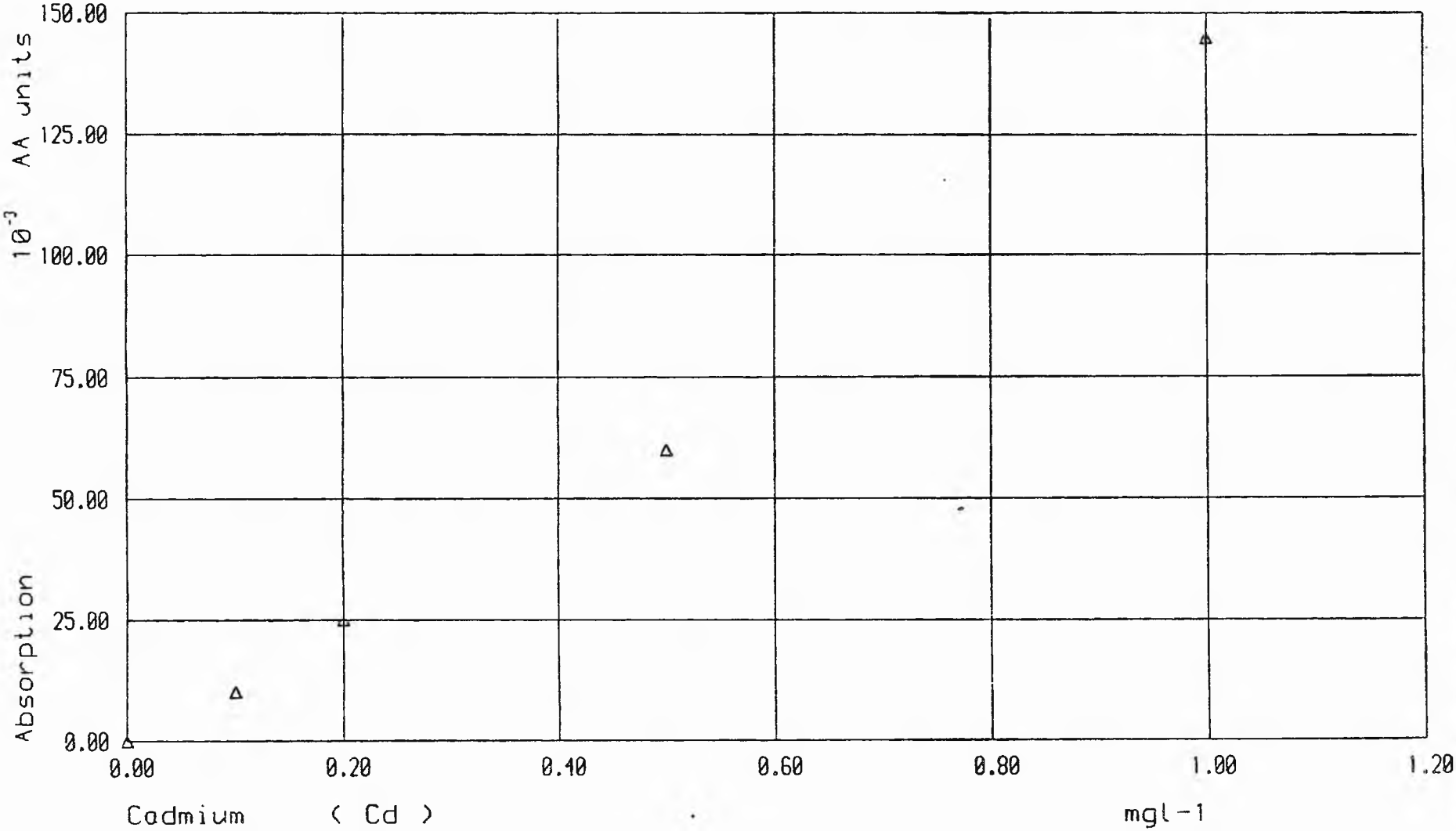
Atomic Absorption Spectrophotometry Calibration Curve For Manganese.

Figure 5.22



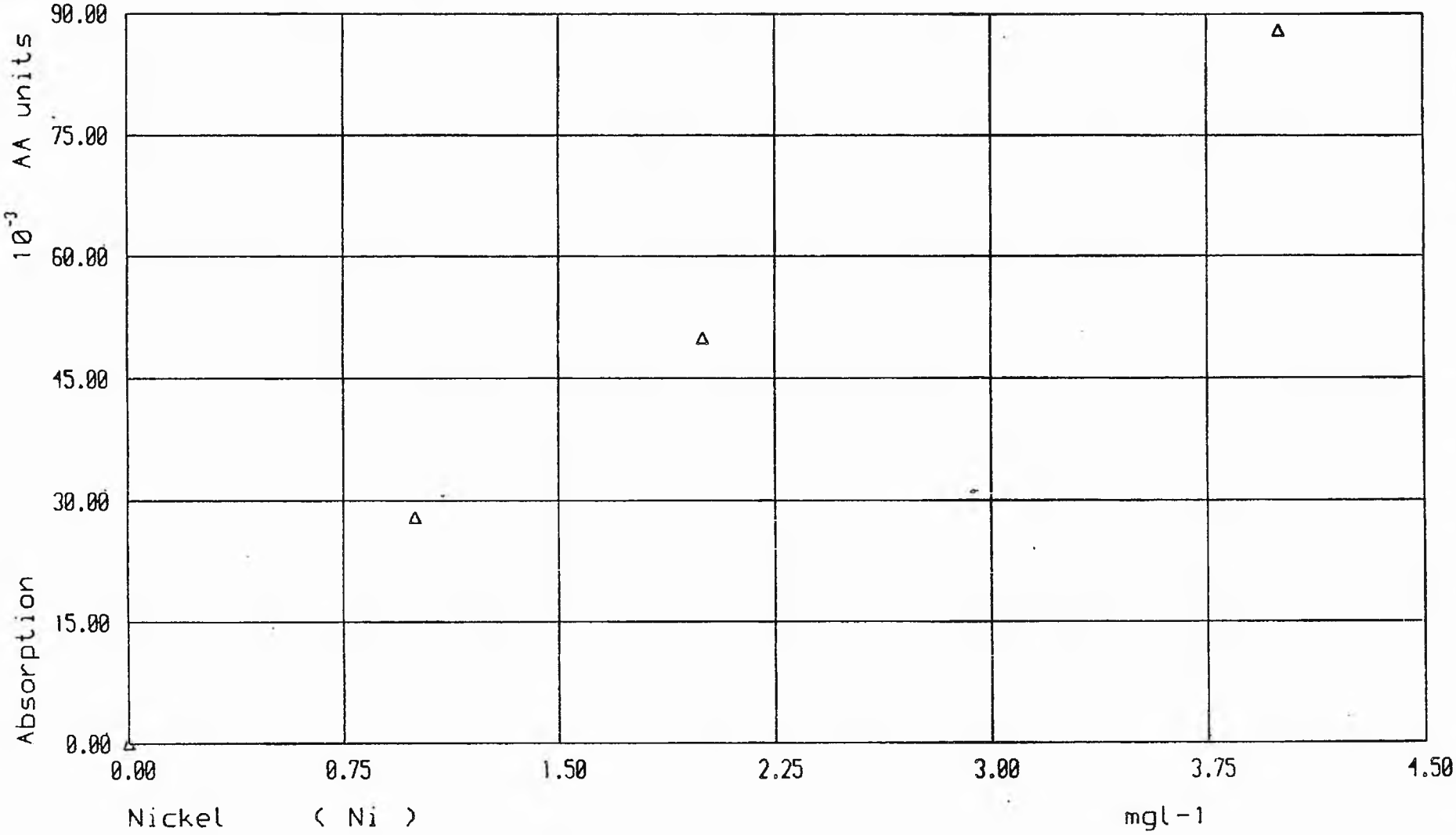
Atomic Absorption Spectrophotometry Calibration Curve For Copper.

Figure 5.23



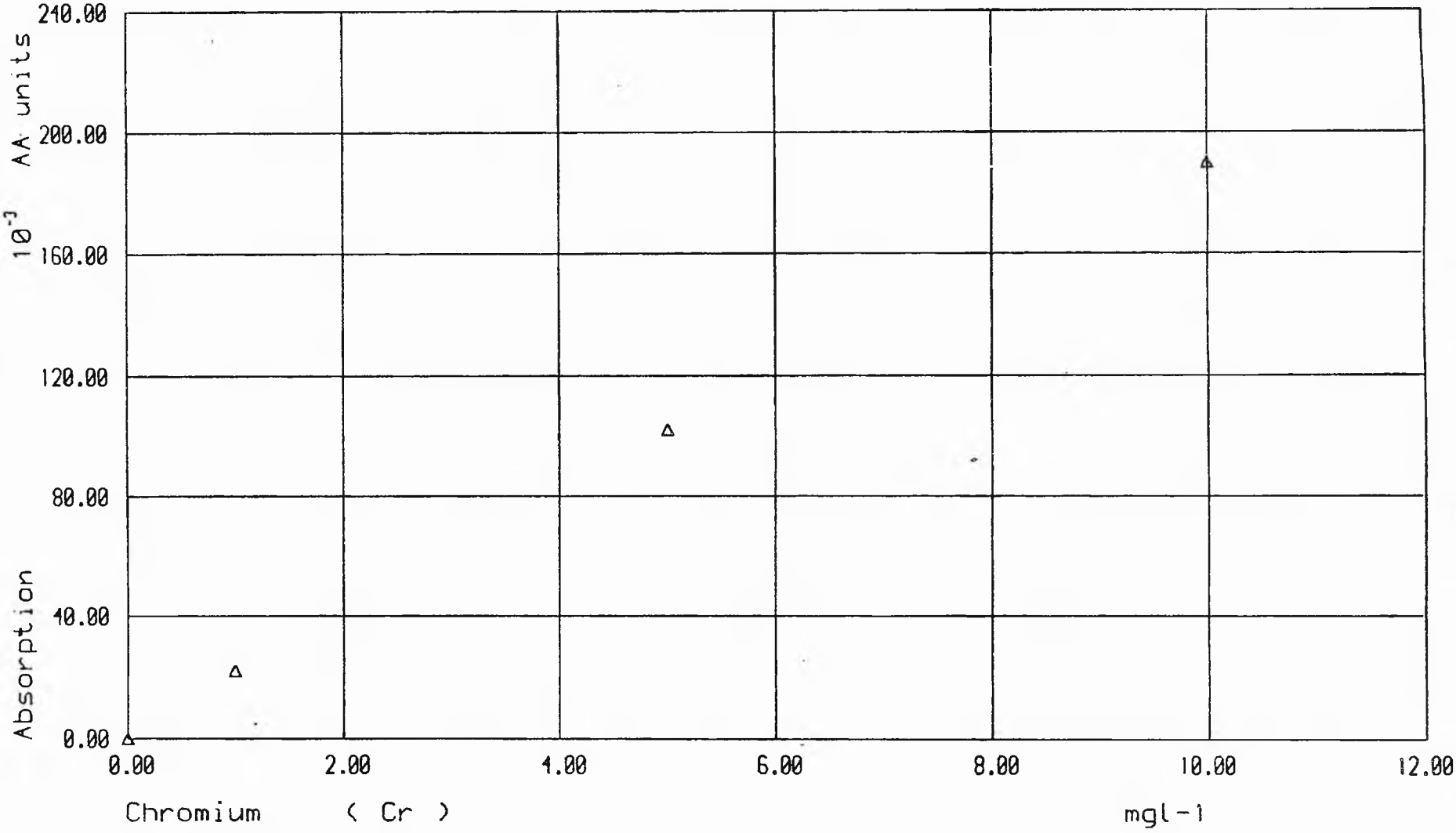
Atomic Absorption Spectrophotometry Calibration Curve for Cadmium.

Figure 5.24



Atomic Absorption Spectrophotometry Calibration Curve For Nickel.

Figure 5.25



Atomic Absorption Spectrophotometry Calibration Curve for Chromium.

Figure 5.26

Chapter 6 : Atmospheric Influences upon Stormwater Quality.

6.1 Introduction.

The deposition of airborne contaminants upon urban surfaces has caused concern for some time. Many studies have now been carried out throughout the world, to investigate the nature and transportation of atmospheric contaminants (Hallsworth and Adams 1974; Laxen and Harrison 1977; Beston, Overton and Barkdoll 1977; Malmquist 1983; Halverson, De Walle and Sharpe 1984; Salomons and Forstner 1984; Liljestrand 1985), even though the rise in levels of some atmospheric pollutants has been steadily decreasing in recent years due to effective measures of environmental protection, tougher legislative controls on atmospheric pollution and advances in pollution abatement technology.

The areal distribution of pollutants is generally dependent upon their aerosol size and the prevailing meteorological conditions. The interrelations between the pollutant concentrations in the air and the resulting contamination of rain and subsequent stormwater runoff are not obvious. Atmospheric pollutants consist of solid, liquid and gaseous phases and the atmospheric influence upon stormwater quality can be through dry deposition, which is chiefly through the deposition of wind blown material; and by wet deposition, whereby solid and liquid/gaseous pollutants can be flushed out of the atmosphere during a rainfall event. The most significant atmospheric pollutants are carbon monoxide, sulphur dioxide, nitrous oxides, hydrocarbons and dusts, which all originate from the combustion of domestic fuel, traffic exhausts, industrial and natural combustion processes.

6.2 Atmospheric Fallout.

Goettle (1978) carried out a study in Munich, West Germany into dust fallout from the atmosphere onto the urban surface. The results of this work have been summarised in Table 6.1.

Land Use	Dustfall in g per m^2 per month.
Rural	2.5 - 3.3
Urban	3.3 - 6.3
City Centre	5.5 - 30.0
Industrial	10.0 - 60.0

Table : 6.1 Goettle (1978)

The accumulation of dusts upon the urban surfaces, with their associated heavy metals, nitrates, chlorides, hydrocarbons etc., can influence the resultant runoff quality. The values found in rainwater in the Munich study can be seen in Table 6.1. Goettle (1978) concluded that the dustfall and the pollution of precipitation were of great importance to the quality of stormwater runoff.

Randall et al (1978) found that the principal factors affecting the total quantity of pollutants in rainfall were:

i) air mass movement; and,

ii) antecedent conditions (time since last rainfall event)

Their study in the Occoquan River Catchment adjacent to the Potomac River in Washington D.C., USA showed that the atmospheric constituents were washed out during the first stages of a precipitation event at a rate which was independent of the rainfall intensity. Similar results

have been reported from studies which have looked at the influence of dustfall upon stormwater quality by Beston, Overton and Barkdoll (1977) and Owe, Craul and Halverson (1982), who worked on catchments in Tennessee and Syracuse, New York, respectively.

Laxen and Harrison (1977) reported the significance of traffic exhausts as a further example of atmospheric influences upon the urban surface which would ultimately affect the quality of stormwater runoff. The major source of lead on highway surfaces is from the motor car, whereby lead is added to petrol in the form of tetra-alkyl lead for performance enhancement. The amount of lead being added to petrol in the United Kingdom is now being reduced in response to an EEC Directive, so that petrol purchased in the UK will be brought into line with that currently being sold in other Member States. The magnitude of lead deposition will depend upon many factors, such as traffic density, site characteristics, the age of vehicles, road surface conditions and the prevailing meteorological conditions. Laxen and Harrison (1977) reviewed the studies conducted by Sylvester and De Walle (1972), which found that lead was deposited on a highway at a rate of 2.35 $mgm^{-2}\ day^{-1}$, compared to levels of between 0.046 to 0.186 $mgm^{-2}\ day^{-1}$ at more remote, rural locations in the United Kingdom. Pitt and Amy (1973) stated that nearly all lead found on the street surfaces was insoluble and the main removal process by which the lead entered the storm drainage system, was through sediment transport, rather than in solution. The soluble component of lead is largely present in stormwater as inorganic complexes, such as lead carbonate and lead hydrogen carbonate. The chemical form of lead in highway runoff is also a significant factor with regard to its pollutional strength.

6.3 The Influence of a Single Rainstorm.

Black (1980) carried out a detailed study of water quality patterns during a single rainstorm event on the 18th. June 1978 when 11.4 mm of rainfall fell in 80 minutes on a parking area in the centre of New York. The analysis of rainwater samples collected, added weight to the belief that bulk precipitation may be an important source for many constituents found in urban streams (see Table 6.7).

Halverson, De Walle and Sharpe (1984) conducted a research study in Central Pennsylvania and a regression analysis was carried out to determine whether the precipitation chemistry and the proportion of pollution derived from precipitation were related to the storm size, antecedent dry period etc. The analysis showed that there was no significant link between the stormwater quality and the storm characteristics. The antecedent conditions were considered to be an important influence upon storm runoff quality. The resultant runoff quality seemed to be unique to each event.

6.4 Recent Initiatives in Atmospheric Pollution Studies.

The recent interest in the problems with acid rain has led to an increase in the number of rainwater samples now being analysed throughout the world. Some European countries (most notably France, West Germany, Denmark, Norway, Sweden and Finland) have set up monitoring networks to sample precipitation quality on a regular basis. The collection of such data may lead to a better understanding of the relationships between the precipitation quality and the meteorological characteristics. The influence of the meteorological

input to a consideration of the variability in stormwater discharge quality should not be underestimated and this was exemplified by the work of Malmquist et al on various catchment areas in Goteborg, Sweden (Malmquist 1978; Malmquist and Svensson 1978; Malmquist 1983). Precipitation quality and the variations within it are at present a poorly understood phenomenon. Malmquist (1978) reported that between 7% and 40% of all heavy metals in stormwater come from atmospheric fallout. The quality of urban snow was also seen to differ from that of rainwater. Other forms of precipitation such as frost, hail etc. are not usually considered to be significant in their contribution to stormwater runoff. Snow has the property of accumulating pollutants and the degree of concentration is a function of the time between the snowfall, the thaw and the subsequent runoff.

A series of studies on four residential catchments in Goteborg, Sweden have been carried out by the Department of Sanitary Engineering at the Chalmers Technical University in Goteborg. These studies showed that atmospheric fallout was a dominant source of nitrogen and phosphorus into the urban environment. Atmospheric fallout was also considered to be an important source of lead, copper and zinc but such sources were shown to be highly variable (see Figures 6.1 and 6.2).

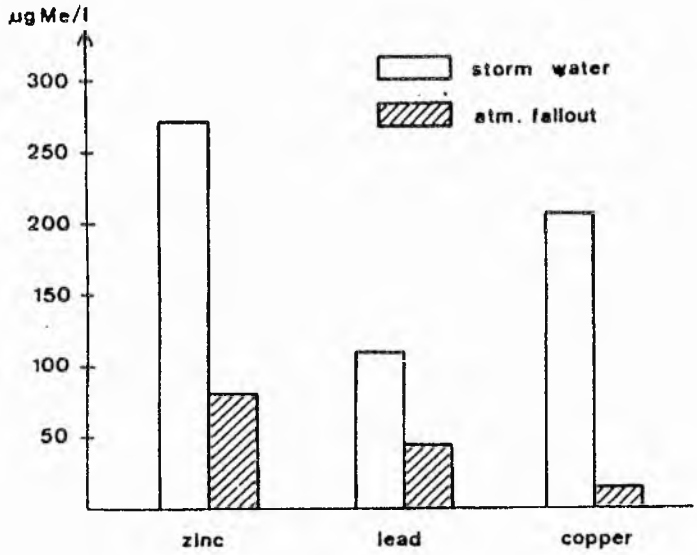
The Goteborg studies were conducted over several years and the comprehensive dataset obtained showed that atmospheric fallout was a significant source of pollutants on the urban surface, but it was a flux which could not be effectively controlled. Its impact was only likely to be reduced by a general enhancement of air quality which has been identified in some countries in recent years. Rainwater analysis showed that concentrations of zinc, lead, phosphorus and sulphate were approximately 40% of the concentrations found in the stormwater and so in the case of these pollutants, rainwater was a significant source.

Chloride and iron concentrations were found to be significantly lower than those in the stormwater and so these pollutants were more likely to be associated with the activities within the catchment areas. Malmquist (1983) presented a series of results to show the importance of atmospheric fallout in the urban environment and a summary of this data is given in Tables 6.2 to 6.6 inclusive and in Figures 6.1 and 6.2.

[The tables are taken from a series of publications by Malmquist (1983), Malmquist and Svensson (1978) and Malmquist (1978)].

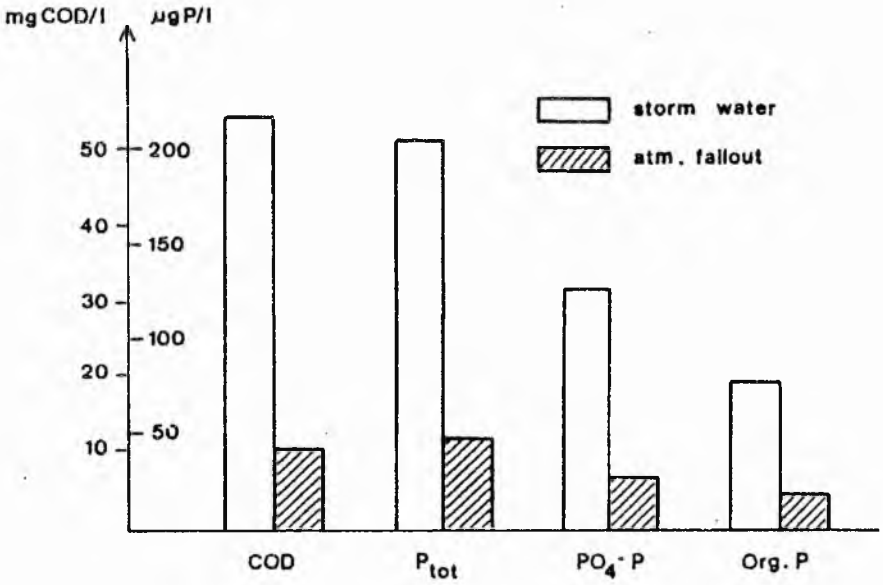
Heavy Metals in Stormwater and Atmospheric Fallout.

Figure 6.1 Malmquist (1983)



COD and Phosphorus in Stormwater and Atmospheric Fallout.

Figure 6.2 Malmquist (1983)



A Description of the Residential Catchments in Goteborg.

Catchment	Area (ha)	Imperviousness %	Population
Vegagatan	5.8	53	1450
Mellbyleden	15.6	39	1800
Bergsjarvangen	4.8	45	400
Floda	18.0	19	400

Table : 6.2

Monthly Atmospheric Fallout of Some Heavy Metals

Catchment	Fe	Zn	Cu	Pb
	(all values are in mg/m2 month)			
Vegagatan	26	7.2	0.95	3.9
Mellbyleden	21	5.8	0.41	2.5
Bergsjarvangan	13	7.8	0.44	2.9
Floda	10	3.6	0.31	2.1

Table : 6.3

Major Inflows of Phosphorus to a Swedish Urban Area.

Source	Flux (variable units)	
Atmospheric Fallout	450 - 830	g P/ha year
Dogs	90	g P/dog year
Birds	3 - 25	g P/bird year
Traffic	0.6	mg P/vehicle km
Vegetation	Highly Variable	
Fertilisers	Highly Variable	

Table : 6.4

Major Inflows of Zinc to a Swedish Urban Area.

Source	Flux (variable units)	
Atmospheric Fallout	50 - 160	mg/m2 year
Corrosion	3 - 8	g/m2 of galvanised surface year
Vehicle Tyres	4	mg/vehicle km
Vehicle Exhaust	35	µg/vehicle km

Table : 6.5

Major Inflows of Copper into a Swedish Urban Area.

Source	Flux (variable units)	
Atmospheric Fallout	12 - 25	mg/m2 year
Corrosion	1.1 - 2.5	g/m2 of copper surface year
Brake Linings	45	µg/vehicle km
Vehicle Exhausts	13	µg/vehicle km

Table : 6.6

The Swedish Study identified four main sources of pollutants in the urban environment which all directly influenced the quality of stormwater discharged from the catchment.

1. Atmospheric Fallout;
2. Vehicular Traffic;
3. Corrosion of the Urban Fabric (eg. paintwork); and
4. Animals and Plants (nutrients).

A Summary of Results of Rainwater Quality Investigations.

(All figures quoted are averages in mgl-1 unless stated).

	Black (1980)	Goettle (1978)
Temperature 'C	26	-
pH pH units	5.5	4.9
SS	-	.16
COD	-	27
Ammonia	2.0	1.6
Sulphate	-	35
Nitrate	-	3.6
Zinc	0.29	-
Lead	0.04	-
Manganese	0.01	-

Table: 6.7

6.5 The Quality of Rainwater Samples collected at Clifton Grove.

As part of the gully pot liquor monitoring programme in this research programme (see Chapter 7), a number of rainwater samples were collected over the one year study period. The purpose of this part of the programme was to look at the values obtained for a limited number of chemical parameters in the rainwater, so that an appreciation of the atmospheric input of these determinands could be made and compared with the values found in the stormwater runoff. The samples were collected in a plastic measuring cylinder which was fed from a plastic funnel. The funnel was fixed into a wooden box which was erected at ground level at a point immediately adjacent to the tipping bucket raingauge on the Clifton Campus at the Trent Polytechnic (see Chapter 4). The composite samples were collected on a weekly basis, but some samples were discarded because there was insufficient to perform the full chemical analysis. During dry periods, the sample collection was conducted less frequently. Over the one year period, a total of twelve rainwater samples were analysed including three samples whose origin was entirely from snowmelt (see Table 6.8). The snow had collected in the throat of the collecting funnel. The results of the analyses were used to provide background information as to the influence of the average rainwater quality to the average stormwater runoff quality. The results give a picture of the average rainwater quality and variations in quality over the sub-catchment areas under study. The results are presented in Table 6.8.

The Quality of Rainwater Samples Collected at Clifton, Nottingham (1984-85).

(ALL values are in mgl-1 unless stated).

	Mean	Range
pH pH units	4.2	3.8 - 4.8
SS	2	0 - 5
BOD	8	5 - 35
COD	21	5 - 47
Nitrate	2.8	0.9 - 6.2
Ammonia	1.2	0.2 - 4.2
Zinc	-	-
Copper	-	-
Lead	-	-
Cadmium	-	-

- means no detectable level.

Table : 6.8

6.6 The Influence of Atmospheric Fallout.

An appreciation of the quality of precipitation water has led to a better understanding of the contributory factors which determine the quality of the stormwater runoff water. The studies conducted by Malmquist et al in Sweden, clearly illustrated the influence that rainwater quality can exert upon the receiving watercourse, irrespective of the type of urban surface over which the overland flow has occurred. The quantification of the atmospheric fallout rates has provided a means by which the various factors influencing stormwater runoff quality (eg. the type of urban fabric, population density, vehicles, traffic density, human activity etc.), could be viewed with respect to their relative significance to the final stormwater discharge quality at the outfall. The reported, insignificant influence of rainwater quality upon stormwater runoff quality in some storm events, provided clear evidence that better land management practice could be used as an effective tool in stormwater pollution abatement programmes. This view has substantial support within the USA, where better land management practices are seen as a preferred overall objective rather than the provision of in-situ treatment facilities for stormwater runoff. The counter argument is provided by the fact that better land management practice can take many years to achieve and it requires the co-operation of a number of different agencies and individuals, and this long term objective although having good intention can not immediately help to solve the problem of deteriorating water quality in many urban watercourses throughout the world.

6.7 Summary of the Results of the Clifton Grove Rainwater Sampling.

The results of the analysis on the 12 rainwater samples collected from the Clifton Grove area as part of the research programme, were consistent with those found in similar studies (see Tables 6.7 and 6.8). Relatively high levels of COD, ammonia and nitrate were found in relation to those found in the stormwater and the precipitation samples had a characteristically low, acidic pH whose mean value (pH = 4.2) was primarily influenced by the pH of the snowmelt samples which were all below pH 4. Four metals (Lead, Zinc, Cadmium and Copper) were included in the rainwater quality analysis but they were not detected in any of the twelve samples at the given level of detection (see Chapter 5). The impact of precipitation quality upon the quality of the gully pot liquor, and therefore, subsequently the stormwater outfall quality, was not found to be significant during the gully pot monitoring programme, but the rainwater did provide a substantial amount of COD, nitrate and ammonia to the pot liquor, and it served to reduce the pH values in the gully pot liquor after a snowmelt runoff following a period of thaw within the catchment area. The rainwater samples were collected and analysed so that the influence of atmospheric input upon stormwater quality could be assessed for the Clifton Grove catchment areas under study, and the results can be used to infer the influence of the other factors within the urban environment (as outlined above) in determining the quality of stormwater discharges from separately-sewered, residential catchment areas. The rainwater quality data was a valuable aid in analysing the storm event data and it provided confirmation of the findings within other urban catchments.

A P P E N D I C E S.

Appendix A: Reference Chapter 4: Computer Programme Listings.

Appendix B: Reference Chapters 4 and 8:

Storm Hyetographs and Inlet Storm Hydrographs.

Appendix C: Reference Chapter 7:

Gully Pot Liquor Monitoring Programme Data Tables.

Appendix D: Reference Chapter 8:

Storm Event Sampling Programme Data Tables and Graphs.

Appendix E: Published Papers.

- - - - - - - - - - - - - - - - - -

APPENDIX A.

Reference: Chapter 4.

Computer Programme.	Description.
A.	Rainfall Data Processing Programme for the Tame Close Gauge.
B.	Rainfall Data Processing Programme with Graphics for the Tame Close Gauge.
C.	Rainfall Data Processing Programme for the Pieris Drive Gauge.
D.	Rainfall Data Processing Programme with Graphics for the Pieris Drive (Barton Green) Gauge.
E.	Rainfall Data Processing Programme for the Roof Rig Gauge.
F.	Rainfall Data Processing Programme with Graphics for the Roof Rig (Trent Polytechnic Campus) Gauge.
G.	LRM Rainfall-Runoff Model Programme for the Tame Close Micro-catchment.
H.	LRM Rainfall-Runoff Model Programme for the Tame Close Micro-catchment with a Graphics Option.
I.	LRM Rainfall-Runoff Model Programme for the Churnet Close Micro-catcment.
J.	LRM Rainfall-Runoff Model Programme for the Churnet Close Micro-catchment with a Graphics Option.
K.	LRM Rainfall-Runoff Model Programme for the Twyford Gardens Micro-catchment.
L.	LRM Rainfall-Runoff Model Programme for the Twyford Gardens Micro-catchment with a Graphics Option.

COMPUTER PROGRAMME A

```
C
C
C*************************************************************************
C*                                                                       *
C*  RAW RAINFALL DATA PROCESSING PROGRAM FOR TAME CLOSE RAINGAUGE FILES  *
C*                                                                       *
C*************************************************************************
C
C
C  PROGRAM READS IN RAINFALL DATA FROM TAME CLOSE DATA FILES AND
C  PRINTS OUTPUT ON LINEPRINTER AFTER PROCESSING THE RAW DATA.
C  THE NAME OF THE FILE TO BE PROCESSED IS TYPED IN WHEN THE
C  PROGRAM IS RUN.
C
C
C    PROGRAM DEVELOPED BY :   Mr. MASUD A. PARKAR,
C    PROGRAM EDITED BY    :   Mr. G. A. FULCHER
C
C
C
C
C
C      DATE:                  JANUARY  1986.
C      *****                  **************
C
C  START OF PROGRAM : DIMENSION STATEMENTS ETC.
C
      DIMENSION IT(4500),IH(4500),IM(4500),ET(4500),RNF(4500),RDP(4500)
      CHARACTER*9 NAME,DAY,MONTH,YEAR
C
        I128 = 0; ICH = 0; IA=0; I=0
C
C  FILENAME INPUT AND OPENING DATA FILE.
C
        WRITE(5,10)
 10     FORMAT(///,'0',20X,'WHAT FILE DO YOU WANT TO PROCESS?',////)
        READ(5,15) NAME
 15     FORMAT(A9)
        OPEN(UNIT=20,FILE=NAME,ACCESS='SEQIN')
        DAY=NAME(7:8)
        MONTH=NAME(5:6)
        YEAR=NAME(3:4)
C
C  READING IN THE FOUR COLUMNS OF DATA
C
 5    CONTINUE
        I= I+1
        READ(20,21,END=99) IB,IT(I),IH(I),IM(I)
 21     FORMAT(6I)
        IF(IB.LT.238.OR.IB.GT.243) GOTO 1000
C
        IHC=0;IMC=0
        IHC=IH(1)+(IM(1)+(I-1)/2)/60
        IMC=IM(1)+(I-1)/2
        IF(IHC.GE.24) IY=IHC/24
        IF(IMC.GE.60) IZ=IMC/60
        IHC=IHC-24*IY
```

```
        IMC=IMC-60*IZ
        IF(IHC.NE.IH(I)) GOTO 1100
        IF(IMC.NE.IM(I)) GOTO 1100
        IA=IA+1
        IF (I.EQ.4500) GOTO 2500
      GOTO 5
C
 99     WRITE(5,2000) IA
 2000   FORMAT(///,25X,'THIS FILE CONTAINS',I5,' LINES')
C
C  WRITE STATEMENTS FOR HEADINGS ETC.
C
      WRITE (3,20)
 20   FORMAT (1H1,//,30X,'RAINFALL RECORD FOR TAME CLOSE RAINGAUGE')
      WRITE (3,30)
 30   FORMAT (30X,40('*'),////)
      WRITE (3,40) DAY,MONTH,YEAR
 40   FORMAT (85X,'DATE OF STORM: ',A2,'-',A2,'-',A2)
      WRITE(3,50)
 50   FORMAT(85X,23('*'))
      WRITE(3,60)
 60   FORMAT(6(/),5X,'REAL TIME',5X,'RAINFALL INTENSITY',5X
     * ,'ELAPSED',5X,'RAINFALL')
      WRITE(3,70)
 70   FORMAT(5X,9('*'),5X,18('*'),5X,7('*'),5X,8('*'))
      WRITE(3,80)
 80   FORMAT(5X,'HRS',3X,'MNS',9X,'(MM./HOUR)'
     * ,9X,'TIME(M)',4X,'DEPTH(MM.)')
      WRITE(3,90)
 90   FORMAT(5X,'***',3X,'***',9X,10('*'),9X.
     * ,7('*'),4X,10('*'))
C
C  START OF DATA PROCESSING
C
      DO 100 I = 2,IA
         IT(I) = IT(I) + I128
         IF (IT(I).GE.IT(I-1)) GOTO 100
         I128 = I128 + 128
         IT(I) = IT(I) + 128
 100  CONTINUE
C
      DO 400 I = 2,IA
         IF (IT(I).EQ.IT(I-1)) 400,120
 120     ICH = ICH + 1
         IF (ICH.EQ.1) 130,140
 130     IP1 = I
         NT1 = IT(I) - IT(I-1)
         GOTO 400
 140     IF (ICH.EQ.2) 150,250
 150     IDF1 = I - IP1
 152     IS = IP1 - IDF1 + 1
C
         T = FLOAT(IDF1)*30.0
         A = FLOAT(NT1)-0.5
         B = FLOAT(IT(I)) - FLOAT(IT(I-1))
C
       DO 160 J = IS,IP1
```

```
          IF (IDF1.EQ.1) GOTO 165
          RNF(J) = 310.8329*A/T
          GOTO 160
 165      RNF(J) = (12.86*A) - (0.6024) + (0.2515*A*A)
 160   CONTINUE
C
       DO 200 J = IP1+1,I
          IF (IDF1.EQ.1) GOTO 205
          RNF(J) = 310.8329*B/T
          GOTO 200
 205      RNF(J) = (12.86*B) - (0.6024) + (0.2515*B*B)
 200   CONTINUE
C
          GOTO 390
C
 250      IDF = I-IPS
C
          C = FLOAT(IT(I)) - FLOAT(IT(I-1))
          T = FLOAT(IDF)*30.0
C
       DO 220 J = IPS+1,I
          IF (IDF.EQ.1) GOTO 255
          RNF(J) = 310.8329*C/T
          GOTO 220
 255      RNF(J) = (12.86*C) - (0.6024) + (0.2515*C*C)
 220   CONTINUE
C
          IF (IT(I).EQ.IT(IA)) 300,390
 300      IDF = I-IPS
          T = FLOAT(IDF)*30.0
          D = (FLOAT(IT(I)) - FLOAT(IT(I-1))) - 0.5
C
       DO 275 J = I+1,I+IDF
          IF (IDF.EQ.1) GOTO 280
          RNF(J) = 310.8329*D/T
C
          GOTO 275
C
 280      RNF(J) = (12.86*D) - (0.6024) + (0.2515*D*D)
 275   CONTINUE
C
         GOTO 425
C
 390     IPS = I
 400   CONTINUE
C
 425      DO 600 I = IS-1,IA
          IF (I.EQ.(IS-1)) 420,430
 430      ET(I) = ET(I-1) + 0.5
          RDP(I) = RDP(I-1) + (RNF(I)/120.0)
 440         WRITE(3,505)IH(I),IM(I),RNF(I),ET(I),RDP(I)
 505         FORMAT(5X,2(I2,4X),7X,F6.2,12X,F5.1,8X,F5.2)
C
            GOTO 600
C
 420         ET(I)=0.0;RDP(I)=0.0
           GOTO 440
```

```
C
 600      CONTINUE
          GOTO 999
C
C  WRITING OUT ERROR MESSAGES.
C
 1000    WRITE(5,105) IA
 105     FORMAT(///,25X,'WARNING! BATTERY CHECK FAULT @ LINE ',I5)
              GOTO 999
 1100   WRITE(5,2550)IB,IT(I-1),IH(I-1),IM(I-1)
 2550   FORMAT(///,20X,'TIME CHANNEL ERROR AFTER LINE ',6(I4),///)
              GOTO 999
 2500   WRITE (5,2510)
 2510   FORMAT(///,5X,'DATA FILE TOO LONG; REDIMENSION
     * ARRAYS --> 4500')
C
 999         STOP
             END
```

COMPUTER PROGRAMME B.

```
C
C
C*************************************************************************
C*                                                                       *
C*  RAW RAINFALL DATA PROCESSING PROGRAM FOR TAME CLOSE RAINGAUGE FILES  *
C*  PLOTTING PROGRAM FOR TAME CLOSE DATA FILES, Screen or Plotter option.*
C*                                                                       *
C*************************************************************************
C
C
C  PROGRAM READS IN RAINFALL DATA FROM TAME CLOSE DATA FILES AND
C  AFTER PROCESSING THE RAW DATA THE HYETOGRAPH IS DRAWN ON THE
C  SCREEN OR PLOTTER.  THE NAME OF THE FILE TO BE PROCESSED IS
C  TYPED IN WHEN THE PROGRAM IS RUN.
C
C
C  WARNING!!  THE SCREEN OPTION SWITCHES A CIFER T5 TERMINAL TO
C  *********  GRAPHICS MODE AUTOMATICALLY.  DO NOT USE THIS
C             PROGRAM WITH ANY OTHER TYPE OF TERMINAL.
C
C
C    PROGRAM DEVELOPED BY :   Mr. MASUD A. PARKAR,
C    PROGRAM EDITED BY    :   Mr. G. A. FULCHER
C
C
C
C
C
C      DATE:                  JANUARY  1986.
C      *****                  **************
C
C  START OF PROGRAM : DIMENSION STATEMENTS ETC.
C
      DIMENSION IT(4500),IH(4500),IM(4500),RNF(4500),HR(4500)
      DIMENSION NAM(9),IDATE(8)
      CHARACTER*9 NAME,DAY,MONTH,YEAR
      DOUBLE PRECISION FN
      I128 = 0; ICH = 0; IA=0; I=0
C
C  FILENAME INPUT AND OPENING DATA FILE.
C
       WRITE(5,10)
 10    FORMAT(//,'0',20X,'WHAT FILE DO YOU WANT TO PROCESS?',//)
       READ(5,15) FN
 15    FORMAT(A9)
       REREAD 16,NAM
 16    FORMAT(9A1)
       OPEN(UNIT=20,FILE=FN,ACCESS='SEQIN')
C
C  SETTING UP DATE OF EVENT FOR PLOTTING.
       IHYP='-'; IDATE(1)=NAM(7); IDATE(2)=NAM(8); IDATE(3)=IHYP
       IDATE(4)=NAM(5); IDATE(5)=NAM(6); IDATE(6)=IHYP
       IDATE(7)=NAM(3); IDATE(8)=NAM(4)
C
C  READING IN THE FOUR COLUMNS OF DATA
C
5      I= I+1
```

```
        READ(20,21,END=99) IB,IT(I),IH(I),IM(I)
 21     FORMAT(6I)
        IF(IB.LT.238.OR.IB.GT.243) GOTO 1000
C
        IHC=0;IMC=0
        IHC=IH(1)+(IM(1)+(I-1)/2)/60
        IMC=IM(1)+(I-1)/2
        IF(IHC.GE.24) IY=IHC/24
        IF(IMC.GE.60) IZ=IMC/60
        IHC=IHC-24*IY
        IMC=IMC-60*IZ
        IF(IHC.NE.IH(I)) GOTO 1100
        IF(IMC.NE.IM(I)) GOTO 1100
        IA=IA+1
        IF (I.EQ.4500) GOTO 2500
        HR(I) = FLOAT(IH(1))+(FLOAT(IM(1))+(FLOAT(I)-1.0)/2.0)/60.0
      GOTO 5
C
 99     WRITE(5,2000) IA
 2000   FORMAT(///,25X,'THIS FILE CONTAINS',I5,' LINES')
C
C  START OF DATA PROCESSING
C
      DO 100 I = 2,IA
         IT(I) = IT(I) + I128
         IF (IT(I).GE.IT(I-1)) GOTO 100
         I128 = I128 + 128
         IT(I) = IT(I) + 128
 100  CONTINUE
C
      DO 400 I = 2,IA
         IF (IT(I).EQ.IT(I-1)) 400,120
 120     ICH = ICH + 1
         IF (ICH.EQ.1) 130,140
 130     IP1 = I
         NT1 = IT(I) - IT(I-1)
         GOTO 400
 140     IF (ICH.EQ.2) 150,250
 150     IDF1 = I - IP1
 152     IS = IP1 - IDF1 + 1
C
         T = FLOAT(IDF1)*30.0
         A = FLOAT(NT1)-0.5
         B = FLOAT(IT(I)) - FLOAT(IT(I-1))
C
       DO 160 J = IS,IP1
          IF (IDF1.EQ.1) GOTO 165
          RNF(J) = 310.8329*A/T
          GOTO 160
 165      RNF(J) = (12.86*A) - (0.6024) + (0.2515*A*A)
 160   CONTINUE
C
       DO 200 J = IP1+1,I
          IF (IDF1.EQ.1) GOTO 205
          RNF(J) = 310.8329*B/T
          GOTO 200
 205      RNF(J) = (12.86*B) - (0.6024) + (0.2515*B*B)
```

```
 200   CONTINUE
C
          GOTO 390
C
 250      IDF = I-IPS
C
          C = FLOAT(IT(I)) - FLOAT(IT(I-1))
          T = FLOAT(IDF)*30.0
C
       DO 220 J = IPS+1,I
          IF (IDF.EQ.1) GOTO 255
          RNF(J) = 310.8329*C/T
          GOTO 220
 255      RNF(J) = (12.86*C) - (0.6024) + (0.2515*C*C)
 220   CONTINUE
C
          IF (IT(I).EQ.IT(IA)) 300,390
 300      IDF = I-IPS
          T = FLOAT(IDF)*30.0
          D = (FLOAT(IT(I)) - FLOAT(IT(I-1))) - 0.5
C
       DO 275 J = I+1,I+IDF
          IF (IDF.EQ.1) GOTO 280
          RNF(J) = 310.8329*D/T
          GOTO 275
 280      RNF(J) = (12.86*D) - (0.6024) + (0.2515*D*D)
 275   CONTINUE
          GOTO 425
 390      IPS = I
 400   CONTINUE
C
C  CALCULATE PEAK RAINFALL VALUE.
C
425    PRNF=0.0
       DO 429 I=1,IA
         IF(RNF(I).GT.PRNF) PRNF = RNF(I)
429    CONTINUE
C
C  PLOTTING ROUTINES USING NAG GRAPHICAL SUPPLEMENT.
C  ************************************************
C
433   CALL X04AAF(1,5)        ! Sets error messages to appear on screen.
C
C  SELECT AND SET UP PLOTTING DEVICES (SCREEN OR PAPER).
C
      WRITE(5,2)
2     FORMAT(///,'  Do you want a Screen or Paper plot? (S or P)',///)
      READ(5,4) IANS
4     FORMAT(80A1)
      IF (IANS.EQ.'S') THEN
      WRITE(5,*)' h'
      CALL T4014; SDX=365.0; SDY=365.0
      ENDIF
      IF (IANS.EQ.'P') THEN
      CALL C1039; SDX=860.0; SDY=860.0
      ENDIF
      XFR=210.0; YFR=297.0; XPL=20.0; YPL=20.0
```

```
C
      CALL PICCLE                    ! Clear drawing area.
      CALL J06WAF                    ! Initialise the NAG system.
C
C INITIALISE AND DRAW A4 SIZE BORDER.
C
      XU=(XPL+XFR)/SDX; XL=XPL/SDX; YU=(YPL+YFR)/SDY; YL=YPL/SDY
      CALL J06WBF(0.0,1.0,0.0,1.0,0)! Defines mapping area of data region.
      CALL J06WCF(XL,XU,YL,YU)       ! Sets current viewport on plot surface.
      CALL J06YAF(0.0,0.0)           !
      CALL J06YCF(0.995,0.0)         !
      CALL J06YCF(0.995,0.995)       ! DRAWS A4 SIZE BORDER
      CALL J06YCF(0.0,0.995)         !
      CALL J06YCF(0.0,0.0)           !
C
C  DRAWING THE HYETOGRAPH
C
      XWU=0.95; XWL=0.12; YWU=0.7; YWL=0.35
      XU=(XPL+XWU*XFR)/SDX; XL=(XPL+XWL*XFR)/SDX
      YU=(YPL+YWU*YFR)/SDY; YL=(YPL+YWL*YFR)/SDY
      CALL J06WBF(HR(1),HR(IA),0.0,1.1*PRNF,1)  ! X  Y min.  max. values.
      CALL J06WCF(XL,XU,YL,YU)       ! Set current viewport on plot surface.
      DELX=1.0/120.0
      CALL J06YAF(HR(1)-DELX,0.0)    ! Move pen to the point X,Y
      DO 111 I=2,IA                  !
      CALL J06YCF(HR(I)-DELX,RNF(I))!
      CALL J06YCF(HR(I),RNF(I))      ! Do Loop draws inverted hyetograph.
111   CONTINUE                       !
      CALL J06XFF(2)                 ! Set high quality marker.
      CALL J06AEF                    ! Draw frame round plot and add axis.
      CALL J06AJF(2,24HRainfall Intensity mm/hr,24) ! Label Y-axis.
C
C ADD HEADINGS, DATE AND X-AXIS TITLE.
C
      XX=(XPL+0.18*XFR)/SDX; YY=(YPL+0.9*YFR)/SDY
      CALL J06WBF(0.0,1.0,0.0,1.0,0)! Defines mapping area of data region.
      CALL J06WCF(0.0,1.0,0.0,1.0)   ! Set current viewport on plot surface.
      CALL J06XGF(1.0,1.0)           ! Set scale factor for character size.
      CALL J06XHF(1.0)               ! Set marker size scale factor.
      CALL J06YLF(3.0/SDX,0.0)       ! Set character spacing .
      CALL J06YKF(2.5/SDX,3.0/SDY)   ! Set character width and height size.
      CALL J06YJF(2.0)               ! Set marker size.
      CALL J06XFF(2)                 ! Set high quality marker.
      CALL J06YAF(XX,YY)             ! Move to required position on plot.
      CALL J06ZAF(44HRAINFALL HYETOGRAPH FOR TAME CLOSE RAINGAUGE,44)
      XX=(XPL+0.54*XFR)/SDX; YY=(YPL+0.83*YFR)/SDY
      CALL J06YAF(XX,YY)             ! Move to required position on plot.
      CALL J06ZAF(16HDate of Event : ,16)
      CALL J06YHF(IDATE,8)           ! Write the date of event.
      XX=(XPL+0.48*XFR)/SDX; YY=(YPL+0.35*YFR)/SDY
      CALL J06YAF(XX,YY)             ! Move to required position on plot.
      CALL J06YKF(1.5/SDX,2.0/SDY)   ! Set character width and height size.
      CALL J06ZAF(11HTIME (Hrs.),11)! Label X-axis.
      CALL CHAMOD
      CALL DEVEND
      IF (IANS.EQ.'S') THEN
      READ (5,1234) ACHAR
```

```
 1234 FORMAT (1A1)
      WRITE(5,*)' 1p'
      ENDIF
      GOTO 999
C
C  WRITING OUT ERROR MESSAGES: MISSING/ROGUE VALUES.
C
 1000   WRITE(5,105) IA
 105    FORMAT(///,25X,'WARNING! BATTERY CHECK FAULT @ LINE ',I5)
            GOTO 999
 1100  WRITE(5,2550)IB,IT(I-1),IH(I-1),IM(I-1)
 2550  FORMAT(///,20X,'TIME CHANNEL ERROR AFTER LINE ',6(I4),///)
            GOTO 999
 2500  WRITE (5,2510)
 2510  FORMAT(///,5X,'DATA FILE TOO LONG; REDIMENSION
     * ARRAYS --> 4500')
C
 999         STOP
             END
```

COMPUTER PROGRAMME C.

```
C
C
C*************************************************************************
C*                                                                       *
C*  RAW RAINFALL DATA PROCESSING PROGRAM FOR PIERIS DRIVE RAINGAUGE FILES*
C*                                                                       *
C*************************************************************************
C
C
C  PROGRAM READS IN RAINFALL DATA FROM PIERIS DRIVE DATA FILES AND
C  PRINTS OUTPUT ON LINEPRINTER AFTER PROCESSING THE RAW DATA.
C  THE NAME OF THE FILE TO BE PROCESSED IS TYPED IN WHEN THE
C  PROGRAM IS RUN.
C
C
C    PROGRAM DEVELOPED BY :   Mr. MASUD A. PARKAR,
C    PROGRAM EDITED BY    :   Mr. G. A. FULCHER
C
C
C
C
C
C      DATE:                  JANUARY  1986.
C      *****                  **************
C
C  START OF PROGRAM : DIMENSION STATEMENTS ETC.
C
      DIMENSION IT(4500),IH(4500),IM(4500),ET(4500),RNF(4500),RDP(4500)
      CHARACTER*9 NAME,DAY,MONTH,YEAR
C
       I128 = 0; ICH = 0; IA=0; I=0
C
C  FILENAME INPUT AND OPENING DATA FILE.
C
       WRITE(5,10)
 10    FORMAT(///,'0',20X,'WHAT FILE DO YOU WANT TO PROCESS?',////)
       READ(5,15) NAME
 15    FORMAT(A9)
       OPEN(UNIT=20,FILE=NAME,ACCESS='SEQIN')
       DAY=NAME(7:8)
       MONTH=NAME(5:6)
       YEAR=NAME(3:4)
C
C  READING IN THE FOUR COLUMNS OF DATA
C
 5     CONTINUE
         I= I+1
       READ(20,21,END=99) IB,IT(I),IH(I),IM(I)
 21    FORMAT(6I)
       IF(IB.LT.238.OR.IB.GT.243) GOTO 1000
C
       IHC=0;IMC=0
       IHC=IH(1)+(IM(1)+(I-1)/2)/60
       IMC=IM(1)+(I-1)/2
       IF(IHC.GE.24) IY=IHC/24
       IF(IMC.GE.60) IZ=IMC/60
       IHC=IHC-24*IY
```

```
        IMC=IMC-60*IZ
        IF(IHC.NE.IH(I)) GOTO 1100
        IF(IMC.NE.IM(I)) GOTO 1100
        IA=IA+1
        IF (I.EQ.4500) GOTO 2500
      GOTO 5
C
 99     WRITE(5,2000) IA
 2000   FORMAT(///,25X,'THIS FILE CONTAINS',I5,' LINES')
C
C  WRITE STATEMENTS FOR HEADINGS ETC.
C
       WRITE (3,20)
 20    FORMAT (1H1,//,30X,'RAINFALL RECORD FOR PIERIS DRIVE RAINGAUGE')
       WRITE (3,30)
 30    FORMAT (30X,40('*'),////)
       WRITE (3,40) DAY,MONTH,YEAR
 40    FORMAT (85X,'DATE OF STORM: ',A2,'-',A2,'-',A2)
       WRITE(3,50)
 50    FORMAT(85X,23('*'))
       WRITE(3,60)
 60    FORMAT(6(/),5X,'REAL TIME',5X,'RAINFALL INTENSITY',5X
     * ,'ELAPSED',5X,'RAINFALL')
       WRITE(3,70)
 70    FORMAT(5X,9('*'),5X,18('*'),5X,7('*'),5X,8('*'))
       WRITE(3,80)
 80    FORMAT(5X,'HRS',3X,'MNS',9X,'(MM./HOUR)'
     * ,9X,'TIME(M)',4X,'DEPTH(MM.)')
       WRITE(3,90)
 90    FORMAT(5X,'***',3X,'***',9X,10('*'),9X
     * ,7('*'),4X,10('*'))
C
C  START OF DATA PROCESSING
C
      DO 100 I = 2,IA
         IT(I) = IT(I) + I128
         IF (IT(I).GE.IT(I-1)) GOTO 100
         I128 = I128 + 128
         IT(I) = IT(I) + 128
 100  CONTINUE
C
      DO 400 I = 2,IA
         IF (IT(I).EQ.IT(I-1)) 400,120
 120     ICH = ICH + 1
         IF (ICH.EQ.1) 130,140
 130     IP1 = I
         NT1 = IT(I) - IT(I-1)
         GOTO 400
 140     IF (ICH.EQ.2) 150,250
 150     IDF1 = I - IP1
 152     IS = IP1 - IDF1 + 1
C
         T = FLOAT(IDF1)*30.0
         A = FLOAT(NT1)-0.5
         B = FLOAT(IT(I)) - FLOAT(IT(I-1))
C
       DO 160 J = IS,IP1
```

```
          IF (IDF1.EQ.1) GOTO 165
          RNF(J) = 341.91618*A/T
          GOTO 160
 165      RNF(J) = (11.17274106*A)+(0.206155721*A*A)-0.0032023079*A*A*A
 160   CONTINUE
C
       DO 200 J = IP1+1,I
          IF (IDF1.EQ.1) GOTO 205
          RNF(J) = 341.91618*B/T
          GOTO 200
 205      RNF(J) = (11.17274106*B)+(0.0206155721*B*B)-0.0032023079*B*B*B
 200   CONTINUE
C
          GOTO 390
C
 250      IDF = I-IPS
C
          C = FLOAT(IT(I)) - FLOAT(IT(I-1))
          T = FLOAT(IDF)*30.0
C
       DO 220 J = IPS+1,I
          IF (IDF.EQ.1) GOTO 255
          RNF(J) = 341.91618*C/T
          GOTO 220
 255      RNF(J) = (11.17274106*C)+(0.206155721*C*C)-0.0032023079*C*C*C
 220   CONTINUE
C
          IF (IT(I).EQ.IT(IA)) 300,390
 300      IDF = I-IPS
          T = FLOAT(IDF)*30.0
          D = (FLOAT(IT(I)) - FLOAT(IT(I-1))) - 0.5
C
       DO 275 J = I+1,I+IDF
          IF (IDF.EQ.1) GOTO 280
          RNF(J) = 341.91618*D/T
C
          GOTO 275
C
 280      RNF(J) = (11.17274106*D)+(0.206155721*D*D)-0.0032023079*D*D*D
 275   CONTINUE
C
         GOTO 425
C
 390     IPS = I
 400   CONTINUE
C
 425       DO 600 I = IS-1,IA
          IF (I.EQ.(IS-1)) 420,430
 430      ET(I) = ET(I-1) + 0.5
          RDP(I) = RDP(I-1) + (RNF(I)/120.0)
 440         WRITE(3,505)IH(I),IM(I),RNF(I),ET(I),RDP(I)
 505         FORMAT(5X,2(I2,4X),7X,F6.2,12X,F5.1,8X,F5.2)
C
            GOTO 600
C
 420        ET(I)=0.0;RDP(I)=0.0
           GOTO 440
```

```
C
 600      CONTINUE
          GOTO 999
C
C  WRITING OUT ERROR MESSAGES.
C
 1000    WRITE(5,105) IA
 105     FORMAT(///,25X,'WARNING! BATTERY CHECK FAULT @ LINE ',I5)
             GOTO 999
 1100   WRITE(5,2550)IB,IT(I-1),IH(I-1),IM(I-1)
 2550   FORMAT(///,20X,'TIME CHANNEL ERROR AFTER LINE ',6(I4),///)
             GOTO 999
 2500   WRITE (5,2510)
 2510   FORMAT(///,5X,'DATA FILE TOO LONG; REDIMENSION
     * ARRAYS --> 4500')
C
 999         STOP
             END
```

COMPUTER PROGRAMME D.

```
C
C
C*************************************************************************
C*                                                                       *
C*  RAW RAINFALL DATA PROCESSING PROGRAM FOR PIERIS DRIVE RAINGAUGE FILES*
C*  PLOTTING PROGRAM FOR TAME CLOSE DATA FILES, Screen or Plotter option.*
C*                                                                       *
C*************************************************************************
C
C
C  PROGRAM READS IN RAINFALL DATA FROM PIERIS DRIVE DATA FILES AND
C  AFTER PROCESSING THE RAW DATA THE HYETOGRAPH IS DRAWN ON THE
C  SCREEN OR PLOTTER.  THE NAME OF THE FILE TO BE PROCESSED IS
C  TYPED IN WHEN THE PROGRAM IS RUN.
C
C
C  WARNING!!  THE SCREEN OPTION SWITCHES A CIFER T5 TERMINAL TO
C  *********  GRAPHICS MODE AUTOMATICALLY.  DO NOT USE THIS
C             PROGRAM WITH ANY OTHER TYPE OF TERMINAL.
C
C
C    PROGRAM DEVELOPED BY :   Mr. MASUD A. PARKAR,
C    PROGRAM EDITED BY    :   Mr. G. A. FULCHER
C
C
C
C
C
C      DATE:                  JANUARY  1986.
C      *****                  **************
C
C  START OF PROGRAM : DIMENSION STATEMENTS ETC.
C
      DIMENSION IT(4500),IH(4500),IM(4500),RNF(4500),HR(4500)
      DIMENSION NAM(9),IDATE(8)
      CHARACTER*9 NAME,DAY,MONTH,YEAR
      DOUBLE PRECISION FN
      I128 = 0; ICH = 0; IA=0; I=0
C
C  FILENAME INPUT AND OPENING DATA FILE.
C
       WRITE(5,10)
 10    FORMAT(//,'0',20X,'WHAT FILE DO YOU WANT TO PROCESS?',//)
       READ(5,15) FN
 15    FORMAT(A9)
       REREAD 16,NAM
 16    FORMAT(9A1)
       OPEN(UNIT=20,FILE=FN,ACCESS='SEQIN')
C
C  SETTING UP DATE OF EVENT FOR PLOTTING.
       IHYP='-'; IDATE(1)=NAM(7); IDATE(2)=NAM(8); IDATE(3)=IHYP
       IDATE(4)=NAM(5); IDATE(5)=NAM(6); IDATE(6)=IHYP
       IDATE(7)=NAM(3); IDATE(8)=NAM(4)
C
C  READING IN THE FOUR COLUMNS OF DATA
C
5      I= I+1
```

```
        READ(20,21,END=99) IB,IT(I),IH(I),IM(I)
 21     FORMAT(6I)
        IF(IB.LT.238.OR.IB.GT.243) GOTO 1000
C
        IHC=0;IMC=0
        IHC=IH(1)+(IM(1)+(I-1)/2)/60
        IMC=IM(1)+(I-1)/2
        IF(IHC.GE.24) IY=IHC/24
        IF(IMC.GE.60) IZ=IMC/60
        IHC=IHC-24*IY
        IMC=IMC-60*IZ
        IF(IHC.NE.IH(I)) GOTO 1100
        IF(IMC.NE.IM(I)) GOTO 1100
        IA=IA+1
        IF (I.EQ.4500) GOTO 2500
        HR(I) = FLOAT(IH(1))+(FLOAT(IM(1))+(FLOAT(I)-1.0)/2.0)/60.0
      GOTO 5
C
 99     WRITE(5,2000) IA
 2000   FORMAT(///,25X,'THIS FILE CONTAINS',I5,' LINES')
C
C  START OF DATA PROCESSING
C
      DO 100 I = 2,IA
         IT(I) = IT(I) + I128
         IF (IT(I).GE.IT(I-1)) GOTO 100
         I128 = I128 + 128
         IT(I) = IT(I) + 128
 100  CONTINUE
C
      DO 400 I = 2,IA
         IF (IT(I).EQ.IT(I-1)) 400,120
 120     ICH = ICH + 1
         IF (ICH.EQ.1) 130,140
 130     IP1 = I
         NT1 = IT(I) - IT(I-1)
         GOTO 400
 140     IF (ICH.EQ.2) 150,250
 150     IDF1 = I - IP1
 152     IS = IP1 - IDF1 + 1
C
         T = FLOAT(IDF1)*30.0
         A = FLOAT(NT1)-0.5
         B = FLOAT(IT(I)) - FLOAT(IT(I-1))
C
       DO 160 J = IS,IP1
          IF (IDF1.EQ.1) GOTO 165
          RNF(J) = 341.91618*A/T
          GOTO 160
 165      RNF(J) = (11.17274106*A)+(0.206155721*A*A)-0.0032023079*A*A*A
 160   CONTINUE
C
       DO 200 J = IP1+1,I
          IF (IDF1.EQ.1) GOTO 205
          RNF(J) = 341.91618*B/T
          GOTO 200
 205      RNF(J) = (11.17274106*B)+(0.206155721*B*B)-0.0032023079*B*B*B
```

```
 200    CONTINUE
C
           GOTO 390
C
 250       IDF = I-IPS
C
           C = FLOAT(IT(I)) - FLOAT(IT(I-1))
           T = FLOAT(IDF)*30.0
C
       DO 220 J = IPS+1,I
           IF (IDF.EQ.1) GOTO 255
           RNF(J) = 341.91618*C/T
           GOTO 220
 255       RNF(J) = (11.17274106*C)+(0.206155721*C*C)-0.0032023079*C*C*C
 220   CONTINUE
C
           IF (IT(I).EQ.IT(IA)) 300,390
 300       IDF = I-IPS
           T = FLOAT(IDF)*30.0
           D = (FLOAT(IT(I)) - FLOAT(IT(I-1))) - 0.5
C
       DO 275 J = I+1,I+IDF
           IF (IDF.EQ.1) GOTO 280
           RNF(J) = 341.91618*D/T
           GOTO 275
 280       RNF(J) = (11.17274106*D)+(0.206155721*D*D)-0.0032023079*D*D*D
 275   CONTINUE
           GOTO 425  .
 390       IPS = I
 400   CONTINUE
C
C  CALCULATE PEAK RAINFALL VALUE.
C
425    PRNF=0.0
       DO 429 I=1,IA
         IF(RNF(I).GT.PRNF) PRNF = RNF(I)
429    CONTINUE
C
C  PLOTTING ROUTINES USING NAG GRAPHICAL SUPPLEMENT.
C  ************************************************
C
433   CALL X04AAF(1,5)          ! Sets error messages to appear on screen.
C
C  SELECT AND SET UP PLOTTING DEVICES (SCREEN OR PAPER).
C
      WRITE(5,2)
2     FORMAT(///,'  Do you want a Screen or Paper plot? (S or P)',///)
      READ(5,4) IANS
4     FORMAT(80A1)
      IF (IANS.EQ.'S') THEN
      WRITE(5,*)' h'
      CALL T4014; SDX=365.0; SDY=365.0
      ENDIF
      IF (IANS.EQ.'P') THEN
      CALL C1039; SDX=860.0; SDY=860.0
      ENDIF
      XFR=210.0; YFR=297.0; XPL=20.0; YPL=20.0
```

```
C
      CALL PICCLE                      ! Clear drawing area.
      CALL J06WAF                      ! Initialise the NAG system.
C
C INITIALISE AND DRAW A4 SIZE BORDER.
C
      XU=(XPL+XFR)/SDX; XL=XPL/SDX; YU=(YPL+YFR)/SDY; YL=YPL/SDY
      CALL J06WBF(0.0,1.0,0.0,1.0,0)! Defines mapping area of data region.
      CALL J06WCF(XL,XU,YL,YU)       ! Sets current viewport on plot surface.
      CALL J06YAF(0.0,0.0)           !
      CALL J06YCF(0.995,0.0)         !
      CALL J06YCF(0.995,0.995)       ! DRAWS A4 SIZE BORDER
      CALL J06YCF(0.0,0.995)         !
      CALL J06YCF(0.0,0.0)           !
C
C  DRAWING THE HYETOGRAPH
C
      XWU=0.95; XWL=0.12; YWU=0.7; YWL=0.35
      XU=(XPL+XWU*XFR)/SDX; XL=(XPL+XWL*XFR)/SDX
      YU=(YPL+YWU*YFR)/SDY; YL=(YPL+YWL*YFR)/SDY
      CALL J06WBF(HR(1),HR(IA),0.0,1.1*PRNF,1)  ! X  Y min.  max. values.

      CALL J06WCF(XL,XU,YL,YU)       ! Set current viewport on plot surface.
      DELX=1.0/120.0
      CALL J06YAF(HR(1)-DELX,0.0)    ! Move pen to the point X,Y
      DO 111 I=2,IA                  !
      CALL J06YCF(HR(I)-DELX,RNF(I))!
      CALL J06YCF(HR(I),RNF(I))      ! Do Loop draws inverted hyetograph.
111   CONTINUE                       !
      CALL J06XFF(2)                 ! Set high quality marker.
      CALL J06AEF                    ! Draw frame round plot and add axis.
      CALL J06AJF(2,24HRainfall Intensity mm/hr,24) ! Label Y-axis.
C
C ADD HEADINGS, DATE AND X-AXIS TITLE.
C
      XX=(XPL+0.18*XFR)/SDX; YY=(YPL+0.9*YFR)/SDY
      CALL J06WBF(0.0,1.0,0.0,1.0,0)! Defines mapping area of data region.
      CALL J06WCF(0.0,1.0,0.0,1.0)  ! Set current viewport on plot surface.
      CALL J06XGF(1.0,1.0)           ! Set scale factor for character size.
      CALL J06XHF(1.0)               ! Set marker size scale factor.
      CALL J06YLF(3.0/SDX,0.0)       ! Set character spacing .
      CALL J06YKF(2.5/SDX,3.0/SDY)  ! Set character width and height size.
      CALL J06YJF(2.0)               ! Set marker size.
      CALL J06XFF(2)                 ! Set high quality marker.
      CALL J06YAF(XX,YY)             ! Move to required position on plot.
      CALL J06ZAF(44HRAINFALL HYETOGRAPH FOR TAME CLOSE RAINGAUGE,44)
      XX=(XPL+0.54*XFR)/SDX; YY=(YPL+0.83*YFR)/SDY
      CALL J06YAF(XX,YY)             ! Move to required position on plot.
      CALL J06ZAF(16HDate of Event : ,16)
      CALL J06YHF(IDATE,8)           ! Write the date of event.
      XX=(XPL+0.48*XFR)/SDX; YY=(YPL+0.35*YFR)/SDY
      CALL J06YAF(XX,YY)             ! Move to required position on plot.
      CALL J06YKF(1.5/SDX,2.0/SDY)  ! Set character width and height size.
      CALL J06ZAF(11HTIME (Hrs.),11)! Label X-axis.
      CALL CHAMOD
      CALL DEVEND
      IF (IANS.EQ.'S') THEN
      READ (5,1234) ACHAR
```

```
 1234 FORMAT (1A1)
      WRITE(5,*)' 1p'
      ENDIF
      GOTO 999
C
C  WRITING OUT ERROR MESSAGES: MISSING/ROGUE VALUES.
C
 1000   WRITE(5,105) IA
 105    FORMAT(///,25X,'WARNING! BATTERY CHECK FAULT @ LINE ',I5)
            GOTO 999
 1100  WRITE(5,2550)IB,IT(I-1),IH(I-1),IM(I-1)
 2550  FORMAT(///,20X,'TIME CHANNEL ERROR AFTER LINE ',6(I4),///)
            GOTO 999
 2500  WRITE (5,2510)
 2510  FORMAT(///,5X,'DATA FILE TOO LONG; REDIMENSION
     * ARRAYS --> 4500')
C
 999         STOP
             END
```

COMPUTER PROGRAMME E.

```
C
C
C*************************************************************************
C*                                                                       *
C*  RAW RAINFALL DATA PROCESSING PROGRAM FOR ROOF RIG RAINGAUGE FILES     *
C*                                                                       *
C*************************************************************************
C
C
C  PROGRAM READS IN RAINFALL DATA FROM THE ROOF RIG RAINGAUGE DATA FILES AND
C  PRINTS OUTPUT ON LINEPRINTER AFTER PROCESSING THE RAW DATA.
C  THE NAME OF THE FILE TO BE PROCESSED IS TYPED IN WHEN THE
C  PROGRAM IS RUN.
C
C
C    PROGRAM DEVELOPED BY :   Mr. MASUD A. PARKAR,
C    PROGRAM EDITED BY    :   Mr. G. A. FULCHER
C
C
C
C
C
C      DATE:                  JANUARY  1986.
C      *****                  **************
C
C  START OF PROGRAM : DIMENSION STATEMENTS ETC.
C
      DIMENSION IT(4500),IH(4500),IM(4500),ET(4500),RNF(4500),RDP(4500)
      CHARACTER*9 NAME,DAY,MONTH,YEAR
C
        I128 = 0; ICH = 0; IA=0; I=0
C
C  FILENAME INPUT AND OPENING DATA FILE.
C
        WRITE(5,10)
 10     FORMAT(///,'0',20X,'WHAT FILE DO YOU WANT TO PROCESS?',////)
        READ(5,15) NAME
 15     FORMAT(A9)
        OPEN(UNIT=20,FILE=NAME,ACCESS='SEQIN')
        DAY=NAME(7:8)
        MONTH=NAME(5:6)
        YEAR=NAME(3:4)
C
C  READING IN THE FOUR COLUMNS OF DATA
C
 5    CONTINUE
        I= I+1
        READ(20,21,END=99) IB,IT(I),IH(I),IM(I)
 21     FORMAT(6I)
        IF(IB.LT.238.OR.IB.GT.243) GOTO 1000
C
        IHC=0;IMC=0
        IHC=IH(1)+(IM(1)+(I-1)/2)/60
        IMC=IM(1)+(I-1)/2
        IF(IHC.GE.24) IY=IHC/24
        IF(IMC.GE.60) IZ=IMC/60
        IHC=IHC-24*IY
```

```
        IMC=IMC-60*IZ
        IF(IHC.NE.IH(I)) GOTO 1100
        IF(IMC.NE.IM(I)) GOTO 1100
        IA=IA+1
        IF (I.EQ.4500) GOTO 2500
      GOTO 5
C
 99     WRITE(5,2000) IA
 2000   FORMAT(///,25X,'THIS FILE CONTAINS',I5,' LINES')
C
C  WRITE STATEMENTS FOR HEADINGS ETC.
C
       WRITE (3,20)
 20    FORMAT (1H1,//,30X,'RAINFALL RECORD FOR ROOF RIG RAINGAUGE')
       WRITE (3,30)
 30    FORMAT (30X,40('*'),////)
       WRITE (3,40) DAY,MONTH,YEAR
 40    FORMAT (85X,'DATE OF STORM: ',A2,'-',A2,'-',A2)
       WRITE(3,50)
 50    FORMAT(85X,23('*'))
       WRITE(3,60)
 60    FORMAT(6(/),5X,'REAL TIME',5X,'RAINFALL INTENSITY',5X
     * ,'ELAPSED',5X,'RAINFALL')
       WRITE(3,70)
 70    FORMAT(5X,9('*'),5X,18('*'),5X,7('*'),5X,8('*'))
       WRITE(3,80)
 80    FORMAT(5X,'HRS',3X,'MNS',9X,'(MM./HOUR)'
     * ,9X,'TIME(M)',4X,'DEPTH(MM.)')
       WRITE(3,90)
 90    FORMAT(5X,'***',3X,'***',9X,10('*'),9X
     * ,7('*'),4X,10('*'))
C
C  START OF DATA PROCESSING
C
      DO 100 I = 2,IA
         IT(I) = IT(I) + I128
         IF (IT(I).GE.IT(I-1)) GOTO 100
         I128 = I128 + 128
         IT(I) = IT(I) + 128
 100  CONTINUE
C
      DO 400 I = 2,IA
         IF (IT(I).EQ.IT(I-1)) 400,120
 120     ICH = ICH + 1
         IF (ICH.EQ.1) 130,140
 130     IP1 = I
         NT1 = IT(I) - IT(I-1)
         GOTO 400
 140     IF (ICH.EQ.2) 150,250
 150     IDF1 = I - IP1
 152     IS = IP1 - IDF1 + 1
C
         T = FLOAT(IDF1)*30.0
         A = FLOAT(NT1)-0.5
         B = FLOAT(IT(I)) - FLOAT(IT(I-1))
C
       DO 160 J = IS,IP1
```

```
          IF (IDF1.EQ.1) GOTO 165
          RNF(J) = 344.13347*A/T
          GOTO 160
 165      RNF(J) = 13.9408*A - 0.02064*A*A
 160   CONTINUE
C
       DO 200 J = IP1+1,I
          IF (IDF1.EQ.1) GOTO 205
          RNF(J) = 344.13347*B/T
          GOTO 200
 205      RNF(J) = 13.9408*B - 0.02064*B*B
 200   CONTINUE
C
          GOTO 390
C
 250      IDF = I-IPS
C
          C = FLOAT(IT(I)) - FLOAT(IT(I-1))
          T = FLOAT(IDF)*30.0
C
       DO 220 J = IPS+1,I
          IF (IDF.EQ.1) GOTO 255
          RNF(J) = 344.13347*C/T
          GOTO 220
 255      RNF(J) = 13.9408*C - 0.02064*C*C
 220   CONTINUE
C
          IF (IT(I).EQ.IT(IA)) 300,390
 300      IDF = I-IPS
          T = FLOAT(IDF)*30.0
          D = (FLOAT(IT(I)) - FLOAT(IT(I-1))) - 0.5
C
       DO 275 J = I+1,I+IDF
          IF (IDF.EQ.1) GOTO 280
          RNF(J) = 344.13347*D/T
C
          GOTO 275
C
 280      RNF(J) = 13.9408*D - 0.02064*D*D
 275   CONTINUE
C
         GOTO 425
C
 390     IPS = I
 400   CONTINUE
C
 425       DO 600 I = IS-1,IA
          IF (I.EQ.(IS-1)) 420,430
 430      ET(I) = ET(I-1) + 0.5
          RDP(I) = RDP(I-1) + (RNF(I)/120.0)
 440         WRITE(3,505)IH(I),IM(I),RNF(I),ET(I),RDP(I)
 505         FORMAT(5X,2(I2,4X),7X,F6.2,12X,F5.1,8X,F5.2)
C
            GOTO 600
C
 420         ET(I)=0.0;RDP(I)=0.0
           GOTO 440
```

```
C
 600      CONTINUE
          GOTO 999
C
C  WRITING OUT ERROR MESSAGES.
C
 1000    WRITE(5,105) IA
 105     FORMAT(///,25X,'WARNING! BATTERY CHECK FAULT @ LINE ',I5)
              GOTO 999
 1100  WRITE(5,2550)IB,IT(I-1),IH(I-1),IM(I-1)
 2550  FORMAT(///,20X,'TIME CHANNEL ERROR AFTER LINE ',6(I4),///)
              GOTO 999
 2500  WRITE (5,2510)
 2510  FORMAT(///,5X,'DATA FILE TOO LONG; REDIMENSION
     * ARRAYS --> 4500')
C
 999          STOP
              END
```

COMPUTER PROGRAMME F.

```
C
C
C*************************************************************************
C*                                                                       *
C*  RAW RAINFALL DATA PROCESSING PROGRAM FOR ROOF RIG RAINGAUGE FILES     *
C*  PLOTTING PROGRAM FOR ROOF RIG DATA FILES, Screen or Plotter option.  *
C*                                                                       *
C*************************************************************************
C
C
C  PROGRAM READS IN RAINFALL DATA FROM ROOF RIG DATA FILES AND
C  AFTER PROCESSING THE RAW DATA THE HYETOGRAPH IS DRAWN ON THE
C  SCREEN OR PLOTTER.  THE NAME OF THE FILE TO BE PROCESSED IS
C  TYPED IN WHEN THE PROGRAM IS RUN.
C
C
C  WARNING!!  THE SCREEN OPTION SWITCHES A CIFER T5 TERMINAL TO
C  *********  GRAPHICS MODE AUTOMATICALLY.  DO NOT USE THIS
C             PROGRAM WITH ANY OTHER TYPE OF TERMINAL.
C
C
C    PROGRAM DEVELOPED BY :   Mr. MASUD A. PARKAR,
C    PROGRAM EDITED BY    :   Mr. G. A. FULCHER
C
C
C
C
C
C      DATE:                  JANUARY  1986.
C      *****                  **************
C
C  START OF PROGRAM : DIMENSION STATEMENTS ETC.
C
      DIMENSION IT(4500),IH(4500),IM(4500),RNF(4500),HR(4500)
      DIMENSION NAM(9),IDATE(8)
      CHARACTER*9 NAME,DAY,MONTH,YEAR
      DOUBLE PRECISION FN
      I128 = 0; ICH = 0; IA=0; I=0
C
C  FILENAME INPUT AND OPENING DATA FILE.
C
       WRITE(5,10)
 10    FORMAT(//,'0',20X,'WHAT FILE DO YOU WANT TO PROCESS?',//)
       READ(5,15) FN
 15    FORMAT(A9)
       REREAD 16,NAM
 16    FORMAT(9A1)
       OPEN(UNIT=20,FILE=FN,ACCESS='SEQIN')
C
C  SETTING UP DATE OF EVENT FOR PLOTTING.
       IHYP='-'; IDATE(1)=NAM(7); IDATE(2)=NAM(8); IDATE(3)=IHYP
       IDATE(4)=NAM(5); IDATE(5)=NAM(6); IDATE(6)=IHYP
       IDATE(7)=NAM(3); IDATE(8)=NAM(4)
C
C  READING IN THE FOUR COLUMNS OF DATA
C
5      I= I+1
```

```
        READ(20,21,END=99) IB,IT(I),IH(I),IM(I)
 21     FORMAT(6I)
        IF(IB.LT.238.OR.IB.GT.243) GOTO 1000
C
        IHC=0;IMC=0
        IHC=IH(1)+(IM(1)+(I-1)/2)/60
        IMC=IM(1)+(I-1)/2
        IF(IHC.GE.24) IY=IHC/24
        IF(IMC.GE.60) IZ=IMC/60
        IHC=IHC-24*IY
        IMC=IMC-60*IZ
        IF(IHC.NE.IH(I)) GOTO 1100
        IF(IMC.NE.IM(I)) GOTO 1100
        IA=IA+1
        IF (I.EQ.4500) GOTO 2500
        HR(I) = FLOAT(IH(1))+(FLOAT(IM(1))+(FLOAT(I)-1.0)/2.0)/60.0
      GOTO 5
C
 99     WRITE(5,2000) IA
 2000   FORMAT(///,25X,'THIS FILE CONTAINS',I5,' LINES')
C
C  START OF DATA PROCESSING
C
      DO 100 I = 2,IA
         IT(I) = IT(I) + I128
         IF (IT(I).GE.IT(I-1)) GOTO 100
         I128 = I128 + 128
         IT(I) = IT(I) + 128
 100  CONTINUE
C
      DO 400 I = 2,IA
         IF (IT(I).EQ.IT(I-1)) 400,120
 120     ICH = ICH + 1
         IF (ICH.EQ.1) 130,140
 130     IP1 = I
         NT1 = IT(I) - IT(I-1)
         GOTO 400
 140     IF (ICH.EQ.2) 150,250
 150     IDF1 = I - IP1
 152     IS = IP1 - IDF1 + 1
C
         T = FLOAT(IDF1)*30.0
         A = FLOAT(NT1)-0.5
         B = FLOAT(IT(I)) - FLOAT(IT(I-1))
C
       DO 160 J = IS,IP1
          IF (IDF1.EQ.1) GOTO 165
          RNF(J) = 344.13347*A/T
          GOTO 160
 165      RNF(J) = 13.9408*A - 0.02064*A*A
 160   CONTINUE
C
       DO 200 J = IP1+1,I
          IF (IDF1.EQ.1) GOTO 205
          RNF(J) = 344.13347*B/T
          GOTO 200
 205      RNF(J) = 13.9408*B - 0.02064*B*B
```

```
 200   CONTINUE
C
          GOTO 390
C
 250      IDF = I-IPS
C
          C = FLOAT(IT(I)) - FLOAT(IT(I-1))
          T = FLOAT(IDF)*30.0
C
       DO 220 J = IPS+1,I
          IF (IDF.EQ.1) GOTO 255
          RNF(J) = 344.13347*C/T
          GOTO 220
 255      RNF(J) = 13.9408*C - 0.02064*C*C
 220   CONTINUE
C
          IF (IT(I).EQ.IT(IA)) 300,390
 300      IDF = I-IPS
          T = FLOAT(IDF)*30.0
          D = (FLOAT(IT(I)) - FLOAT(IT(I-1))) - 0.5
C
       DO 275 J = I+1,I+IDF
          IF (IDF.EQ.1) GOTO 280
          RNF(J) = 344.13347*D/T
          GOTO 275
 280      RNF(J) = 13.9408*D - 0.02064*D*D
 275   CONTINUE
          GOTO 425
 390      IPS = I
 400   CONTINUE
C
C  CALCULATE PEAK RAINFALL VALUE.
C
425    PRNF=0.0
       DO 429 I=1,IA
         IF(RNF(I).GT.PRNF) PRNF = RNF(I)
429    CONTINUE
C
C  PLOTTING ROUTINES USING NAG GRAPHICAL SUPPLEMENT.
C  ************************************************
C
433   CALL X04AAF(1,5)        ! Sets error messages to appear on screen.
C
C  SELECT AND SET UP PLOTTING DEVICES (SCREEN OR PAPER).
C
      WRITE(5,2)
2     FORMAT(///,'  Do you want a Screen or Paper plot? (S or P)',///)
      READ(5,4) IANS
4     FORMAT(80A1)
      IF (IANS.EQ.'S') THEN
      WRITE(5,*)' h'
      CALL T4014; SDX=365.0; SDY=365.0
      ENDIF
      IF (IANS.EQ.'P') THEN
      CALL C1039; SDX=860.0; SDY=860.0
      ENDIF
      XFR=210.0; YFR=297.0; XPL=20.0; YPL=20.0
```

```
C
      CALL PICCLE                       ! Clear drawing area.
      CALL J06WAF                       ! Initialise the NAG system.
C
C INITIALISE AND DRAW A4 SIZE BORDER.
C
      XU=(XPL+XFR)/SDX; XL=XPL/SDX; YU=(YPL+YFR)/SDY; YL=YPL/SDY
      CALL J06WBF(0.0,1.0,0.0,1.0,0)! Defines mapping area of data region.
      CALL J06WCF(XL,XU,YL,YU)      ! Sets current viewport on plot surface.
      CALL J06YAF(0.0,0.0)          !
      CALL J06YCF(0.995,0.0)        !
      CALL J06YCF(0.995,0.995)      ! DRAWS A4 SIZE BORDER
      CALL J06YCF(0.0,0.995)        !
      CALL J06YCF(0.0,0.0)          !
C
C  DRAWING THE HYETOGRAPH
C
      XWU=0.95; XWL=0.12; YWU=0.7; YWL=0.35
      XU=(XPL+XWU*XFR)/SDX; XL=(XPL+XWL*XFR)/SDX
      YU=(YPL+YWU*YFR)/SDY; YL=(YPL+YWL*YFR)/SDY
      CALL J06WBF(HR(1),HR(IA),0.0,1.1*PRNF,1)  ! X  Y min.  max. values.

      CALL J06WCF(XL,XU,YL,YU)      ! Set current viewport on plot surface.
      DELX=1.0/120.0
      CALL J06YAF(HR(1)-DELX,0.0)   ! Move pen to the point X,Y
      DO 111 I=2,IA                 !
      CALL J06YCF(HR(I)-DELX,RNF(I))!
      CALL J06YCF(HR(I),RNF(I))     ! Do Loop draws inverted hyetograph.
111   CONTINUE                      !
      CALL J06XFF(2)                ! Set high quality marker.
      CALL J06AEF                   ! Draw frame round plot and add axis.
      CALL J06AJF(2,24HRainfall Intensity mm/hr,24) ! Label Y-axis.
C
C ADD HEADINGS, DATE AND X-AXIS TITLE.
C
      XX=(XPL+0.18*XFR)/SDX; YY=(YPL+0.9*YFR)/SDY
      CALL J06WBF(0.0,1.0,0.0,1.0,0)! Defines mapping area of data region.
      CALL J06WCF(0.0,1.0,0.0,1.0)  ! Set current viewport on plot surface.
      CALL J06XGF(1.0,1.0)          ! Set scale factor for character size.
      CALL J06XHF(1.0)              ! Set marker size scale factor.
      CALL J06YLF(3.0/SDX,0.0)      ! Set character spacing .
      CALL J06YKF(2.5/SDX,3.0/SDY)  ! Set character width and height size.
      CALL J06YJF(2.0)              ! Set marker size.
      CALL J06XFF(2)                ! Set high quality marker.
      CALL J06YAF(XX,YY)            ! Move to required position on plot.
      CALL J06ZAF(44HRAINFALL HYETOGRAPH FOR TAME CLOSE RAINGAUGE,44)
      XX=(XPL+0.54*XFR)/SDX; YY=(YPL+0.83*YFR)/SDY
      CALL J06YAF(XX,YY)            ! Move to required position on plot.
      CALL J06ZAF(16HDate of Event : ,16)
      CALL J06YHF(IDATE,8)          ! Write the date of event.
      XX=(XPL+0.48*XFR)/SDX; YY=(YPL+0.35*YFR)/SDY
      CALL J06YAF(XX,YY)            ! Move to required position on plot.
      CALL J06YKF(1.5/SDX,2.0/SDY)  ! Set character width and height size.
      CALL J06ZAF(11HTIME (Hrs.),11)! Label X-axis.
      CALL CHAMOD
      CALL DEVEND
      IF (IANS.EQ.'S') THEN
      READ (5,1234) ACHAR
```

```
 1234 FORMAT (1A1)
      WRITE(5,*)' 1p'
      ENDIF
      GOTO 999
C
C  WRITING OUT ERROR MESSAGES: MISSING/ROGUE VALUES.
C
 1000   WRITE(5,105) IA
 105    FORMAT(///,25X,'WARNING! BATTERY CHECK FAULT @ LINE ',I5)
            GOTO 999
 1100  WRITE(5,2550)IB,IT(I-1),IH(I-1),IM(I-1)
 2550  FORMAT(///,20X,'TIME CHANNEL ERROR AFTER LINE ',6(I4),///)
            GOTO 999
 2500  WRITE (5,2510)
 2510  FORMAT(///,5X,'DATA FILE TOO LONG; REDIMENSION
     * ARRAYS --> 4500')
C
 999         STOP
             END
```

```
C
C ***************************************************************
C * LINEAR RESERVOIR MODEL: PULSE RESPONSE WITH VARIABLE "K". *
C ***************************************************************
C
C  PROGRAM MODIFIED TO READ IN RAINFALL DATA FROM TAME CLOSE
C  RAINGAUGE FILES AND SIMULATING FLOWS THROUGH GULLYMETER
C  No. 304.104 (TAME CLOSE).
C  THE PROGRAM PRODUCES LINE PRINTER OUTPUT WITH A COMPLETE
C  TABULATION OF THE SIMULATED FLOWS.
C
C    PROGRAM DEVELOPED BY :   Mr. MASUD A. PARKAR,
C    PROGRAM EDITED BY    :   Mr. G. A. FULCHER
C
C
C
C
C      DATE:                  JANUARY 1986.
C      *****                  *************
C
C  START OF PROGRAM : DIMENSION STATEMENTS ETC.
C
      DIMENSION IT(4500),IH(4500),IM(4500),RNF(4500)
      DIMENSION RH1(4500),Q1(4500),ET(4500)
      CHARACTER*9 NAME,DAY,MONTH,YEAR
      DOUBLE PRECISION RAD,QO,RK,RH1,DPST01
      I128 = 0; ICH = 0; IA=0; I=0
C
C  RAINFALL FILE (TAME CLOSE) NAME; INPUT AND OPENED.
C
      WRITE(5,10)
10    FORMAT(//,20X,'NAME OF RAINFALL (TAME CLOSE) FILE ?',//)
      READ(5,15) NAME
15    FORMAT(A9)
      OPEN(UNIT=20,FILE=NAME,ACCESS='SEQIN')
      DAY=NAME(7:8)
      MONTH=NAME(5:6)
      YEAR=NAME(3:4)
C
C  READING IN RAINFALL DATA AND CHECKING FOR MISSING/ROGUE VALUES.
C
5     I = I + 1
        READ(20,21,END=99) IB,IT(I),IH(I),IM(I)
21      FORMAT(6I)                              ! Data File Read.
        IF(IB.LT.238.OR.IB.GT.243) GOTO 1000 ! Battery Check.
        IHC=0;IMC=0
        IHC=IH(1)+(IM(1)+(I-1)/2)/60
        IMC=IM(1)+(I-1)/2
        IF(IHC.GE.24) IY=IHC/24
        IF(IMC.GE.60) IZ=IMC/60
        IHC=IHC-24*IY                           ! Calculated Hour.
        IMC=IMC-60*IZ                           ! Calculated Minute.
        IF(IHC.NE.IH(I)) GOTO 1100              ! Hour Check.
        IF(IMC.NE.IM(I)) GOTO 1100              ! Minute Check.
        IA=IA+1
        IF (I.EQ.4500) GOTO 2500                ! Check Array Size.
      GOTO 5
```

```
C
C  CHECKING AND ALLOWING FOR TIP COUNTS OVER 127.
C
99     DO 100 I = 2,IA
         IT(I) = IT(I) + I128
         IF (IT(I).GE.IT(I-1)) GOTO 100
         I128 = I128 + 128
         IT(I) = IT(I) + 128
100    CONTINUE
C
C  RAINGAUGE TIPS TO RAINFALL INTENSITY: START OF RAINFALL.
C
       DO 400 I = 2,IA
         IF (IT(I).EQ.IT(I-1)) 400,120
120      ICH = ICH + 1
         IF (ICH.EQ.1) 130,140
130      IP1 = I
         NT1 = IT(I) - IT(I-1)
         GOTO 400
140      IF (ICH.EQ.2) 150,250
150      IDF1 = I - IP1
152      IS = IP1 - IDF1 + 1
         T = FLOAT(IDF1)*30.0
         A = FLOAT(NT1)-0.5
         B = FLOAT(IT(I)) - FLOAT(IT(I-1))
C
C  START OF RAINFALL TO FIRST TIP: HALF BUCKET SUBTRACTED.
C
       DO 160 J = IS,IP1
         IF (IDF1.EQ.1) GOTO 165
         RNF(J) = 310.8329*A/T
         GOTO 160
165      RNF(J) = (12.86*A) - (0.6024) + (0.2515*A*A)
160    CONTINUE
C
C  FROM FIRST TIP TO SECOND TIP.
C
       DO 200 J = IP1+1,I
         IF (IDF1.EQ.1) GOTO 205
         RNF(J) = 310.8329*B/T
         GOTO 200
205      RNF(J) = (12.86*B) - (0.6024) + (0.2515*B*B)
200    CONTINUE
         GOTO 390
C
C        ALL THE REMAINING TIPS, EXCEPT THE LAST ONE.
C
250      IDF = I-IPS
         C = FLOAT(IT(I)) - FLOAT(IT(I-1))
         T = FLOAT(IDF)*30.0
       DO 220 J = IPS+1,I
         IF (IDF.EQ.1) GOTO 255
         RNF(J) = 310.8329*C/T
         GOTO 220
255      RNF(J) = (12.86*C) - (0.6024) + (0.2515*C*C)
220    CONTINUE
         IF (IT(I).EQ.IT(IA)) 300,390
```

```
C
C       LAST TIP: END OF RAINFALL CALCULATED.
C
 300      IDF = I-IPS
          T = FLOAT(IDF)*30.0
          D = (FLOAT(IT(I)) - FLOAT(IT(I-1))) - 0.5
C
        DO 275 J = I+1,I+IDF
          IF (IDF.EQ.1) GOTO 280
          RNF(J) = 310.8329*D/T
          GOTO 275
 280      RNF(J) = (12.86*D) - (0.6024) + (0.2515*D*D)
 275    CONTINUE
C
          IE = I + IDF
          GOTO 425
 390      IPS = I
 400    CONTINUE
C
C       END OF RAINFALL INTENSITY CALCULATIONS.
C
425     RC1 = 0.9; AREA1 = 228.0; CATCH1 = 11.5; DPSTO1 = 0.76
C
C  OUTPUT WRITE STATEMENTS.
        WRITE(3,55)
55      FORMAT(//,9X,'LINEAR RESERVOIR MODEL SIMULATION.',5X,'Tame
     * Close Catchment No. 304.104')
        WRITE(3,58)
58      FORMAT(9X,34('='),5X,32('='),//)
        WRITE(3,60) DAY,MONTH,YEAR
60      FORMAT(9X,'CATCHMENT CHARACTERISTICS.',15X,'Date Of Event: '
     * A2,'-',A2,'-',A2)
        WRITE(3,63)
63      FORMAT(9X,26('='),15X,23('='),/)
        WRITE(3,65) DPSTO1,RC1*100.0,AREA1,CATCH1
65      FORMAT(9X,'Depression Storage = ',F4.2,' mm.',/,
     * 9X,'Runoff Coefficient = 'F4.1,' %.',/,
     * 9X,'Area',15X,'= ',F5.1,' m2.',/,
     * 9X,'Catch',14X,'= ',F4.1,' .',/)
C
C      DEPRESSION STORAGE LOSS SUBMODEL: Catchment No. 304.104
C
       DO 20 K = IS,IE
        RAD = RNF(K)/120.0
        IF (RAD.LE.DPSTO1) GOTO 25
        RH1(K) = (RAD - DPSTO1)*120.0
        IS1 = K
        GOTO 30
25      IF(K.EQ.(IE-1)) GOTO 1010
        DPSTO1 = DPSTO1 - RAD
        RH1(K) = 0.0
20     CONTINUE
C
30     DO 32 I = IS1+1,IE
        RH1(I) = RNF(I)
32     CONTINUE
C
```

```
C   CONSTANT PROPORTIONAL LOSS SUBMODEL: Catchment No. 304.104
C
      DO 35 L = IS1,IE
       RH1(L) = RH1(L)*RC1
35    CONTINUE
C
C   ROUTING OF EXCESS RAINFALL USING THE PULSE RESPONSE METHOD.
C
      DO 40 I = IS1,IE
       TI = 0.5
       RK = CATCH1/RH1(I)**0.5
       ITIME = INT((4.605*RK) + 1.0)
       ITEND = (2*ITIME) + I
       QO = (0.5*RH1(I)/(RK + 0.25))*(AREA1/3600.0)
      DO 45 J = I,ITEND
       IF (J.GT.(IE+60)) GOTO 40
       CN = -(TI-0.5)/RK
       QC = QO*EXP(CN)
       Q1(J) = Q1(J) + QC
       TI = TI + 0.5
45    CONTINUE
40    CONTINUE
C
C
      WRITE(3,405)
405   FORMAT(/,3X,'TIME',5X,'RAINFALL INTENSITY (mm/h)',3X,
     *'SIMULATED RUNOFF (l/s)')
      WRITE(3,407)
407   FORMAT(3X,4('='),5X,25('='),3X,22('='))
      WRITE(3,409)
409   FORMAT(2X,'Hrs Min',7X,'Total',5X,'Effective',8X,
     *'TAME No. 304.104')
      WRITE(3,411)
411   FORMAT(2X,'=== ===',7X,5('='),5X,9('='),8X,16('='))
      DO 90 I = IS-1,IE+30
      WRITE(3,413) IH(I),IM(I),RNF(I),RH1(I),Q1(I)
413   FORMAT(2(X,I3),8X,F5.2,7X,F5.2,15X,F5.2)
90    CONTINUE
      GOTO 999
1010   WRITE(3,1020)
1020   FORMAT(//,3X,' WARNING! DEPSTO > RAINFALL DEPTH FOR No. 304.104;
     * SIMULATION TERMINATED',//)
      GOTO 999
C
C      WRITING OUT ERROR MESSAGES: MISSING/ROGUE DATA.
C
1000   WRITE(5,105) IA
105    FORMAT(///,25X,'WARNING! BATTERY CHECK FAULT @ LINE ',I5)
           GOTO 999
1100  WRITE(5,2550)IB,IT(I-1),IH(I-1),IM(I-1)
2550  FORMAT(///,20X,'TIME CHANNEL ERROR AFTER LINE ',6(I4),///)
           GOTO 999
2500  WRITE (5,2510)
2510  FORMAT(///,5X,'DATA FILE TOO LONG; REDIMENSION ARRAYS --> 4500')
           GOTO 999
C
 999       STOP
           END
```

```
C
C ***************************************************************
C * LINEAR RESERVOIR MODEL: PULSE RESPONSE WITH VARIABLE "K". *
C ***************************************************************
C
C  PROGRAM MODIFIED TO READ IN RAINFALL DATA FROM TAME CLOSE
C  RAINGAUGE FILES AND SIMULATING FLOWS THROUGH GULLYMETER
C  No. 304.104 (TAME CLOSE).  THIS PROGRAM PLOTS THE NET
C  HYETOGRAPH AND THE SIMULATED HYDROGRAPH AFTER PERFORMING
C  THE CALCULATIONS.
C
C
C  WARNING!!  THE SCREEN OPTION SWITCHES A CIFER T5 TERMINAL
C  *********  TO GRAPHICS MODE AUTOMATICALLY.  DO NOT USE THIS
C             PROGRAM WITH ANY OTHER TYPE OF TERMINAL.
C
C
C    PROGRAM DEVELOPED BY :   Mr. MASUD A. PARKAR,
C    PROGRAM EDITED    BY :   Mr. G. A. FULCHER
C
C
C
C
C
C      DATE:                  JANUARY 1986.
C      *****                  *************
C
C  START OF PROGRAM : DIMENSION STATEMENTS ETC.
C
      DIMENSION IT(4500),IH(4500),IM(4500),RNF(4500),HR(4500)
      DIMENSION RH1(4500),Q1(4500),ET(4500),NAM(9),IDATE(8)
      CHARACTER*9 NAME,DAY,MONTH,YEAR
      DOUBLE PRECISION RAD,QO,RK,RH1,DPST01,FN
      I128 = 0; ICH = 0; IA=0; I=0
C
C  RAINFALL FILE (TAME CLOSE) NAME; INPUT AND OPENED.
C
      WRITE(5,10)
10    FORMAT(//,20X,'NAME OF RAINFALL (TAME CLOSE) FILE ?',//)
      READ(5,15) FN
15    FORMAT(A9)
      REREAD 16,NAM
16    FORMAT(9A1)
      OPEN(UNIT=20,FILE=FN,ACCESS='SEQIN')
C
C  SETTING UP DATE OF EVENT FOR PLOTTING.
C
      IHYP='-'; IDATE(1)=NAM(7); IDATE(2)=NAM(8); IDATE(3)=IHYP
      IDATE(4)=NAM(5); IDATE(5)=NAM(6); IDATE(6)=IHYP
      IDATE(7)=NAM(3); IDATE(8)=NAM(4)
C
C  READING IN RAINFALL DATA AND CHECKING FOR MISSING/ROGUE VALUES.
C
5     I = I + 1
        READ(20,21,END=99) IB,IT(I),IH(I),IM(I)
21      FORMAT(6I)                              ! Data File Read.
        IF(IB.LT.238.OR.IB.GT.243) GOTO 1000 ! Battery Check.
```

```
        IHC=0;IMC=0
        IHC=IH(1)+(IM(1)+(I-1)/2)/60
        IMC=IM(1)+(I-1)/2
        IF(IHC.GE.24) IY=IHC/24
        IF(IMC.GE.60) IZ=IMC/60
        IHC=IHC-24*IY                          ! Calculated Hour.
        IMC=IMC-60*IZ                          ! Calculated Minute.
        IF(IHC.NE.IH(I)) GOTO 1100             ! Hour Check.
        IF(IMC.NE.IM(I)) GOTO 1100             ! Minute Check.
        IA=IA+1
        IF (I.EQ.4500) GOTO 2500               ! Check Array Size.
        HR(I) = FLOAT(IH(1))+(FLOAT(IM(1))+(FLOAT(I)-1.0)/2.0)/60.0
      GOTO 5
C
C  CHECKING AND ALLOWING FOR TIP COUNTS OVER 127.
C
99    DO 100 I = 2,IA
        IT(I) = IT(I) + I128
        IF (IT(I).GE.IT(I-1)) GOTO 100
        I128 = I128 + 128
        IT(I) = IT(I) + 128
100   CONTINUE
C
C  RAINGAUGE TIPS TO RAINFALL INTENSITY: START OF RAINFALL.
C
      DO 400 I = 2,IA
        IF (IT(I).EQ.IT(I-1)) 400,120
120     ICH = ICH + 1
        IF (ICH.EQ.1) 130,140
130     IP1 = I
        NT1 = IT(I) - IT(I-1)
        GOTO 400
140     IF (ICH.EQ.2) 150,250
150     IDF1 = I - IP1
152     IS = IP1 - IDF1 + 1
        T = FLOAT(IDF1)*30.0
        A = FLOAT(NT1)-0.5
        B = FLOAT(IT(I)) - FLOAT(IT(I-1))
C
C  START OF RAINFALL TO FIRST TIP: HALF BUCKET SUBTRACTED.
C
      DO 160 J = IS,IP1
        IF (IDF1.EQ.1) GOTO 165
        RNF(J) = 310.8329*A/T
        GOTO 160
165     RNF(J) = (12.86*A) - (0.6024) + (0.2515*A*A)
160   CONTINUE
C
C  FROM FIRST TIP TO SECOND TIP.
C
      DO 200 J = IP1+1,I
        IF (IDF1.EQ.1) GOTO 205
        RNF(J) = 310.8329*B/T
        GOTO 200
205     RNF(J) = (12.86*B) - (0.6024) + (0.2515*B*B)
200   CONTINUE
        GOTO 390
```

```
C
C       ALL THE REMAINING TIPS, EXCEPT THE LAST ONE.
C
250     IDF = I-IPS
        C = FLOAT(IT(I)) - FLOAT(IT(I-1))
        T = FLOAT(IDF)*30.0
      DO 220 J = IPS+1,I
        IF (IDF.EQ.1) GOTO 255
        RNF(J) = 310.8329*C/T
        GOTO 220
255     RNF(J) = (12.86*C) - (0.6024) + (0.2515*C*C)
220   CONTINUE
        IF (IT(I).EQ.IT(IA)) 300,390
C
C       LAST TIP: END OF RAINFALL CALCULATED.
C
 300      IDF = I-IPS
          T = FLOAT(IDF)*30.0
          D = (FLOAT(IT(I)) - FLOAT(IT(I-1))) - 0.5
C
       DO 275 J = I+1,I+IDF
          IF (IDF.EQ.1) GOTO 280
          RNF(J) = 310.8329*D/T
          GOTO 275
 280      RNF(J) = (12.86*D) - (0.6024) + (0.2515*D*D)
 275   CONTINUE
C
         IE = I + IDF
         GOTO 425
 390     IPS = I
 400   CONTINUE
C
C       END OF RAINFALL INTENSITY CALCULATIONS.
C
425    RC1 = 0.9; AREA1 = 228.0; CATCH1 = 11.5; DPST01 = 0.76
       DS1 = DPST01
C
C     DEPRESSION STORAGE LOSS SUBMODEL: Catchment No. 304.104
C
      DO 20 K = IS,IE
       RAD = RNF(K)/120.0
       IF (RAD.LE.DPST01) GOTO 25
       RH1(K) = (RAD - DPST01)*120.0
       IS1 = K
       GOTO 30
25     IF(K.EQ.(IE-1)) GOTO 1010
       DPST01 = DPST01 - RAD
       RH1(K) = 0.0
20    CONTINUE
C
30    DO 32 I = IS1+1,IE
       RH1(I) = RNF(I)
32    CONTINUE
C
C   CONSTANT PROPORTIONAL LOSS SUBMODEL: Catchment No. 304.104
C
      DO 35 L = IS1,IE
```

```
       RH1(L) = RH1(L)*RC1
35     CONTINUE
C
C   ROUTING OF EXCESS RAINFALL USING THE PULSE RESPONSE METHOD.
C
       DO 40 I = IS1,IE
        TI = 0.5
        RK = CATCH1/RH1(I)**0.5
        ITIME = INT((4.605*RK) + 1.0)
        ITEND = (2*ITIME) + I
        QO = (0.5*RH1(I)/(RK + 0.25))*(AREA1/3600.0)
       DO 45 J = I,ITEND
        IF (J.GT.(IE+60)) GOTO 40
        CN = -(TI-0.5)/RK
        QC = QO*EXP(CN)
        Q1(J) = Q1(J) + QC
        TI = TI + 0.5
45     CONTINUE
40     CONTINUE
C
C  OBTAINING PEAK VALUES AND TOTAL VOLUME
C
       PRNF=0.0; PQ1=0.0; TV=0.0
       DO 429 I=1,IA
        IF(RNF(I).GT.PRNF) PRNF = RNF(I)
        IF(Q1(I).GT.PQ1) PQ1 = Q1(I)
        TV = TV + (Q1(I)+Q1(I+1))*15.0
429    CONTINUE
C
C  PLOTTING ROUTINES USING NAG GRAPHICAL SUPPLEMENT.
C  ************************************************
C
       CALL X04AAF(1,5)              ! Error messages to screen.
C
C  SELECT AND SET UP PLOTTING DEVICES (SCREEN OR PAPER).
C
       WRITE(5,2)
2      FORMAT(/,'  TAME CLOSE (No. 304.104) SIMULATION',//
      *'  Do you want a Screen or Paper plot? (S or P)',/)
       READ(5,4) IANS
4      FORMAT(80A1)
       IF (IANS.EQ.'S') THEN
       WRITE(5,*)' h'
       CALL T4014; SDX=365.0; SDY=365.0
       ENDIF
       IF (IANS.EQ.'P') THEN
       CALL C1039; SDX=860.0; SDY=860.0
       ENDIF
       XFR=210.0; YFR=297.0; XPL=20.0; YPL=20.0
C
       CALL PICCLE                   ! Clear drawing area.
       CALL J06WAF                   ! Initialise the NAG system.
C
C INITIALISE AND DRAW A4 SIZE BORDER.
C
       XU=(XPL+XFR)/SDX; XL=XPL/SDX; YU=(YPL+YFR)/SDY; YL=YPL/SDY
       CALL J06WBF(0.0,1.0,0.0,1.0,0)!Defines mapping area of data region.
```

```
      CALL J06WCF(XL,XU,YL,YU)      ! Sets current viewport on plot surface.
      CALL J06YAF(0.0,0.0)          !
      CALL J06YCF(0.995,0.0)        !
      CALL J06YCF(0.995,0.995)      ! DRAWS A4 SIZE BORDER
      CALL J06YCF(0.0,0.995)        !
      CALL J06YCF(0.0,0.0)          !
C
C  INVERTED HYETOGRAPH - UPSIDE DOWN WINDOW SET.
C  DRAW RECORDED AND NET HYETOGRAPHS FOR No. 304.104
C
      XWU=0.95; XWL=0.12; YWU=0.8; YWL=0.55
      XU=(XPL+XWU*XFR)/SDX; XL=(XPL+XWL*XFR)/SDX
      YU=(YPL+YWU*YFR)/SDY; YL=(YPL+YWL*YFR)/SDY
      CALL J06WBF(HR(1),HR(IA),1.1*PRNF,0.0,1)!Reversed Y-max.  Y-min.

      CALL J06WCF(XL,XU,YL,YU)      ! Set current viewport on plot surface.
      DELX=1.0/120.0
      CALL J06YAF(HR(1)-DELX,0.0)   ! Move pen to the point X,Y
      DO 60 I=2,IA                  !
      CALL J06YCF(HR(I)-DELX,RH1(I))!
      CALL J06YCF(HR(I),RH1(I))     ! Loop draws net hyetograph (inverted).
60    CONTINUE                      !
      CALL J06XDF(2,2,3,3)          ! Set red colour marker.
      CALL J06YMF(2)                ! Set line type (2 = broken).
      CALL J06XFF(2)                ! Set high quality marker.
      CALL J06YAF(HR(1)-DELX,0.0)   ! Move pen to the point X,Y
      DO 175 I=2,IA                 !
      CALL J06YCF(HR(I)-DELX,RNF(I))!
      CALL J06YCF(HR(I),RNF(I))     ! Loop draws total hyetograph (inverted).
175   CONTINUE                      !
      CALL J06XDF(1,1,1,1)          ! Set black colour marker.
      CALL J06YMF(1)                ! Set line type to normal.
      CALL J06XFF(2)                ! Set high quality marker.
      CALL J06AEF                   ! Draw frame round plot and add axis.
      CALL J06AJF(2,24HRainfall Intensity mm/hr,24)! Label Y-axis.
C
C DRAW SIMULATED HYDROGRAPH FOR No. 304.104 (TAME).
C
      XWU=0.95; XWL=0.12; YWU=0.55; YWL=0.3
      XU=(XPL+XWU*XFR)/SDX; XL=(XPL+XWL*XFR)/SDX
      YU=(YPL+YWU*YFR)/SDY; YL=(YPL+YWL*YFR)/SDY
      CALL J06YJF(0.00005)          ! Set marker size.
      CALL J06XHF(0.5)              ! Set marker size scale factor.
      CALL J06WCF(XL,XU,YL,YU)      ! Set current viewport on plot surface.
      CALL J06WBF(HR(1),HR(IA),0.0,1.1*PQ1,1)! Set axis max./min. values.
      CALL J06BAF(HR,Q1,IA,1,1,0)   ! Draw 304.104 Simulated hydrograph.
      CALL J06AEF                   ! Draw frame round plot and add axis.
      CALL J06AJF(2,9HFlow  l/s,9) ! Label Y-axis.
C
C ADD HEADINGS, DATE AND X-AXIS TITLE.
C
      XX=(XPL+0.18*XFR)/SDX; YY=(YPL+0.9*YFR)/SDY
      CALL J06WBF(0.0,1.0,0.0,1.0,0)! Defines mapping area of data region.
      CALL J06WCF(0.0,1.0,0.0,1.0) ! Set current viewport on plot surface.
      CALL J06XGF(1.0,1.0)          ! Set scale factor for character size.
      CALL J06XHF(1.0)              ! Set marker size scale factor.
      CALL J06YLF(3.0/SDX,0.0)      ! Set character spacing .
      CALL J06YKF(2.5/SDX,3.0/SDY) ! Set character width and height size.
```

```
      CALL J06YJF(2.0)              ! Set marker size.
      CALL J06XFF(2)                ! Set high quality marker.
      CALL J06YAF(XX,YY)            ! Move to required position on plot.
      CALL J06ZAF(42HLINEAR RESERVOIR MODEL SIMULATION PLOT FOR,42)
      CALL J06YBF(-127.0/SDX,-5.0/SDY)! Move position by X,Y increments.
      CALL J06ZAF(37HTAME CLOSE MICROCATCHMENT No. 304.104,37)
      XX=(XPL+0.54*XFR)/SDX; YY=(YPL+0.83*YFR)/SDY
      CALL J06YAF(XX,YY)            ! Move to required position on plot.
      CALL J06ZAF(16HDate of Event : ,16)
      CALL J06YHF(IDATE,8)          ! Write the date of event.
      XX=(XPL+0.48*XFR)/SDX; YY=(YPL+0.30*YFR)/SDY
      CALL J06YAF(XX,YY)            ! Move to required position on plot.
      CALL J06YKF(1.5/SDX,2.0/SDY) ! Set character width and height size.
      CALL J06YLF(3.0/SDX,0.0)      ! Set character spacing .
      CALL J06ZAF(11HTIME (Hrs.),11)! Label X-axis.
C
C  WRITING OUT THE KEY
C
      XX=(XPL+0.15*XFR)/SDX; YY=(YPL+0.26*YFR)/SDY
      CALL J06YAF(XX,YY)            ! Move to required position on plot.
      CALL J06XDF(2,2,3,3)          ! Set red colour marker.
      CALL J06YMF(2)                ! Set line type (2 = broken).
      CALL J06XFF(2)                ! Set high quality marker.
      CALL J06YCF(XX+0.02,YY)       ! Draw line to X,Y
      CALL J06YBF(4.5/SDX,0.0)      ! Leave a small gap.
      CALL J06XDF(1,1,1,1)          ! Set black colour marker.
      CALL J06YMF(1)                ! Set line type to normal.
      CALL J06ZAF(16HTotal Hyetograph,16)
      CALL J06YBF(12.0/SDX,0.0)     ! Leave a small gap.
      CALL J06ZAF(20HDepression Storage= ,20)
      CALL J06ZDF(DS1,4,2)
      CALL J06ZAF(4H mm.,4)
      CALL J06YAF(XX,YY-5.0/SDY)    ! Move to required position on plot.
      CALL J06YCF(XX+0.02,YY-5.0/SDY) ! Draw line to X,Y
      CALL J06YBF(4.5/SDX,0.0)      ! Leave a small gap.
      CALL J06ZAF(14HNet Hyetograph,14)
      CALL J06YBF(18.0/SDX,0.0)     ! Leave a small gap.
      CALL J06ZAF(20HRunoff Coefficient= ,20)
      CALL J06ZDF(RC1*100.0,4,1)
      CALL J06ZAF(3H %.,3)
      CALL J06YAF(XX,YY-10.0/SDY)   ! Move to required position on plot.
      CALL J06YCF(XX+0.02,YY-10.0/SDY) ! Draw line to X,Y
      CALL J06YBF(4.5/SDX,0.0)      ! Leave a small gap.
      CALL J06ZAF(14HSimulated Flow,14)
      CALL J06YBF(21.0/SDX,0.0)     ! Leave a small gap.
      CALL J06ZAF(20H              CATCH= ,20)
      CALL J06ZDF(CATCH1,4,1)
      CALL J06YAF(XX,YY-15.0/SDY)   ! Move to required position on plot.
      CALL J06YBF(75.0/SDX,0.0)     ! Leave a small gap.
      CALL J06ZAF(20HSimulated Peak Flow=,20)
      CALL J06ZDF(PQ1,5,2)
      CALL J06ZAF(5H l/s.,5)
      CALL J06YAF(XX,YY-20.0/SDY)   ! Move to required position on plot.
      CALL J06YBF(68.0/SDX,0.0)     ! Leave a small gap.
      CALL J06ZAF(23HSimulated Total Volume=,23)
      CALL J06ZDF(TV,6,1)
      CALL J06ZAF(7H litres,7)
```

```
      CALL CHAMOD
      CALL DEVEND
      IF (IANS.EQ.'S') THEN
      READ (5,1236) ACHR
 1236 FORMAT (1A1)
      WRITE(5,*)' 1p'
      ENDIF
C
      GOTO 999
C
1010   WRITE(5,1020)
1020   FORMAT(//,3X,' WARNING! DEPSTO > RAINFALL DEPTH FOR No. 304.104;
     * SIMULATION TERMINATED',//)
        GOTO 999
C
C      WRITING OUT ERROR MESSAGES: MISSING/ROGUE DATA.
C
1000   WRITE(5,105) IA
105    FORMAT(///,25X,'WARNING! BATTERY CHECK FAULT @ LINE ',I5)
            GOTO 999
1100  WRITE(5,2550)IB,IT(I-1),IH(I-1),IM(I-1)
2550  FORMAT(///,20X,'TIME CHANNEL ERROR AFTER LINE ',6(I4),///)
            GOTO 999
2500  WRITE (5,2510)
2510  FORMAT(///,5X,'DATA FILE TOO LONG; REDIMENSION ARRAYS --> 4500')
            GOTO 999
C
 999          STOP
              END
```

```
C
C ***************************************************************
C * LINEAR RESERVOIR MODEL: PULSE RESPONSE WITH VARIABLE "K". *
C ***************************************************************
C
C  PROGRAM MODIFIED TO READ IN RAINFALL DATA FROM CHURNET CLOSE
C  RAINGAUGE FILES AND SIMULATING FLOWS THROUGH GULLYMETER
C  No. 305.53 (CHURNET CLOSE).
C  THE PROGRAM PRODUCES LINE PRINTER OUTPUT WITH A COMPLETE
C  TABULATION OF THE SIMULATED FLOWS.
C
C    PROGRAM DEVELOPED BY :   Mr. MASUD A. PARKAR,
C    PROGRAM EDITED BY    :   Mr. G. A. FULCHER
C
C
C
C
C
C      DATE:                  JANUARY 1986.
C      *****                  *************
C
C  START OF PROGRAM : DIMENSION STATEMENTS ETC.
C
      DIMENSION IT(4500),IH(4500),IM(4500),RNF(4500)
      DIMENSION RH1(4500),Q1(4500),ET(4500)
      CHARACTER*9 NAME,DAY,MONTH,YEAR
      DOUBLE PRECISION RAD,QO,RK,RH1,DPST01
      I128 = 0; ICH = 0; IA=0; I=0
C
C  RAINFALL FILE (TAME CLOSE) NAME; INPUT AND OPENED.
C
      WRITE(5,10)
10    FORMAT(//,20X,'NAME OF RAINFALL (TAME CLOSE) FILE ?',//)
      READ(5,15) NAME
15    FORMAT(A9)
      OPEN(UNIT=20,FILE=NAME,ACCESS='SEQIN')
      DAY=NAME(7:8)
      MONTH=NAME(5:6)
      YEAR=NAME(3:4)
C
C  READING IN RAINFALL DATA AND CHECKING FOR MISSING/ROGUE VALUES.
C
5     I = I + 1
        READ(20,21,END=99) IB,IT(I),IH(I),IM(I)
21      FORMAT(6I)                              ! Data File Read.
        IF(IB.LT.238.OR.IB.GT.243) GOTO 1000 ! Battery Check.
        IHC=0;IMC=0
        IHC=IH(1)+(IM(1)+(I-1)/2)/60
        IMC=IM(1)+(I-1)/2
        IF(IHC.GE.24) IY=IHC/24
        IF(IMC.GE.60) IZ=IMC/60
        IHC=IHC-24*IY                           ! Calculated Hour.
        IMC=IMC-60*IZ                           ! Calculated Minute.
        IF(IHC.NE.IH(I)) GOTO 1100              ! Hour Check.
        IF(IMC.NE.IM(I)) GOTO 1100              ! Minute Check.
        IA=IA+1
        IF (I.EQ.4500) GOTO 2500                ! Check Array Size.
```

```
      GOTO 5
C
C  CHECKING AND ALLOWING FOR TIP COUNTS OVER 127.
C
99    DO 100 I = 2,IA
        IT(I) = IT(I) + I128
        IF (IT(I).GE.IT(I-1)) GOTO 100
        I128 = I128 + 128
        IT(I) = IT(I) + 128
100   CONTINUE
C
C  RAINGAUGE TIPS TO RAINFALL INTENSITY: START OF RAINFALL.
C
      DO 400 I = 2,IA
        IF (IT(I).EQ.IT(I-1)) 400,120
120     ICH = ICH + 1
        IF (ICH.EQ.1) 130,140
130     IP1 = I
        NT1 = IT(I) - IT(I-1)
        GOTO 400
140     IF (ICH.EQ.2) 150,250
150     IDF1 = I - IP1
152     IS = IP1 - IDF1 + 1
        T = FLOAT(IDF1)*30.0
        A = FLOAT(NT1)-0.5
        B = FLOAT(IT(I)) - FLOAT(IT(I-1))
C
C  START OF RAINFALL TO FIRST TIP: HALF BUCKET SUBTRACTED.
C
      DO 160 J = IS,IP1
        IF (IDF1.EQ.1) GOTO 165
        RNF(J) = 310.8329*A/T
        GOTO 160
165     RNF(J) = (12.86*A) - (0.6024) + (0.2515*A*A)
160   CONTINUE
C
C  FROM FIRST TIP TO SECOND TIP.
C
      DO 200 J = IP1+1,I
        IF (IDF1.EQ.1) GOTO 205
        RNF(J) = 310.8329*B/T
        GOTO 200
205     RNF(J) = (12.86*B) - (0.6024) + (0.2515*B*B)
200   CONTINUE
        GOTO 390
C
C       ALL THE REMAINING TIPS, EXCEPT THE LAST ONE.
C
250     IDF = I-IPS
        C = FLOAT(IT(I)) - FLOAT(IT(I-1))
        T = FLOAT(IDF)*30.0
      DO 220 J = IPS+1,I
        IF (IDF.EQ.1) GOTO 255
        RNF(J) = 310.8329*C/T
        GOTO 220
255     RNF(J) = (12.86*C) - (0.6024) + (0.2515*C*C)
220   CONTINUE
```

```
        IF (IT(I).EQ.IT(IA)) 300,390
C
C       LAST TIP: END OF RAINFALL CALCULATED.
C
 300      IDF = I-IPS
          T = FLOAT(IDF)*30.0
          D = (FLOAT(IT(I)) - FLOAT(IT(I-1))) - 0.5
C
       DO 275 J = I+1,I+IDF
          IF (IDF.EQ.1) GOTO 280
          RNF(J) = 310.8329*D/T
          GOTO 275
 280      RNF(J) = (12.86*D) - (0.6024) + (0.2515*D*D)
 275   CONTINUE
C
         IE = I + IDF
         GOTO 425
 390     IPS = I
 400   CONTINUE
C
C       END OF RAINFALL INTENSITY CALCULATIONS.
C
425    RC1 = 0.81; AREA1 = 241.0; CATCH1 = 10.5; DPST01 = 0.66
C
C  OUTPUT WRITE STATEMENTS.
       WRITE(3,55)
55     FORMAT(//,9X,'LINEAR RESERVOIR MODEL SIMULATION.',5X,'Churnet
     * Close Catchment No. 305.53')
       WRITE(3,58)
58     FORMAT(9X,34('='),5X,34('='),//)
       WRITE(3,60) DAY,MONTH,YEAR
60     FORMAT(9X,'CATCHMENT CHARACTERISTICS.',15X,'Date Of Event: '
     * A2,'-',A2,'-',A2)
       WRITE(3,63)
63     FORMAT(9X,26('='),15X,23('='),/)
       WRITE(3,65) DPST01,RC1*100.0,AREA1,CATCH1
65     FORMAT(9X,'Depression Storage = ',F4.2,' mm.',/,
     * 9X,'Runoff Coefficient = 'F4.1,' %.',/,
     * 9X,'Area',15X,'= ',F5.1,' m2.',/,
     * 9X,'Catch',14X,'= ',F4.1,' .',/)
C
C     DEPRESSION STORAGE LOSS SUBMODEL: Catchment No. 305.53
C
      DO 20 K = IS,IE
       RAD = RNF(K)/120.0
       IF (RAD.LE.DPST01) GOTO 25
       RH1(K) = (RAD - DPST01)*120.0
       IS1 = K
       GOTO 30
25     IF(K.EQ.(IE-1)) GOTO 1010
       DPST01 = DPST01 - RAD
       RH1(K) = 0.0
20    CONTINUE
C
30    DO 32 I = IS1+1,IE
       RH1(I) = RNF(I)
32    CONTINUE
```

```
C
C   CONSTANT PROPORTIONAL LOSS SUBMODEL: Catchment No. 305.53
C
      DO 35 L = IS1,IE
       RH1(L) = RH1(L)*RC1
35    CONTINUE
C
C   ROUTING OF EXCESS RAINFALL USING THE PULSE RESPONSE METHOD.
C
      DO 40 I = IS1,IE
       TI = 0.5
       RK = CATCH1/RH1(I)**0.5
       ITIME = INT((4.605*RK) + 1.0)
       ITEND = (2*ITIME) + I
       QO = (0.5*RH1(I)/(RK + 0.25))*(AREA1/3600.0)
      DO 45 J = I,ITEND
       IF (J.GT.(IE+60)) GOTO 40
       CN = -(TI-0.5)/RK
       QC = QO*EXP(CN)
       Q1(J) = Q1(J) + QC
       TI = TI + 0.5
45    CONTINUE
40    CONTINUE
C
C
      WRITE(3,405)
405   FORMAT(/,3X,'TIME',5X,'RAINFALL INTENSITY (mm/h)',3X,
     *'SIMULATED RUNOFF (l/s)')
      WRITE(3,407)
407   FORMAT(3X,4('='),5X,25('='),3X,22('='))
      WRITE(3,409)
409   FORMAT(2X,'Hrs Min',7X,'Total',5X,'Effective',7X,
     *'CHURNET No. 305.53')
      WRITE(3,411)
411   FORMAT(2X,'=== ===',7X,5('='),5X,9('='),7X,18('='))
      DO 90 I = IS-1,IE+30
      WRITE(3,413) IH(I),IM(I),RNF(I),RH1(I),Q1(I)
413   FORMAT(2(X,I3),8X,F5.2,7X,F5.2,15X,F5.2)
90    CONTINUE
      GOTO 999
1010   WRITE(3,1020)
1020   FORMAT(//,3X,' WARNING! DEPSTO > RAINFALL DEPTH FOR No. 305.53;
     * SIMULATION TERMINATED',//)
      GOTO 999
C
C      WRITING OUT ERROR MESSAGES: MISSING/ROGUE DATA.
C
1000   WRITE(5,105) IA
105    FORMAT(///,25X,'WARNING! BATTERY CHECK FAULT @ LINE ',I5)
            GOTO 999
1100  WRITE(5,2550)IB,IT(I-1),IH(I-1),IM(I-1)
2550  FORMAT(///,20X,'TIME CHANNEL ERROR AFTER LINE ',6(I4),///)
            GOTO 999
2500  WRITE (5,2510)
2510  FORMAT(///,5X,'DATA FILE TOO LONG; REDIMENSION ARRAYS --> 4500')
            GOTO 999
C
999   STOP
      END
```

COMPUTER PROGRAMME J.

```
C
C ***************************************************************
C * LINEAR RESERVOIR MODEL: PULSE RESPONSE WITH VARIABLE "K". *
C ***************************************************************
C
C  PROGRAM MODIFIED TO READ IN RAINFALL DATA FROM CHURNET CLOSE
C  RAINGAUGE FILES AND SIMULATING FLOWS THROUGH GULLYMETER
C  No. 305.53 (CHURNET CLOSE).  THIS PROGRAM PLOTS THE NET
C  HYETOGRAPH AND THE SIMULATED HYDROGRAPH AFTER PERFORMING
C  THE CALCULATIONS.
C
C
C  WARNING!!  THE SCREEN OPTION SWITCHES A CIFER T5 TERMINAL
C  *********  TO GRAPHICS MODE AUTOMATICALLY.  DO NOT USE THIS
C             PROGRAM WITH ANY OTHER TYPE OF TERMINAL.
C
C
C    PROGRAM DEVELOPED BY :   Mr. MASUD A. PARKAR,
C    PROGRAM EDITED BY    :   Mr. G. A. FULCHER
C
C
C
C
C
C      DATE:                  JANUARY 1986.
C      *****                  *************
C
C  START OF PROGRAM : DIMENSION STATEMENTS ETC.
C
      DIMENSION IT(4500),IH(4500),IM(4500),RNF(4500),HR(4500)
      DIMENSION RH1(4500),Q1(4500),ET(4500),NAM(9),IDATE(8)
      CHARACTER*9 NAME,DAY,MONTH,YEAR
      DOUBLE PRECISION RAD,QO,RK,RH1,DPST01,FN
      I128 = 0; ICH = 0; IA=0; I=0
C
C  RAINFALL FILE (TAME CLOSE) NAME; INPUT AND OPENED.
C
      WRITE(5,10)
10    FORMAT(//,20X,'NAME OF RAINFALL (TAME CLOSE) FILE ?',//)
      READ(5,15) FN
15    FORMAT(A9)
      REREAD 16,NAM
16    FORMAT(9A1)
      OPEN(UNIT=20,FILE=FN,ACCESS='SEQIN')
C
C  SETTING UP DATE OF EVENT FOR PLOTTING.
C
      IHYP='-'; IDATE(1)=NAM(7); IDATE(2)=NAM(8); IDATE(3)=IHYP
      IDATE(4)=NAM(5); IDATE(5)=NAM(6); IDATE(6)=IHYP
      IDATE(7)=NAM(3); IDATE(8)=NAM(4)
C
C  READING IN RAINFALL DATA AND CHECKING FOR MISSING/ROGUE VALUES.
C
5     I = I + 1
        READ(20,21,END=99) IB,IT(I),IH(I),IM(I)
21      FORMAT(6I)                              ! Data File Read.
        IF(IB.LT.238.OR.IB.GT.243) GOTO 1000 ! Battery Check.
```

```
        IHC=0;IMC=0
        IHC=IH(1)+(IM(1)+(I-1)/2)/60
        IMC=IM(1)+(I-1)/2
        IF(IHC.GE.24) IY=IHC/24
        IF(IMC.GE.60) IZ=IMC/60
        IHC=IHC-24*IY                          ! Calculated Hour.
        IMC=IMC-60*IZ                          ! Calculated Minute.
        IF(IHC.NE.IH(I)) GOTO 1100             ! Hour Check.
        IF(IMC.NE.IM(I)) GOTO 1100             ! Minute Check.
        IA=IA+1
        IF (I.EQ.4500) GOTO 2500               ! Check Array Size.
        HR(I) = FLOAT(IH(1))+(FLOAT(IM(1))+(FLOAT(I)-1.0)/2.0)/60.0
      GOTO 5
C
C  CHECKING AND ALLOWING FOR TIP COUNTS OVER 127.
C
99    DO 100 I = 2,IA
        IT(I) = IT(I) + I128
        IF (IT(I).GE.IT(I-1)) GOTO 100
        I128 = I128 + 128
        IT(I) = IT(I) + 128
100   CONTINUE
C
C  RAINGAUGE TIPS TO RAINFALL INTENSITY: START OF RAINFALL.
C
      DO 400 I = 2,IA
        IF (IT(I).EQ.IT(I-1)) 400,120
120     ICH = ICH + 1
        IF (ICH.EQ.1) 130,140
130     IP1 = I
        NT1 = IT(I) - IT(I-1)
        GOTO 400
140     IF (ICH.EQ.2) 150,250
150     IDF1 = I - IP1
152     IS = IP1 - IDF1 + 1
        T = FLOAT(IDF1)*30.0
        A = FLOAT(NT1)-0.5
        B = FLOAT(IT(I)) - FLOAT(IT(I-1))
C
C  START OF RAINFALL TO FIRST TIP: HALF BUCKET SUBTRACTED.
C
      DO 160 J = IS,IP1
        IF (IDF1.EQ.1) GOTO 165
        RNF(J) = 310.8329*A/T
        GOTO 160
165     RNF(J) = (12.86*A) - (0.6024) + (0.2515*A*A)
160   CONTINUE
C
C  FROM FIRST TIP TO SECOND TIP.
C
      DO 200 J = IP1+1,I
        IF (IDF1.EQ.1) GOTO 205
        RNF(J) = 310.8329*B/T
        GOTO 200
205     RNF(J) = (12.86*B) - (0.6024) + (0.2515*B*B)
200   CONTINUE
        GOTO 390
```

```
C
C       ALL THE REMAINING TIPS, EXCEPT THE LAST ONE.
C
250     IDF = I-IPS
        C = FLOAT(IT(I)) - FLOAT(IT(I-1))
        T = FLOAT(IDF)*30.0
      DO 220 J = IPS+1,I
        IF (IDF.EQ.1) GOTO 255
        RNF(J) = 310.8329*C/T
        GOTO 220
255     RNF(J) = (12.86*C) - (0.6024) + (0.2515*C*C)
220   CONTINUE
        IF (IT(I).EQ.IT(IA)) 300,390
C
C       LAST TIP: END OF RAINFALL CALCULATED.
C
 300      IDF = I-IPS
          T = FLOAT(IDF)*30.0
          D = (FLOAT(IT(I)) - FLOAT(IT(I-1))) - 0.5
C
       DO 275 J = I+1,I+IDF
          IF (IDF.EQ.1) GOTO 280
          RNF(J) = 310.8329*D/T
          GOTO 275
 280      RNF(J) = (12.86*D) - (0.6024) + (0.2515*D*D)
 275   CONTINUE
C
         IE = I + IDF
         GOTO 425
 390     IPS = I
 400   CONTINUE
C
C       END OF RAINFALL INTENSITY CALCULATIONS.
C
425    RC1 = 0.81; AREA1 = 241.0; CATCH1 = 10.5; DPST01 = 0.66
       DS1 = DPST01
C
C     DEPRESSION STORAGE LOSS SUBMODEL: Catchment No. 305.53
C
      DO 20 K = IS,IE
       RAD = RNF(K)/120.0
       IF (RAD.LE.DPST01) GOTO 25
       RH1(K) = (RAD - DPST01)*120.0
       IS1 = K
       GOTO 30
25     IF(K.EQ.(IE-1)) GOTO 1010
       DPST01 = DPST01 - RAD
       RH1(K) = 0.0
20    CONTINUE
C
30    DO 32 I = IS1+1,IE
       RH1(I) = RNF(I)
32    CONTINUE
C
C   CONSTANT PROPORTIONAL LOSS SUBMODEL: Catchment No. 305.53
C
      DO 35 L = IS1,IE
```

```
       RH1(L) = RH1(L)*RC1
35     CONTINUE
C
C    ROUTING OF EXCESS RAINFALL USING THE PULSE RESPONSE METHOD.
C
       DO 40 I = IS1,IE
        TI = 0.5
        RK = CATCH1/RH1(I)**0.5
        ITIME = INT((4.605*RK) + 1.0)
        ITEND = (2*ITIME) + I
        QO = (0.5*RH1(I)/(RK + 0.25))*(AREA1/3600.0)
       DO 45 J = I,ITEND
        IF (J.GT.(IE+60)) GOTO 40
        CN = -(TI-0.5)/RK
        QC = QO*EXP(CN)
        Q1(J) = Q1(J) + QC
        TI = TI + 0.5
45     CONTINUE
40     CONTINUE
C
C  OBTAINING PEAK VALUES AND TOTAL VOLUME
C
       PRNF=0.0; PQ1=0.0; TV=0.0
       DO 429 I=1,IA
        IF(RNF(I).GT.PRNF) PRNF = RNF(I)
        IF(Q1(I).GT.PQ1) PQ1 = Q1(I)
        TV = TV + (Q1(I)+Q1(I+1))*15.0
429    CONTINUE
C
C  PLOTTING ROUTINES USING NAG GRAPHICAL SUPPLEMENT.
C  ************************************************
C
       CALL X04AAF(1,5)              ! Error messages to screen.
C
C  SELECT AND SET UP PLOTTING DEVICES (SCREEN OR PAPER).
C
       WRITE(5,2)
2      FORMAT(/,'  CHURNET CLOSE (No. 305.53) SIMULATION',//
      *'  Do you want a Screen or Paper plot? (S or P)',/)
       READ(5,4) IANS
4      FORMAT(80A1)
       IF (IANS.EQ.'S') THEN
       WRITE(5,*)' h'
       CALL T4014; SDX=365.0; SDY=365.0
       ENDIF
       IF (IANS.EQ.'P') THEN
       CALL C1039; SDX=860.0; SDY=860.0
       ENDIF
       XFR=210.0; YFR=297.0; XPL=20.0; YPL=20.0
C
       CALL PICCLE                   ! Clear drawing area.
       CALL J06WAF                   ! Initialise the NAG system.
C
C INITIALISE AND DRAW A4 SIZE BORDER.
C
       XU=(XPL+XFR)/SDX; XL=XPL/SDX; YU=(YPL+YFR)/SDY; YL=YPL/SDY
       CALL J06WBF(0.0,1.0,0.0,1.0,0)!Defines mapping area of data region.
```

```
      CALL J06WCF(XL,XU,YL,YU)      ! Sets current viewport on plot surface.
      CALL J06YAF(0.0,0.0)          !
      CALL J06YCF(0.995,0.0)        !
      CALL J06YCF(0.995,0.995)      ! DRAWS A4 SIZE BORDER
      CALL J06YCF(0.0,0.995)        !
      CALL J06YCF(0.0,0.0)          !
C
C  INVERTED HYETOGRAPH - UPSIDE DOWN WINDOW SET.
C  DRAW RECORDED AND NET HYETOGRAPHS FOR No. 305.53
C
      XWU=0.95; XWL=0.12; YWU=0.8; YWL=0.55
      XU=(XPL+XWU*XFR)/SDX; XL=(XPL+XWL*XFR)/SDX
      YU=(YPL+YWU*YFR)/SDY; YL=(YPL+YWL*YFR)/SDY
      CALL J06WBF(HR(1),HR(IA),1.1*PRNF,0.0,1)!Reversed Y-max.  Y-min.

      CALL J06WCF(XL,XU,YL,YU)      ! Set current viewport on plot surface.
      DELX=1.0/120.0
      CALL J06YAF(HR(1)-DELX,0.0)   ! Move pen to the point X,Y
      DO 60 I=2,IA                  !
      CALL J06YCF(HR(I)-DELX,RH1(I))!
      CALL J06YCF(HR(I),RH1(I))     ! Loop draws net hyetograph (inverted).
60    CONTINUE                      !
      CALL J06XDF(2,2,3,3)          ! Set red colour marker.
      CALL J06YMF(2)                ! Set line type (2 = broken).
      CALL J06XFF(2)                ! Set high quality marker.
      CALL J06YAF(HR(1)-DELX,0.0)   ! Move pen to the point X,Y
      DO 175 I=2,IA                 !
      CALL J06YCF(HR(I)-DELX,RNF(I))!
      CALL J06YCF(HR(I),RNF(I))     ! Loop draws total hyetograph (inverted).
175   CONTINUE                      !
      CALL J06XDF(1,1,1,1)          ! Set black colour marker.
      CALL J06YMF(1)                ! Set line type to normal.
      CALL J06XFF(2)                ! Set high quality marker.
      CALL J06AEF                   ! Draw frame round plot and add axis.
      CALL J06AJF(2,24HRainfall Intensity mm/hr,24)! Label Y-axis.
C
C DRAW SIMULATED HYDROGRAPH FOR No. 305.53 (CHURNET).
C
      XWU=0.95; XWL=0.12; YWU=0.55; YWL=0.3
      XU=(XPL+XWU*XFR)/SDX; XL=(XPL+XWL*XFR)/SDX
      YU=(YPL+YWU*YFR)/SDY; YL=(YPL+YWL*YFR)/SDY
      CALL J06YJF(0.00005)          ! Set marker size.
      CALL J06XHF(0.5)              ! Set marker size scale factor.
      CALL J06WCF(XL,XU,YL,YU)      ! Set current viewport on plot surface.
      CALL J06WBF(HR(1),HR(IA),0.0,1.1*PQ1,1)! Set axis max./min. values.
      CALL J06BAF(HR,Q1,IA,1,1,0)   ! Draw 305.53 Simulated hydrograph.
      CALL J06AEF                   ! Draw frame round plot and add axis.
      CALL J06AJF(2,9HFlow  l/s,9) ! Label Y-axis.
C
C ADD HEADINGS, DATE AND X-AXIS TITLE.
C
      XX=(XPL+0.18*XFR)/SDX; YY=(YPL+0.9*YFR)/SDY
      CALL J06WBF(0.0,1.0,0.0,1.0,0)! Defines mapping area of data region.
      CALL J06WCF(0.0,1.0,0.0,1.0) ! Set current viewport on plot surface.
      CALL J06XGF(1.0,1.0)          ! Set scale factor for character size.
      CALL J06XHF(1.0)              ! Set marker size scale factor.
      CALL J06YLF(3.0/SDX,0.0)      ! Set character spacing .
      CALL J06YKF(2.5/SDX,3.0/SDY) ! Set character width and height size.
```

```
      CALL J06YJF(2.0)              ! Set marker size.
      CALL J06XFF(2)                ! Set high quality marker.
      CALL J06YAF(XX,YY)            ! Move to required position on plot.
      CALL J06ZAF(42HLINEAR RESERVOIR MODEL SIMULATION PLOT FOR,42)
      CALL J06YBF(-127.0/SDX,-5.0/SDY)! Move position by X,Y increments.
      CALL J06ZAF(39HCHURNET CLOSE MICROCATCHMENT No. 305.53,39)
      XX=(XPL+0.54*XFR)/SDX; YY=(YPL+0.83*YFR)/SDY
      CALL J06YAF(XX,YY)            ! Move to required position on plot.
      CALL J06ZAF(16HDate of Event : ,16)
      CALL J06YHF(IDATE,8)          ! Write the date of event.
      XX=(XPL+0.48*XFR)/SDX; YY=(YPL+0.30*YFR)/SDY
      CALL J06YAF(XX,YY)            ! Move to required position on plot.
      CALL J06YKF(1.5/SDX,2.0/SDY) ! Set character width and height size.
      CALL J06YLF(3.0/SDX,0.0)      ! Set character spacing .
      CALL J06ZAF(11HTIME (Hrs.),11)! Label X-axis.
C
C  WRITING OUT THE KEY
C
      XX=(XPL+0.15*XFR)/SDX; YY=(YPL+0.26*YFR)/SDY
      CALL J06YAF(XX,YY)            ! Move to required position on plot.
      CALL J06XDF(2,2,3,3)          ! Set red colour marker.
      CALL J06YMF(2)                ! Set line type (2 = broken).
      CALL J06XFF(2)                ! Set high quality marker.
      CALL J06YCF(XX+0.02,YY)       ! Draw line to X,Y
      CALL J06YBF(4.5/SDX,0.0)      ! Leave a small gap.
      CALL J06XDF(1,1,1,1)          ! Set black colour marker.
      CALL J06YMF(1)                ! Set line type to normal.
      CALL J06ZAF(16HTotal Hyetograph,16)
      CALL J06YBF(12.0/SDX,0.0)     ! Leave a small gap.
      CALL J06ZAF(20HDepression Storage= ,20)
      CALL J06ZDF(DS1,4,2)
      CALL J06ZAF(4H mm.,4)
      CALL J06YAF(XX,YY-5.0/SDY)    ! Move to required position on plot.
      CALL J06YCF(XX+0.02,YY-5.0/SDY) ! Draw line to X,Y
      CALL J06YBF(4.5/SDX,0.0)      ! Leave a small gap.
      CALL J06ZAF(14HNet Hyetograph,14)
      CALL J06YBF(18.0/SDX,0.0)     ! Leave a small gap.
      CALL J06ZAF(20HRunoff Coefficient= ,20)
      CALL J06ZDF(RC1*100.0,4,1)
      CALL J06ZAF(3H %.,3)
      CALL J06YAF(XX,YY-10.0/SDY)   ! Move to required position on plot.
      CALL J06YCF(XX+0.02,YY-10.0/SDY) ! Draw line to X,Y
      CALL J06YBF(4.5/SDX,0.0)      ! Leave a small gap.
      CALL J06ZAF(14HSimulated Flow,14)
      CALL J06YBF(21.0/SDX,0.0)     ! Leave a small gap.
      CALL J06ZAF(20H              CATCH= ,20)
      CALL J06ZDF(CATCH1,4,1)
      CALL J06YAF(XX,YY-15.0/SDY)   ! Move to required position on plot.
      CALL J06YBF(75.0/SDX,0.0)     ! Leave a small gap.
      CALL J06ZAF(20HSimulated Peak Flow=,20)
      CALL J06ZDF(PQ1,5,2)
      CALL J06ZAF(5H l/s.,5)
      CALL J06YAF(XX,YY-20.0/SDY)   ! Move to required position on plot.
      CALL J06YBF(68.0/SDX,0.0)     ! Leave a small gap.
      CALL J06ZAF(23HSimulated Total Volume=,23)
      CALL J06ZDF(TV,6,1)
      CALL J06ZAF(7H litres,7)
```

```
      CALL CHAMOD
      CALL DEVEND
      IF (IANS.EQ.'S') THEN
      READ (5,1236) ACHR
 1236 FORMAT (1A1)
      WRITE(5,*)' 1p'
      ENDIF
C
      GOTO 999
C
1010   WRITE(5,1020)
1020   FORMAT(//,3X,' WARNING! DEPSTO > RAINFALL DEPTH FOR No. 305.53;
     * SIMULATION TERMINATED',//)
        GOTO 999
C
C      WRITING OUT ERROR MESSAGES: MISSING/ROGUE DATA.
C
1000   WRITE(5,105) IA
105    FORMAT(///,25X,'WARNING! BATTERY CHECK FAULT @ LINE ',I5)
            GOTO 999
1100  WRITE(5,2550)IB,IT(I-1),IH(I-1),IM(I-1)
2550  FORMAT(///,20X,'TIME CHANNEL ERROR AFTER LINE ',6(I4),///)
            GOTO 999
2500  WRITE (5,2510)
2510  FORMAT(///,5X,'DATA FILE TOO LONG; REDIMENSION ARRAYS --> 4500')
            GOTO 999
C
 999        STOP
            END
```

COMPUTER PROGRAMME K.

```
C
C ****************************************************************
C * LINEAR RESERVOIR MODEL: PULSE RESPONSE WITH VARIABLE "K". *
C ****************************************************************
C
C  PROGRAM MODIFIED TO READ IN RAINFALL DATA FROM TWYFORD GARDENS
C  RAINGAUGE FILES AND SIMULATING FLOWS THROUGH GULLYMETER
C  No. 301.39 (TWYFORD GARDENS).
C  THE PROGRAM PRODUCES LINE PRINTER OUTPUT WITH A COMPLETE
C  TABULATION OF THE SIMULATED FLOWS.
C
C    PROGRAM DEVELOPED BY :   Mr. MASUD A. PARKAR,
C    PROGRAM EDITED BY    :   Mr. G. A. FULCHER
C
C
C
C
C
C      DATE:                  JANUARY 1986.
C      *****                  *************
C
C  START OF PROGRAM : DIMENSION STATEMENTS ETC.
C
      DIMENSION IT(4500),IH(4500),IM(4500),RNF(4500)
      DIMENSION RH1(4500),Q1(4500),ET(4500)
      CHARACTER*9 NAME,DAY,MONTH,YEAR
      DOUBLE PRECISION RAD,QO,RK,RH1,DPSTO1
      I128 = 0; ICH = 0; IA=0; I=0
C
C  RAINFALL FILE (TAME CLOSE) NAME; INPUT AND OPENED.
C
      WRITE(5,10)
10    FORMAT(//,20X,'NAME OF RAINFALL (TAME CLOSE) FILE ?',//)
      READ(5,15) NAME
15    FORMAT(A9)
      OPEN(UNIT=20,FILE=NAME,ACCESS='SEQIN')
      DAY=NAME(7:8)
      MONTH=NAME(5:6)
      YEAR=NAME(3:4)
C
C  READING IN RAINFALL DATA AND CHECKING FOR MISSING/ROGUE VALUES.
C
5     I = I + 1
        READ(20,21,END=99) IB,IT(I),IH(I),IM(I)
21      FORMAT(6I)                              ! Data File Read.
        IF(IB.LT.238.OR.IB.GT.243) GOTO 1000 ! Battery Check.
        IHC=0;IMC=0
        IHC=IH(1)+(IM(1)+(I-1)/2)/60
        IMC=IM(1)+(I-1)/2
        IF(IHC.GE.24) IY=IHC/24
        IF(IMC.GE.60) IZ=IMC/60
        IHC=IHC-24*IY                           ! Calculated Hour.
        IMC=IMC-60*IZ                           ! Calculated Minute.
        IF(IHC.NE.IH(I)) GOTO 1100              ! Hour Check.
        IF(IMC.NE.IM(I)) GOTO 1100              ! Minute Check.
        IA=IA+1
        IF (I.EQ.4500) GOTO 2500                ! Check Array Size.
```

```
      GOTO 5
C
C  CHECKING AND ALLOWING FOR TIP COUNTS OVER 127.
C
99    DO 100 I = 2,IA
        IT(I) = IT(I) + I128
        IF (IT(I).GE.IT(I-1)) GOTO 100
        I128 = I128 + 128
        IT(I) = IT(I) + 128
100   CONTINUE
C
C  RAINGAUGE TIPS TO RAINFALL INTENSITY: START OF RAINFALL.
C
      DO 400 I = 2,IA
        IF (IT(I).EQ.IT(I-1)) 400,120
120     ICH = ICH + 1
        IF (ICH.EQ.1) 130,140
130     IP1 = I
        NT1 = IT(I) - IT(I-1)
        GOTO 400
140     IF (ICH.EQ.2) 150,250
150     IDF1 = I - IP1
152     IS = IP1 - IDF1 + 1
        T = FLOAT(IDF1)*30.0
        A = FLOAT(NT1)-0.5
        B = FLOAT(IT(I)) - FLOAT(IT(I-1))
C
C  START OF RAINFALL TO FIRST TIP: HALF BUCKET SUBTRACTED.
C
      DO 160 J = IS,IP1
        IF (IDF1.EQ.1) GOTO 165
        RNF(J) = 310.8329*A/T
        GOTO 160
165     RNF(J) = (12.86*A) - (0.6024) + (0.2515*A*A)
160   CONTINUE
C
C  FROM FIRST TIP TO SECOND TIP.
C
      DO 200 J = IP1+1,I
        IF (IDF1.EQ.1) GOTO 205
        RNF(J) = 310.8329*B/T
        GOTO 200
205     RNF(J) = (12.86*B) - (0.6024) + (0.2515*B*B)
200   CONTINUE
        GOTO 390
C
C       ALL THE REMAINING TIPS, EXCEPT THE LAST ONE.
C
250     IDF = I-IPS
        C = FLOAT(IT(I)) - FLOAT(IT(I-1))
        T = FLOAT(IDF)*30.0
      DO 220 J = IPS+1,I
        IF (IDF.EQ.1) GOTO 255
        RNF(J) = 310.8329*C/T
        GOTO 220
255     RNF(J) = (12.86*C) - (0.6024) + (0.2515*C*C)
220   CONTINUE
```

```
        IF (IT(I).EQ.IT(IA)) 300,390
C
C       LAST TIP: END OF RAINFALL CALCULATED.
C
 300      IDF = I-IPS
          T = FLOAT(IDF)*30.0
          D = (FLOAT(IT(I)) - FLOAT(IT(I-1))) - 0.5
C
       DO 275 J = I+1,I+IDF
          IF (IDF.EQ.1) GOTO 280
          RNF(J) = 310.8329*D/T
          GOTO 275
 280      RNF(J) = (12.86*D) - (0.6024) + (0.2515*D*D)
 275   CONTINUE
C
         IE = I + IDF
         GOTO 425
 390     IPS = I
 400   CONTINUE
C
C       END OF RAINFALL INTENSITY CALCULATIONS.
C
425    RC1 = 0.83; AREA1 = 382.0; CATCH1 = 15.9; DPSTO1 = 1.22
C
C  OUTPUT WRITE STATEMENTS.
       WRITE(3,55)
55     FORMAT(//,9X,'LINEAR RESERVOIR MODEL SIMULATION.',5X,'Twyford
     * Gardens Catchment No. 301.39')
       WRITE(3,58)
58     FORMAT(9X,34('='),5X,36('='),//)
       WRITE(3,60) DAY,MONTH,YEAR
60     FORMAT(9X,'CATCHMENT CHARACTERISTICS.',15X,'Date Of Event: '
     * A2,'-',A2,'-',A2)
       WRITE(3,63)
63     FORMAT(9X,26('='),15X,23('='),/)
       WRITE(3,65) DPSTO1,RC1*100.0,AREA1,CATCH1
65     FORMAT(9X,'Depression Storage = ',F4.2,' mm.',/,
     * 9X,'Runoff Coefficient = 'F4.1,' %.',/,
     * 9X,'Area',15X,'= ',F5.1,' m2.',/,
     * 9X,'Catch',14X,'= ',F4.1,' .',/)
C
C     DEPRESSION STORAGE LOSS SUBMODEL: Catchment No. 301.39
C
      DO 20 K = IS,IE
       RAD = RNF(K)/120.0
       IF (RAD.LE.DPSTO1) GOTO 25
       RH1(K) = (RAD - DPSTO1)*120.0
       IS1 = K
       GOTO 30
25     IF(K.EQ.(IE-1)) GOTO 1010
       DPSTO1 = DPSTO1 - RAD
       RH1(K) = 0.0
20    CONTINUE
C
30    DO 32 I = IS1+1,IE
       RH1(I) = RNF(I)
32    CONTINUE
```

```
C
C   CONSTANT PROPORTIONAL LOSS SUBMODEL: Catchment No. 301.39
C
      DO 35 L = IS1,IE
       RH1(L) = RH1(L)*RC1
35    CONTINUE
C
C   ROUTING OF EXCESS RAINFALL USING THE PULSE RESPONSE METHOD.
C
      DO 40 I = IS1,IE
       TI = 0.5
       RK = CATCH1/RH1(I)**0.5
       ITIME = INT((4.605*RK) + 1.0)
       ITEND = (2*ITIME) + I
       QO = (0.5*RH1(I)/(RK + 0.25))*(AREA1/3600.0)
      DO 45 J = I,ITEND
       IF (J.GT.(IE+60)) GOTO 40
       CN = -(TI-0.5)/RK
       QC = QO*EXP(CN)
       Q1(J) = Q1(J) + QC
       TI = TI + 0.5
45    CONTINUE
40    CONTINUE
C
C
      WRITE(3,405)
405   FORMAT(/,3X,'TIME',5X,'RAINFALL INTENSITY (mm/h)',3X,
     *'SIMULATED RUNOFF (l/s)')
      WRITE(3,407)
407   FORMAT(3X,4('='),5X,25('='),3X,22('='))
      WRITE(3,409)
409   FORMAT(2X,'Hrs Min',7X,'Total',5X,'Effective',7X,
     *'TWYFORD No. 301.39')
      WRITE(3,411)
411   FORMAT(2X,'=== ===',7X,5('='),5X,9('='),7X,18('='))
      DO 90 I = IS-1,IE+30
      WRITE(3,413) IH(I),IM(I),RNF(I),RH1(I),Q1(I)
413   FORMAT(2(X,I3),8X,F5.2,7X,F5.2,15X,F5.2)
90    CONTINUE
      GOTO 999
1010   WRITE(3,1020)
1020   FORMAT(//,3X,' WARNING! DEPSTO > RAINFALL DEPTH FOR No. 301.39;
     * SIMULATION TERMINATED',//)
      GOTO 999
C
C      WRITING OUT ERROR MESSAGES: MISSING/ROGUE DATA.
C
1000   WRITE(5,105) IA
105    FORMAT(///,25X,'WARNING! BATTERY CHECK FAULT @ LINE ',I5)
            GOTO 999
1100  WRITE(5,2550)IB,IT(I-1),IH(I-1),IM(I-1)
2550  FORMAT(///,20X,'TIME CHANNEL ERROR AFTER LINE ',6(I4),///)
            GOTO 999
2500  WRITE (5,2510)
2510  FORMAT(///,5X,'DATA FILE TOO LONG; REDIMENSION ARRAYS --> 4500')
            GOTO 999
C
999   STOP
      END
```

COMPUTER PROGRAMME L.

```
C
C ***************************************************************
C * LINEAR RESERVOIR MODEL: PULSE RESPONSE WITH VARIABLE "K". *
C ***************************************************************
C
C  PROGRAM MODIFIED TO READ IN RAINFALL DATA FROM TWYFORD GARDENS
C  RAINGAUGE FILES AND SIMULATING FLOWS THROUGH GULLYMETER
C  No. 301.39 (TWYFORD GARDENS).  THIS PROGRAM PLOTS THE NET
C  HYETOGRAPH AND THE SIMULATED HYDROGRAPH AFTER PERFORMING
C  THE CALCULATIONS.
C
C
C  WARNING!!  THE SCREEN OPTION SWITCHES A CIFER T5 TERMINAL
C  *********  TO GRAPHICS MODE AUTOMATICALLY.  DO NOT USE THIS
C             PROGRAM WITH ANY OTHER TYPE OF TERMINAL.
C
C
C    PROGRAM DEVELOPED BY :   Mr. MASUD A. PARKAR,
C    PROGRAM EDITED BY    :   Mr. G. A. FULCHER
C
C
C
C
C
C      DATE:                  JANUARY 1986.
C      *****                  *************
C
C  START OF PROGRAM : DIMENSION STATEMENTS ETC.
C
      DIMENSION IT(4500),IH(4500),IM(4500),RNF(4500),HR(4500)
      DIMENSION RH1(4500),Q1(4500),ET(4500),NAM(9),IDATE(8)
      CHARACTER*9 NAME,DAY,MONTH,YEAR
      DOUBLE PRECISION RAD,QO,RK,RH1,DPST01,FN
      I128 = 0; ICH = 0; IA=0; I=0
C
C  RAINFALL FILE (TAME CLOSE) NAME; INPUT AND OPENED.
C
      WRITE(5,10)
10    FORMAT(//,20X,'NAME OF RAINFALL (TAME CLOSE) FILE ?',//)
      READ(5,15) FN
15    FORMAT(A9)
      REREAD 16,NAM
16    FORMAT(9A1)
      OPEN(UNIT=20,FILE=FN,ACCESS='SEQIN')
C
C  SETTING UP DATE OF EVENT FOR PLOTTING.
C
      IHYP='-'; IDATE(1)=NAM(7); IDATE(2)=NAM(8); IDATE(3)=IHYP
      IDATE(4)=NAM(5); IDATE(5)=NAM(6); IDATE(6)=IHYP
      IDATE(7)=NAM(3); IDATE(8)=NAM(4)
C
C  READING IN RAINFALL DATA AND CHECKING FOR MISSING/ROGUE VALUES.
C
5     I = I + 1
        READ(20,21,END=99) IB,IT(I),IH(I),IM(I)
21      FORMAT(6I)                              ! Data File Read.
        IF(IB.LT.238.OR.IB.GT.243) GOTO 1000 ! Battery Check.
```

```
        IHC=0;IMC=0
        IHC=IH(1)+(IM(1)+(I-1)/2)/60
        IMC=IM(1)+(I-1)/2
        IF(IHC.GE.24) IY=IHC/24
        IF(IMC.GE.60) IZ=IMC/60
        IHC=IHC-24*IY                          ! Calculated Hour.
        IMC=IMC-60*IZ                          ! Calculated Minute.
        IF(IHC.NE.IH(I)) GOTO 1100             ! Hour Check.
        IF(IMC.NE.IM(I)) GOTO 1100             ! Minute Check.
        IA=IA+1
        IF (I.EQ.4500) GOTO 2500               ! Check Array Size.
        HR(I) = FLOAT(IH(1))+(FLOAT(IM(1))+(FLOAT(I)-1.0)/2.0)/60.0
      GOTO 5
C
C  CHECKING AND ALLOWING FOR TIP COUNTS OVER 127.
C
99    DO 100 I = 2,IA
        IT(I) = IT(I) + I128
        IF (IT(I).GE.IT(I-1)) GOTO 100
        I128 = I128 + 128
        IT(I) = IT(I) + 128
100   CONTINUE
C
C  RAINGAUGE TIPS TO RAINFALL INTENSITY: START OF RAINFALL.
C
      DO 400 I = 2,IA
        IF (IT(I).EQ.IT(I-1)) 400,120
120     ICH = ICH + 1
        IF (ICH.EQ.1) 130,140
130     IP1 = I
        NT1 = IT(I) - IT(I-1)
        GOTO 400
140     IF (ICH.EQ.2) 150,250
150     IDF1 = I - IP1
152     IS = IP1 - IDF1 + 1
        T = FLOAT(IDF1)*30.0
        A = FLOAT(NT1)-0.5
        B = FLOAT(IT(I)) - FLOAT(IT(I-1))
C
C  START OF RAINFALL TO FIRST TIP: HALF BUCKET SUBTRACTED.
C
      DO 160 J = IS,IP1
        IF (IDF1.EQ.1) GOTO 165
        RNF(J) = 310.8329*A/T
        GOTO 160
165     RNF(J) = (12.86*A) - (0.6024) + (0.2515*A*A)
160   CONTINUE
C
C  FROM FIRST TIP TO SECOND TIP.
C
      DO 200 J = IP1+1,I
        IF (IDF1.EQ.1) GOTO 205
        RNF(J) = 310.8329*B/T
        GOTO 200
205     RNF(J) = (12.86*B) - (0.6024) + (0.2515*B*B)
200   CONTINUE
        GOTO 390
```

```
C
C       ALL THE REMAINING TIPS, EXCEPT THE LAST ONE.
C
250     IDF = I-IPS
        C = FLOAT(IT(I)) - FLOAT(IT(I-1))
        T = FLOAT(IDF)*30.0
      DO 220 J = IPS+1,I
        IF (IDF.EQ.1) GOTO 255
        RNF(J) = 310.8329*C/T
        GOTO 220
255     RNF(J) = (12.86*C) - (0.6024) + (0.2515*C*C)
220   CONTINUE
        IF (IT(I).EQ.IT(IA)) 300,390
C
C       LAST TIP: END OF RAINFALL CALCULATED.
C
 300      IDF = I-IPS
          T = FLOAT(IDF)*30.0
          D = (FLOAT(IT(I)) - FLOAT(IT(I-1))) - 0.5
C
       DO 275 J = I+1,I+IDF
          IF (IDF.EQ.1) GOTO 280
          RNF(J) = 310.8329*D/T
          GOTO 275
 280      RNF(J) = (12.86*D) - (0.6024) + (0.2515*D*D)
 275   CONTINUE
C
         IE = I + IDF
         GOTO 425
 390     IPS = I
 400   CONTINUE
C
C       END OF RAINFALL INTENSITY CALCULATIONS.
C
425    RC1 = 0.83; AREA1 = 382.0; CATCH1 = 15.9; DPST01 = 1.22
       DS1 = DPST01
C
C     DEPRESSION STORAGE LOSS SUBMODEL: Catchment No. 301.39
C
      DO 20 K = IS,IE
       RAD = RNF(K)/120.0
       IF (RAD.LE.DPST01) GOTO 25
       RH1(K) = (RAD - DPST01)*120.0
       IS1 = K
       GOTO 30
25     IF(K.EQ.(IE-1)) GOTO 1010
       DPST01 = DPST01 - RAD
       RH1(K) = 0.0
20    CONTINUE
C
30    DO 32 I = IS1+1,IE
       RH1(I) = RNF(I)
32    CONTINUE
C
C   CONSTANT PROPORTIONAL LOSS SUBMODEL: Catchment No. 301.39
C
      DO 35 L = IS1,IE
```

```
       RH1(L) = RH1(L)*RC1
35     CONTINUE
C
C    ROUTING OF EXCESS RAINFALL USING THE PULSE RESPONSE METHOD.
C
       DO 40 I = IS1,IE
        TI = 0.5
        RK = CATCH1/RH1(I)**0.5
        ITIME = INT((4.605*RK) + 1.0)
        ITEND = (2*ITIME) + I
        Q0 = (0.5*RH1(I)/(RK + 0.25))*(AREA1/3600.0)
       DO 45 J = I,ITEND
        IF (J.GT.(IE+60)) GOTO 40
        CN = -(TI-0.5)/RK
        QC = Q0*EXP(CN)
        Q1(J) = Q1(J) + QC
        TI = TI + 0.5
45     CONTINUE
40     CONTINUE
C
C  OBTAINING PEAK VALUES AND TOTAL VOLUME
C
       PRNF=0.0; PQ1=0.0; TV=0.0
       DO 429 I=1,IA
        IF(RNF(I).GT.PRNF) PRNF = RNF(I)
        IF(Q1(I).GT.PQ1) PQ1 = Q1(I)
        TV = TV + (Q1(I)+Q1(I+1))*15.0
429    CONTINUE
C
C  PLOTTING ROUTINES USING NAG GRAPHICAL SUPPLEMENT.
C  ************************************************
C
       CALL X04AAF(1,5)              ! Error messages to screen.
C
C  SELECT AND SET UP PLOTTING DEVICES (SCREEN OR PAPER).
C
       WRITE(5,2)
2      FORMAT(/,'  TWYFORD GARDENS (No. 301.39) SIMULATION',//
      *'  Do you want a Screen or Paper plot? (S or P)',/)
       READ(5,4) IANS
4      FORMAT(80A1)
       IF (IANS.EQ.'S') THEN
       WRITE(5,*)' h'
       CALL T4014; SDX=365.0; SDY=365.0
       ENDIF
       IF (IANS.EQ.'P') THEN
       CALL C1039; SDX=860.0; SDY=860.0
       ENDIF
       XFR=210.0; YFR=297.0; XPL=20.0; YPL=20.0
C
       CALL PICCLE                   ! Clear drawing area.
       CALL J06WAF                   ! Initialise the NAG system.
C
C INITIALISE AND DRAW A4 SIZE BORDER.
C
       XU=(XPL+XFR)/SDX; XL=XPL/SDX; YU=(YPL+YFR)/SDY; YL=YPL/SDY
       CALL J06WBF(0.0,1.0,0.0,1.0,0)!Defines mapping area of data region.
```

```
      CALL J06WCF(XL,XU,YL,YU)      ! Sets current viewport on plot surface.
      CALL J06YAF(0.0,0.0)          !
      CALL J06YCF(0.995,0.0)        !
      CALL J06YCF(0.995,0.995)      ! DRAWS A4 SIZE BORDER
      CALL J06YCF(0.0,0.995)        !
      CALL J06YCF(0.0,0.0)          !
C
C  INVERTED HYETOGRAPH - UPSIDE DOWN WINDOW SET.
C  DRAW RECORDED AND NET HYETOGRAPHS FOR No. 301.39
C
      XWU=0.95; XWL=0.12; YWU=0.8; YWL=0.55
      XU=(XPL+XWU*XFR)/SDX; XL=(XPL+XWL*XFR)/SDX
      YU=(YPL+YWU*YFR)/SDY; YL=(YPL+YWL*YFR)/SDY
      CALL J06WBF(HR(1),HR(IA),1.1*PRNF,0.0,1)!Reversed Y-max.  Y-min.

      CALL J06WCF(XL,XU,YL,YU)      ! Set current viewport on plot surface.
      DELX=1.0/120.0
      CALL J06YAF(HR(1)-DELX,0.0)   ! Move pen to the point X,Y
      DO 60 I=2,IA                  !
      CALL J06YCF(HR(I)-DELX,RH1(I))!
      CALL J06YCF(HR(I),RH1(I))     ! Loop draws net hyetograph (inverted).
60    CONTINUE                      !
      CALL J06XDF(2,2,3,3)          ! Set red colour marker.
      CALL J06YMF(2)                ! Set line type (2 = broken).
      CALL J06XFF(2)                ! Set high quality marker.
      CALL J06YAF(HR(1)-DELX,0.0)   ! Move pen to the point X,Y
      DO 175 I=2,IA                 !
      CALL J06YCF(HR(I)-DELX,RNF(I))!
      CALL J06YCF(HR(I),RNF(I))     ! Loop draws total hyetograph (inverted).
175   CONTINUE                      !
      CALL J06XDF(1,1,1,1)          ! Set black colour marker.
      CALL J06YMF(1)                ! Set line type to normal.
      CALL J06XFF(2)                ! Set high quality marker.
      CALL J06AEF                   ! Draw frame round plot and add axis.
      CALL J06AJF(2,24HRainfall Intensity mm/hr,24)! Label Y-axis.
C
C DRAW SIMULATED HYDROGRAPH FOR No. 301.39 (TWYFORD).
C
      XWU=0.95; XWL=0.12; YWU=0.55; YWL=0.3
      XU=(XPL+XWU*XFR)/SDX; XL=(XPL+XWL*XFR)/SDX
      YU=(YPL+YWU*YFR)/SDY; YL=(YPL+YWL*YFR)/SDY
      CALL J06YJF(0.00005)          ! Set marker size.
      CALL J06XHF(0.5)              ! Set marker size scale factor.
      CALL J06WCF(XL,XU,YL,YU)      ! Set current viewport on plot surface.
      CALL J06WBF(HR(1),HR(IA),0.0,1.1*PQ1,1)! Set axis max./min. values.
      CALL J06BAF(HR,Q1,IA,1,1,0)   ! Draw 301.39 Simulated hydrograph.
      CALL J06AEF                   ! Draw frame round plot and add axis.
      CALL J06AJF(2,9HFlow  l/s,9) ! Label Y-axis.
C
C ADD HEADINGS, DATE AND X-AXIS TITLE.
C
      XX=(XPL+0.18*XFR)/SDX; YY=(YPL+0.9*YFR)/SDY
      CALL J06WBF(0.0,1.0,0.0,1.0,0)! Defines mapping area of data region.
      CALL J06WCF(0.0,1.0,0.0,1.0) ! Set current viewport on plot surface.
      CALL J06XGF(1.0,1.0)          ! Set scale factor for character size.
      CALL J06XHF(1.0)              ! Set marker size scale factor.
      CALL J06YLF(3.0/SDX,0.0)      ! Set character spacing .
      CALL J06YKF(2.5/SDX,3.0/SDY) ! Set character width and height size.
```

```
      CALL J06YJF(2.0)              ! Set marker size.
      CALL J06XFF(2)                ! Set high quality marker.
      CALL J06YAF(XX,YY)            ! Move to required position on plot.
      CALL J06ZAF(42HLINEAR RESERVOIR MODEL SIMULATION PLOT FOR,42)
      CALL J06YBF(-127.0/SDX,-5.0/SDY)! Move position by X,Y increments.
      CALL J06ZAF(41HTWYFORD GARDENS MICROCATCHMENT No. 301.39,41)
      XX=(XPL+0.54*XFR)/SDX; YY=(YPL+0.83*YFR)/SDY
      CALL J06YAF(XX,YY)            ! Move to required position on plot.
      CALL J06ZAF(16HDate of Event : ,16)
      CALL J06YHF(IDATE,8)          ! Write the date of event.
      XX=(XPL+0.48*XFR)/SDX; YY=(YPL+0.30*YFR)/SDY
      CALL J06YAF(XX,YY)            ! Move to required position on plot.
      CALL J06YKF(1.5/SDX,2.0/SDY) ! Set character width and height size.
      CALL J06YLF(3.0/SDX,0.0)      ! Set character spacing .
      CALL J06ZAF(11HTIME (Hrs.),11)! Label X-axis.
C
C  WRITING OUT THE KEY
C
      XX=(XPL+0.15*XFR)/SDX; YY=(YPL+0.26*YFR)/SDY
      CALL J06YAF(XX,YY)            ! Move to required position on plot.
      CALL J06XDF(2,2,3,3)          ! Set red colour marker.
      CALL J06YMF(2)                ! Set line type (2 = broken).
      CALL J06XFF(2)                ! Set high quality marker.
      CALL J06YCF(XX+0.02,YY)       ! Draw line to X,Y
      CALL J06YBF(4.5/SDX,0.0)      ! Leave a small gap.
      CALL J06XDF(1,1,1,1)          ! Set black colour marker.
      CALL J06YMF(1)                ! Set line type to normal.
      CALL J06ZAF(16HTotal Hyetograph,16)
      CALL J06YBF(12.0/SDX,0.0)     ! Leave a small gap.
      CALL J06ZAF(20HDepression Storage= ,20)
      CALL J06ZDF(DS1,4,2)
      CALL J06ZAF(4H mm.,4)
      CALL J06YAF(XX,YY-5.0/SDY)    ! Move to required position on plot.
      CALL J06YCF(XX+0.02,YY-5.0/SDY) ! Draw line to X,Y
      CALL J06YBF(4.5/SDX,0.0)      ! Leave a small gap.
      CALL J06ZAF(14HNet Hyetograph,14)
      CALL J06YBF(18.0/SDX,0.0)     ! Leave a small gap.
      CALL J06ZAF(20HRunoff Coefficient= ,20)
      CALL J06ZDF(RC1*100.0,4,1) .
      CALL J06ZAF(3H %.,3)
      CALL J06YAF(XX,YY-10.0/SDY)   ! Move to required position on plot.
      CALL J06YCF(XX+0.02,YY-10.0/SDY) ! Draw line to X,Y
      CALL J06YBF(4.5/SDX,0.0)      ! Leave a small gap.
      CALL J06ZAF(14HSimulated Flow,14)
      CALL J06YBF(21.0/SDX,0.0)     ! Leave a small gap.
      CALL J06ZAF(20H              CATCH= ,20)
      CALL J06ZDF(CATCH1,4,1)
      CALL J06YAF(XX,YY-15.0/SDY)   ! Move to required position on plot.
      CALL J06YBF(75.0/SDX,0.0)     ! Leave a small gap.
      CALL J06ZAF(20HSimulated Peak Flow=,20)
      CALL J06ZDF(PQ1,5,2)
      CALL J06ZAF(5H l/s.,5)
      CALL J06YAF(XX,YY-20.0/SDY)   ! Move to required position on plot.
      CALL J06YBF(68.0/SDX,0.0)     ! Leave a small gap.
      CALL J06ZAF(23HSimulated Total Volume=,23)
      CALL J06ZDF(TV,6,1)
      CALL J06ZAF(7H litres,7)
```

```
      CALL CHAMOD
      CALL DEVEND
      IF (IANS.EQ.'S') THEN
      READ (5,1236) ACHR
 1236 FORMAT (1A1)
      WRITE(5,*)' 1p'
      ENDIF
C
      GOTO 999
C
1010   WRITE(5,1020)
1020   FORMAT(//,3X,' WARNING! DEPSTO > RAINFALL DEPTH FOR No. 301.39;
     * SIMULATION TERMINATED',//)
        GOTO 999
C
C      WRITING OUT ERROR MESSAGES: MISSING/ROGUE DATA.
C
1000   WRITE(5,105) IA
105    FORMAT(///,25X,'WARNING! BATTERY CHECK FAULT @ LINE ',I5)
            GOTO 999
1100  WRITE(5,2550)IB,IT(I-1),IH(I-1),IM(I-1)
2550  FORMAT(///,20X,'TIME CHANNEL ERROR AFTER LINE ',6(I4),///)
            GOTO 999
2500  WRITE (5,2510)
2510  FORMAT(///,5X,'DATA FILE TOO LONG; REDIMENSION ARRAYS --> 4500')
            GOTO 999
C
 999        STOP
            END
```

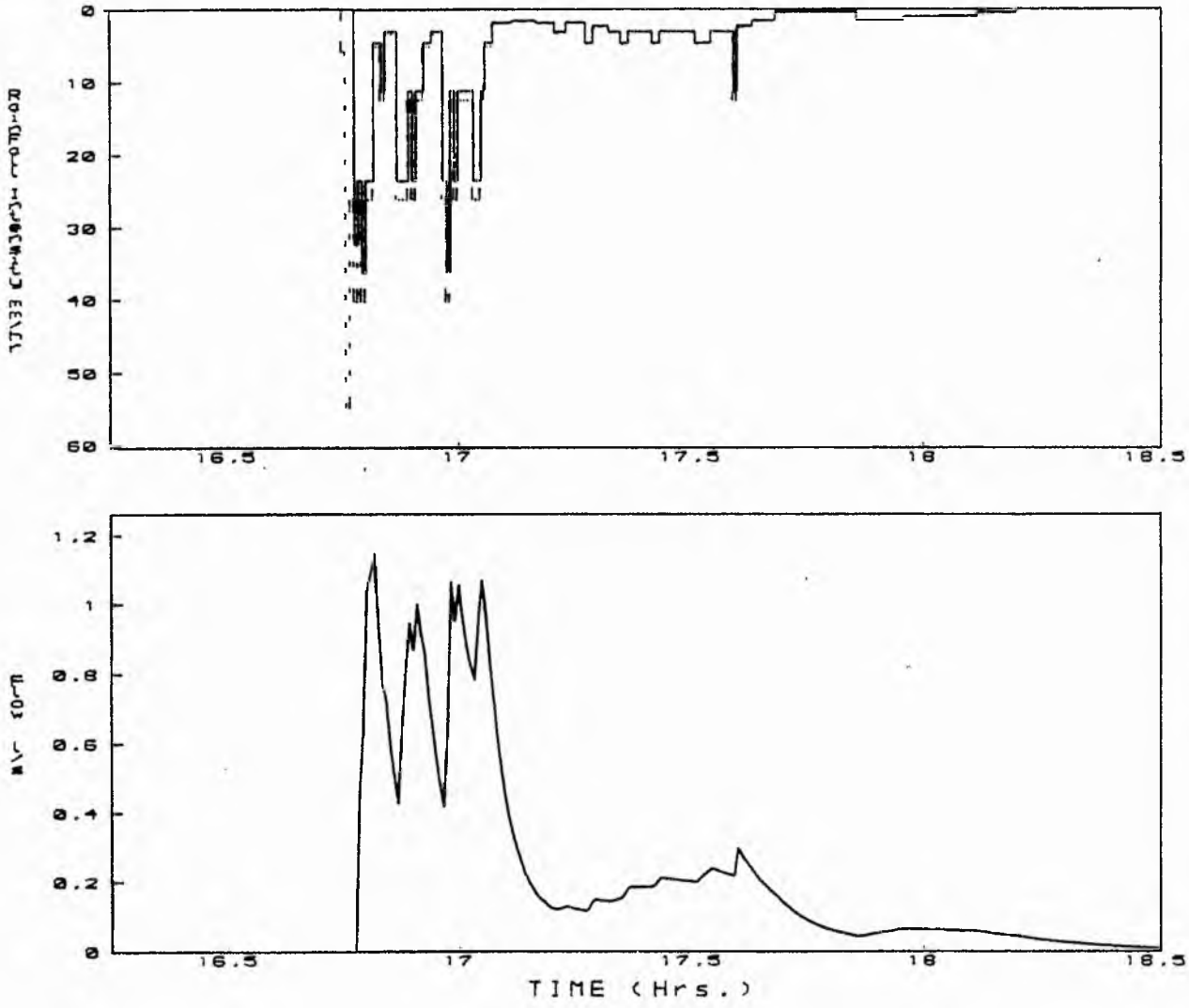
APPENDIX B.

Reference: Chapter 4 and Chapter 8.

Inverted Storm Hyetograph and Inlet Storm Hydrograph Plots for the Rainstorm Events Analysed in the "Storm Event Sampling Programme". The figures for the simulated peak flow (in litres per second) and the simulated flow volume (in litres) are given on the graphs.

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TAME CLOSE MICROCATCHMENT

Date of Event : 20-06-84

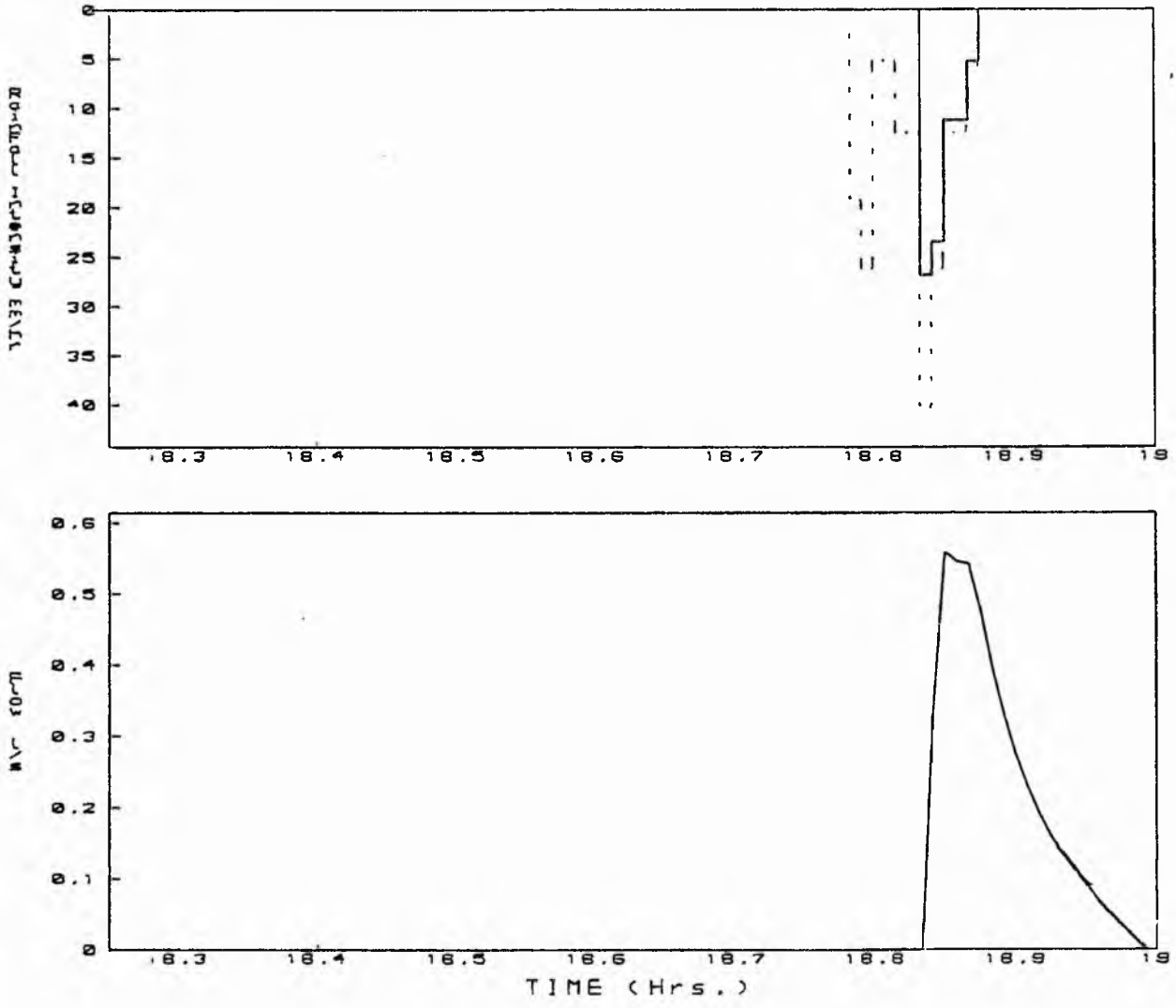


_ _ _ _ _ Total Hyetograph
_____ Net Hyetograph
_____ Simulated Flow

Depression Storage= 0.76 mm.
Runoff Coefficient= 90.0 %.
CATCH= 11.5
Simulated Peak Flow= 1.15 l/s.
Simulated Total Volume=1468.6 litre

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TAME CLOSE MICROCATCHMENT

Date of Event : 12-07-84

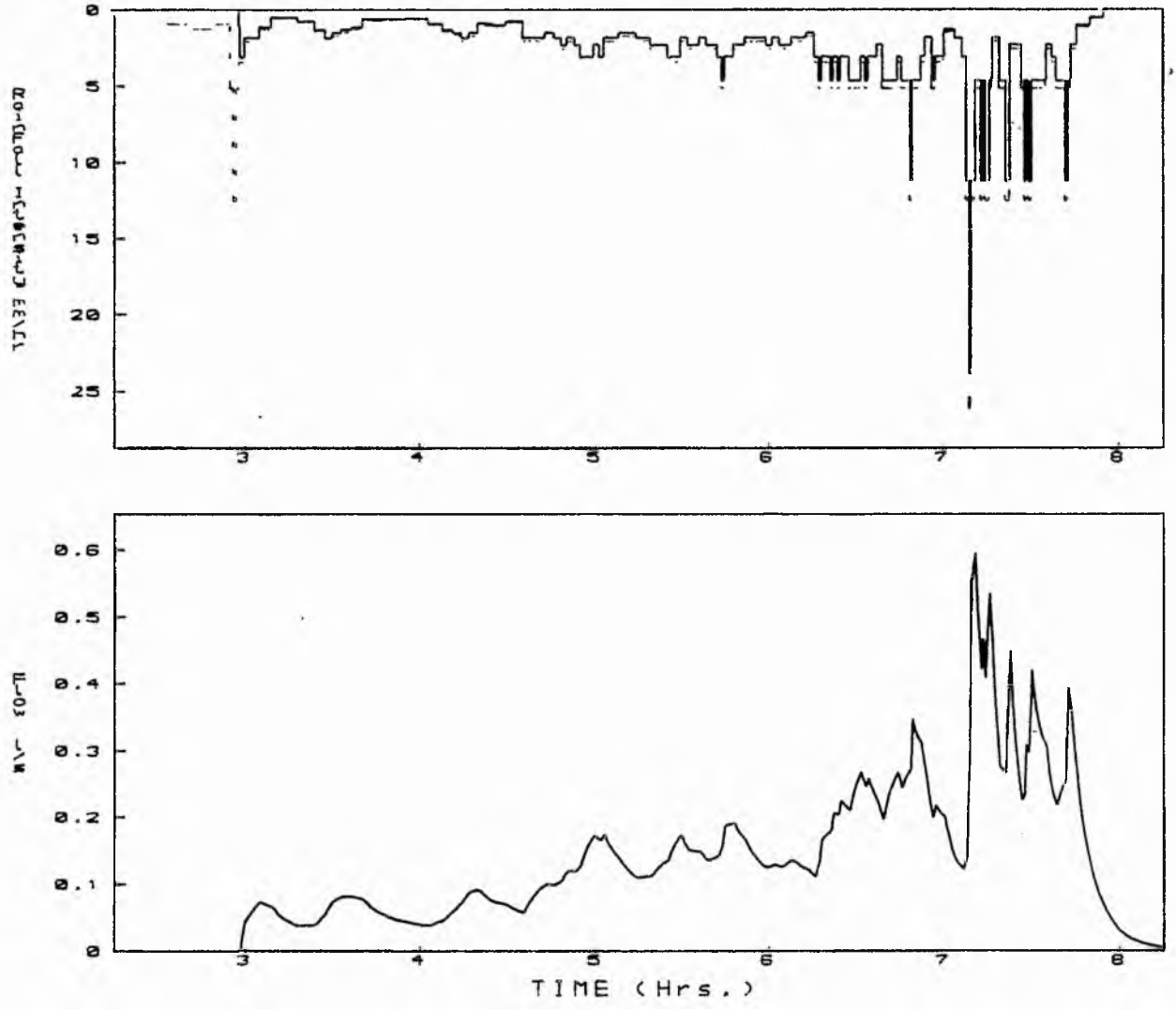


. . . . . Total Hyetograph
_____ Net Hyetograph
_____ Simulated Flow

Depression Storage= 0.76 mm.
RunoFF CoeFficient= 90.0 %.
CATCH= 11.5
Simulated Peak Flow= 0.56 l/s.
Simulated Total Volume= 142.6 litres

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TAME CLOSE MICROCATCHMENT

Date of Event : 02-08-84



_ _ _ _ _ Total Hyetograph

_____ Net Hyetograph

_____ Simulated Flow

Depression Storage= 0.76 mm.

RunoFF CoeFFicient= 90.0 %.

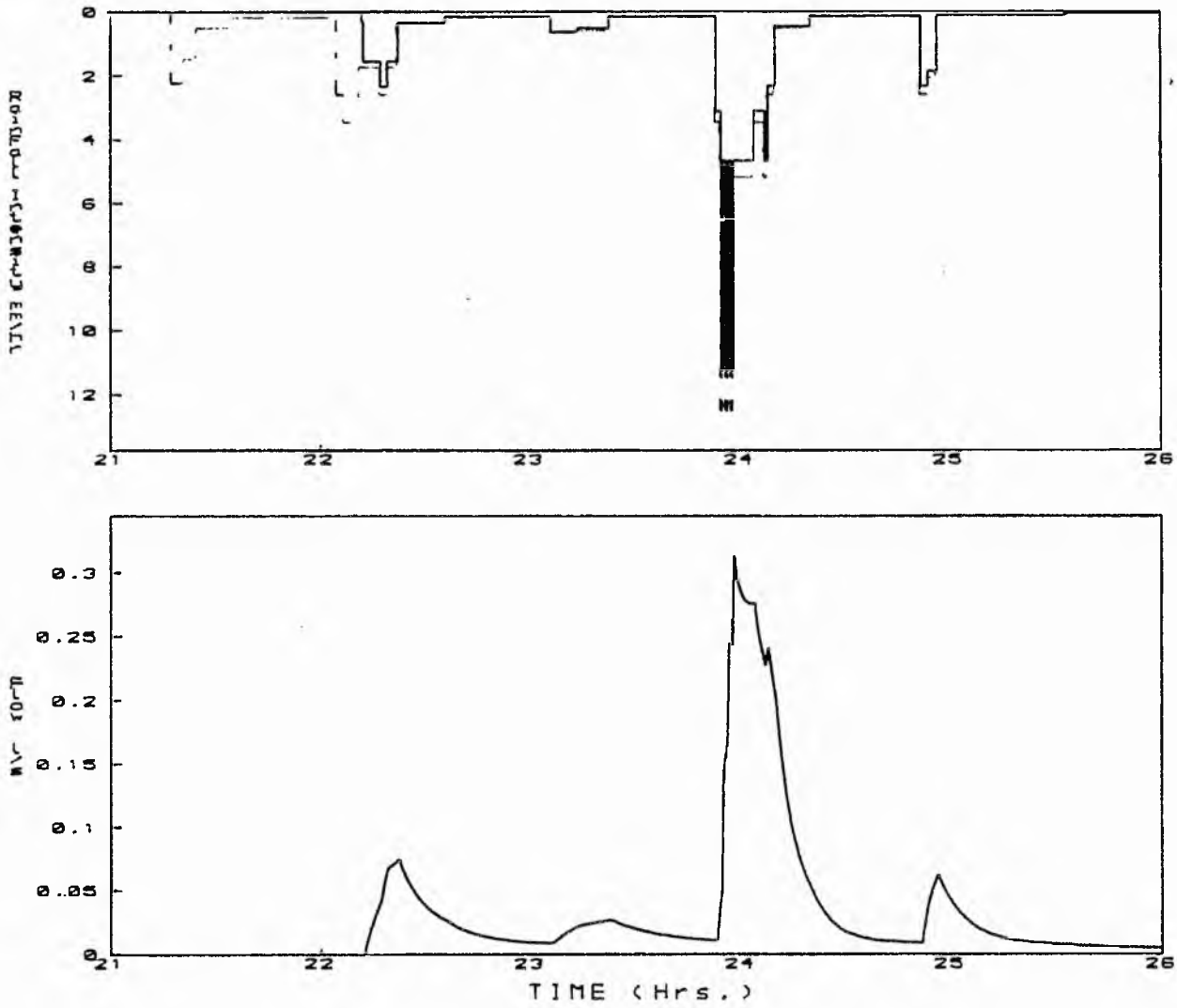
CATCH= 11.5

Simulated Peak Flow= 0.59 l/s.

Simulated Total Volume=2736.0 litres

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TAME CLOSE MICROCATCHMENT

Date of Event : 13-09-84



. . . . . Total Hyetograph

_____ Net Hyetograph

_____ Simulated Flow

Depression Storage= 0.76 mm.

RunoFF CoeFFicient= 90.0 %.

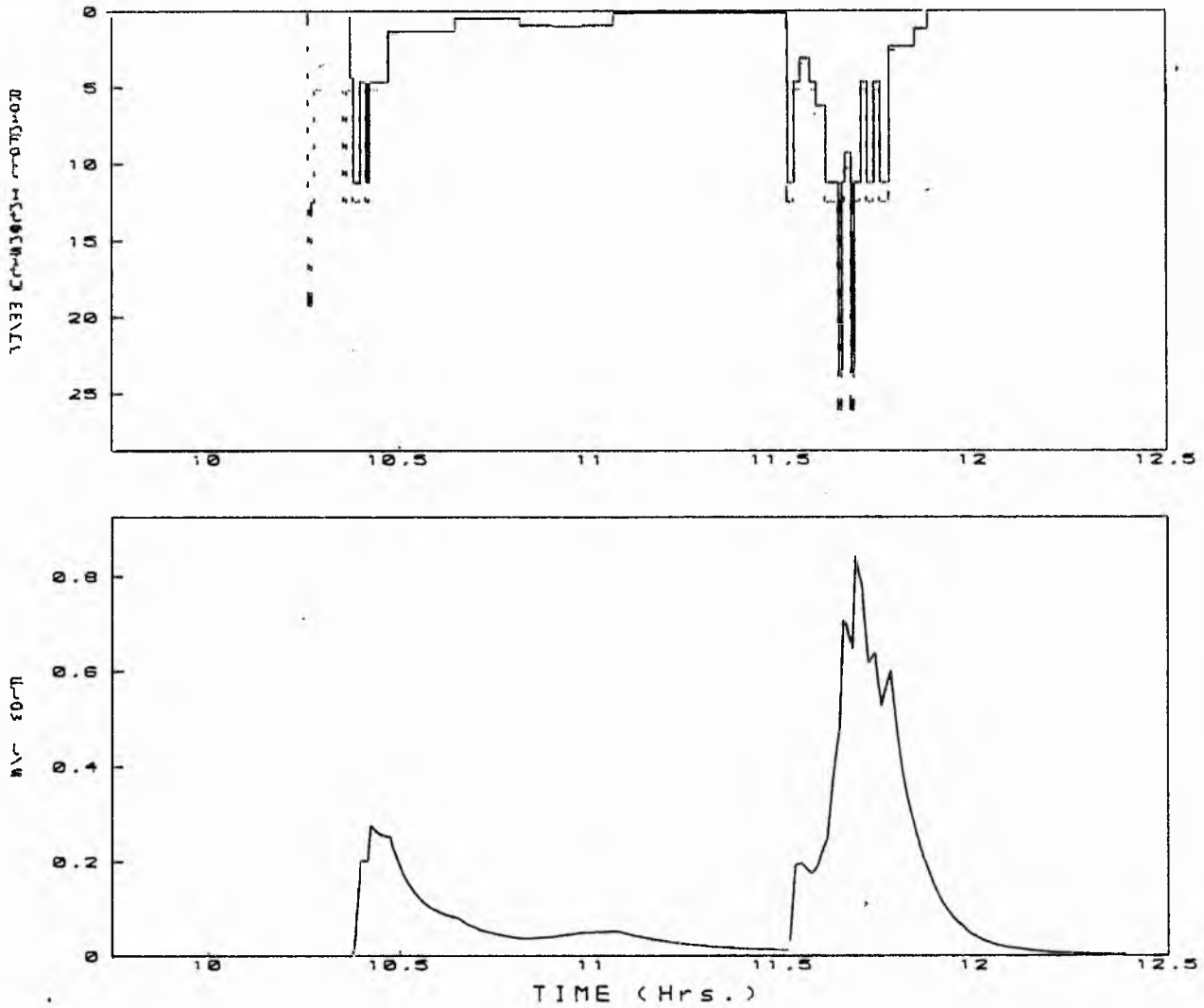
CATCH= 11.5

Simulated Peak Flow= 0.31 l/s.

Simulated Total Volume= 529.2 litres

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TAME CLOSE MICROCATCHMENT

Date of Event : 02-11-84

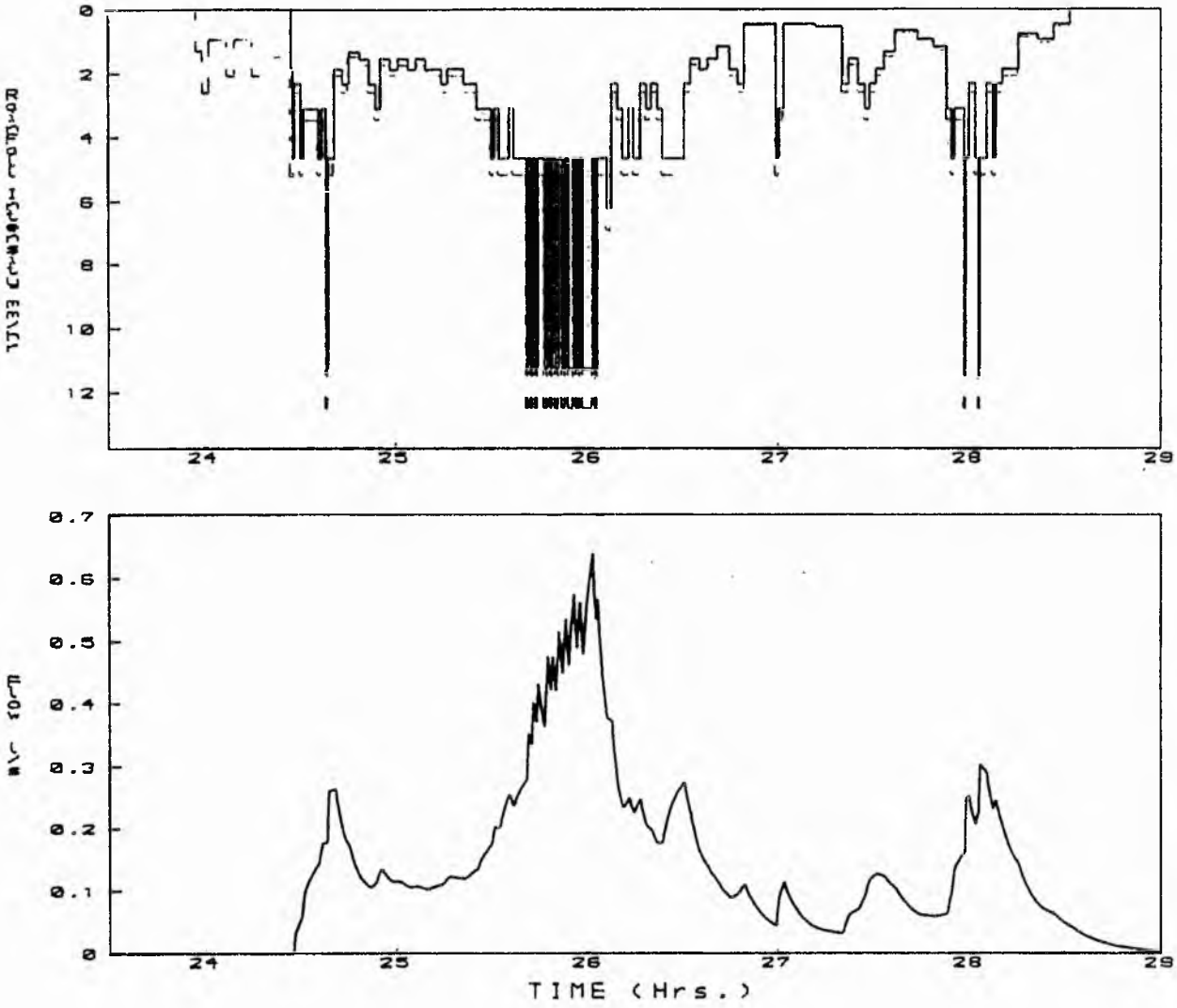


. . . . . Total Hyetograph
_____ Net Hyetograph
_____ Simulated Flow

Depression Storage= 0.76 mm.
RunoFF CoeFFicient= 90.0 %.
CATCH= 11.5
Simulated Peak Flow= 0.84 l/s.
Simulated Total Volume= 869.5 litres

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TAME CLOSE MICROCATCHMENT

Date of Event : 07-11-85

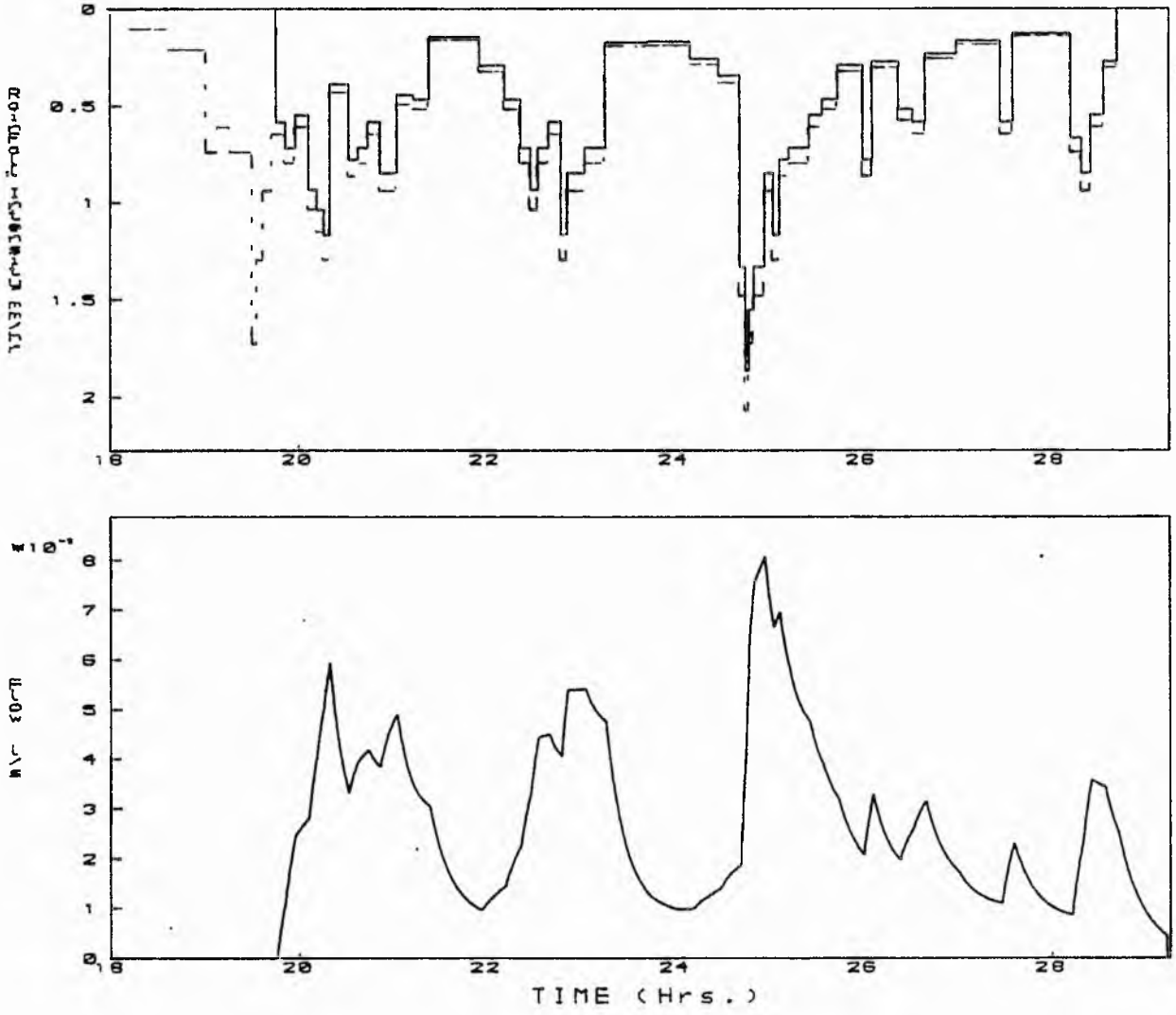


. . . . . Total Hyetograph
_____ Net Hyetograph
_____ Simulated Flow

Depression Storage= 0.76 mm.
RunoFF CoeFficient= 90.0 %.
CATCH= 11.5
Simulated Peak Flow= 0.64 l/s.
Simulated Total Volume=2518.1 litre

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TAME CLOSE MICROCATCHMENT

Date of Event : 14-11-85



_ _ _ _ _ Total Hyetograph

_____ Net Hyetograph

_____ Simulated Flow

Depression Storage= 0.76 mm.

RunoFF CoeFFicient= 90.0 %.

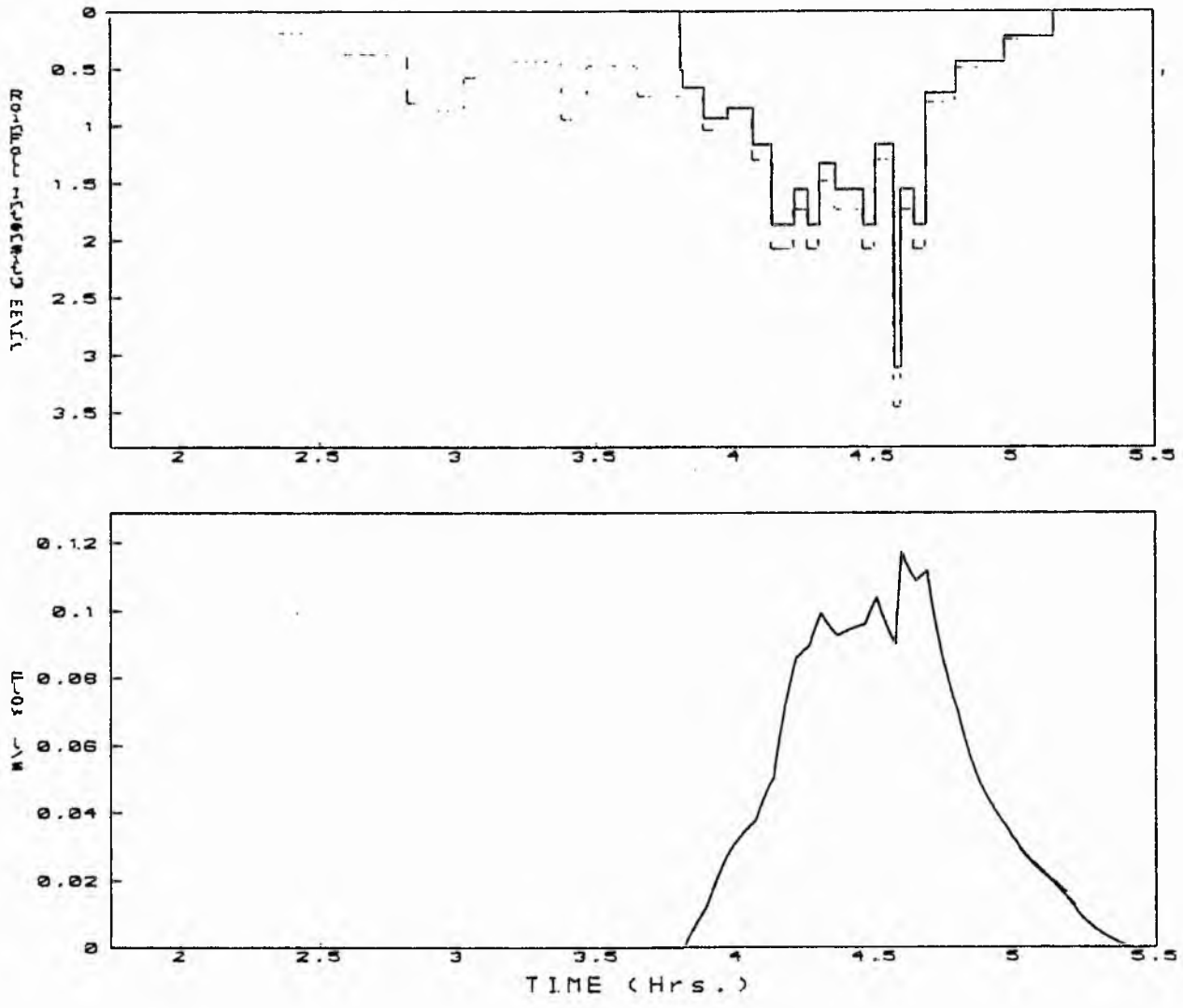
CATCH= 11.5

Simulated Peak Flow= 0.08 l/s.

Simulated Total Volume= 946.8 litres

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TAME CLOSE MICROCATCHMENT

Date of Event : 30-11-85



. . . . . Total Hyetograph

_____ Net Hyetograph

_____ Simulated Flow

Depression Storage= 0.76 mm.

RunoFF CoeFFicient= 90.0 %.

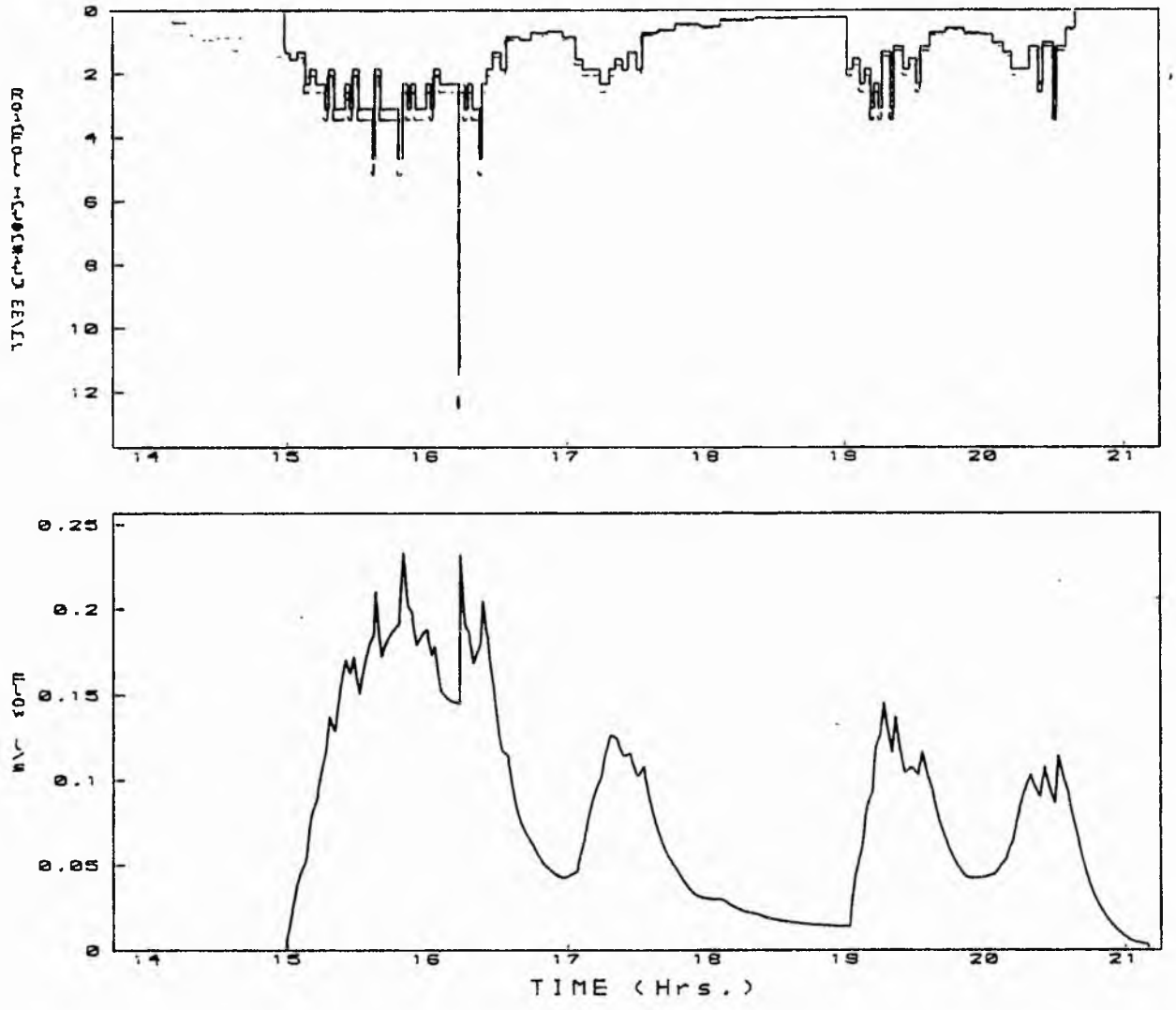
CATCH= 11.5

Simulated Peak Flow= 0.12 l/s.

Simulated Total Volume= 314.3 litres

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TAME CLOSE MICROCATCHMENT

Date of Event : 06-12-85

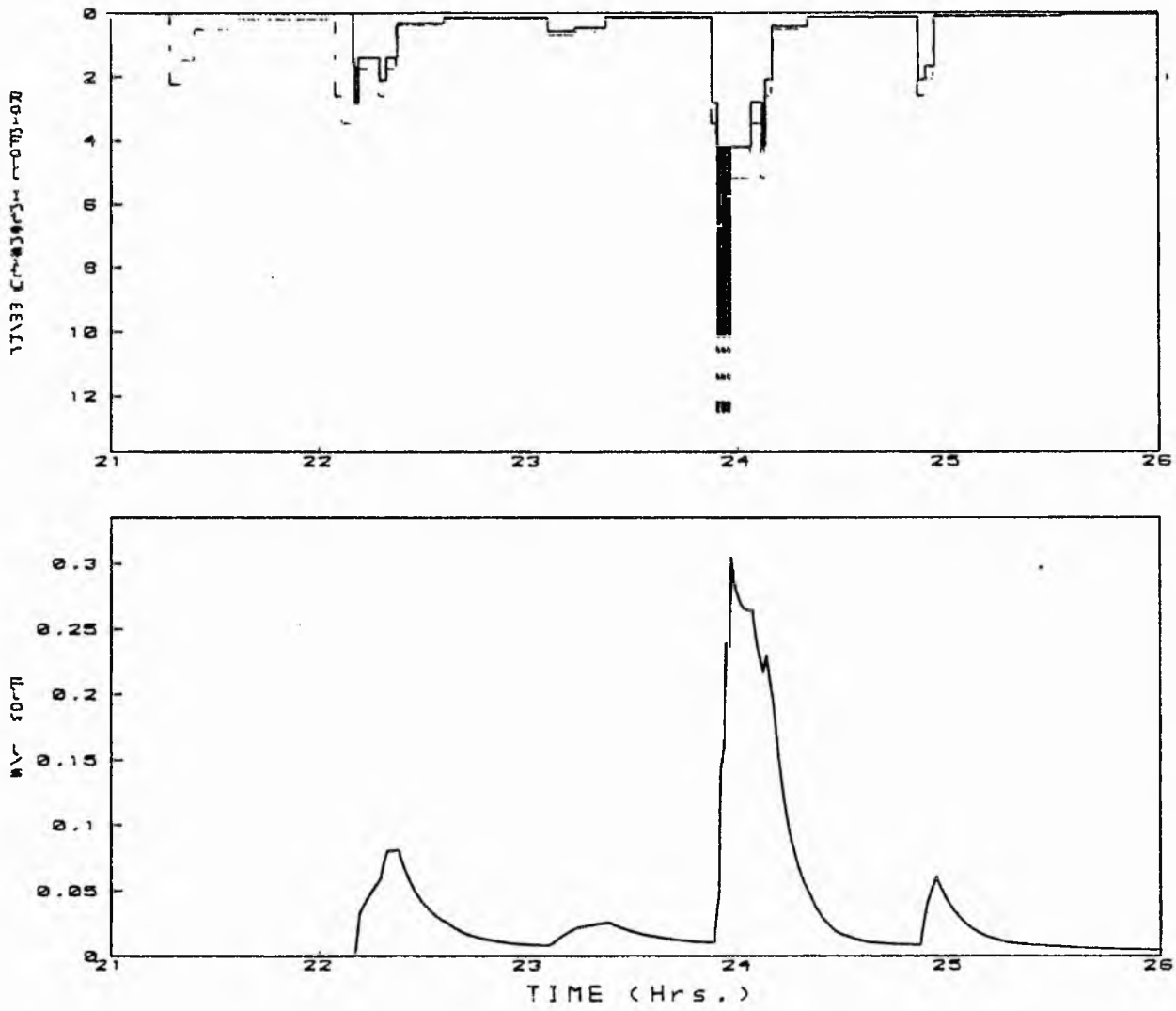


. . . . . Total Hyetograph
_____ Net Hyetograph
_____ Simulated Flow

Depression Storage= 0.76 mm.
RunoFF CoeFFicient= 90.0 %.
CATCH= 11.5
Simulated Peak Flow= 0.23 l/s.
Simulated Total Volume=1814.8 litres

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR CHURNET CLOSE MICROCATCHMENT

Date of Event : 13-09-84



Total Hyetograph

Net Hyetograph

Simulated Flow

Depression Storage= 0.66 mm.

RunoFF CoeFficient= 81.0 %.

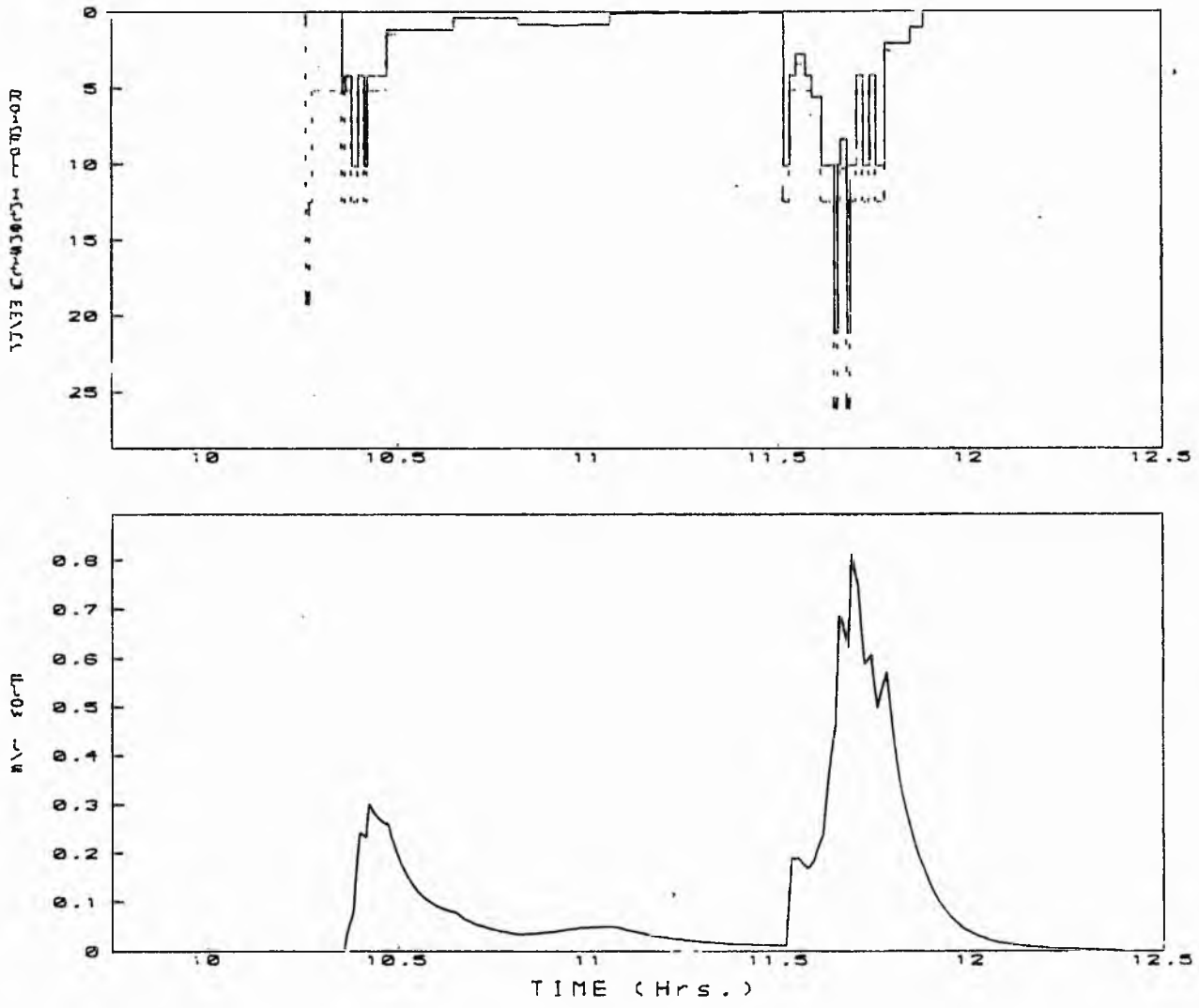
CATCH= 10.5

Simulated Peak Flow= 0.30 l/s.

Simulated Total Volume= 523.2 litres

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR CHURNET CLOSE MICROCATCHMENT

Date of Event : 02-11-84



_ _ _ _ _ Total Hyetograph

_____ Net Hyetograph

_____ Simulated Flow

Depression Storage= 0.66 mm.

Runoff Coefficient= 81.0 %.

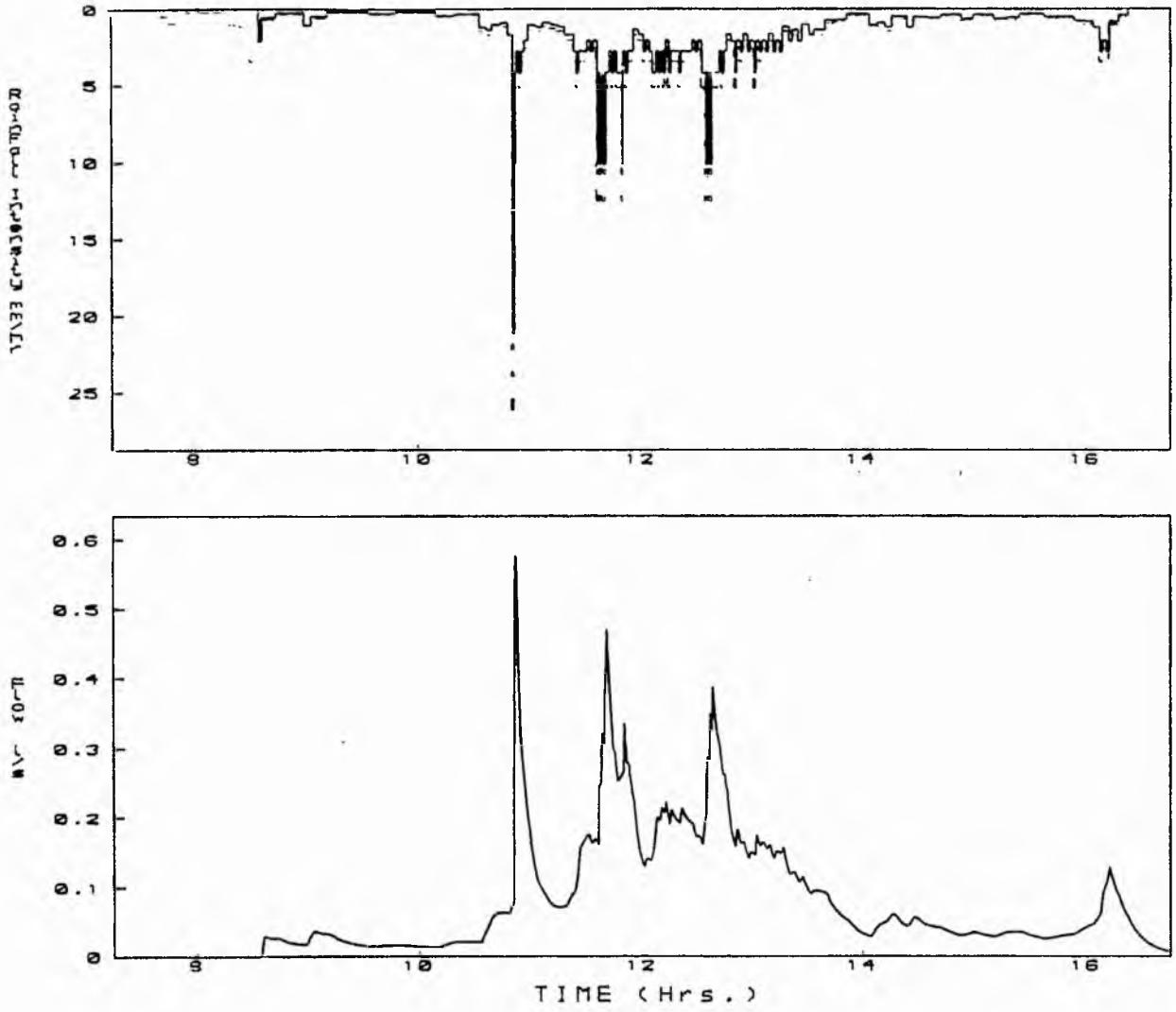
CATCH= 10.5

Simulated Peak Flow= 0.81 l/s.

Simulated Total Volume= 847.4 litres

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR CHURNET CLOSE MICROCATCHMENT

Date of Event : 05-12-85

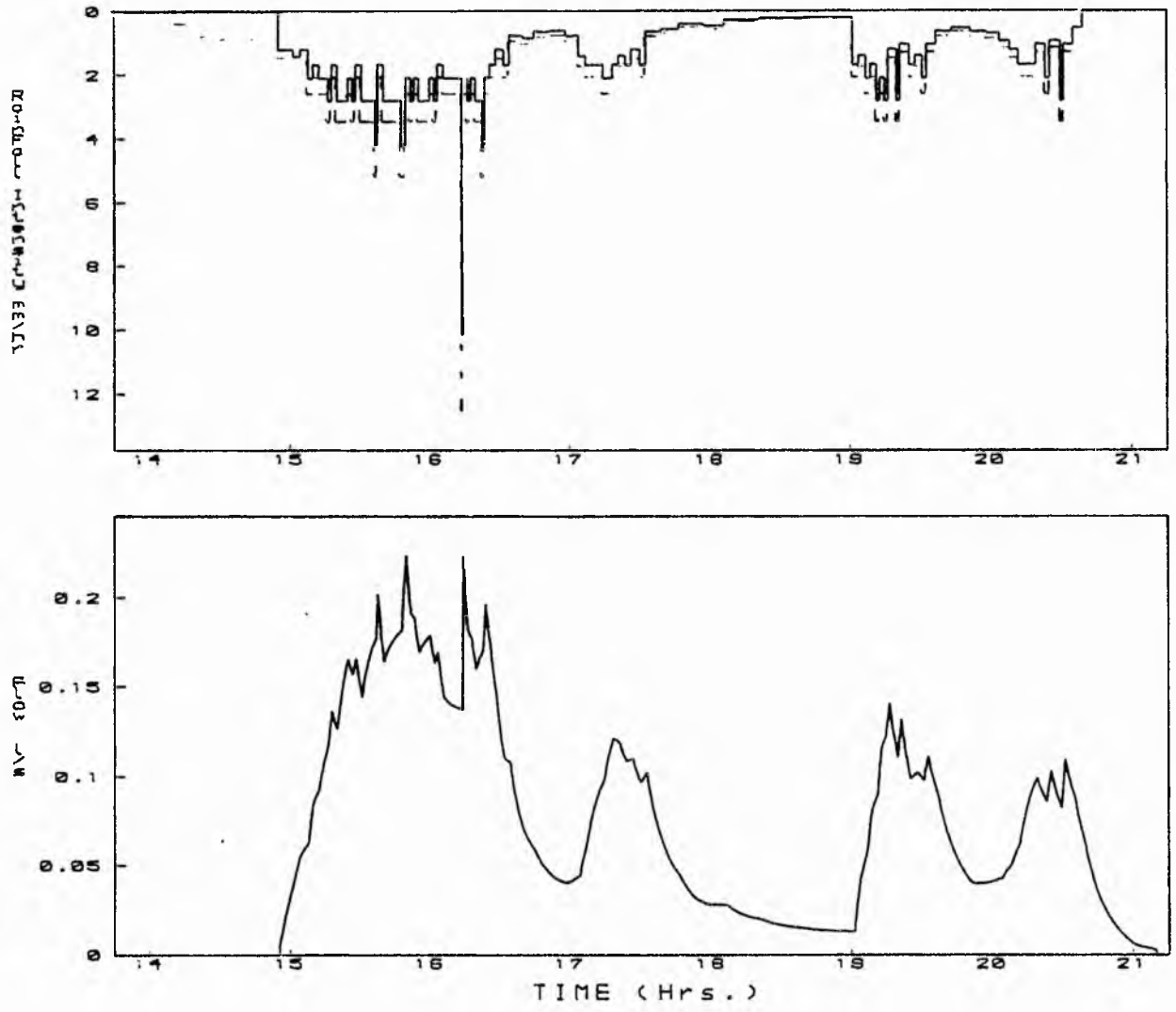


. . . . . Total Hyetograph
_____ Net Hyetograph
_____ Simulated Flow

Depression Storage= 0.66 mm.
RunoFF CoeFficient= 81.0 %.
CATCH= 10.5
Simulated Peak Flow= 0.58 l/s.
Simulated Total Volume=2529.0 litre

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR CHURNET CLOSE MICROCATCHMENT

Date of Event : 06-12-85

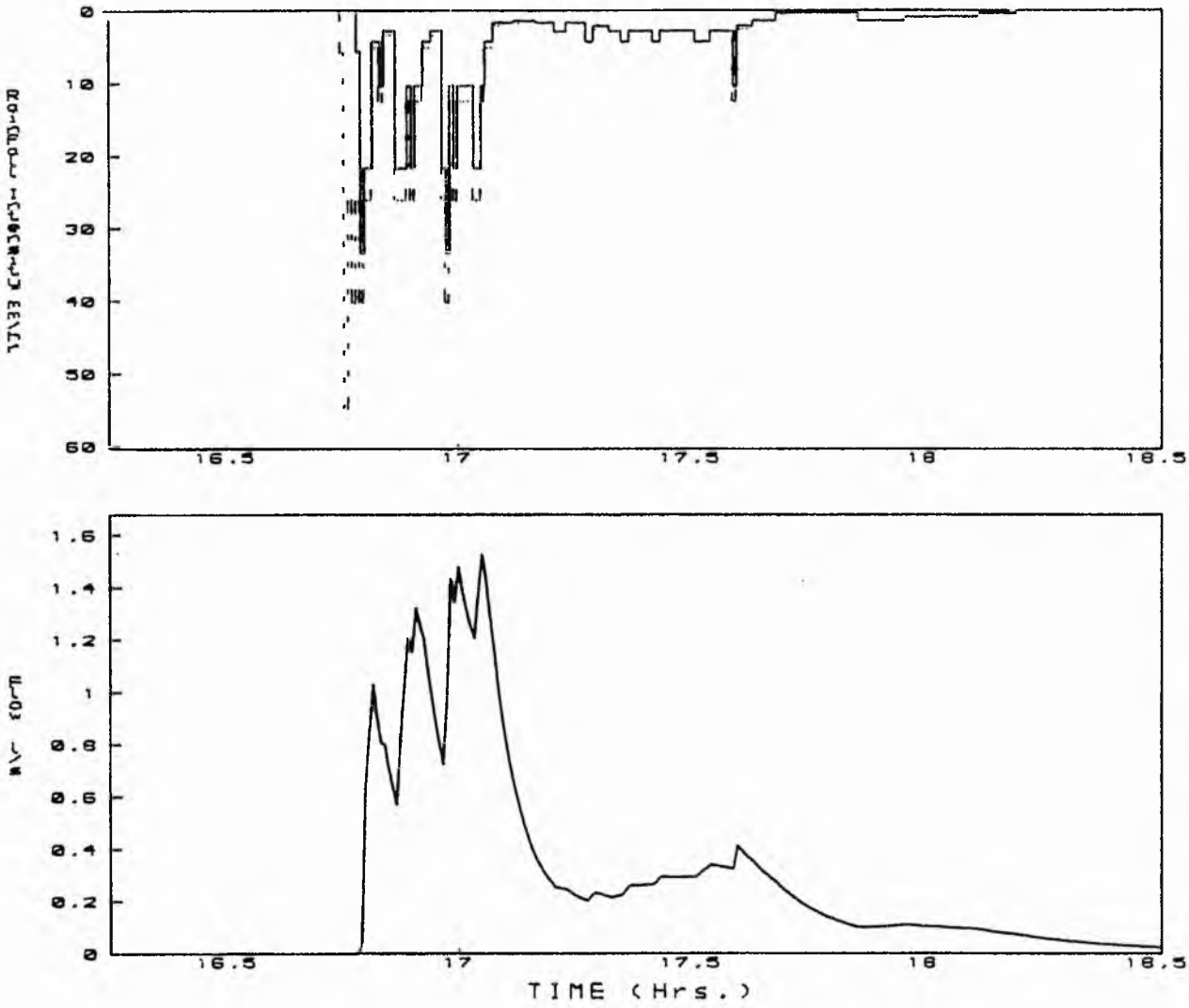


Total Hyetograph
Net Hyetograph
Simulated Flow

Depression Storage= 0.66 mm.
RunoFF CoeFFicient= 81.0 %.
CATCH= 10.5
Simulated Peak Flow= 0.22 l/s.
Simulated Total Volume=1746.0 litres

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TWYFORD GARDENS MICROCATCHMENT

Date of Event : 20-06-84

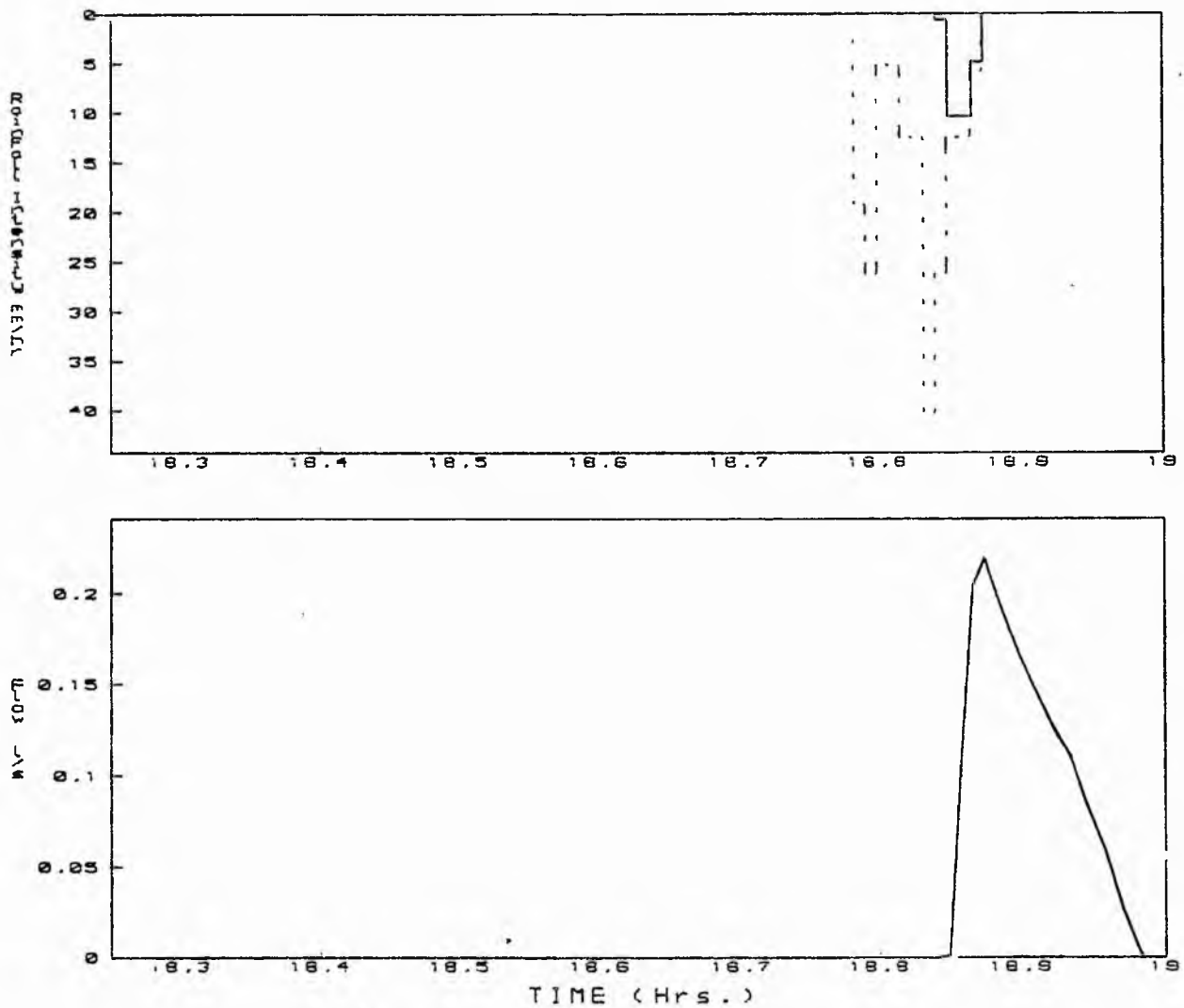


. . . . . Total Hyetograph
_____ Net Hyetograph
_____ Simulated Flow

Depression Storage= 1.22 mm.
Runoff Coefficient= 83.0 %.
CATCH= 15.9
Simulated Peak Flow= 1.52 l/s.
Simulated Total Volume=2108.4 litre

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TWYFORD GARDENS MICROCATCHMENT

Date of Event : 12-07-84



_ _ _ _ _ Total Hyetograph

_____ Net Hyetograph

_____ Simulated Flow

Depression Storage= 1.22 mm.

Runoff Coefficient= 83.0 %.

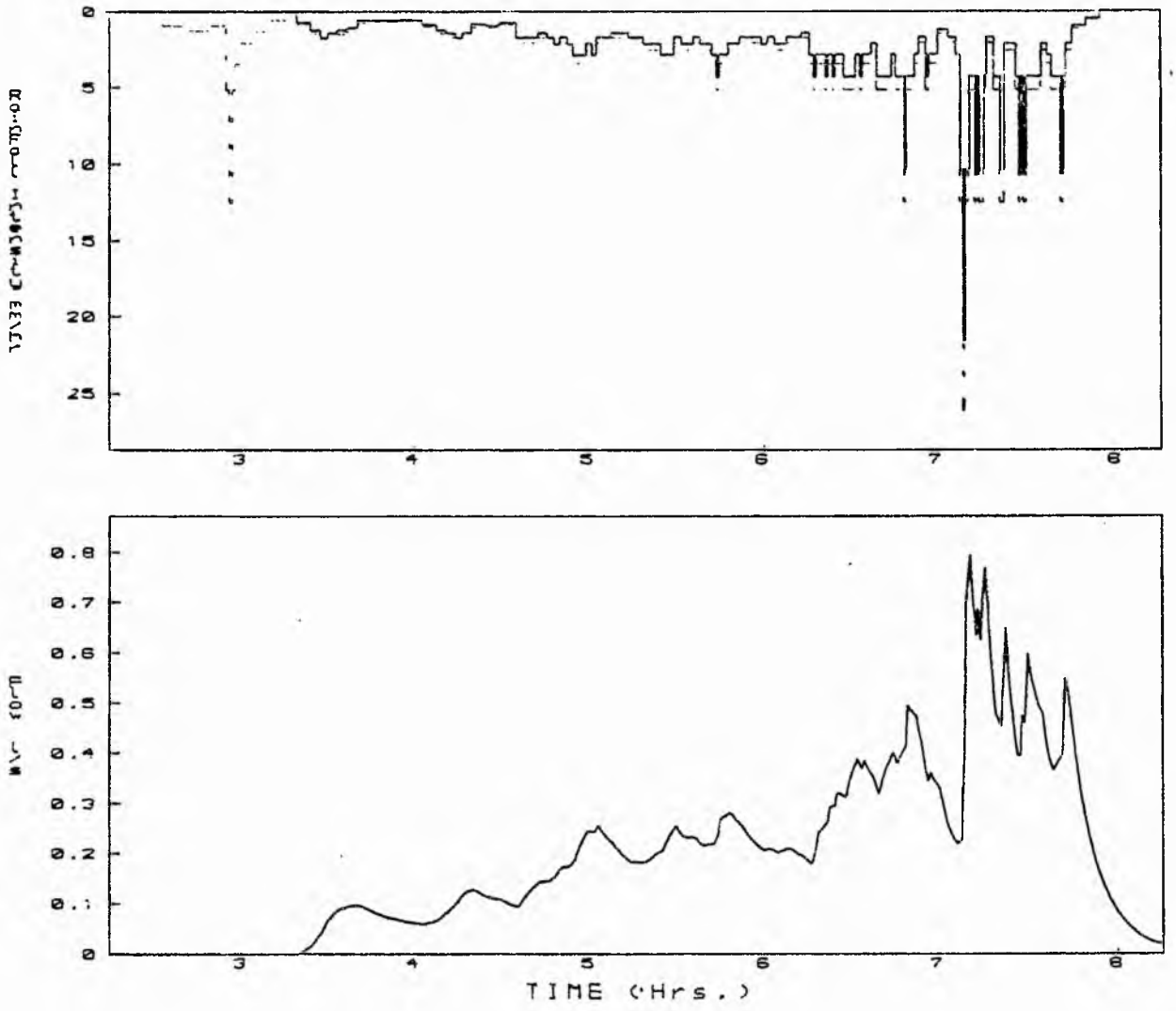
CATCH= 15.9

Simulated Peak Flow= 0.22 l/s.

Simulated Total Volume= 66.8 litres

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TWYFORD GARDENS MICROCATCHMENT

Date of Event : 02-08-84

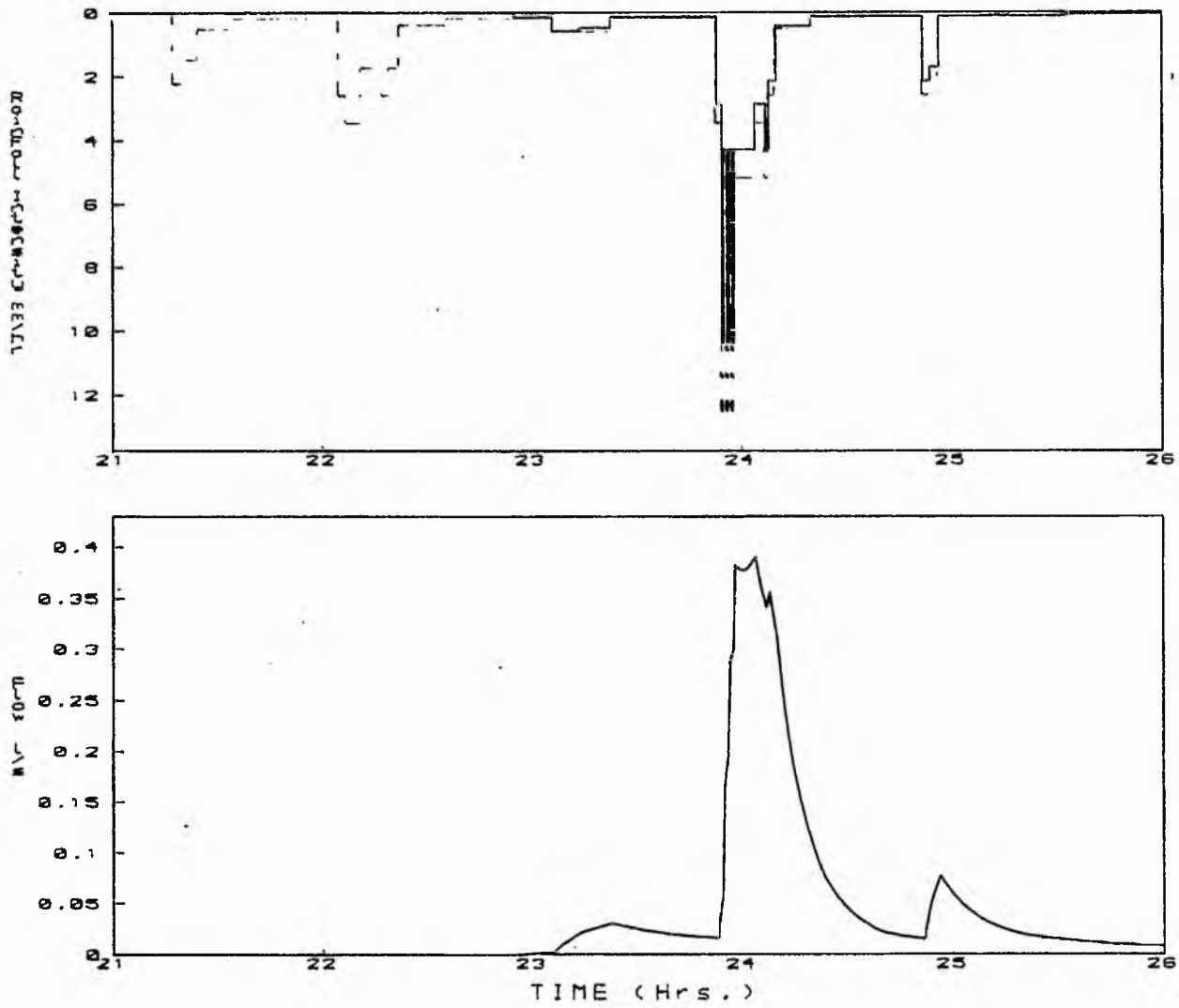


. . . . . Total Hyetograph
_____ Net Hyetograph
_____ Simulated Flow

Depression Storage= 1.22 mm.
Runoff Coefficient= 83.0 %.
CATCH= 15.9
Simulated Peak Flow= 0.79 l/s.
Simulated Total Volume=4073.2 litres

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TWYFORD GARDENS MICROCATCHMENT

Date of Event : 13-09-84



_ _ _ _ _ Total Hyetograph

_____ Net Hyetograph

_____ Simulated Flow

Depression Storage= 1.22 mm.

Runoff Coefficient= 83.0 %.

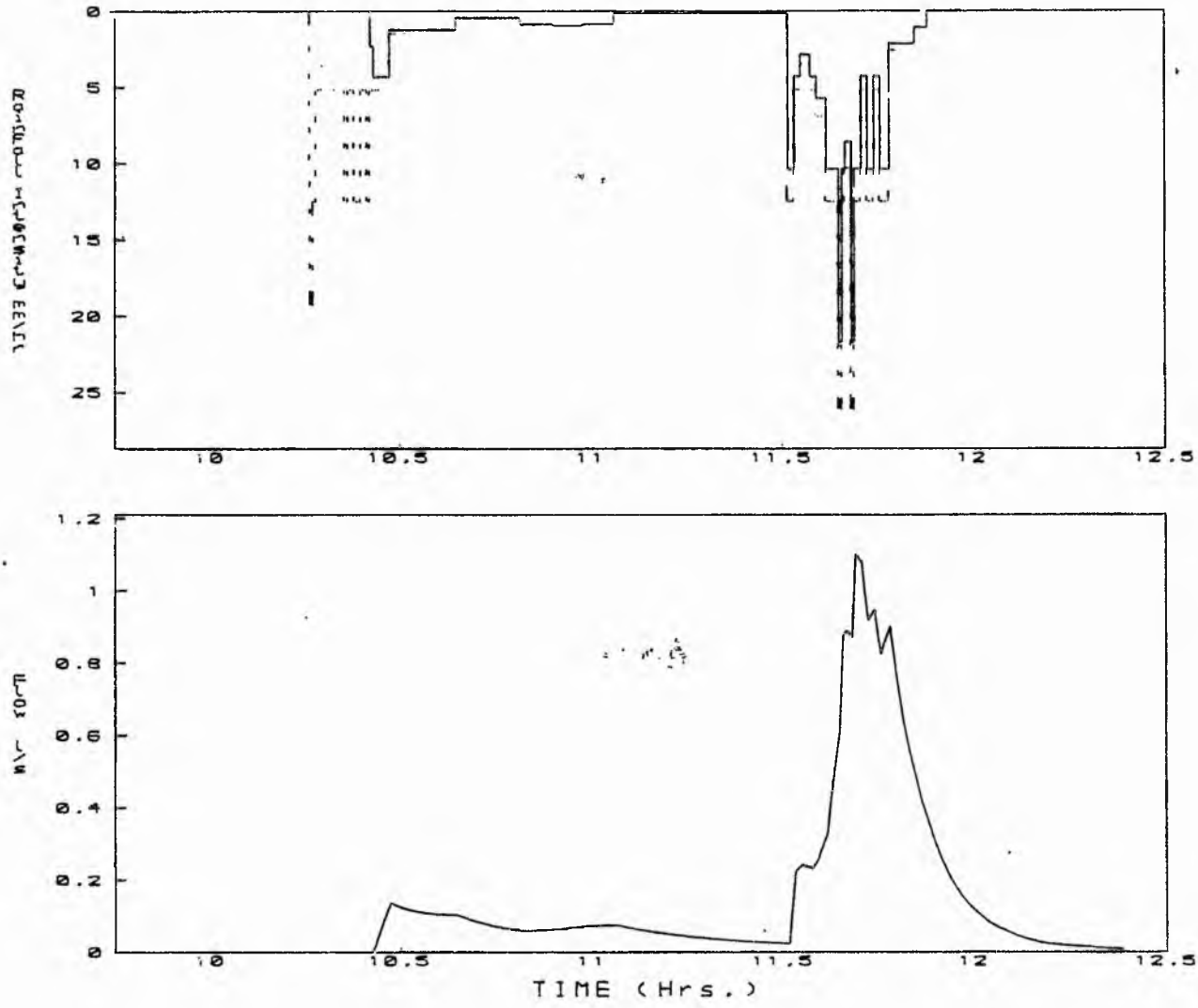
CATCH= 15.9

Simulated Peak Flow= 0.39 l/s.

Simulated Total Volume= 665.4 litres

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TWYFORD GARDENS MICROCATCHMENT

Date of Event : 02-11-84

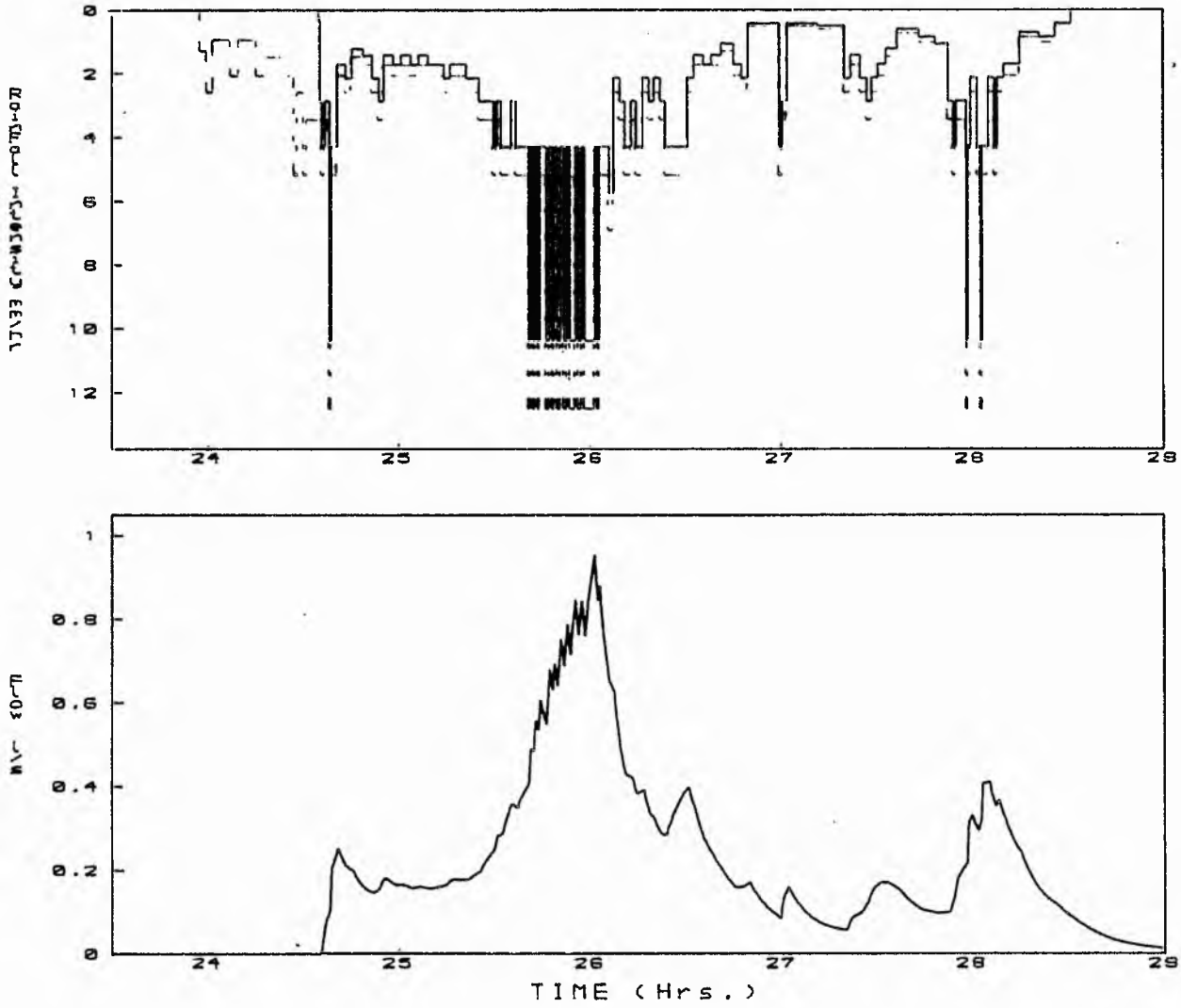


- - - - - Total Hyetograph
_____ Net Hyetograph
_____ Simulated Flow

Depression Storage= 1.22 mm.
RunoFF CoeFficient= 83.0 %.
CATCH= 15.9
Simulated Peak Flow= 1.10 l/s.
Simulated Total Volume=1191.7 litres

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TWYFORD GARDENS MICROCATCHMENT

Date of Event : 07-11-85



_ _ _ _ _ Total Hyetograph

_____ Net Hyetograph

_____ Simulated Flow

Depression Storage= 1.22 mm.

Runoff Coefficient= 83.0 %.

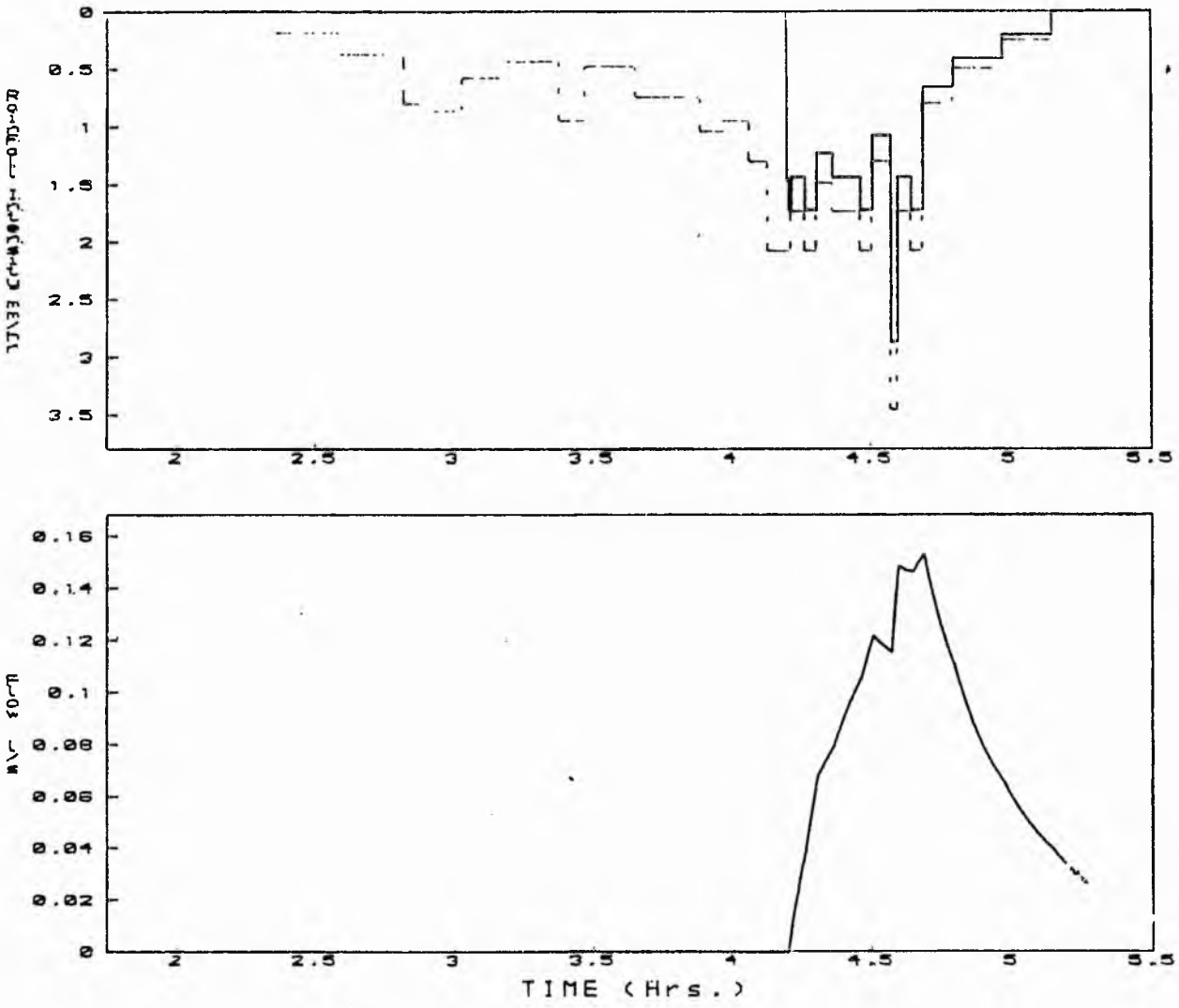
CATCH= 15.9

Simulated Peak Flow= 0.95 l/s.

Simulated Total Volume=3736.8 litres

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TWYFORD GARDENS MICROCATCHMENT

Date of Event : 30-11-85



_ _ _ _ _ Total Hyetograph

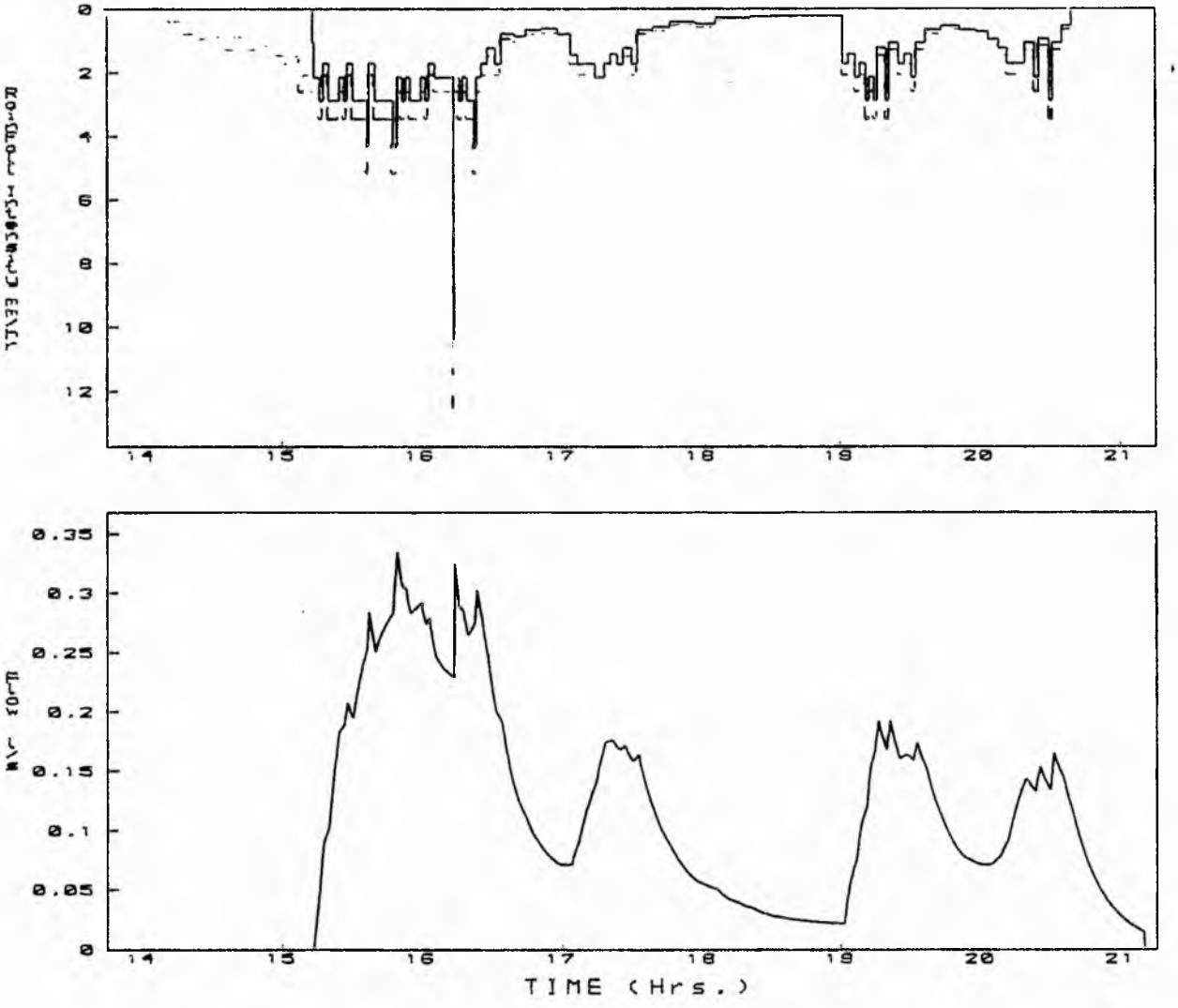
_____ Net Hyetograph

_____ Simulated Flow

Depression Storage= 1.22 mm.
Runoff Coefficient= 83.0 %.
CATCH= 15.9
Simulated Peak Flow= 0.15 l/s.
Simulated Total Volume= 333.7 litres

LINEAR RESERVOIR MODEL SIMULATION PLOT FOR TWYFORD GARDENS MICROCATCHMENT

Date of Event : 06-12-85



. . . . . Total Hyetograph

_____ Net Hyetograph

_____ Simulated Flow

Depression Storage= 1.22 mm.

Runoff Coefficient= 83.0 %.

CATCH= 15.9

Simulated Peak Flow= 0.33 l/s.

Simulated Total Volume=2650.1 litres

APPENDIX C.

Reference: Chapter 7.

Complete set of Data Tables of all Chemical Analysis carried out in the "Gully Pot Standing Liquor Monitoring Programme".

GULLY POT LIQUOR ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840509
DATE SAMPLES COLLECTED : 840509
DATE SAMPLES ANALYSED : 840509
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Temp C :	DO mg/l :	pH pH units :	Alk mg/l as CaCO3 :	TH mg/l as CaCO3 :
T1	11.0	1.4	7.0	200.0	170.0
T2	11.0	2.1	7.3	170.0	220.0
T3	10.5	2.0	7.0	360.0	310.0
T4	11.5	2.0	6.6	240.0	270.0
C1	12.0	4.1	7.0	190.0	280.0
C2	11.0	3.1	7.5	210.0	210.0
C3	11.0	2.8	6.6	320.0	220.0
C4	11.5	2.8	6.3	120.0	300.0
TW1	11.5	2.7	7.6	310.0	190.0
TW2	11.5	2.5	8.2	170.0	230.0
TW3	11.5	2.5	8.0	260.0	230.0
TW4	11.5	2.5	7.1	210.0	200.0

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840509
DATE SAMPLES COLLECTED : 840509
DATE SAMPLES ANALYSED : 840509
Conductivity, Suspended Solids, BOD and COD

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Cond uscm-1 (x1000) :	SS mg/l :	BOD mg/l :	COD mg/l :
T1	0.39	-1	62	439
T2	0.55	-1	9	119
T3	0.68	-1	61	279
T4	0.46	-1	24	413
C1	0.47	-1	16	243
C2	0.55	-1	5	289
C3	0.62	-1	59	150
C4	0.40	-1	58	537
TW1	0.42	-1	17	10
TW2	0.51	-1	10	16
TW3	0.57	-1	12	356
TW4	0.81	-1	53	160

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840509
DATE SAMPLES COLLECTED : 840509
DATE SAMPLES ANALYSED : 840511
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	7.5	17.7	67.Ø	Ø.2	-1.Ø
T2	Ø.5	17.7	135.Ø	Ø.2	-1.Ø
T3	5.4	17.7	288.Ø	9.Ø	-1.Ø
T4	1.4	21.3	192.Ø	Ø.3	-1.Ø
C1	1.4	24.8	135.Ø	2.1	-1.Ø
C2	Ø.3	14.2	2Ø2.Ø	Ø.6	-1.Ø
C3	2.1	21.3	1Ø.Ø	Ø.1	-1.Ø
C4	2.6	21.3	211.Ø	4.1	-1.Ø
TW1	Ø.9	17.7	1Ø6.Ø	Ø.6	-1.Ø
TW2	Ø.2	17.7	192.Ø	Ø.2	-1.Ø
TW3	Ø.4	42.5	163.Ø	Ø.3	-1.Ø
TW4	4.Ø	56.7	2Ø2.Ø	Ø.5	-1.Ø

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE:840516
DATE SAMPLES COLLECTED : 840516
DATE SAMPLES ANALYSED : 840516
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	14.0	4.5	6.8	100.0	70.0
T2	14.0	4.0	6.5	80.0	90.0
T3	13.5	3.6	6.8	100.0	60.0
T4	13.5	2.0	6.5	90.0	110.0
C1	13.5	3.6	6.9	80.0	70.0
C2	14.0	2.1	6.2	50.0	70.0
C3	13.0	3.5	6.7	90.0	50.0
C4	13.5	4.3	6.7	80.0	80.0
TW1	14.0	2.8	6.6	100.0	50.0
TW2	14.0	7.9	6.8	70.0	70.0
TW3	13.0	3.4	7.3	150.0	70.0
TW4	13.0	6.5	6.7	90.0	50.0

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840516
DATE SAMPLES COLLECTED : 840516
DATE SAMPLES ANALYSED : 840516
Conductivity, Suspended Solids, BOD and COD

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Cond uscm-1 (x1000) :	SS mg/l :	BOD mg/l :	COD mg/l :
T1	0.12	69	5	48
T2	0.11	5	5	43
T3	0.12	64	23	64
T4	0.12	53	19	75
C1	0.12	84	15	32
C2	0.10	3	16	70
C3	0.11	6	23	113
C4	0.10	22	9	32
TW1	0.10	7	10	54
TW2	0.09	0	5	64
TW3	0.46	1	7	70
TW4	0.32	0	14	86

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840516
DATE SAMPLES COLLECTED : 840516
DATE SAMPLES ANALYSED : 840518
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	1.9	28.4	260.0	0.1	-1.0
T2	1.4	24.8	260.0	0.2	-1.0
T3	1.6	24.8	48.0	7.6	-1.0
T4	1.6	24.8	192.0	0.3	-1.0
C1	1.6	39.0	288.0	1.7	-1.0
C2	1.4	21.3	115.0	0.5	-1.0
C3	1.3	31.9	221.0	0.1	-1.0
C4	1.6	24.8	202.0	4.1	-1.0
TW1	1.6	24.8	0.0	0.6	-1.0
TW2	1.3	28.4	48.0	0.3	-1.0
TW3	0.8	49.6	125.0	0.3	-1.0
TW4	1.6	60.3	202.0	0.5	-1.0

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME.
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840523
DATE SAMPLES COLLECTED : 840523
DATE SAMPLES ANALYSED : 840523
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	16.Ø	2.5	7.7	25Ø.Ø	31Ø.Ø
T2	14.5	3.2	7.4	17Ø.Ø	29Ø.Ø
T3	14.Ø	4.1	6.9	27Ø.Ø	24Ø.Ø
T4	15.Ø	3.2	7.Ø	22Ø.Ø	21Ø.Ø
C1	14.Ø	1.9	7.3	22Ø.Ø	3ØØ.Ø
C2	14.Ø	1.7	6.9	18Ø.Ø	29Ø.Ø
C3	14.Ø	2.8	7.Ø	2ØØ.Ø	35Ø.Ø
C4	14.Ø	2.1	9.8	19Ø.Ø	19Ø.Ø
TW1	14.Ø	3.2	6.2	18Ø.Ø	22Ø.Ø
TW2	13.Ø	3.3	6.4	19Ø.Ø	28Ø.Ø
TW3	12.5	3.3	7.2	17Ø.Ø	28Ø.Ø
TW4	13.Ø	2.7	6.9	21Ø.Ø	24Ø.Ø

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840523
DATE SAMPLES COLLECTED : 840523
DATE SAMPLES ANALYSED : 840523
Conductivity, Suspended Solids, BOD and COD

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Cond uscm-1 (x1000) :	SS mg/l :	BOD mg/l :	COD mg/l :
T1 :	0.10 :	-1 :	5 :	53 :
T2 :	0.09 :	-1 :	5 :	42 :
T3 :	0.06 :	-1 :	3 :	5 :
T4 :	0.08 :	-1 :	8 :	53 :
C1 :	0.08 :	-1 :	7 :	16 :
C2 :	0.08 :	-1 :	0 :	42 :
C3 :	0.08 :	-1 :	6 :	48 :
C4 :	0.11 :	-1 :	5 :	0 :
TW1 :	0.07 :	-1 :	6 :	26 :
TW2 :	0.05 :	-1 :	2 :	11 :
TW3 :	0.09 :	-1 :	9 :	21 :
TW4 :	0.11 :	-1 :	9 :	37 :

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840523
DATE SAMPLES COLLECTED : 840523
DATE SAMPLES ANALYSED : 840525
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	PO4(3-) mg/l as P :	Cl(-) mg/l as Cl :	SO4(2-) mg/l as SO4 :	NH3 mg/l as N :	NO3(-) mg/l as N :
T1	Ø.6	39.Ø	183.Ø	Ø.3	-1.Ø
T2	Ø.6	6Ø.3	Ø.Ø	Ø.2	-1.Ø
T3	Ø.7	67.4	77.Ø	9.2	-1.Ø
T4	1.2	42.5	1Ø6.Ø	Ø.3	-1.Ø
C1	Ø.9	39.Ø	135.Ø	2.2	-1.Ø
C2	Ø.5	49.6	173.Ø	Ø.7	-1.Ø
C3	Ø.7	7Ø.9	125.Ø	Ø.1	-1.Ø
C4	1.7	49.6	Ø.Ø	4.2	-1.Ø
TW1	1.3	248.2	86.Ø	Ø.7	-1.Ø
TW2	Ø.7	7Ø.9	48.Ø	Ø.3	-1.Ø
TW3	Ø.5	67.4	125.Ø	Ø.3	-1.Ø
TW4	Ø.5	131.2	Ø.Ø	Ø.6	-1.Ø

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840530
DATE SAMPLES COLLECTED : 840530
DATE SAMPLES ANALYSED : 840530
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	14.5	1.1	6.5	-1.0	-1.0
T2	14.5	4.1	6.5	-1.0	-1.0
T3	15.0	3.1	6.5	-1.0	-1.0
T4	14.5	4.1	6.6	-1.0	-1.0
C1	15.0	4.0	6.7	-1.0	-1.0
C2	15.0	4.9	6.7	-1.0	-1.0
C3	15.0	4.8	6.7	-1.0	-1.0
C4	14.5	6.3	9.3	-1.0	-1.0
TW1	15.0	4.1	6.5	-1.0	-1.0
TW2	14.0	4.9	6.5	-1.0	-1.0
TW3	14.0	3.3	6.6	-1.0	-1.0
TW4	14.5	5.6	6.6	-1.0	-1.0

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 84Ø53Ø
DATE SAMPLES COLLECTED : 84Ø53Ø
DATE SAMPLES ANALYSED : 84Ø53Ø
Conductivity, Suspended Solids, BOD and COD

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Cond uscm-1 (x1ØØØ) :	SS mg/l :	BOD mg/l :	COD mg/l :
T1	Ø.27	-1	38	-1
T2	Ø.Ø8	-1	4	-1
T3	Ø.Ø8	-1	Ø	-1
T4	Ø.Ø7	-1	Ø	-1
C1	Ø.Ø9	-1	3	-1
C2	Ø.Ø8	-1	Ø	-1
C3	Ø.Ø8	-1	Ø	-1
C4	Ø.Ø9	-1	Ø	-1
TW1	Ø.Ø8	-1	Ø	-1
TW2	Ø.Ø6	-1	6	-1
TW3	Ø.Ø8	-1	2	-1
TW4	Ø.1Ø	-1	Ø	-1

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 84Ø53Ø
DATE SAMPLES COLLECTED : 84Ø53Ø
DATE SAMPLES ANALYSED : 84Ø53Ø
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	-1.Ø	-1.Ø	-1.Ø	-1.Ø	-1.Ø
T2	-1.Ø	-1.Ø	-1.Ø	-1.Ø	-1.Ø
T3	-1.Ø	-1.Ø	-1.Ø	-1.Ø	-1.Ø
T4	-1.Ø	-1.Ø	-1.Ø	-1.Ø	-1.Ø
C1	-1.Ø	-1.Ø	-1.Ø	-1.Ø	-1.Ø
C2	-1.Ø	-1.Ø	-1.Ø	-1.Ø	-1.Ø
C3	-1.Ø	-1.Ø	-1.Ø	-1.Ø	-1.Ø
C4	-1.Ø	-1.Ø	-1.Ø	-1.Ø	-1.Ø
TW1	-1.Ø	-1.Ø	-1.Ø	-1.Ø	-1.Ø
TW2	-1.Ø	-1.Ø	-1.Ø	-1.Ø	-1.Ø
TW3	-1.Ø	-1.Ø	-1.Ø	-1.Ø	-1.Ø
TW4	-1.Ø	-1.Ø	-1.Ø	-1.Ø	-1.Ø

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840606
DATE SAMPLES COLLECTED : 840606
DATE SAMPLES ANALYSED : 840606
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	14.5	7.1	7.0	-1.0	-1.0
T2	14.5	6.4	6.7	-1.0	-1.0
T3	14.0	5.6	6.8	-1.0	-1.0
T4	14.5	5.4	6.6	-1.0	-1.0
C1	15.0	5.7	6.8	-1.0	-1.0
C2	15.0	7.6	6.8	-1.0	-1.0
C3	14.5	6.5	6.8	-1.0	-1.0
C4	15.0	8.3	8.7	-1.0	-1.0
TW1	14.0	7.1	6.8	-1.0	-1.0
TW2	15.0	7.2	6.8	-1.0	-1.0
TW3	14.5	3.3	7.2	-1.0	-1.0
TW4	15.0	7.6	7.0	-1.0	-1.0

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 84Ø6Ø6
DATE SAMPLES COLLECTED : 84Ø6Ø6
DATE SAMPLES ANALYSED : 84Ø6Ø6
Conductivity, Suspended Solids, BOD and COD

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Cond uscm-1 (x1ØØØ) :	SS mg/l :	BOD mg/l :	COD mg/l :
T1	Ø.19	-1	22	-1
T2	Ø.14	-1	4	-1
T3	Ø.13	-1	11	-1
T4	Ø.12	-1	5	-1
C1	Ø.16	-1	5	-1
C2	Ø.16	-1	5	-1
C3	Ø.14	-1	4	-1
C4	Ø.17	-1	7	-1
TW1	Ø.Ø9	-1	6	-1
TW2	Ø.Ø9	-1	8	-1
TW3	Ø.1Ø	-1	5	-1
TW4	Ø.12	-1	7	-1

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840606
DATE SAMPLES COLLECTED : 840606
DATE SAMPLES ANALYSED : 840606
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	-1.0	-1.0	-1.0	-1.0	-1.0
T2	-1.0	-1.0	-1.0	-1.0	-1.0
T3	-1.0	-1.0	-1.0	-1.0	-1.0
T4	-1.0	-1.0	-1.0	-1.0	-1.0
C1	-1.0	-1.0	-1.0	-1.0	-1.0
C2	-1.0	-1.0	-1.0	-1.0	-1.0
C3	-1.0	-1.0	-1.0	-1.0	-1.0
C4	-1.0	-1.0	-1.0	-1.0	-1.0
TW1	-1.0	-1.0	-1.0	-1.0	-1.0
TW2	-1.0	-1.0	-1.0	-1.0	-1.0
TW3	-1.0	-1.0	-1.0	-1.0	-1.0
TW4	-1.0	-1.0	-1.0	-1.0	-1.0

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840613
DATE SAMPLES COLLECTED : 840613
DATE SAMPLES ANALYSED : 840613
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	17.Ø	1.8	6.5	43Ø.Ø	32Ø.Ø
T2	17.Ø	2.1	6.8	9Ø.Ø	12Ø.Ø
T3	17.Ø	1.1	8.4	22Ø.Ø	25Ø.Ø
T4	18.Ø	Ø.9	7.5	18Ø.Ø	22Ø.Ø
C1	17.5	2.9	6.8	24Ø.Ø	21Ø.Ø
C2	17.5	3.2	6.5	5Ø.Ø	2Ø.Ø
C3	18.Ø	1.7	7.1	19Ø.Ø	21Ø.Ø
C4	17.5	2.6	11.4	2ØØ.Ø	26Ø.Ø
TW1	16.5	Ø.9	7.2	12Ø.Ø	16Ø.Ø
TW2	16.5	1.4	6.6	4Ø.Ø	9Ø.Ø
TW3	16.Ø	1.4	6.6	18Ø.Ø	33Ø.Ø
TW4	16.Ø	1.6	7.6	17Ø.Ø	18Ø.Ø

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 84Ø613
DATE SAMPLES COLLECTED : 84Ø613
DATE SAMPLES ANALYSED : 84Ø614
Conductivity, Suspended Solids, BOD and COD

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Cond uscm-1 (x1ØØØ) :	SS mg/l :	BOD mg/l :	COD mg/l :
T1 :	Ø.91 :	484 :	41 :	879 :
T2 :	Ø.12 :	Ø :	55 :	5 :
T3 :	Ø.72 :	192 :	48 :	345 :
T4 :	Ø.49 :	98 :	33 :	21 :
C1 :	Ø.39 :	49 :	5Ø :	229 :
C2 :	Ø.Ø7 :	Ø :	59 :	1Ø :
C3 :	Ø.42 :	199 :	62 :	193 :
C4 :	1.56 :	2449 :	59 :	97 :
TW1 :	Ø.51 :	562 :	6Ø :	51 :
TW2 :	Ø.Ø9 :	14 :	36 :	5 :
TW3 :	Ø.38 :	623 :	51 :	71 :
TW4 :	Ø.99 :	7 :	55 :	2Ø :

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840613
DATE SAMPLES COLLECTED : 840613
DATE SAMPLES ANALYSED : 840615
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	10.6	284.0	10.0	8.8	3.2
T2	2.0	18.0	346.0	13.6	3.9
T3	2.7	89.0	327.0	23.8	9.1
T4	2.0	39.0	260.0	9.8	8.4
C1	5.2	32.0	202.0	4.2	4.9
C2	1.5	7.0	288.0	2.9	6.9
C3	4.7	50.0	183.0	8.0	53.2
C4	1.6	50.0	404.0	16.8	11.9
TW1	5.3	71.0	135.0	19.6	105.0
TW2	1.0	11.0	144.0	26.6	6.6
TW3	2.6	28.0	279.0	10.4	7.7
TW4	3.5	163.0	365.0	7.4	4.2

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840620
DATE SAMPLES COLLECTED : 840620
DATE SAMPLES ANALYSED : 840620
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	20.5	1.4	6.8	500.0	220.0
T2	19.5	1.1	7.0	100.0	260.0
T3	19.5	1.2	7.5	310.0	530.0
T4	19.0	1.2	7.1	280.0	420.0
C1	20.0	0.6	7.3	240.0	400.0
C2	19.0	0.9	6.5	80.0	340.0
C3	20.0	0.5	6.9	270.0	370.0
C4	19.5	4.2	11.4	300.0	390.0
TW1	19.0	2.3	7.4	240.0	370.0
TW2	19.5	3.2	7.9	80.0	230.0
TW3	19.0	0.2	7.1	390.0	370.0
TW4	19.0	1.0	7.7	220.0	340.0

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840620
DATE SAMPLES COLLECTED : 840620
DATE SAMPLES ANALYSED : 840620
Conductivity, Suspended Solids, BOD and COD

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Cond uscm-1 (x1000) :	SS mg/l :	BOD mg/l :	COD mg/l :
T1	1.09	432	47	905
T2	0.18	21	14	79
T3	0.80	166	56	374
T4	0.65	43	59	162
C1	0.59	62	16	153
C2	0.16	17	18	34
C3	0.51	47	43	138
C4	1.65	202	38	98
TW1	0.68	445	31	74
TW2	0.12	9	6	30
TW3	0.55	1256	42	59
TW4	1.18	6	16	216

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 84Ø62Ø
DATE SAMPLES COLLECTED : 84Ø62Ø
DATE SAMPLES ANALYSED : 84Ø621
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	PO4(3-) mg/l as P :	Cl(-) mg/l as Cl :	SO4(2-) mg/l as SO4 :	NH3 mg/l as N :	NO3(-) mg/l as N :
T1	3.2	149.Ø	Ø.Ø	6.2	2.1
T2	1.4	28.Ø	452.Ø	5.Ø	2.5
T3	5.3	131.Ø	49Ø.Ø	13.6	7.6
T4	6.3	67.Ø	Ø.Ø	1Ø.6	4.2
C1	1.7	71.Ø	211.Ø	6.2	2.9
C2	1.1	18.Ø	673.Ø	4.5	11.7
C3	3.3	67.Ø	413.Ø	22.4	84.Ø
C4	Ø.6	71.Ø	163.Ø	11.2	12.6
TW1	1.9	92.Ø	327.Ø	1.8	56.Ø
TW2	Ø.3	25.Ø	2Ø2.Ø	5.6	4.3
TW3	1.4	35.Ø	221.Ø	18.2	4.3
TW4	Ø.6	277.Ø	365.Ø	4.2	2.5

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840627
DATE SAMPLES COLLECTED : 840627
DATE SAMPLES ANALYSED : 840627
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

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GULLY POT LIQUOR ANALYSIS

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LOCATION :	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	20.0	1.4	6.6	130.0	90.0
T2	21.0	1.9	6.4	220.0	210.0
T3	19.5	1.0	6.1	160.0	90.0
T4	19.5	1.7	6.4	100.0	110.0
C1	19.5	0.9	6.1	100.0	50.0
C2	21.0	2.2	5.9	120.0	90.0
C3	20.0	1.7	6.5	170.0	160.0
C4	19.0	1.9	7.1	210.0	80.0
TW1	19.0	2.3	6.3	90.0	80.0
TW2	21.0	2.3	8.9	140.0	230.0
TW3	18.5	0.7	6.4	140.0	90.0
TW4	19.0	1.1	6.2	160.0	120.0

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840627
DATE SAMPLES COLLECTED : 840627
DATE SAMPLES ANALYSED : 840627
Conductivity, Suspended Solids, BOD and COD

****

GULLY POT LIQUOR ANALYSIS

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LOCATION :	Cond uscm-1 (x1000) :	SS mg/l :	BOD mg/l :	COD mg/l :
T1	0.26	390	5	562
T2	0.95	84	26	351
T3	0.25	201	45	268
T4	0.16	50	9	294
C1	0.19	55	3	144
C2	0.32	28	6	170
C3	0.28	90	18	139
C4	0.23	184	2	83
TW1	0.14	507	5	36
TW2	0.28	39	30	46
TW3	0.25	873	33	62
TW4	0.21	29	7	237

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840627
DATE SAMPLES COLLECTED : 840627
DATE SAMPLES ANALYSED : 840628
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

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GULLY POT LIQUOR ANALYSIS

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LOCATION	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	3.8	21.Ø	-1.Ø	7.Ø	2.5
T2	5.6	160.Ø	-1.Ø	8.7	Ø.1
T3	4.5	39.Ø	-1.Ø	16.8	10.4
T4	6.Ø	25.Ø	-1.Ø	15.4	12.Ø
C1	1.2	21.Ø	-1.Ø	7.Ø	6.3
C2	1.Ø	57.Ø	-1.Ø	6.9	4.5
C3	3.Ø	39.Ø	-1.Ø	26.6	109.2
C4	Ø.3	252.Ø	-1.Ø	2.4	7.Ø
TW1	2.1	21.Ø	-1.Ø	1.5	109.2
TW2	Ø.4	43.Ø	-1.Ø	3.8	2.9
TW3	1.1	32.Ø	-1.Ø	14.Ø	3.6
TW4	1.Ø	35.Ø	-1.Ø	3.4	5.3

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840704
DATE SAMPLES COLLECTED : 840704
DATE SAMPLES ANALYSED : 840704
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

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GULLY POT LIQUOR ANALYSIS

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LOCATION :	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	23.0	2.2	7.6	250.0	420.0
T2	25.0	3.4	7.5	170.0	220.0
T3	24.5	3.4	7.4	220.0	310.0
T4	24.0	3.7	7.1	190.0	280.0
C1	25.0	5.1	7.2	270.0	310.0
C2	24.5	5.0	7.6	250.0	270.0
C3	24.0	3.7	8.0	230.0	330.0
C4	24.0	3.9	7.9	220.0	290.0
TW1	24.0	4.3	7.6	150.0	320.0
TW2	24.5	4.3	7.7	310.0	250.0
TW3	24.5	4.8	7.5	200.0	420.0
TW4	24.0	3.1	7.2	270.0	280.0

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840704
DATE SAMPLES COLLECTED : 840704
DATE SAMPLES ANALYSED : 840705
Conductivity, Suspended Solids, BOD and COD

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GULLY POT LIQUOR ANALYSIS

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LOCATION	Cond uscm-1 (x1000)	SS mg/l	BOD mg/l	COD mg/l
T1	0.80	305	35	129
T2	0.25	110	19	666
T3	0.33	230	59	913
T4	0.32	77	29	98
C1	0.33	81	11	67
C2	0.23	50	37	93
C3	0.40	112	44	124
C4	0.34	227	17	67
TW1	0.20	440	11	46
TW2	0.29	80	35	144
TW3	0.27	612	5	129
TW4	0.33	54	22	114

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

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Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 84Ø7Ø4
DATE SAMPLES COLLECTED : 84Ø7Ø4
DATE SAMPLES ANALYSED : 84Ø7Ø6
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

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GULLY POT LIQUOR ANALYSIS

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LOCATION :	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	3.8	92.Ø	481.Ø	Ø.9	4.2
T2	5.7	32.Ø	192.Ø	Ø.2	8.4
T3	5.2	32.Ø	279.Ø	Ø.2	42.Ø
T4	4.7	46.Ø	29.Ø	Ø.5	12.Ø
C1	Ø.6	113.Ø	567.Ø	Ø.Ø	18.2
C2	Ø.5	128.Ø	452.Ø	Ø.1	11.2
C3	3.7	6Ø.Ø	Ø.Ø	Ø.1	13.3
C4	Ø.6	35.Ø	163.Ø	Ø.2	6.3
TW1	1.4	28.Ø	5Ø9.Ø	Ø.1	12.Ø
TW2	Ø.6	195.Ø	24Ø.Ø	Ø.1	9.8
TW3	Ø.9	43.Ø	154.Ø	Ø.1	19.6
TW4	Ø.9	124.Ø	413.Ø	Ø.3	18.2

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840711
DATE SAMPLES COLLECTED : 840711
DATE SAMPLES ANALYSED : 840711
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

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GULLY POT LIQUOR ANALYSIS

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LOCATION	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	23.Ø	1.2	6.8	21Ø.Ø	32Ø.Ø
T2	22.5	Ø.7	6.9	17Ø.Ø	27Ø.Ø
T3	23.Ø	Ø.6	6.3	4ØØ.Ø	53Ø.Ø
T4	23.Ø	Ø.9	6.9	29Ø.Ø	5ØØ.Ø
C1	22.5	1.1	7.Ø	17Ø.Ø	35Ø.Ø
C2	22.5	1.4	6.9	16Ø.Ø	24Ø.Ø
C3	23.Ø	Ø.7	6.8	26Ø.Ø	41Ø.Ø
C4	23.Ø	Ø.7	8.1	19Ø.Ø	46Ø.Ø
TW1	24.Ø	1.Ø	6.8	16Ø.Ø	3ØØ.Ø
TW2	22.5	1.2	8.1	21Ø.Ø	51Ø.Ø
TW3	23.Ø	1.Ø	7.2	23Ø.Ø	39Ø.Ø
TW4	23.Ø	2.5	7.4	28Ø.Ø	37Ø.Ø

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 84Ø711
DATE SAMPLES COLLECTED : 84Ø711
DATE SAMPLES ANALYSED : 84Ø712
Conductivity, Suspended Solids, BOD and COD

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GULLY POT LIQUOR ANALYSIS

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LOCATION :	Cond uscm-1 (x1ØØØ) :	SS mg/l :	BOD mg/l :	COD mg/l :
T1	Ø.67	56	41	123
T2	Ø.26	23	3Ø	139
T3	Ø.63	52	43	976
T4	Ø.58	49	45	134
C1	Ø.31	32	19	129
C2	Ø.24	21	13	75
C3	Ø.43	53	25	172
C4	Ø.4Ø	63	31	118
TW1	.Ø.21	2Ø	5	113
TW2	Ø.53	15	17	75
TW3	Ø.33	1Ø	14	43
TW4	Ø.42	11	4	1Ø7

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840711
DATE SAMPLES COLLECTED : 840711
DATE SAMPLES ANALYSED : 840714
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

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GULLY POT LIQUOR ANALYSIS

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LOCATION :	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	1.9	32.Ø	394.Ø	Ø.6	4Ø.6
T2	Ø.9	21.Ø	365.Ø	1.1	7.7
T3	1.Ø	245.Ø	1Ø.Ø	1.2	266.Ø
T4	1.1	135.Ø	461.Ø	1.1	1Ø9.2
C1	Ø.7	28.Ø	394.Ø	1.2	85.4
C2	1.Ø	18.Ø	394.Ø	2.1	7Ø.Ø
C3	1.4	43.Ø	327.Ø	1.Ø	43.4
C4	1.1	35.Ø	375.Ø	3.4	47.6
TW1	1.3	25.Ø	298.Ø	Ø.7	37.8
TW2	1.5	57.Ø	5Ø9.Ø	1Ø.6	47.6
TW3	1.2	1Ø6.Ø	644.Ø	1.5	43.4
TW4	1.6	316.Ø	Ø.Ø	1.8	35.Ø

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840718
DATE SAMPLES COLLECTED : 840718
DATE SAMPLES ANALYSED : 840718
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

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GULLY POT LIQUOR ANALYSIS

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LOCATION :	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	18.Ø	2.3	6.5	24Ø.Ø	17Ø.Ø
T2	2Ø.Ø	2.5	6.7	8Ø.Ø	27Ø.Ø
T3	21.Ø	Ø.6	6.1	13Ø.Ø	24Ø.Ø
T4	2Ø.Ø	1.8	6.5	9Ø.Ø	26Ø.Ø
C1	2Ø.Ø	2.3	6.7	16Ø.Ø	22Ø.Ø
C2	2Ø.Ø	2.9	6.4	18Ø.Ø	24Ø.Ø
C3	21.Ø	2.7	6.3	12Ø.Ø	24Ø.Ø
C4	2Ø.Ø	2.1	6.8	8Ø.Ø	42Ø.Ø
TW1	2Ø.Ø	2.1	6.6	8Ø.Ø	31Ø.Ø
TW2	2Ø.Ø	3.6	6.8	1ØØ.Ø	26Ø.Ø
TW3	2Ø.Ø	1.Ø	7.1	18Ø.Ø	43Ø.Ø
TW4	19.5	2.1	6.7	11Ø.Ø	32Ø.Ø

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840718
DATE SAMPLES COLLECTED : 840718
DATE SAMPLES ANALYSED : 840721
Conductivity, Suspended Solids, BOD and COD

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GULLY POT LIQUOR ANALYSIS

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LOCATION :	Cond uscm-1 (x1000) :	SS mg/l :	BOD mg/l :	COD mg/l :
T1	0.10	19	7	54
T2	0.12	24	11	5
T3	0.12	26	19	75
T4	0.10	19	17	21
C1	0.12	47	9	21
C2	0.10	28	18	11
C3	0.10	13	16	16
C4	0.11	17	9	16
TW1	0.10	22	0	54
TW2	0.10	21	11	43
TW3	0.31	18	21	145
TW4	0.17	62	11	38

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840718
DATE SAMPLES COLLECTED : 840718
DATE SAMPLES ANALYSED : 840720
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

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GULLY POT LIQUOR ANALYSIS

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LOCATION	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	2.1	234.0	567.0	1.1	0.8
T2	3.0	18.0	577.0	0.5	0.9
T3	1.1	25.0	365.0	1.0	4.9
T4	2.5	14.0	846.0	0.3	1.8
C1	2.2	32.0	202.0	0.3	0.8
C2	2.6	35.0	144.0	0.2	0.9
C3	1.8	25.0	442.0	0.2	1.5
C4	4.0	25.0	807.0	0.2	1.5
TW1	1.7	28.0	548.0	0.1	1.0
TW2	2.3	25.0	826.0	1.1	2.9
TW3	1.9	35.0	596.0	0.2	1.4
TW4	2.9	35.0	702.0	0.6	1.4

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840725
DATE SAMPLES COLLECTED : 840725
DATE SAMPLES ANALYSED : 840725
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

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GULLY POT LIQUOR ANALYSIS

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LOCATION :	Temp C :	DO mg/l :	pH pH units :	Alk mg/l as CaCO3 :	TH mg/l as CaCO3 :
T1	17.5	Ø.9	6.9	19Ø.Ø	21Ø.Ø
T2	17.5	1.9	6.7	11Ø.Ø	22Ø.Ø
T3	17.Ø	Ø.7	6.7	14Ø.Ø	27Ø.Ø
T4	17.5	Ø.6	7.1	16Ø.Ø	26Ø.Ø
C1	17.Ø	Ø.5	6.7	19Ø.Ø	14Ø.Ø
C2	16.Ø	2.9	6.6	11Ø.Ø	23Ø.Ø
C3	17.Ø	Ø.8	6.7	21Ø.Ø	19Ø.Ø
C4	17.Ø	Ø.3	7.3	21Ø.Ø	24Ø.Ø
TW1	17.5	1.Ø	6.5	18Ø.Ø	15Ø.Ø
TW2	17.5	3.3	7.6	2ØØ.Ø	19Ø.Ø
TW3	17.5	Ø.6	7.3	21Ø.Ø	3ØØ.Ø
TW4	17.Ø	Ø.8	7.Ø	19Ø.Ø	22Ø.Ø

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840725
DATE SAMPLES COLLECTED : 840725
DATE SAMPLES ANALYSED : 840726
Conductivity, Suspended Solids, BOD and COD

****

GULLY POT LIQUOR ANALYSIS

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LOCATION :	Cond uscm-1 (x1000) :	SS mg/l :	BOD mg/l :	COD mg/l :
T1	0.20	184	41	66
T2	0.13	29	11	27
T3	0.19	53	25	99
T4	0.17	21	44	49
C1	0.19	333	27	77
C2	0.12	14	20	49
C3	0.17	10	32	60
C4	0.17	28	17	66
TW1	0.11	10	4	11
TW2	0.16	9	33	49
TW3	0.35	13	36	132
TW4	0.33	33	20	66

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840725
DATE SAMPLES COLLECTED : 840725
DATE SAMPLES ANALYSED : 840727
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

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GULLY POT LIQUOR ANALYSIS

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LOCATION :	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	1.8	28.Ø	4Ø4.Ø	2.4	82.6
T2	Ø.6	21.Ø	567.Ø	1.1	19.6
T3	1.5	21.Ø	423.Ø	1.4	46.2
T4	2.Ø	18.Ø	673.Ø	5.2	18.2
C1	Ø.7	21.Ø	423.Ø	2.1	1Ø.5
C2	Ø.8	21.Ø	471.Ø	Ø.5	9.1
C3	1.Ø	32.Ø	615.Ø	Ø.2	6.4
C4	1.5	28.Ø	596.Ø	1.4	6.4
TW1	1.9	25.Ø	432.Ø	Ø.3	6.4
TW2	1.1	64.Ø	577.Ø	7.Ø	1Ø.5
TW3	1.4	53.Ø	375.Ø	2.4	7.6
TW4	1.1	85.Ø	365.Ø	1.4	1Ø.5

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841Ø31
DATE SAMPLES COLLECTED : 841Ø31
DATE SAMPLES ANALYSED : 841Ø31
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

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GULLY POT LIQUOR ANALYSIS

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LOCATION :	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	12.Ø	6.7	7.3	7Ø.Ø	7Ø.Ø
T2	12.Ø	6.4	5.7	3Ø.Ø	4Ø.Ø
T3	12.Ø	4.2	5.8	4Ø.Ø	4Ø.Ø
T4	12.Ø	5.Ø	5.8	3Ø.Ø	4Ø.Ø
C1	12.Ø	6.4	6.1	4Ø.Ø	5Ø.Ø
C2	12.Ø	7.2	6.1	3Ø.Ø	5Ø.Ø
C3	12.Ø	6.Ø	6.Ø	3Ø.Ø	5Ø.Ø
C4	12.Ø	6.1	5.9	3Ø.Ø	4Ø.Ø
TW1	12.Ø	6.Ø	5.9	2Ø.Ø	4Ø.Ø
TW2	12.Ø	7.4	5.7	2Ø.Ø	4Ø.Ø
TW3	12.Ø	1.4	6.5	5Ø.Ø	6Ø.Ø
TW4	12.Ø	5.Ø	6.2	4Ø.Ø	5Ø.Ø

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841031
DATE SAMPLES COLLECTED : 841031
DATE SAMPLES ANALYSED : 841031
Conductivity, Suspended Solids, BOD and COD

****

GULLY POT LIQUOR ANALYSIS

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LOCATION	Cond uscm-1 (x1000)	SS mg/l	BOD mg/l	COD mg/l
T1	0.12	180	15	219
T2	0.08	9	6	60
T3	0.09	18	8	114
T4	0.08	45	14	114
C1	0.09	64	26	35
C2	0.07	44	22	80
C3	0.07	34	15	86
C4	0.07	27	12	55
TW1	0.08	0	5	0
TW2	0.07	4	19	70
TW3	0.11	0	7	40
TW4	0.10	28	16	70

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841Ø31
DATE SAMPLES COLLECTED : 841Ø31
DATE SAMPLES ANALYSED : 841Ø31
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

****

GULLY POT LIQUOR ANALYSIS

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LOCATION	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	2.5	28.4	125.Ø	Ø.2	Ø.7
T2	1.4	35.5	211.Ø	Ø.3	1.2
T3	1.1	31.9	96.Ø	Ø.3	Ø.9
T4	1.8	31.9	192.Ø	Ø.4	1.4
C1	1.3	28.4	Ø.Ø	Ø.1	1.5
C2	1.1	31.9	1Ø.Ø	Ø.3	1.7
C3	1.4	28.4	2Ø2.Ø	Ø.1	2.Ø
C4	2.1	28.4	Ø.Ø	Ø.3	1.5
TW1	1.2	28.4	Ø.Ø	Ø.3	2.9
TW2	1.5	28.4	77.Ø	Ø.2	4.2
TW3	2.7	24.8	77.Ø	Ø.4	6.7
TW4	1.4	31.9	Ø.Ø	Ø.5	3.2

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841107
DATE SAMPLES COLLECTED : 841107
DATE SAMPLES ANALYSED : 841107
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Temp C :	DO mg/l :	pH pH units :	Alk mg/l as CaCO3 :	TH mg/l as CaCO3 :
T1	10.0	3.5	6.1	310.0	90.0
T2	10.0	4.6	6.0	140.0	50.0
T3	10.0	1.1	6.2	120.0	70.0
T4	10.0	1.4	6.3	20.0	60.0
C1	10.0	0.9	6.7	170.0	40.0
C2	10.0	3.3	6.4	70.0	50.0
C3	10.0	0.8	5.8	160.0	40.0
C4	10.0	0.4	6.0	150.0	50.0
TW1	10.0	1.0	5.5	100.0	50.0
TW2	10.0	5.2	5.9	110.0	40.0
TW3	10.0	0.6	6.4	80.0	60.0
TW4	10.0	1.1	6.2	50.0	60.0

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841107
DATE SAMPLES COLLECTED : 841107
DATE SAMPLES ANALYSED : 841108
Conductivity, Suspended Solids, BOD and COD

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Cond uscm-1 (x1000) :	SS mg/l :	BOD mg/l :	COD mg/l :
T1	0.45	90	2	54
T2	0.11	66	11	64
T3	0.12	147	8	119
T4	0.09	26	9	54
C1	0.08	56	18	84
C2	0.10	26	11	25
C3	0.08	46	16	129
C4	0.09	75	9	84
TW1	0.08	37	0	20
TW2	0.09	46	3	30
TW3	0.11	40	5	45
TW4	0.10	38	11	20

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841107
DATE SAMPLES COLLECTED : 841107
DATE SAMPLES ANALYSED : 841109
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	Ø.9	251.6	29.Ø	Ø.2	2.4
T2	Ø.3	39.Ø	48.Ø	Ø.2	1.7
T3	Ø.5	42.5	48.Ø	Ø.2	2.Ø
T4	Ø.5	113.4	19.Ø	Ø.3	3.6
C1	Ø.7	42.5	Ø.Ø	Ø.2	2.Ø
C2	Ø.1	24.8	48.Ø	Ø.2	2.4
C3	Ø.4	35.5	Ø.Ø	Ø.2	1.5
C4	Ø.7	31.9	58.Ø	Ø.3	1.5
TW1	Ø.3	31.9	Ø.Ø	Ø.1	1.5
TW2	Ø.3	24.8	1Ø6.Ø	Ø.2	2.7
TW3	Ø.3	17.7	Ø.Ø	Ø.2	1.7
TW4	Ø.7	1Ø.6	29.Ø	Ø.2	1.5

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841114
DATE SAMPLES COLLECTED : 841114
DATE SAMPLES ANALYSED : 841114
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

GULLY POT LIQUOR ANALYSIS

LOCATION :	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	10.0	7.2	7.3	60.0	50.0
T2	10.0	5.3	6.2	50.0	40.0
T3	10.0	4.5	5.9	50.0	50.0
T4	10.0	4.1	6.2	50.0	50.0
C1	10.0	4.8	6.5	50.0	40.0
C2	10.0	4.0	6.4	40.0	30.0
C3	10.0	1.8	6.0	40.0	40.0
C4	10.0	2.5	6.1	50.0	40.0
TW1	10.0	4.8	5.7	40.0	40.0
TW2	10.0	6.7	6.2	40.0	50.0
TW3	10.0	4.1	6.8	60.0	60.0
TW4	10.0	3.9	6.4	40.0	40.0

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841114
DATE SAMPLES COLLECTED : 841114
DATE SAMPLES ANALYSED : 841115
Conductivity, Suspended Solids, BOD and COD

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Cond uscm-1 (x1000) :	SS mg/l :	BOD mg/l :	COD mg/l :
T1	0.08	34	40	17
T2	0.05	30	54	0
T3	0.06	39	56	0
T4	0.06	57	55	23
C1	0.08	17	45	0
C2	0.05	11	39	51
C3	0.05	47	42	34
C4	0.05	66	39	51
TW1	0.04	15	56	6
TW2	0.04	17	41	0
TW3	0.09	25	37	11
TW4	0.06	24	45	0

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841114
DATE SAMPLES COLLECTED : 841114
DATE SAMPLES ANALYSED : 841116
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	Ø.1	21.3	96.Ø	Ø.2	2.7
T2	Ø.3	17.7	154.Ø	Ø.2	2.1
T3	Ø.Ø	21.3	67.Ø	Ø.2	Ø.3
T4	Ø.Ø	21.3	86.Ø	Ø.2	1.7
C1	1.Ø	21.3	115.Ø	Ø.2	2.5
C2	Ø.8	17.7	77.Ø	Ø.2	2.1
C3	Ø.8	17.7	Ø.Ø	Ø.2	1.5
C4	Ø.9	17.7	96.Ø	Ø.1	2.Ø
TW1	Ø.5	17.7	96.Ø	Ø.1	Ø.3
TW2	Ø.6	21.3	96.Ø	Ø.1	2.2
TW3	1.1	17.7	38.Ø	Ø.1	2.7
TW4	1.3	17.7	48.Ø	Ø.1	2.Ø

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841121
DATE SAMPLES COLLECTED : 841121
DATE SAMPLES ANALYSED : 841121
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

GULLY POT LIQUOR ANALYSIS

LOCATION	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	10.0	4.9	6.9	60.0	260.0
T2	10.0	8.2	6.1	50.0	140.0
T3	10.0	8.5	6.2	50.0	100.0
T4	10.0	5.5	6.0	40.0	130.0
C1	8.0	6.2	6.3	30.0	120.0
C2	8.0	6.7	6.7	30.0	170.0
C3	8.0	5.5	6.3	20.0	130.0
C4	8.0	3.9	6.1	30.0	170.0
TW1	8.0	4.0	6.3	30.0	110.0
TW2	8.0	6.2	5.9	40.0	110.0
TW3	8.0	6.7	6.2	30.0	120.0
TW4	8.0	5.5	6.4	30.0	110.0

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841121
DATE SAMPLES COLLECTED : 841121
DATE SAMPLES ANALYSED : 841122
Conductivity, Suspended Solids, BOD and COD

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Cond. uscm-1 (x1ØØØ) :	SS mg/l :	BOD mg/l :	COD mg/l :
T1	Ø.Ø7	1Ø	11	Ø
T2	Ø.Ø4	27	6	Ø
T3	Ø.Ø5	43	1Ø	5
T4	Ø.Ø3	14	15	Ø
C1	Ø.Ø6	21	28	Ø
C2	Ø.Ø4	26	28	Ø
C3	Ø.Ø4	49	31	82
C4	Ø.Ø5	26	25	Ø
TW1	Ø.Ø4	23	16	Ø
TW2	Ø.Ø4	9	2Ø	Ø
TW3	Ø.Ø5	3Ø	25	Ø
TW4	Ø.Ø5	19	31	Ø

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841121
DATE SAMPLES COLLECTED : 841121
DATE SAMPLES ANALYSED : 841123
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	Ø.Ø	7.1	211.Ø	Ø.5	Ø.6
T2	Ø.Ø	7.1	115.Ø	Ø.2	1.Ø
T3	Ø.Ø	7.1	67.Ø	Ø.1	Ø.7
T4	Ø.Ø	1Ø.6	29.Ø	Ø.1	Ø.7
C1	Ø.3	7.1	48.Ø	Ø.1	1.3
C2	Ø.Ø	7.1	115.Ø	Ø.1	1.1
C3	Ø.Ø	7.1	86.Ø	Ø.1	1.Ø
C4	Ø.Ø	7.1	135.Ø	Ø.1	Ø.8
TW1	Ø.Ø	7.1	1Ø6.Ø	Ø.1	Ø.8
TW2	Ø.Ø	7.1	48.Ø	Ø.1	1.1
TW3	Ø.Ø	7.1	135.Ø	Ø.2	1.7
TW4	Ø.4	5.3	96.Ø	Ø.1	Ø.9

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841128
DATE SAMPLES COLLECTED : 841128
DATE SAMPLES ANALYSED : 841128
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

GULLY POT LIQUOR ANALYSIS

LOCATION :	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	8.Ø	3.7	7.3	4Ø.Ø	26Ø.Ø
T2	8.Ø	4.9	6.7	3Ø.Ø	18Ø.Ø
T3	8.Ø	4.5	6.6	6Ø.Ø	24Ø.Ø
T4	8.Ø	7.Ø	6.7	5Ø.Ø	21Ø.Ø
C1	7.Ø	7.1	6.4	2Ø.Ø	15Ø.Ø
C2	7.Ø	5.9	6.6	2Ø.Ø	12Ø.Ø
C3	7.Ø	5.9	6.3	2Ø.Ø	16Ø.Ø
C4	7.Ø	6.Ø	6.3	3Ø.Ø	15Ø.Ø
TW1	8.Ø	6.4	6.3	2Ø.Ø	18Ø.Ø
TW2	8.Ø	6.2	6.4	2Ø.Ø	1ØØ.Ø
TW3	8.Ø	5.9	6.3	3Ø.Ø	17Ø.Ø
TW4	8.Ø	7.1	6.5	3Ø.Ø	8Ø.Ø

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841128
DATE SAMPLES COLLECTED : 841128
DATE SAMPLES ANALYSED : 841128
Conductivity, Suspended Solids, BOD and COD

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Cond uscm-1 (x1000) :	SS mg/l :	BOD mg/l :	COD mg/l :
T1 :	0.22 :	28 :	10 :	93 :
T2 :	0.05 :	141 :	8 :	99 :
T3 :	0.15 :	159 :	10 :	148 :
T4 :	0.10 :	19 :	6 :	0 :
C1 :	0.03 :	40 :	2 :	0 :
C2 :	0.04 :	28 :	3 :	0 :
C3 :	0.03 :	70 :	4 :	38 :
C4 :	0.04 :	70 :	4 :	110 :
TW1 :	0.06 :	40 :	3 :	22 :
TW2 :	0.06 :	45 :	2 :	0 :
TW3 :	0.10 :	105 :	3 :	27 :
TW4 :	0.05 :	55 :	1 :	0 :

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841128
DATE SAMPLES COLLECTED : 841128
DATE SAMPLES ANALYSED : 841130
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	1.1	17.7	230.0	0.4	2.9
T2	1.6	10.6	192.0	0.2	1.4
T3	0.4	17.7	288.0	0.5	0.6
T4	1.0	10.6	202.0	0.5	0.7
C1	0.4	10.6	135.0	0.5	0.7
C2	0.6	14.2	58.0	0.4	1.0
C3	0.6	10.6	125.0	0.4	0.6
C4	0.3	14.2	96.0	0.4	0.5
TW1	0.2	17.7	163.0	0.5	0.5
TW2	0.3	17.7	58.0	0.4	0.7
TW3	0.6	14.2	144.0	0.5	0.9
TW4	0.4	17.7	58.0	0.6	0.7

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985
CODE : 850220
DATE SAMPLES COLLECTED : 850220
DATE SAMPLES ANALYSED : 850220
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

GULLY POT LIQUOR ANALYSIS

LOCATION	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	3.0	5.3	9.4	75.0	1065.0
T2	3.5	2.3	7.2	80.0	435.0
T3	2.5	2.4	7.3	110.0	320.0
T4	2.0	2.2	7.4	100.0	180.0
C1	3.0	6.6	8.2	45.0	1240.0
C2	2.5	5.7	7.3	70.0	970.0
C3	2.5	2.9	7.2	70.0	210.0
C4	2.5	2.2	6.9	70.0	210.0
TW1	2.5	5.6	7.6	45.0	255.0
TW2	3.0	4.0	7.7	40.0	840.0
TW3	2.5	2.6	7.6	65.0	170.0
TW4	3.0	3.2	7.0	100.0	600.0

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985
CODE : 85Ø22Ø
DATE SAMPLES COLLECTED : 85Ø22Ø
DATE SAMPLES ANALYSED : 85Ø22Ø
Conductivity, Suspended Solids, BOD and COD

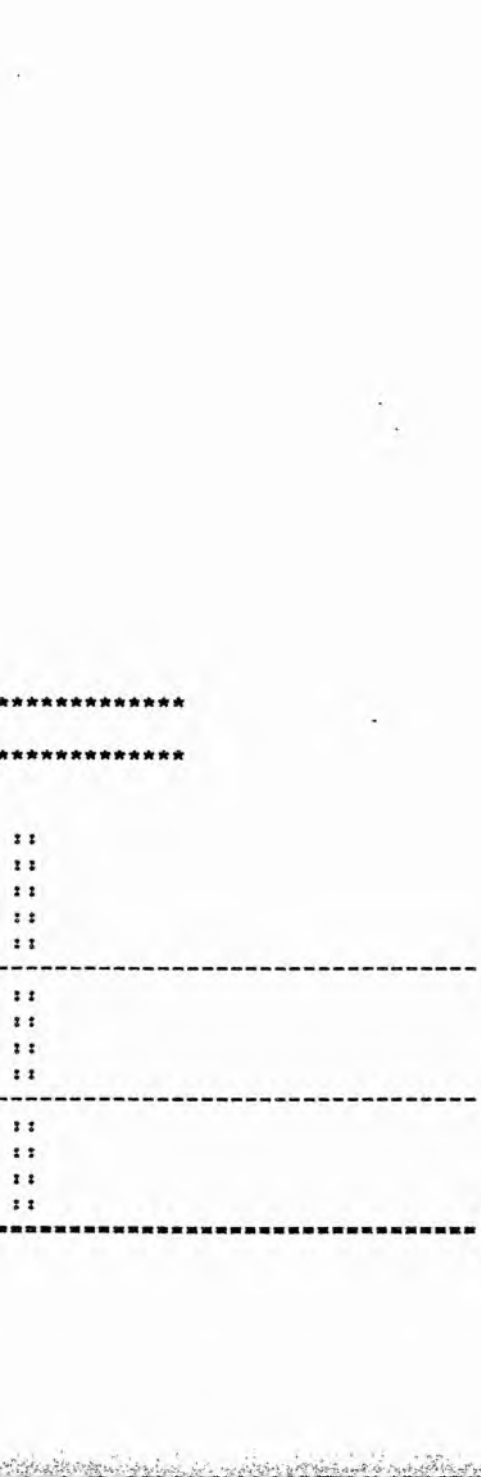
****

GULLY POT LIQUOR ANALYSIS

****

LOCATION	Cond uscm-1 (x1ØØØ)	SS mg/l	BOD mg/l	COD mg/l
T1	9Ø.6Ø	4Ø9	21	-1
T2	17.3Ø	27	7	3Ø
T3	9.42	144	27	15
T4	5.42	4Ø	47	76
C1	114.1Ø	27	26	-1
C2	38.9Ø	124	4Ø	126
C3	3.21	8	36	1Ø
C4	6.15	88	51	71
TW1	6.6Ø	31Ø	7	15
TW2	47.6Ø	85	8	-1
TW3	5.11	11	39	5
TW4	17.75	8	59	1Ø

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS



Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985
CODE : 85Ø22Ø
DATE SAMPLES COLLECTED : 85Ø22Ø
DATE SAMPLES ANALYSED : 85Ø222
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	2.3	42894.Ø	1465.Ø	2.8	-1.Ø
T2	1.9	7Ø9Ø.Ø	418.Ø	3.1	-1.Ø
T3	5.9	46Ø9.Ø	288.Ø	2.Ø	-1.Ø
T4	13.Ø	3Ø13.Ø	317.Ø	1.Ø	-1.Ø
C1	5.2	54593.Ø	171Ø.Ø	1.5	-1.Ø
C2	1.9	17547.Ø	1115.Ø	1.3	-1.Ø
C3	1.9	1773.Ø	327.Ø	1.1	-1.Ø
C4	6.9	3191.Ø	432.Ø	Ø.9	-1.Ø
TW1	1.3	3545.Ø	197.Ø	Ø.4	-1.Ø
TW2	1.4	2Ø916.Ø	682.Ø	1.5	-1.Ø
TW3	3.3	3545.Ø	288.Ø	Ø.8	-1.Ø
TW4	4.6	7799.Ø	346.Ø	3.2	-1.Ø

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850227
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	4.5	5.2	9.8	100.0	104.0
T2	4.0	2.3	7.2	9.0	36.0
T3	4.0	1.4	7.5	13.0	24.0
T4	3.5	0.6	7.6	100.0	19.0
C1	4.5	3.3	7.8	6.0	106.0
C2	4.5	1.4	7.2	8.0	92.0
C3	3.5	1.1	7.5	85.0	28.0
C4	4.0	0.6	7.0	13.0	25.0
TW1	4.0	3.3	7.6	6.0	29.0
TW2	4.0	1.6	8.4	5.0	82.0
TW3	3.5	1.3	8.1	8.0	18.0
TW4	4.0	0.6	7.3	100.0	53.0

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985
CODE : 85Ø227
DATE SAMPLES COLLECTED : 85Ø227
DATE SAMPLES ANALYSED : 85Ø227
Conductivity, Suspended Solids, BOD and COD

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Cond uscm-1 (x1ØØØ) :	SS mg/l :	BOD mg/l :	COD mg/l :
T1 :	93.3Ø :	459 :	25 :	-1 :
T2 :	14.52 :	87 :	9 :	173 :
T3 :	5.Ø6 :	4Ø :	8 :	117 :
T4 :	5.2Ø :	55 :	18 :	234 :
C1 :	95.ØØ :	482 :	1Ø :	-1 :
C2 :	39.9Ø :	23Ø :	7 :	-1 :
C3 :	3.58 :	37 :	6 :	82 :
C4 :	5.86 :	46 :	41 :	275 :
TW1 :	6.98 :	35 :	4 :	1Ø2 :
TW2 :	46.6Ø :	361 :	Ø :	76 :
TW3 :	5.5Ø :	55 :	6 :	66 :
TW4 :	14.9Ø :	136 :	21 :	128 :

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850228
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

GULLY POT LIQUOR ANALYSIS

LOCATION	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	2.0	42540.0	865.0	4.9	-1.0
T2	1.7	7090.0	481.0	7.3	-1.0
T3	3.4	2836.0	356.0	3.4	-1.0
T4	6.9	2836.0	567.0	4.2	-1.0
C1	1.7	43249.0	1124.0	0.4	-1.0
C2	2.1	16662.0	1095.0	0.2	-1.0
C3	1.0	2836.0	634.0	0.1	-1.0
C4	1.9	2836.0	471.0	0.0	-1.0
TW1	1.6	3900.0	836.0	0.6	-1.0
TW2	1.8	20916.0	769.0	4.3	-1.0
TW3	2.4	2836.0	1115.0	2.9	-1.0
TW4	1.6	6736.0	1162.0	9.1	-1.0

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985
CODE : 850306
DATE SAMPLES COLLECTED : 850306
DATE SAMPLES ANALYSED : 850306
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	5.5	4.2	9.8	240.0	1220.0
T2	5.5	4.0	7.8	150.0	710.0
T3	5.0	3.8	7.8	340.0	760.0
T4	5.0	2.9	7.6	170.0	580.0
C1	5.5	2.8	8.9	190.0	840.0
C2	5.0	4.3	9.6	140.0	590.0
C3	5.0	4.1	7.5	190.0	910.0
C4	5.0	4.9	7.9	170.0	400.0
TW1	5.0	4.0	8.1	160.0	720.0
TW2	5.0	2.6	8.5	130.0	1010.0
TW3	5.0	2.7	8.7	150.0	300.0
TW4	5.5	3.2	7.8	180.0	410.0

NOTE: The figure 0.00 means non-detectable level
NOTE: The figure -1.0 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985
CODE : 85Ø3Ø6
DATE SAMPLES COLLECTED : 85Ø3Ø6
DATE SAMPLES ANALYSED : 85Ø3Ø6
Conductivity, Suspended Solids, BOD and COD

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Cond uscm-1 (x1ØØØ) :	SS mg/l :	BOD mg/l :	COD mg/l :
T1 :	81.5Ø :	455 :	23 :	-1 :
T2 :	14.32 :	81 :	5 :	98 :
T3 :	4.77 :	34 :	1Ø :	83 :
T4 :	5.17 :	39 :	22 :	44 :
C1 :	37.4Ø :	167 :	6 :	74 :
C2 :	8.88 :	71 :	8 :	118 :
C3 :	13.39 :	116 :	7 :	59 :
C4 :	1.45 :	62 :	3 :	74 :
TW1 :	6.ØØ :	5Ø :	5 :	34 :
TW2 :	41.7Ø :	316 :	1 :	93 :
TW3 :	5.17 :	52 :	3 :	29 :
TW4 :	2.19 :	41 :	2 :	59 :

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985
CODE : 850306
DATE SAMPLES COLLECTED : 850306
DATE SAMPLES ANALYSED : 850308
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	3.7	574.Ø	1778.Ø	Ø.8	81.2
T2	Ø.2	113.Ø	1Ø76.Ø	1.3	16.8
T3	2.5	67.Ø	1547.Ø	Ø.1	7.3
T4	5.6	99.Ø	2268.Ø	Ø.Ø	6.3
C1	Ø.8	216.Ø	1326.Ø	Ø.5	33.6
C2	8.2	64.Ø	759.Ø	Ø.5	1Ø.9
C3	Ø.2	89.Ø	1143.Ø	1.2	12.6
C4	1.Ø	53.Ø	1451.Ø	Ø.4	4.6
TW1	Ø.1	5Ø.Ø	1345.Ø	Ø.7	5.3
TW2	Ø.6	219.Ø	961.Ø	Ø.9	29.4
TW3	Ø.1	149.Ø	1Ø96.Ø	Ø.7	5.2
TW4	Ø.4	39.Ø	673.Ø	Ø.4	25.6

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985
CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø313
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	6.Ø	7.Ø	1Ø.7	13Ø.Ø	89Ø.Ø
T2	6.Ø	2.Ø	7.3	1ØØ.Ø	66Ø.Ø
T3	5.5	3.5	8.Ø	1ØØ.Ø	45Ø.Ø
T4	5.5	3.5	8.6	12Ø.Ø	44Ø.Ø
C1	6.Ø	4.6	9.8	9Ø.Ø	1ØØØ.Ø
C2	5.5	5.9	9.9	9Ø.Ø	62Ø.Ø
C3	5.5	6.1	7.3	5Ø.Ø	53Ø.Ø
C4	5.5	3.9	7.3	5Ø.Ø	51Ø.Ø
TW1	6.Ø	1.9	7.8	6Ø.Ø	57Ø.Ø
TW2	5.5	2.9	9.9	9Ø.Ø	1Ø6Ø.Ø
TW3	5.5	1.5	9.3	1ØØ.Ø	4ØØ.Ø
TW4	5.5	4.8	8.1	6Ø.Ø	27Ø.Ø

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985
CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø314
Conductivity, Suspended Solids, BOD and COD

GULLY POT LIQUOR ANALYSIS

LOCATION	Cond uscm-1 (x1ØØØ)	SS mg/l	BOD mg/l	COD mg/l
T1	51.ØØ	61Ø	16	5Ø3
T2	12.73	125	11	35
T3	3.33	36	7	4Ø
T4	4.59	3Ø	23	151
C1	56.2Ø	479	7	-1
C2	9.49	124	5	45
C3	3.41	56	8	1Ø
C4	Ø.42	3Ø	1Ø	5Ø
TW1	3.86	5Ø	1Ø	Ø
TW2	39.8Ø	332	6	8Ø
TW3	4.6Ø	7Ø	13	Ø
TW4	Ø.66	43	8	65

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985
CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø315
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION :	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	Ø.Ø	26942.Ø	932.Ø	1.5	33.6
T2	Ø.5	5317.5	663.Ø	3.5	8.4
T3	Ø.9	1276.2	75Ø.Ø	1.2	4.Ø
T4	4.4	1737.1	644.Ø	2.Ø	11.9
C1	Ø.Ø	29424.Ø	961.Ø	1.2	7Ø.Ø
C2	Ø.3	3899.5	894.Ø	1.4	16.1
C3	Ø.Ø	1276.2	798.Ø	Ø.9	7.7
C4	Ø.7	81.5	25Ø.Ø	Ø.5	6.3
TW1	Ø.3	1488.9	759.Ø	Ø.9	8.4
TW2	Ø.9	2Ø2Ø7.Ø	894.Ø	1.5	53.2
TW3	Ø.1	179Ø.2	24Ø.Ø	Ø.8	7.7
TW4	Ø.4	173.7	625.Ø	Ø.4	6.3

****

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985
CODE : 85Ø32Ø
DATE SAMPLES COLLECTED : 85Ø32Ø
DATE SAMPLES ANALYSED : 85Ø32Ø
Temperature, Dissolved Oxygen, pH, Alkalinity and Total Hardness

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION	Temp C	DO mg/l	pH pH units	Alk mg/l as CaCO3	TH mg/l as CaCO3
T1	5.5	5.8	9.3	25Ø.Ø	94Ø.Ø
T2	5.Ø	5.9	7.4	24Ø.Ø	67Ø.Ø
T3	5.Ø	5.3	7.5	46Ø.Ø	67Ø.Ø
T4	4.5	5.6	7.9	19Ø.Ø	1Ø9Ø.Ø
C1	5.Ø	6.Ø	8.5	22Ø.Ø	85Ø.Ø
C2	4.5	7.6	7.6	19Ø.Ø	63Ø.Ø
C3	4.5	6.1	7.1	19Ø.Ø	67Ø.Ø
C4	4.5	6.1	7.1	15Ø.Ø	53Ø.Ø
TW1	5.Ø	4.5	7.6	14Ø.Ø	47Ø.Ø
TW2	4.5	5.8	9.3	21Ø.Ø	83Ø.Ø
TW3	4.5	4.5	8.5	37Ø.Ø	56Ø.Ø
TW4	5.Ø	5.9	7.6	14Ø.Ø	72Ø.Ø

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985
CODE : 85Ø32Ø
DATE SAMPLES COLLECTED : 85Ø32Ø
DATE SAMPLES ANALYSED : 85Ø32Ø
Conductivity, Suspended Solids, BOD and COD

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION	Cond uscm-1 (x1ØØØ)	SS mg/l	BOD mg/l	COD mg/l
T1	52.2Ø	268	32	686
T2	9.58	71	32	113
T3	2.Ø5	29	14	149
T4	4.27	38	27	1Ø3
C1	42.ØØ	195	17	-1
C2	5.21	48	23	77
C3	5.35	52	11	57
C4	Ø.5Ø	82	14	149
TW1	4.Ø8	22	19	72
TW2	4Ø.3Ø	288	23	-1
TW3	5.Ø5	27	15	57
TW4	2.16	1Ø	32	93

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985
CODE : 85Ø32Ø
DATE SAMPLES COLLECTED : 85Ø32Ø
DATE SAMPLES ANALYSED : 85Ø321
Phosphate,Chloride,Sulphate,Ammonia and Nitrate

****

GULLY POT LIQUOR ANALYSIS

****

LOCATION	PO4(3-) mg/l as P	Cl(-) mg/l as Cl	SO4(2-) mg/l as SO4	NH3 mg/l as N	NO3(-) mg/l as N
T1	6.9	542.Ø	865.Ø	2.6	51.8
T2	1.8	298.Ø	529.Ø	4.9	3Ø.1
T3	4.3	223.Ø	375.Ø	1.7	69.3
T4	5.1	468.Ø	1345.Ø	1.7	138.6
C1	3.7	429.Ø	721.Ø	1.4	39.2
C2	4.Ø	5ØØ.Ø	413.Ø	1.4	69.3
C3	4.4	355.Ø	5Ø9.Ø	1.5	9.Ø
C4	5.6	1Ø6.Ø	7Ø2.Ø	Ø.7	8.1
TW1	3.9	34Ø.Ø	6Ø5.Ø	Ø.6	42.Ø
TW2	3.1	3Ø1.Ø	865.Ø	1.5	217.Ø
TW3	1.8	238:Ø	432.Ø	1.7	75.6
TW4	4.2	319.Ø	8Ø7.Ø	9.Ø	69.3

NOTE: The figure Ø.ØØ means non-detectable level
NOTE: The figure -1.Ø stands for NO ANALYSIS

APPENDIX C Continued.

GULLY POT LIQUOR ANALYSIS

METALS

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840509
DATE SAMPLES COLLECTED : 840509
DATE SAMPLES ANALYSED : 840511

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

****

	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
LOCATION :						
T1	12.60	12.20	0.50	0.00	45.00	0.00
T2	38.00	3.90	0.20	0.00	48.00	0.00
T3	38.80	11.40	0.80	0.00	58.00	0.00
T4	23.20	5.00	0.10	0.00	54.00	0.00
C1	16.80	6.20	0.70	0.00	50.00	0.00
C2	32.80	5.00	0.50	0.00	57.00	0.00
C3	32.40	5.40	1.70	0.00	62.00	0.00
C4	16.20	10.50	0.40	0.00	44.00	0.00
TW1	18.60	6.20	0.50	0.00	47.00	0.00
TW2	8.80	4.20	0.10	0.00	58.00	0.00
TW3	10.40	5.40	0.20	0.00	75.00	0.00
TW4	90.00	5.80	0.50	0.00	72.00	0.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840509
DATE SAMPLES COLLECTED : 840509
DATE SAMPLES ANALYSED : 840511

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	0.11	0.14	0.00	0.00	0.00	0.00
T2	0.31	0.06	0.00	0.00	0.00	0.00
T3	0.18	0.32	0.00	0.00	0.00	0.00
T4	0.14	0.00	0.00	0.00	0.00	0.00
C1	0.10	0.03	0.00	0.00	0.00	0.00
C2	0.08	0.08	0.00	0.00	0.00	0.00
C3	0.10	0.49	0.00	0.00	0.00	0.00
C4	0.07	0.13	0.00	0.00	0.00	0.00
TW1	0.17	0.06	0.00	0.05	0.00	0.00
TW2	0.06	0.03	0.00	0.03	0.00	0.00
TW3	0.06	0.06	0.00	0.00	0.00	0.00
TW4	0.19	0.44	0.00	0.00	0.00	0.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840516
DATE SAMPLES COLLECTED : 840516
DATE SAMPLES ANALYSED : 840518

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
LOCATION						
T1	9.20	3.00	0.40	0.00	20.00	0.00
T2	8.60	3.00	0.30	0.00	19.00	0.00
T3	7.20	3.90	0.40	0.00	17.00	0.00
T4	3.90	9.80	0.20	0.00	19.00	0.00
C1	7.40	3.00	0.60	0.00	18.00	0.00
C2	5.30	3.00	0.30	0.00	13.00	0.00
C3	6.60	3.40	0.50	0.00	16.00	0.00
C4	1.50	1.70	0.10	0.00	15.00	0.00
TW1	6.60	3.40	0.20	0.00	14.00	0.00
TW2	7.80	2.50	0.20	0.00	17.00	0.00
TW3	18.80	3.60	0.30	0.00	61.00	0.00
TW4	25.60	2.40	0.20	0.00	30.00	0.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840516
DATE SAMPLES COLLECTED : 840516
DATE SAMPLES ANALYSED : 840518

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	0.08	0.13	0.00	0.00	0.00	0.00
T2	0.84	0.09	0.00	0.00	0.00	0.00
T3	0.46	0.14	0.00	0.00	0.00	0.00
T4	0.31	0.22	0.00	0.00	0.00	0.00
C1	0.10	0.16	0.00	0.00	0.00	0.00
C2	0.42	0.09	0.00	0.00	0.00	0.00
C3	0.18	0.14	0.00	0.00	0.00	0.00
C4	1.18	0.16	0.00	0.00	0.00	0.00
TW1	0.08	0.08	0.00	0.00	0.00	0.00
TW2	0.24	0.13	0.00	0.00	0.00	0.00
TW3	0.23	0.16	0.00	0.00	0.00	0.00
TW4	0.25	0.13	0.00	0.00	0.00	0.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840523
DATE SAMPLES COLLECTED : 840523
DATE SAMPLES ANALYSED : 840525

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

****

	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
LOCATION						
T1	1.10	0.80	0.10	0.00	11.30	0.00
T2	1.10	0.70	0.10	0.00	10.50	0.00
T3	0.70	0.80	0.10	0.00	9.20	0.00
T4	0.80	0.60	0.10	0.00	11.30	0.00
C1	4.00	1.60	0.20	0.00	15.00	0.00
C2	1.70	1.20	0.20	0.00	11.30	0.00
C3	1.70	1.00	0.10	0.00	9.60	0.00
C4	1.10	1.30	0.30	0.00	15.20	0.00
TW1	1.10	1.10	0.20	0.00	10.50	0.00
TW2	0.70	0.60	0.20	0.00	7.00	0.00
TW3	1.80	1.30	0.20	0.00	12.20	0.00
TW4	4.80	1.20	0.20	0.00	12.60	0.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840523
DATE SAMPLES COLLECTED : 840523
DATE SAMPLES ANALYSED : 840525

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

****

	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
LOCATION						
T1	0.11	0.06	0.00	0.00	0.00	0.00
T2	0.08	0.06	0.00	0.00	0.00	0.00
T3	0.07	0.10	0.00	0.00	0.00	0.00
T4	0.08	0.06	0.00	0.00	0.00	0.00
C1	0.04	0.04	0.00	0.00	0.00	0.00
C2	0.08	0.04	0.00	0.00	0.00	0.00
C3	0.06	0.04	0.00	0.00	0.00	0.00
C4	0.04	0.06	0.00	0.00	0.00	0.00
TW1	0.09	0.13	0.00	0.00	0.00	0.00
TW2	0.08	0.12	0.00	0.00	0.00	0.00
TW3	0.11	0.11	0.00	0.00	0.00	0.00
TW4	0.07	0.10	0.00	0.00	0.00	0.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840530
DATE SAMPLES COLLECTED : 840530
DATE SAMPLES ANALYSED : 840530

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

****

	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
LOCATION :						
T1	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
T2	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
T3	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
T4	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
C1	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
C2	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
C3	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
C4	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
TW1	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
TW2	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
TW3	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
TW4	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840530
DATE SAMPLES COLLECTED : 840530
DATE SAMPLES ANALYSED : 840530

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

****

	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
LOCATION :						
T1	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
T2	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
T3	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
T4	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
C1	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
C2	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
C3	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
C4	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
TW1	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
TW2	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
TW3	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
TW4	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840606
DATE SAMPLES COLLECTED : 840606
DATE SAMPLES ANALYSED : 840606

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METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

****

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
T2	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
T3	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
T4	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
C1	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
C2	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
C3	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
C4	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
TW1	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
TW2	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
TW3	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
TW4	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840606
DATE SAMPLES COLLECTED : 840606
DATE SAMPLES ANALYSED : 840606

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

****

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
T2	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
T3	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
T4	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
C1	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
C2	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
C3	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
C4	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
TW1	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
TW2	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
TW3	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
TW4	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840613
DATE SAMPLES COLLECTED : 840613
DATE SAMPLES ANALYSED : 840613

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	29.00	11.20	4.30	0.00	86.00	40.00
T2	8.00	1.00	0.60	0.00	19.00	0.90
T3	57.00	4.00	0.60	0.00	63.00	10.00
T4	24.00	3.00	0.60	0.00	48.00	130.00
C1	13.00	3.80	2.60	0.00	48.00	115.00
C2	4.00	1.20	0.20	0.00	13.00	7.00
C3	27.00	4.00	0.80	0.00	36.00	105.00
C4	34.00	17.50	0.40	0.00	100.00	1.00
TW1	44.00	5.20	0.70	0.00	48.00	70.00
TW2	6.00	1.00	0.60	0.00	16.00	8.50
TW3	18.00	2.50	4.10	0.00	48.00	40.00
TW4	125.00	3.20	0.20	0.00	61.00	120.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840613
DATE SAMPLES COLLECTED : 840613
DATE SAMPLES ANALYSED : 840615

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	0.22	1.00	0.06	0.00	0.00	0.00
T2	0.20	0.15	0.00	0.00	0.00	0.00
T3	0.20	0.12	0.00	0.00	0.00	0.00
T4	0.17	0.22	0.00	0.00	0.00	0.00
C1	0.17	0.70	0.00	0.00	0.00	0.00
C2	0.16	0.10	0.00	0.00	0.00	0.00
C3	0.15	0.40	0.00	0.00	0.00	0.00
C4	0.08	0.05	0.13	0.00	0.00	0.00
TW1	0.20	0.55	0.00	0.00	0.00	0.00
TW2	0.26	0.15	0.00	0.00	0.00	0.00
TW3	0.22	2.50	0.05	0.00	0.00	0.00
TW4	0.19	0.40	0.05	0.00	0.00	0.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840620
DATE SAMPLES COLLECTED : 840620
DATE SAMPLES ANALYSED : 840621

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	58.00	6.30	50.00	0.00	102.50	17.00
T2	7.50	2.50	10.50	0.20	30.00	0.50
T3	62.50	5.00	5.00	0.00	87.50	5.00
T4	22.50	5.00	10.50	0.00	70.00	14.00
C1	22.00	3.00	10.50	0.35	70.00	12.00
C2	2.50	1.20	16.00	0.35	30.00	2.00
C3	25.00	5.00	17.00	0.35	65.00	12.00
C4	22.00	5.00	5.00	0.00	130.00	3.00
TW1	47.50	5.50	10.50	0.00	75.00	7.50
TW2	2.50	0.55	3.00	0.00	20.00	0.68
TW3	0.20	5.00	16.00	0.00	65.00	14.00
TW4	150.00	5.00	3.00	0.20	80.00	12.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840620
DATE SAMPLES COLLECTED : 840620
DATE SAMPLES ANALYSED : 840621

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METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

****

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	0.35	0.85	0.00	0.00	0.00	0.00
T2	0.45	0.15	0.00	2.00	0.00	0.00
T3	0.25	0.00	0.00	1.00	0.00	0.00
T4	0.26	0.15	0.00	1.00	0.00	0.00
C1	0.20	0.30	0.00	2.00	0.00	0.00
C2	0.10	0.30	0.00	1.00	0.00	0.00
C3	0.15	0.58	0.00	1.00	0.00	0.00
C4	0.10	0.00	0.00	0.00	0.00	0.00
TW1	0.30	0.45	0.00	0.00	0.00	0.00
TW2	0.10	0.00	0.00	1.00	0.00	0.00
TW3	0.20	2.50	0.00	0.00	0.00	0.00
TW4	0.20	0.30	0.00	0.00	0.00	0.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840627
DATE SAMPLES COLLECTED : 840627
DATE SAMPLES ANALYSED : 840629

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	40.00	12.50	2.40	0.00	55.00	6.50
T2	10.00	10.00	2.70	0.00	27.50	2.00
T3	15.00	5.00	2.70	0.00	45.00	3.00
T4	30.00	4.50	2.70	0.00	37.50	2.00
C1	25.00	3.50	5.80	0.35	55.00	3.00
C2	2.50	6.50	1.20	0.35	37.50	2.00
C3	17.50	7.00	2.70	0.35	45.00	5.00
C4	7.50	6.50	0.80	0.70	37.50	3.00
TW1	2.50	1.50	1.80	0.00	17.50	2.00
TW2	22.50	6.50	2.00	0.15	37.50	3.00
TW3	13.00	7.50	2.00	0.15	17.50	2.00
TW4	17.50	7.50	2.00	0.15	0.00	2.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840627
DATE SAMPLES COLLECTED : 840627
DATE SAMPLES ANALYSED : 840629

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

****

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	0.15	0.30	0.00	0.00	0.00	0.00
T2	0.10	0.35	0.00	0.00	0.00	0.00
T3	0.25	0.10	0.00	0.15	0.00	0.00
T4	0.15	0.10	0.00	0.22	0.00	0.00
C1	0.00	0.00	0.00	0.30	0.00	0.00
C2	0.05	0.20	0.13	0.40	0.00	0.00
C3	0.00	0.90	0.13	0.55	0.00	0.00
C4	0.00	0.00	0.20	0.00	0.00	0.00
TW1	0.05	0.00	0.00	0.00	0.00	0.00
TW2	0.08	0.40	0.00	0.08	0.00	0.00
TW3	0.07	0.00	0.00	0.08	0.00	0.00
TW4	0.07	0.00	0.00	0.00	0.00	0.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840704
DATE SAMPLES COLLECTED : 840704
DATE SAMPLES ANALYSED : 840706

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

****

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	58.00	21.00	2.00	0.00	70.00	2.00
T2	30.00	17.00	2.00	0.00	102.50	5.00
T3	22.50	17.00	0.00	0.00	70.00	3.00
T4	17.50	9.00	2.70	0.00	70.00	5.00
C1	22.50	11.00	2.00	0.00	102.50	3.00
C2	57.00	18.00	1.80	0.00	80.00	6.50
C3	22.50	19.00	2.70	0.00	102.50	5.00
C4	22.00	25.00	2.70	0.00	70.00	5.00
TW1	17.50	27.00	2.70	0.00	65.00	3.00
TW2	6.50	16.00	2.00	0.00	80.00	2.00
TW3	21.00	15.00	2.40	0.00	102.50	2.00
TW4	21.00	12.00	2.00	0.00	70.00	3.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840704
DATE SAMPLES COLLECTED : 840704
DATE SAMPLES ANALYSED : 840706

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

****

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	0.20	0.15	0.00	0.00	0.00	0.00
T2	0.20	0.00	0.00	0.00	0.00	0.00
T3	0.16	0.00	0.00	0.00	0.00	0.00
T4	0.20	0.15	0.00	0.00	0.00	0.00
C1	0.17	0.30	0.00	0.00	0.00	0.00
C2	0.16	0.48	0.00	0.00	0.00	0.00
C3	0.17	0.30	0.00	0.00	0.00	0.00
C4	0.20	0.28	0.00	0.00	0.00	0.00
TW1	0.25	0.15	0.00	0.00	0.00	0.00
TW2	0.22	0.00	0.00	0.00	0.00	0.00
TW3	0.20	0.15	0.00	0.00	0.00	0.00
TW4	0.20	0.15	0.00	0.00	0.00	0.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840711
DATE SAMPLES COLLECTED : 840711
DATE SAMPLES ANALYSED : 840713

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

****

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	7.50	3.00	0.60	0.35	31.00	2.50
T2	7.00	1.50	0.80	0.45	30.00	5.00
T3	10.00	3.00	3.80	0.35	62.50	3.00
T4	21.00	7.50	0.80	0.00	62.50	2.50
C1	12.20	3.00	0.30	0.20	42.50	2.50
C2	8.70	1.50	0.30	0.00	37.50	1.45
C3	6.25	3.00	1.40	0.35	59.00	5.00
C4	12.50	3.00	0.30	0.70	50.00	1.40
TW1	7.00	1.50	0.30	0.35	100.00	2.50
TW2	17.50	6.50	0.30	0.00	133.00	2.00
TW3	22.50	3.00	0.30	0.00	117.50	5.00
TW4	5.80	7.50	0.60	0.35	141.50	6.25

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840711
DATE SAMPLES COLLECTED : 840711
DATE SAMPLES ANALYSED : 840713

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

****

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	0.14	0.25	0.00	0.00	0.00	0.00
T2	0.20	0.50	0.00	0.00	0.00	0.00
T3	0.35	0.75	0.00	0.03	0.00	0.00
T4	0.14	0.50	0.00	0.03	0.00	0.00
C1	0.20	0.50	0.00	0.00	0.00	0.00
C2	0.14	0.00	0.00	0.00	0.00	0.00
C3	0.14	0.65	0.00	0.00	0.00	0.00
C4	0.08	0.13	0.00	0.00	0.00	0.00
TW1	0.35	0.00	0.00	0.03	0.00	0.00
TW2	0.14	0.25	0.00	0.01	0.00	0.00
TW3	0.08	0.00	0.00	0.00	0.00	0.00
TW4	0.20	0.65	0.00	0.03	0.00	0.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840718
DATE SAMPLES COLLECTED : 840718
DATE SAMPLES ANALYSED : 840720

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

****

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	7.50	1.20	0.30	0.34	116.50	36.00
T2	10.00	1.30	0.30	0.54	107.50	48.50
T3	5.80	1.40	0.30	0.54	150.00	45.00
T4	8.40	1.35	0.30	0.34	100.00	45.50
C1	8.50	1.70	0.50	0.17	150.00	40.00
C2	8.20	1.65	0.50	0.34	116.50	37.50
C3	8.20	1.25	0.50	0.45	190.50	46.00
C4	4.00	1.10	0.30	0.54	141.00	35.00
TW1	8.50	1.60	0.30	0.34	190.50	47.50
TW2	8.40	1.20	0.30	0.34	190.50	50.00
TW3	11.00	8.00	0.30	0.45	190.50	47.50
TW4	16.50	1.85	0.30	0.54	200.00	65.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840718
DATE SAMPLES COLLECTED : 840718
DATE SAMPLES ANALYSED : 840720

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

****

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	0.06	0.00	0.00	0.00	0.00	0.00
T2	0.06	0.13	0.00	0.00	0.00	0.00
T3	0.20	0.25	0.00	0.00	0.00	0.00
T4	0.20	0.13	0.00	0.00	0.00	0.00
C1	0.16	0.00	0.00	0.00	0.00	0.00
C2	0.16	0.00	0.00	0.00	0.15	0.13
C3	0.16	0.13	0.00	0.00	0.00	0.13
C4	0.06	0.00	0.00	0.00	0.00	0.00
TW1	0.06	0.13	0.00	0.00	0.00	0.00
TW2	0.16	0.13	0.00	0.00	0.00	0.00
TW3	0.16	0.50	0.00	0.00	0.00	0.00
TW4	0.16	0.13	0.00	0.00	0.00	0.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840725
DATE SAMPLES COLLECTED : 840725
DATE SAMPLES ANALYSED : 840727

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	11.70	2.00	1.60	0.00	24.40	3.30
T2	6.80	1.50	1.00	0.00	20.50	2.30
T3	7.00	1.20	1.00	0.00	30.50	2.60
T4	7.10	1.50	1.00	0.00	16.30	1.30
C1	8.30	1.50	3.10	0.00	36.50	2.60
C2	8.00	1.20	0.50	0.00	16.30	0.82
C3	7.10	1.50	1.60	0.00	24.40	3.00
C4	7.40	1.20	0.50	0.00	20.50	0.76
TW1	3.70	1.10	0.00	0.00	16.30	0.82
TW2	13.50	2.20	0.00	0.00	28.50	0.96
TW3	5.00	4.50	0.00	0.00	41.50	3.60
TW4	6.80	1.70	0.00	0.00	28.50	2.60

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Summer Survey 1984
CODE : 840725
DATE SAMPLES COLLECTED : 840725
DATE SAMPLES ANALYSED : 840727

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

****

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	Ø.18	Ø.28	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
T2	Ø.26	Ø.18	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
T3	Ø.26	Ø.1Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
T4	Ø.36	Ø.28	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
C1	Ø.13	Ø.38	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
C2	Ø.Ø5	Ø.1Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
C3	Ø.1Ø	Ø.55	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
C4	Ø.Ø5	Ø.1Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
TW1	Ø.Ø8	Ø.18	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
TW2	Ø.1Ø	Ø.1Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
TW3	Ø.13	Ø.7Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
TW4	Ø.13	Ø.38	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ

NOTE: The figure Ø.ØØ means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn 1984.
CODE : 841Ø31
DATE SAMPLES COLLECTED : 841Ø31
DATE SAMPLES ANALYSED : 841Ø2

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

****

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	2.ØØ	Ø.6Ø	Ø.ØØ	Ø.ØØ	16.ØØ	Ø.6Ø
T2	1.8Ø	Ø.5Ø	Ø.ØØ	Ø.ØØ	12.8Ø	Ø.8Ø
T3	1.85	Ø.8Ø	Ø.2Ø	Ø.ØØ	13.ØØ	Ø.7Ø
T4	1.75	Ø.5Ø	Ø.ØØ	Ø.ØØ	13.8Ø	Ø.7Ø
C1	3.7Ø	1.3Ø	Ø.2Ø	Ø.ØØ	12.5Ø	Ø.9Ø
C2	1.78	Ø.8Ø	Ø.2Ø	Ø.ØØ	1Ø.8Ø	Ø.8Ø
C3	1.76	Ø.6Ø	Ø.2Ø	Ø.ØØ	2Ø.1Ø	Ø.8Ø
C4	1.72	Ø.8Ø	Ø.2Ø	Ø.ØØ	1Ø.ØØ	Ø.7Ø
TW1	1.85	Ø.6Ø	Ø.1Ø	Ø.ØØ	15.5Ø	Ø.9Ø
TW2	1.48	Ø.6Ø	Ø.1Ø	Ø.ØØ	1Ø.5Ø	Ø.8Ø
TW3	2.6Ø	1.9Ø	Ø.2Ø	Ø.ØØ	15.ØØ	1.ØØ
TW4	3.ØØ	Ø.9Ø	Ø.4Ø	Ø.ØØ	1Ø.ØØ	1.ØØ

NOTE: The figure Ø.ØØ means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841031
DATE SAMPLES COLLECTED : 841031
DATE SAMPLES ANALYSED : 841102

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METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

****

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	0.02	0.00	0.00	0.00	0.00	0.00
T2	0.05	0.03	0.00	0.00	0.00	0.00
T3	0.05	0.07	0.00	0.00	0.00	0.00
T4	0.05	0.07	0.00	0.00	0.00	0.00
C1	0.05	0.08	0.00	0.00	0.00	0.00
C2	0.04	0.03	0.00	0.00	0.00	0.00
C3	0.02	0.08	0.00	0.00	0.00	0.00
C4	0.02	0.03	0.00	0.00	0.00	0.00
TW1	0.04	0.07	0.00	0.00	0.00	0.00
TW2	0.02	0.10	0.00	0.00	0.00	0.00
TW3	0.04	0.12	0.00	0.00	0.00	0.00
TW4	0.04	0.12	0.00	0.00	0.00	0.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841107
DATE SAMPLES COLLECTED : 841107
DATE SAMPLES ANALYSED : 841109

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

****

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	3.20	0.80	0.00	0.00	23.00	0.80
T2	3.60	0.50	0.00	0.00	13.00	1.10
T3	3.00	0.80	0.00	0.00	15.00	1.00
T4	1.80	0.50	0.00	0.00	10.00	0.70
C1	3.00	1.10	0.00	0.00	10.00	1.10
C2	2.80	0.90	0.00	0.00	9.00	0.90
C3	2.80	1.00	0.00	0.00	9.40	1.00
C4	3.50	0.90	0.00	0.00	9.30	1.20
TW1	2.70	0.70	0.00	0.00	8.20	0.80
TW2	3.00	0.70	0.00	0.00	8.40	1.20
TW3	2.00	1.40	0.00	0.00	10.00	0.80
TW4	2.00	1.10	0.00	0.00	11.10	1.10

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841107
DATE SAMPLES COLLECTED : 841107
DATE SAMPLES ANALYSED : 841109

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

****

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	Ø.18	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
T2	Ø.Ø9	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
T3	Ø.14	Ø.1Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
T4	Ø.15	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
C1	Ø.Ø5	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
C2	Ø.12	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
C3	Ø.61	Ø.2Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
C4	Ø.19	Ø.1Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
TW1	Ø.Ø5	Ø.Ø5	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
TW2	Ø.Ø8	Ø.2Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
TW3	Ø.Ø3	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
TW4	Ø.Ø6	Ø.1Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ

NOTE: The figure Ø.ØØ means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841114
DATE SAMPLES COLLECTED : 841114
DATE SAMPLES ANALYSED : 841115

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

****

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	1.4Ø	Ø.7Ø	Ø.ØØ	Ø.ØØ	14.ØØ	Ø.5Ø
T2	1.7Ø	Ø.5Ø	Ø.ØØ	Ø.ØØ	1Ø.ØØ	Ø.7Ø
T3	1.5Ø	Ø.5Ø	Ø.ØØ	Ø.ØØ	1Ø.ØØ	Ø.7Ø
T4	1.6Ø	Ø.5Ø	Ø.ØØ	Ø.ØØ	1Ø.ØØ	Ø.6Ø
C1	2.7Ø	1.1Ø	Ø.ØØ	Ø.ØØ	12.5Ø	1.1Ø
C2	1.9Ø	Ø.7Ø	Ø.ØØ	Ø.ØØ	9.5Ø	Ø.8Ø
C3	1.6Ø	Ø.5Ø	Ø.ØØ	Ø.ØØ	9.5Ø	Ø.8Ø
C4	1.7Ø	Ø.7Ø	Ø.ØØ	Ø.ØØ	9.ØØ	Ø.7Ø
TW1	1.4Ø	Ø.7Ø	Ø.ØØ	Ø.ØØ	8.ØØ	Ø.6Ø
TW2	1.4Ø	Ø.4Ø	Ø.ØØ	Ø.ØØ	5.8Ø	Ø.6Ø
TW3	1.8Ø	1.3Ø	Ø.ØØ	Ø.ØØ	12.5Ø	Ø.9Ø
TW4	1.9Ø	Ø.6Ø	Ø.ØØ	Ø.ØØ	9.5Ø	Ø.8Ø

NOTE: The figure Ø.ØØ means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841114
DATE SAMPLES COLLECTED : 841114
DATE SAMPLES ANALYSED : 841115

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

****

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	Ø.Ø4	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
T2	Ø.Ø5	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
T3	Ø.Ø7	Ø.1Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
T4	Ø.Ø7	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
C1	Ø.Ø5	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
C2	Ø.Ø4	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
C3	Ø.Ø4	Ø.Ø5	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
C4	Ø.Ø5	Ø.Ø5	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
TW1	Ø.Ø3	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
TW2	Ø.Ø3	Ø.Ø3	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
TW3	Ø.Ø5	Ø.Ø5	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
TW4	Ø.Ø5	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ

NOTE: The figure Ø.ØØ means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841121
DATE SAMPLES COLLECTED : 841121
DATE SAMPLES ANALYSED : 841126

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

****

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	8.4Ø	Ø.5Ø	Ø.ØØ	Ø.ØØ	1Ø.5Ø	Ø.3Ø
T2	4.5Ø	Ø.4Ø	Ø.ØØ	Ø.ØØ	7.ØØ	Ø.4Ø
T3	3.7Ø	Ø.5Ø	Ø.ØØ	Ø.ØØ	8.2Ø	Ø.5Ø
T4	7.2Ø	Ø.3Ø	Ø.ØØ	Ø.ØØ	7.ØØ	Ø.3Ø
C1	3.2Ø	1.ØØ	Ø.ØØ	Ø.ØØ	8.3Ø	Ø.6Ø
C2	3.5Ø	Ø.8Ø	Ø.ØØ	Ø.ØØ	8.6Ø	Ø.6Ø
C3	3.ØØ	Ø.6Ø	Ø.ØØ	Ø.ØØ	1Ø.8Ø	Ø.5Ø
C4	3.7Ø	Ø.7Ø	Ø.ØØ	Ø.ØØ	5.7Ø	Ø.4Ø
TW1	3.5Ø	Ø.7Ø	Ø.ØØ	Ø.ØØ	5.7Ø	Ø.5Ø
TW2	5.7Ø	Ø.6Ø	Ø.ØØ	Ø.ØØ	5.7Ø	Ø.5Ø
TW3	5.ØØ	1.4Ø	Ø.ØØ	Ø.ØØ	9.2Ø	Ø.7Ø
TW4	3.8Ø	Ø.7Ø	Ø.ØØ	Ø.ØØ	7.ØØ	Ø.6Ø

NOTE: The figure Ø.ØØ means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841121
DATE SAMPLES COLLECTED : 841121
DATE SAMPLES ANALYSED : 841126

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	Ø.Ø4	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
T2	Ø.Ø4	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
T3	Ø.22	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
T4	Ø.17	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
C1	Ø.Ø6	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
C2	Ø.22	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
C3	Ø.3Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
C4	Ø.22	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
TW1	Ø.Ø2	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
TW2	Ø.Ø6	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
TW3	Ø.Ø9	Ø.Ø2	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
TW4	Ø.17	Ø.Ø2	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ

NOTE: The figure Ø.ØØ means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841128
DATE SAMPLES COLLECTED : 841128
DATE SAMPLES ANALYSED : 841204

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

****

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	8.00	1.30	0.00	0.00	22.00	1.40
T2	4.00	0.40	0.00	0.00	6.80	0.60
T3	3.40	1.00	0.00	0.00	16.60	1.20
T4	7.20	1.00	0.00	0.00	13.00	0.80
C1	3.60	0.70	0.00	0.00	4.60	0.40
C2	2.70	0.80	0.00	0.00	4.60	0.50
C3	3.30	0.40	0.00	0.00	5.30	0.40
C4	3.60	0.60	0.00	0.00	4.60	0.40
TW1	3.60	0.60	0.00	0.00	5.30	0.60
TW2	5.30	0.50	0.00	0.00	4.60	0.70
TW3	4.50	1.40	0.00	0.00	11.40	1.10
TW4	3.60	0.80	0.00	0.00	5.30	0.60

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Autumn Survey 1984
CODE : 841128
DATE SAMPLES COLLECTED : 841128
DATE SAMPLES ANALYSED : 841204

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

****

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	0.04	0.10	0.00	0.00	0.00	0.00
T2	0.02	0.10	0.00	0.00	0.00	0.00
T3	0.13	0.20	0.00	0.00	0.00	0.00
T4	0.11	0.10	0.00	0.00	0.00	0.00
C1	0.04	0.00	0.00	0.00	0.00	0.00
C2	0.03	0.00	0.00	0.00	0.00	0.00
C3	0.03	0.00	0.00	0.00	0.00	0.00
C4	0.03	0.00	0.00	0.00	0.00	0.00
TW1	0.04	0.10	0.00	0.00	0.00	0.00
TW2	0.03	0.10	0.00	0.00	0.00	0.00
TW3	0.04	0.10	0.00	0.00	0.00	0.00
TW4	0.06	0.10	0.00	0.00	0.00	0.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985.
CODE : 850220
DATE SAMPLES COLLECTED : 850220
DATE SAMPLES ANALYSED : 850222

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	22500.00	10.50	1.35	0.68	368.00	5.20
T2	7000.00	4.20	0.39	0.13	158.00	4.00
T3	1100.00	4.20	0.13	0.11	95.00	3.95
T4	19100.00	2.10	0.22	0.11	28.00	2.90
C1	45000.00	10.50	1.80	0.78	410.00	7.00
C2	13000.00	14.10	0.28	0.32	262.00	8.00
C3	9000.00	2.10	0.22	0.00	168.00	3.65
C4	3800.00	4.20	0.52	0.11	80.00	3.15
TW1	1500.00	5.50	0.00	0.00	168.00	3.95
TW2	12000.00	6.50	0.45	0.32	52.00	4.50
TW3	1900.00	4.50	0.12	0.11	26.00	2.72
TW4	4500.00	7.80	0.35	0.15	158.00	8.80

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985.
CODE : 850220
DATE SAMPLES COLLECTED : 850220
DATE SAMPLES ANALYSED : 850222

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	0.28	0.28	0.20	0.22	1.62	0.10
T2	0.63	0.70	0.00	0.00	0.22	0.00
T3	0.08	0.63	0.00	0.02	0.13	0.10
T4	0.16	0.22	0.00	0.00	0.10	0.00
C1	0.34	0.62	0.22	0.28	2.05	0.30
C2	0.16	0.62	0.10	0.06	0.52	0.00
C3	0.07	0.27	0.00	0.00	0.07	0.00
C4	0.18	0.22	0.00	0.03	0.09	0.00
TW1	0.07	0.08	0.00	0.03	0.13	0.00
TW2	0.12	0.42	0.09	0.11	0.65	0.10
TW3	0.05	0.20	0.00	0.00	0.09	0.00
TW4	0.11	1.00	0.00	0.03	0.22	0.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985.
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850302

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METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

****

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	19600.00	42.00	1.58	0.60	420.00	4.80
T2	9000.00	45.00	0.45	0.10	158.00	3.00
T3	18200.00	13.00	0.53	0.00	95.00	6.60
T4	1700.00	21.00	0.66	0.09	105.00	3.90
C1	18700.00	18.00	1.64	0.62	430.00	8.00
C2	9700.00	30.00	0.75	0.30	340.00	6.90
C3	8200.00	34.00	0.62	0.00	250.00	4.15
C4	2500.00	42.00	1.78	0.30	130.00	4.60
TW1	1750.00	21.00	0.48	0.09	80.00	3.52
TW2	1660.00	34.00	0.75	0.34	315.00	5.00
TW3	1560.00	25.00	0.87	0.10	95.00	2.68
TW4	1810.00	21.00	0.92	0.23	146.00	6.50

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985.
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850302

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

****

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	0.14	0.22	0.23	0.34	1.55	0.80
T2	0.37	0.50	0.00	0.06	0.13	0.00
T3	0.28	0.34	0.08	0.06	0.05	0.00
T4	0.40	0.26	0.00	0.06	0.05	0.00
C1	0.28	0.52	0.16	0.37	1.55	0.90
C2	0.16	0.62	0.09	0.13	0.47	0.10
C3	0.08	0.38	0.00	0.02	0.05	0.00
C4	0.22	0.34	0.08	0.02	0.13	0.00
TW1	0.08	0.13	0.00	0.03	0.07	0.00
TW2	0.09	0.37	0.09	0.16	0.62	0.10
TW3	0.05	0.23	0.00	0.03	0.05	0.00
TW4	0.09	0.74	0.00	0.07	0.22	0.10

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985.
CODE : 850306
DATE SAMPLES COLLECTED : 850306
DATE SAMPLES ANALYSED : 850309

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	18300.00	11.50	1.30	0.66	382.00	3.50
T2	14800.00	5.30	1.12	0.16	195.00	4.20
T3	10300.00	4.00	0.52	0.05	110.00	4.80
T4	1280.00	4.00	0.23	0.05	100.00	3.30
C1	1620.00	10.00	0.42	0.24	250.00	3.10
C2	810.00	5.80	0.20	0.05	142.00	1.40
C3	8500.00	5.00	0.45	0.05	220.00	2.30
C4	2300.00	1.20	0.23	0.00	29.00	1.00
TW1	1740.00	7.80	0.28	0.00	120.00	2.50
TW2	1850.00	8.20	0.45	0.28	220.00	3.50
TW3	1550.00	7.40	0.18	0.00	109.00	2.30
TW4	1500.00	4.50	0.16	0.00	76.00	6.00

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985.
CODE : 850306
DATE SAMPLES COLLECTED : 850306
DATE SAMPLES ANALYSED : 850309

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

****

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)	
T1	Ø.11	Ø.18	Ø.22	Ø.36	2.Ø8	Ø.ØØ	
T2	Ø.58	Ø.57	Ø.Ø2	Ø.Ø3	Ø.23	Ø.ØØ	
T3	Ø.16	Ø.27	Ø.Ø3	Ø.ØØ	Ø.11	Ø.ØØ	
T4	Ø.17	Ø.17	Ø.Ø2	Ø.ØØ	Ø.11	Ø.ØØ	
C1	Ø.Ø8	Ø.14	Ø.Ø8	Ø.11	Ø.66	Ø.ØØ	
C2	Ø.Ø4	Ø.Ø4	Ø.Ø8	Ø.ØØ	Ø.19	Ø.ØØ	
C3	Ø.19	Ø.55	Ø.Ø2	Ø.Ø5	Ø.23	Ø.ØØ	
C4	Ø.16	Ø.1Ø	Ø.Ø2	Ø.ØØ	Ø.Ø8	Ø.ØØ	
TW1	Ø.Ø8	Ø.1Ø	Ø.Ø1	Ø.Ø1	Ø.Ø8	Ø.ØØ	
TW2	Ø.Ø8	Ø.26	Ø.Ø9	Ø.13	Ø.7Ø	Ø.ØØ	
TW3	Ø.Ø5	Ø.15	Ø.Ø1	Ø.Ø1	Ø.Ø8	Ø.ØØ	
TW4	Ø.15	Ø.1Ø	Ø.Ø3	Ø.ØØ	Ø.11	Ø.ØØ	

NOTE: The figure Ø.ØØ means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985.
CODE : 850313
DATE SAMPLES COLLECTED : 850313
DATE SAMPLES ANALYSED : 850315

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

****

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	13300.00	8.70	0.90	0.28	460.00	16.40
T2	6500.00	5.50	0.96	0.15	250.00	5.50
T3	620.00	3.80	0.18	0.08	56.00	3.50
T4	800.00	4.50	0.18	0.15	100.00	3.50
C1	14600.00	9.00	0.96	0.40	410.00	5.50
C2	1820.00	5.70	0.33	0.15	314.00	30.00
C3	580.00	2.60	0.10	0.08	62.00	1.50
C4	55.00	1.07	0.18	0.00	33.80	1.50
TW1	610.00	3.00	0.10	0.08	288.00	18.20
TW2	9500.00	7.80	0.65	0.32	420.00	13.80
TW3	880.00	6.60	0.10	0.15	120.00	2.58
TW4	118.00	2.20	0.10	0.00	29.60	2.10

NOTE: The figure 0.00 means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985.
CODE : 850313
DATE SAMPLES COLLECTED : 850313
DATE SAMPLES ANALYSED : 850315

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	Ø.16	Ø.1Ø	Ø.22	Ø.19	1.36	Ø.2Ø
T2	Ø.53	Ø.62	Ø.Ø4	Ø.Ø3	Ø.25	Ø.ØØ
T3	Ø.14	Ø.27	Ø.ØØ	Ø.Ø2	Ø.ØØ	Ø.1Ø
T4	Ø.16	Ø.16	Ø.Ø2	Ø.Ø6	Ø.1Ø	Ø.1Ø
C1	Ø.13	Ø.22	Ø.18	Ø.22	1.36	Ø.1Ø
C2	Ø.Ø7	Ø.Ø7	Ø.Ø5	Ø.Ø5	Ø.1Ø	Ø.2Ø
C3	Ø.16	Ø.11	Ø.Ø2	Ø.Ø2	Ø.1Ø	Ø.1Ø
C4	Ø.16	Ø.1Ø	Ø.ØØ	Ø.Ø2	Ø.ØØ	Ø.1Ø
TW1	Ø.11	Ø.1Ø	Ø.ØØ	Ø.Ø3	Ø.1Ø	Ø.ØØ
TW2	Ø.Ø7	Ø.11	Ø.12	Ø.16	Ø.87	Ø.1Ø
TW3	Ø.Ø7	Ø.11	Ø.Ø2	Ø.Ø3	Ø.25	Ø.ØØ
TW4	Ø.11	Ø.1Ø	Ø.Ø2	Ø.ØØ	Ø.25	Ø.ØØ

NOTE: The figure Ø.ØØ means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985.
CODE : 85Ø32Ø
DATE SAMPLES COLLECTED : 85Ø32Ø
DATE SAMPLES ANALYSED : 85Ø324

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
GULLY LIQUOR SAMPLE

****

LOCATION	Na (ppm)	K (ppm)	Fe (ppm)	Pb (ppm)	Ca (ppm)	Mg (ppm)
T1	112ØØ.ØØ	7.5Ø	Ø.71	Ø.28	182.ØØ	2.ØØ
T2	158Ø.ØØ	2.6Ø	Ø.96	Ø.28	83.5Ø	3.28
T3	61Ø.ØØ	2.7Ø	Ø.18	Ø.ØØ	45.5Ø	2.15
T4	58Ø.ØØ	6.2Ø	Ø.33	Ø.ØØ	5Ø.ØØ	2.53
C1	8ØØØ.ØØ	7.5Ø	Ø.6Ø	Ø.28	168.ØØ	2.53
C2	78Ø.ØØ	3.8Ø	Ø.28	Ø.28	51.ØØ	1.5Ø
C3	4ØØ.ØØ	3.ØØ	Ø.4Ø	Ø.ØØ	4Ø.8Ø	Ø.92
C4	5Ø.ØØ	13.8Ø	Ø.71	Ø.ØØ	18.8Ø	1.28
TW1	52Ø.ØØ	8.7Ø	Ø.33	Ø.28	47.ØØ	2.Ø8
TW2	72ØØ.ØØ	13.8Ø	Ø.5Ø	Ø.28	173.ØØ	3.45
TW3	86Ø.ØØ	7.5Ø	Ø.33	Ø.15	64.3Ø	2.72
TW4	28Ø.ØØ	3.28	Ø.33	Ø.ØØ	6Ø.5Ø	6.1Ø

NOTE: The figure Ø.ØØ means non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
GULLY LIQUOR SURVEY PROGRAMME
G. A. Fulcher (Dept. of Civil Engineering)
Spring Survey 1985.
CODE : 850320
DATE SAMPLES COLLECTED : 850320
DATE SAMPLES ANALYSED : 850324

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
GULLY LIQUOR SAMPLE

LOCATION	Zn (ppm)	Mn (ppm)	Cu (ppm)	Cd (ppm)	Ni (ppm)	Cr (ppm)
T1	0.07	0.07	0.18	0.25	1.08	0.20
T2	0.23	0.44	0.00	0.03	0.25	0.00
T3	0.12	0.21	0.00	0.03	0.00	0.10
T4	0.08	0.16	0.00	0.01	0.10	0.00
C1	0.12	0.22	0.10	0.12	0.10	0.10
C2	0.07	0.10	0.02	0.01	0.25	0.20
C3	0.11	0.32	0.00	0.00	0.10	0.20
C4	0.16	0.22	0.00	0.01	0.10	0.10
TW1	0.07	0.10	0.00	0.00	0.00	0.00
TW2	0.06	0.11	0.09	0.09	0.10	0.20
TW3	0.04	0.16	0.02	0.01	0.00	0.10
TW4	0.14	0.18	0.02	0.03	0.00	0.00

NOTE: The figure 0.00 means non-detectable level

APPENDIX E.

Published Papers:

1. Pratt C.J., Elliott G.E.P. and Fulcher G.A.
   "Suspended Solids Discharge from Highway Gully Pots
   in a Residential Catchment"
   The Science of the Total Environment vol. 59 355-364 1987.

2. Pratt C.J., Elliott G.E.P. and Fulcher G.A.
   "Role of Highway Gullies in Determining Water Quality
   in Separate Storm Sewers"
   in "Urban Storm Water Quality and Effects upon Receiving Waters"
   Proceedings and Information no. 36. Published by CHO/TNO.
   Committee on Hydrological Research, The Hague, Netherlands. 1987.

The Science of the Total Environment, 59 (1987) 355—364
Elsevier Science Publishers B.V., Amsterdam — Printed in The Netherlands

SUSPENDED SOLIDS DISCHARGE FROM HIGHWAY GULLY POTS IN A RESIDENTIAL CATCHMENT

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SUMMARY

Data from field observations of material supply to highway gully inlets and gully pot liquor concentrations over several years are presented. Suspended solids discharge for artificial and natural storm events on gully pots are shown to generally lie in a band of width one order of magnitude of solids discharge for a wide range of flow rates. On the basis of log-normal probability distribution of suspended solids concentration, common for all flow rates, a simple model for the prediction of suspended solids discharge is outlined. The model should be reasonably accurate for the determination of total loads to receiving waters over several events.

INTRODUCTION

For ten years the quality and quantity of stormwater runoff have been investigated on the Clifton Grove residential catchment, Nottingham (refs.1-5). Various aspects have been studied, including spatial and temporal variations in gully pot liquor quality; the different qualities of discharges from highway, roof and total catchment surfaces, sampled at various locations within the separate stormwater drainage system in the catchment; and initial attempts have been made to develop runoff quality and quantity simulation models for the catchment.

More recently research has been directed at the determination of the sedimentation and pollutant transfer characteristics of highway gully pots, in order to improve understanding of suspended solids and associated pollutant transport rates from catchment surfaces into the sewer system. Three highway gullies were equipped with vacuum liquid samplers for the simultaneous collection of runoff samples at the inlet to the gullies and in the gully pot at the outlet to the downstream sewer. The samplers were float-triggered by storm inflow, and corresponding rainfall was recorded at 30s intervals from nearby 0.1mm tipping bucket raingauges.

To assist in the understanding of the sedimentation and resuspension mechanisms operating in gully pots, some artificial storm events were produced

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at arbitrarily chosen gullies on the catchment. Two types of event were created: time-varying inflow with 16 minute duration, but peak discharge varying between events up to that equivalent to approximately a one in five year return period storm; and constant inflow storms, varying from 0.5 to 2 l/s between events, but of different runoff durations such that the total runoff volume was either 500 or 1000 litres, a range typical of monitored events.

A full report is in preparation (ref.6) and some results have been given by Pratt et.al. (ref.7). Here results of the present and past studies of gully pot sedimentation performance are combined to propose a probabalistic approach to the prediction of suspended solids discharge from highway gullies to downstream sewers and receiving waters.

SUSPENDED SOLIDS SUPPLY TO HIGHWAY GULLIES

The rates of sediment and debris supply to five gullies on the Clifton Grove catchment were measured for a twelve month period by Adams (refs.3 & 8: see Fig.1). The observations for each gully are shown separately and it is evident that wide scatter exists both between measurements at gullies in the same 14-day period, and between the results at one gully obtained in different periods of the year.

The rate of material supply into highway gullies is highly variable, both spatially and temporally on the catchment. The spatial variability may be associated with land use and human activity, etc., but these are difficult parameters to incorporate within a supply rate predictive model for a catchment, such as Clifton Grove, which is homogeneous in nature in gross descriptive terms. Temporal variability may be incorporated into a model, as important physical and meteorolgical factors are more easily assessed and quantified.

A peak in material supply was found to occur in June, when soil surfaces dried and water- or wind-mobilised material was readily available, because of gardening and other human and animal activities. At that time grass cuttings, flower debris, etc., were plentiful after the first flush of plant growth. In the months from June to the following February, material supply generally decreased as outdoor activities decreased; soils became wetter, binding particles to surfaces; and available plant matter was limited. The leaf fall in November-December may be significant on some catchments and represent another clear peak in supply. Around February-March snow and freezing conditions resulted in an increase in supply, either as a result of road gritting (in this case not in the catchment, but as material brought in from adjacent highways by vehicles), or during the thaw when frost-loosened material was transported to gullies. Other locations in the U.K. might have slightly different timings for peak material inputs according to local climate and environment, but general agreement with the observed patterns on Clifton Grove might be expected.

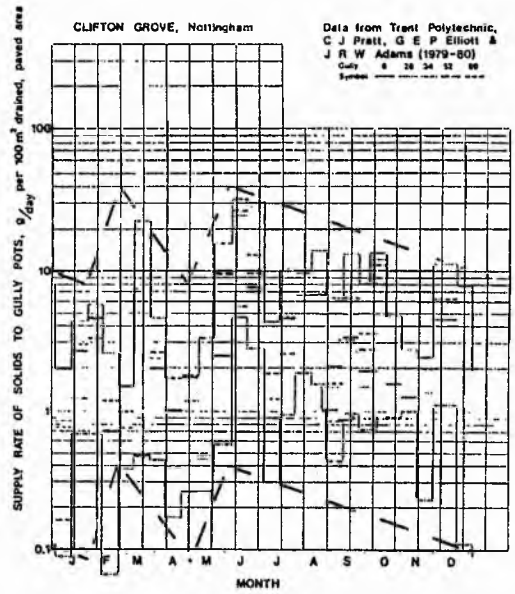

Fig.1. Graph showing variation in the supply rate of solids to highway gullies over 14-day periods.

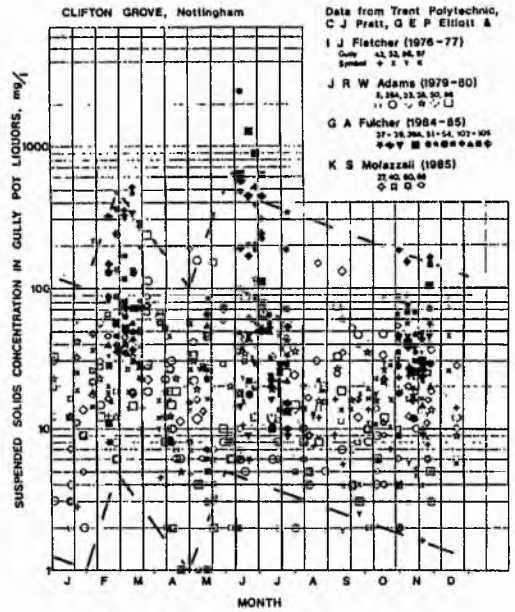

Fig.2. Data combined from studies over several years showing the variation in suspended solids concentration in highway gully pot liquors.

Material entering a highway gully may contribute to the accumulated basal sediments or remain in suspension in the gully pot liquor. Fig.2 shows the observed suspended solids concentrations in various gully pots on the catchment in various years (refs.6-10). There is spatial variability in concentration, but again without any clear systematic or physical basis. It is possible to interpret similar patterns of rise and fall in concentrations as were displayed in material supply rates (see Fig.1).

Simplified upper and lower envelopes have been drawn on Figs. 1 and 2, separated by two orders of magnitude. It has been shown previously that the supply rate observations, throughout a year at any gully, fit a log-normal probability distribution (ref.3), and it is assumed here that: both supply rate and gully liquor concentration fit such a distribution throughout the year at a gully and between gullies across the catchment on any day; and that, with the limited data available, it is reasonable to assume that the envelopes lie at one standard deviation from the mean, forming the basis of simplified predictive models for supply rate and liquor concentration. Such an approach allows for the determination of mean values of supply rate and liquor concentration at any time in the year across the catchment, or for quality simulation by probabalistic prediction at individual gullies for simulation within a runoff quality model for the catchment.

SUSPENDED SOLIDS DISCHARGE DURING ARTIFICIAL STORMS

Time-varying inflow hydrographs

Artificial storms using time-varying inflows and of 16-minute duration were produced using a fire hydrant for supply to a flow meter. Flow was discharged onto the gully grating and immediate surround, to avoid jetting into the gully itself and so as not to wash solids into the gully from the highway. Suspended solids concentration in the pot liquor was determined before and during each storm (see Fig.3). The rate of suspended solids discharge to the downstream sewer was calculated and is shown in Fig.4.

Liquor samples were obtained at one-minute intervals and the open symbols in Fig.4 represent results on the rising limb of the hydrograph, the solid symbols are on the falling limb. Three storm events have their plotted points joined indicating solids discharge variations with flow throughout the hydrographs. Each storm event was conducted on a different gully and/or a different occasion. The gullies were chosen quite arbitrarily, and the initial pot liquor concentration and the amount and nature of the basal deposits available to contribute to the solids discharge were open to chance.

Gully pot liquor suspended solids concentrations have been shown earlier to be extremely variable. On occasions of high initial concentration, suspended

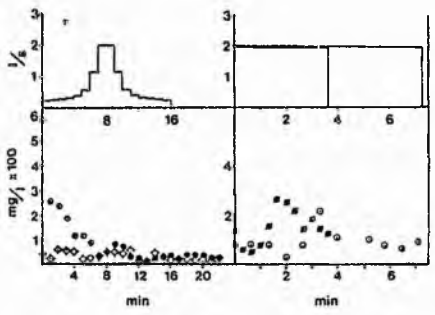

Fig.3. Typical time-varying and constant inflow hydrographs used in artificial storm event studies of suspended solids concentration in gully pot discharges to downstream sewer.

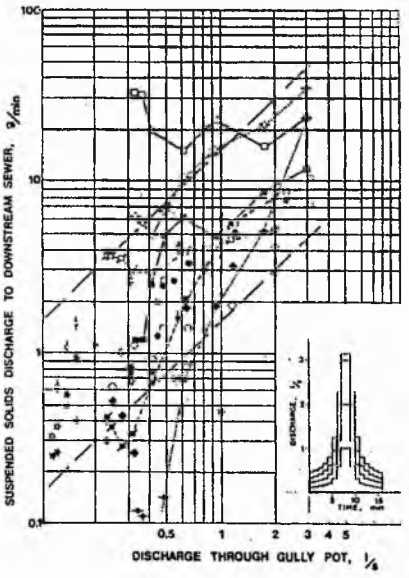

Fig.4. Suspended solids discharges during time-varying inflow hydrographs.

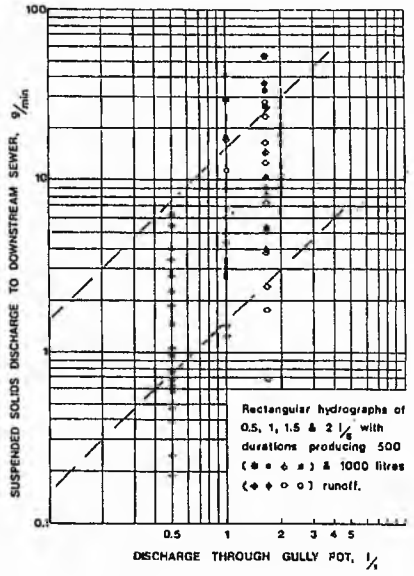

Fig.5 Suspended solids discharge during constant inflow hydrographs on highway gullies.

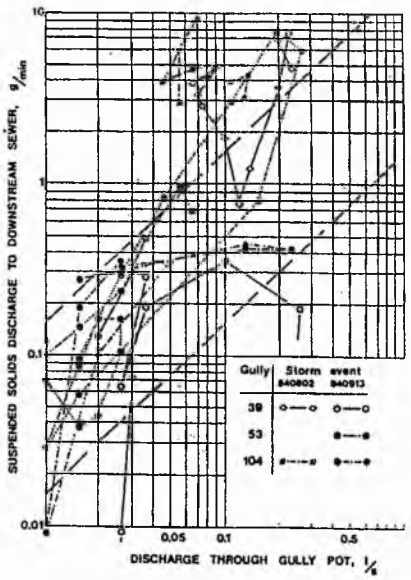

Fig.6. Suspended solids discharge during natural storm events on highway gullies.

solids discharge from the gully pot gradually reduced the pot concentration, without apparent resuspension of basal sediments (□———□,Fig.4). Where the initial pot concentration was not high, the suspended solids discharge to the downstream sewer was a combination of the initial pot concentration and resuspended solids from the basal deposits (□----□,Fig.4). The quantity of suitable material available for resuspension was insufficient at times at a given flow and the solids discharge rate decreased accordingly (◇·····◇,Fig.4).

The artificial storm events generally indicated that the solids discharge rate at a given flow through the gully could be expected to lie in a band, of width one order of magnitude of solids discharge. The upper and lower envelopes represent constant suspended solids concentrations in the downstream sewer of 250 and 25 mg/l respectively. Where the plots of an event lie above the upper envelope, it is considered to be indicative of initially 'high' pot concentrations i.e. 'excess' suspended solids available for discharge, and a dilution mechanism takes place within the gully pot. Below the lower envelope, sediment supply depletion is believed to affect solids discharge.

In this series of events, since no solids were contained in the inflow, additional sediment supply could only be derived from the basal deposits, which might be insufficient or the material unsuitable for resuspension in some cases.

Constant inflow hydrographs

During the constant inflow storm events flow was discharged onto the highway near the kerbside channel and some 20m upstream of the gully under study. The runoff in the channel transported solids to the gully, and both inflow and gully liquor suspended solids concentrations were measured during each event (see Figs.3 & 5). Some events displayed high solids discharge, here interpreted as typical of solids supply 'excess' (e.g. storms at 1 and 1.5 l/s (Fig.5)), but the time of occurrence within the hydrograph was variable. With longer events producing 1000 litres total runoff, sediment 'depletion' occurred on occasions, as the channel was washed clean and the basal deposits were unable to supply additional material (e.g. storms at 0.5 and 1.5 l/s (Fig.5)).

SUSPENDED SOLIDS DISCHARGE IN NATURAL STORM EVENTS

Three gullies were equipped with vacuum liquid samplers to allow both inflow from the highway and gully pot liquor to be sampled simultaneously during natural storm events on Clifton Grove. The calculated suspended solids discharge and the discharge through the three gullies for two events are shown in Fig.6. The results for each event on each gully are connected showing the progression through the hydrograph. Examples of solids 'excess' and 'depletion' may be interpreted relative to the assumed solids discharge-flow envelopes.

A similar graph has been plotted for previous research data in Fig.7

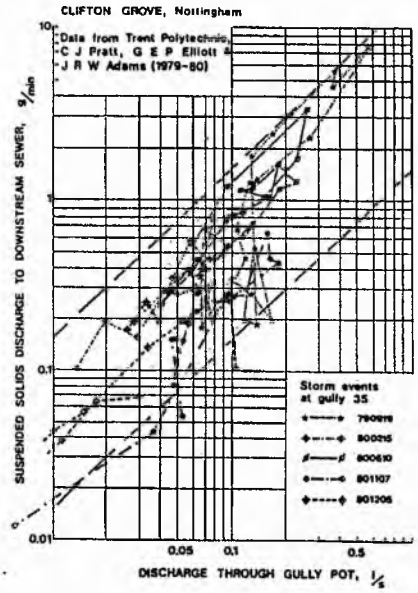

Fig.7. Suspended solids discharge during natural storm events on a highway gully (ref.11).

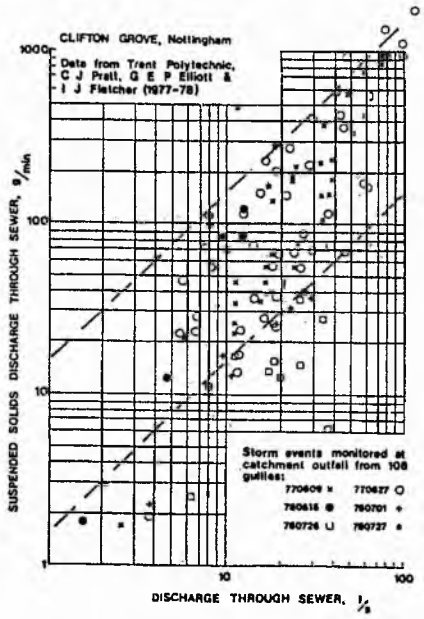

Fig.8. Suspended solids discharge during natural storm events monitored at the outfall from Clifton Grove catchment (ref.9).

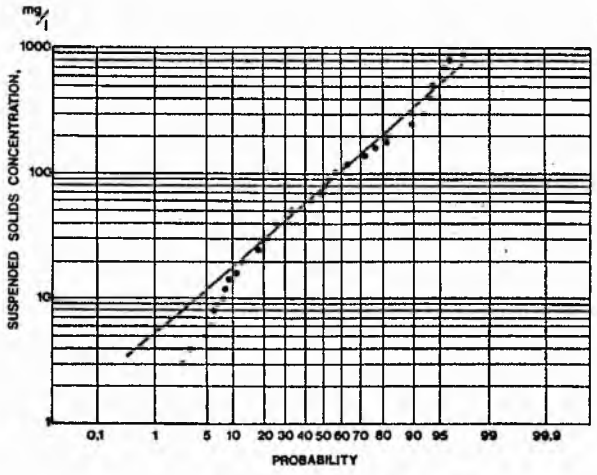

Fig.9. Log-normal probability distribution of suspended solids concentration in flows from highway gullies for data on Figs.6 - 8.

(ref.11), where little evidence of solids 'excess' or 'depletion' is displayed.

The results in Figs.4 - 7 cover a range of discharges through the gullies up to about 3 l/s. A wider range of flow rates exists in data obtained at the outfall of all 108 highway gullies on the Clifton Grove at the catchment outfall (Fig.8).

For natural storm events, suspended solids in storm runoff from paved areas may be derived from the highway surface and kerbside channel above ground, and from gully liquor and gully basal deposits below ground, prior to discharge to the sewer system. On Clifton Grove, it is believed that solids supply from these sources is generally adequate to result in suspended solids concentrations in the sewers of at least 25 mg/l, the lower envelopeon Figs.4 - 8. It has been reported previously that evidence of suspended solids supplydepletion rarely occurs on Clifton Grove, because of its coarse tarmacadam road surfacing which holds large quantities of fine, transportable material (ref.8). It depends upon solids input from the highway surface and the potential of the basal deposits for resuspension during an event, whether dilution of the initial pot concentration occurs, or whether elevated suspended solids discharge results, and sewer concentrations in excess of 250 mg/l are produced. For observations, such as in Fig.8, additional solids supply is available from the in-pipe deposits from previous events.

OUTLINE OF A SUSPENDED SOLIDS DISCHARGE MODEL

Both solids supply rate to highway gullies and gully pot liquor suspended solids concentrations are highly variable, which makes these parameters difficult to predict by a deterministic modelling approach. If both data sets are considered to follow log-normal distributions at any time, with standard deviation of the order of one order of magnitude in each parameter, a simple suspended solids discharge model, based upon a probabalistic approach, is possible. For example for the period of the year from June to February of the following year, mean supply rate of solids, S, may be estimated from the equation:

$$\log S = -0.003.DAYS + 0.146 \quad (1)$$

where DAYS has June 1st as origin and the standard deviation of logS is 1.0 on Fig.1; and the mean suspended solids concentration in the gully pot liquor is given by:

$$\log C_q = -0.003.DAYS + 1.176 \quad (2)$$

with standard deviation of $\log C_q$ = 1.0 on Fig.2.

For suspended solids discharge from gully pots it has been shown that data, covering a wide range of flows from several research studies (Figs.4 - 8), lie in a single band of width one order of magnitude of solids discharge for any given flow rate. The solids discharge rate may vary at any given flow rate

because of the many randomly determined factors. Assuming suspended solids discharge to be random, but of log-normal distribution at any flow rate, mean solids discharge, L g/min, may be expressed as:

$$\log L = \log Q + 0.672 \qquad (\text{i.e. } L = 4.7\,Q) \qquad (3)$$

with standard deviation of logL equal to 0.5: or mean suspended solids concentration in the discharge from a gully to the sewer, C, with probability of occurrence 0.5, is 79 mg/l for all values of flow rate, Q l/s. A log-normal probability distribution of suspended solids concentration for the discharge to the sewer may be used to estimate the concentration at any time in a runoff simulation.

To test this hypothesis of log-normal distribution for suspended solids concentration for all flow rates in this simplified model, a graph was drawn corresponding to the assumed mean (79 mg/l) and standard deviation (logC = 0.5) as shown in Fig.9. If the suspended solids concentration distribution was the same for all flows, data for several events and covering a range of flows could be combined to provide an adequate data set on which to test the hypothesis of log-normal distribution. Accordingly, the event data for natural storms on Figs.6 - 8 were analysed and plotted as points on Fig.9. The hypothesis was confirmed and close fit achieved to the assumed mean and standard deviation. Therefore, given observations of flow and suspended solids concentrations for a catchment from several events, a suitable suspended solids concentration probability distribution may be formed.

Hence the mass of suspended solids, M, discharged in a time interval of length t is given by:

$$_{T}M_{T+t} = (C_T.Q_T + C_{T+t}.Q_{T+t}).t/2 \qquad (4)$$

where Q_T and Q_{T+t} are defined from the hydrograph, and C_T and C_{T+t} are randomly selected on the basis of the normal probability distribution. At the start of the storm the initial gully pot concentration, C_o is randomly selected for the particular time in the year from Eq.2, or its alternative forms through the year, and the initial mass of solids discharged in the first time interval expressed as:

$$_{o}M_{t} = (C_o + C_t).Q_t.t/2 \qquad (5)$$

CONCLUSIONS

A simple suspended solids discharge model has been proposed based upon a probabilistic approach. The simulation of solids discharge might approximate to that observed in individual events, but because of the randomness of solids supply, both from the surface into the drainage system and from the liquor and basal deposits of the highway gullies, accuracy of prediction would be variable. The model is expected to be useful in the general prediction of total suspended solids discharge to receiving waters over several events on a catchment.

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ROLE OF HIGHWAY GULLIES IN DETERMINING WATER QUALITY IN SEPARATE STORM SEWERS

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Abstract

Data are presented from field and laboratory studies of water quality and pollutant attachment to sediments in roadside gully pots in a residential catchment. Results of correlation analysis of water quality parameters are presented and the effect of discharge to a separate storm sewer via gully pots are illustrated for two events, one displaying enhanced suspended solids concentration due to resuspension of pot basal deposits, the other showing improved quality of outflow as a result of sedimentation within the gully. The importance of pH variation in determining the exchange of heavy metals from liquor to sediment phases of pollutant transport, and vice versa, is demonstrated.

1 Introduction

The paper presents results of a partly completed three year research programme undertaken to investigate the influence of gully pots on the quality of urban storm water discharge from highway surfaces to a separate storm sewer system. Typically in the UK, gullies in residential areas receive

storm runoff from some 200m^2 highway surface. Below the inlet grating at the highway surface is a gully pot of some 100l capacity, which provides a water seal to the downstream sewer connection and is intended to trap sediments, preventing their forward transmission through the sewer system.

The investigation reported set out to determine in what ways the discharge quality of highway runoff, with its associated sediments and pollutant loads, was affected by passage through the gully pot prior to entering the sewer system. Three aspects were studied in some detail: gully pot liquor and deposited basal sediment quality; storm runoff quality at inflow and outflow from the gully pot; and factors affecting pollutant transfer to and from sediment-associated and disolved phases.
The study has been based on three cul-de-sacs in a well-maintained, residential housing estate at Clifton, Nottingham. The three sub-catchments selected were all similar in land use but had highway slopes which ranged from 0.5 to 5.5%. The sites had been locations of overland flow research (Pratt & Henderson (1981)),and the catchment as a whole had been previously studied to determine general sediment washoff (Pratt & Adams (1981)) and stormwater discharge quality (Fletcher et al. (1978); Fletcher & Pratt (1981)).

2 Research Programme

2.1 Systematic sampling: liquor

The research has built up a data set of results of 26 water quality variables, including 12 heavy metals (Table 1) from weekly sampling, undertaken in three periods between May '84 and April 1985. Liquor samples were collected from twelve gully pots, four from each of the three sub-catchments. The gullies were all located at the closed end of each cul-de-sac with two on either side of the highway. The sampling programme was conducted over a twelve week period during the

Table 1 Parameters analysed in the gully liqour programme

Water Quality Parameters		Heavy Metals (mg/l)	
Temperature	(^{o}C)	Sodium	(Na)
Dissolved oxygen	(mg/l)	Potassium	(K)
pH	(pH unit)	Iron	(Fe)
BOD_5	(mg/l as BOD)	Lead	(Pb)
COD	(mg/l as COD)	Calcium	(Ca)
Conductivity	(microsiemen/cm)	Magnesium	(Mg)
Suspended solids	(mg/l)	Zinc	(Zn)
Alkalinity	(mg/l as $CaCO_3$)	Manganese	(Mn)
Total hardness	(mg/l as $CaCO_3$)	Copper	(Cu)
Phosphate	(mg/l as P)	Cadmium	(Cd)
Sulphate	(mg/l as SO_4)	Nickel	(Ni)
Chloride	(mg/l as Cl)	Chromium	(Cr)
Nitrate	(mg/l as N)		
Ammonia	(mg/l as N)		

summer 1984 and over two further five week periods during winter 1984/85.

A one litre sample was taken at a depth of half the depth of standing water in the pot chamber. The purpose of this part of the study was to assess and quantify the range of the selected water quality parameters on a temporal and spatial basis. Data are presented for both the total data set to show the overall variability of the twelve gullies within three sub-catchments (Table 2) and for each sub-catchment separately (Table 3).

2.2 Systematic sampling: sediments

Basal sediments from the twelve gully pots were collected on a monthly basis for six months from October 1984 and analysed to determine the heavy metals attachment. The metals were digested in a mixture of 1:1 by volume of

Table 2 Descriptive statistics for the total water quality data set for the gully liquor sampling programme

Statistic	n	mean	max.	min.	σ-
Temperature	264	12.7	25.0	2.0	6.2
Dissolved oxygen	264	3.5	8.5	0.2	2.1
pH	264	7.1	11.4	5.5	0.9
BOD_5	264	19	62	0.0	16.7
COD	230	105	976	0.0	154
Conductivity	264	5.0	114.1	0.0	15.8
Suspended solids	216	114.0	2449	0.0	227
Alkalinity	240	139.5	500.0	20.0	91.7
Total hardness	240	299.0	1240	20.0	260
Phosphate	240	1.8	13.0	0.0	1.9
Sulphate	228	377.0	2268	0.0	382
Chloride	240	1808	54593	5.0	6956
Nitrate	180	18.6	266.0	0.1	35.2
Ammonia	240	2.5	26.6	0.0	4.6
Sodium	240	1596	45000	0.00	4852
Potassium	240	5.42	45.00	0.30	7.40
Iron	240	1.24	50.00	0.00	3.90
Lead	240	0.09	0.78	0.00	0.17
Calcium	240	73.00	460.00	0.00	90.90
Magnesium	240	7.40	130.00	0.00	18.40
Zinc	240	0.15	1.18	0.00	0.13
Manganese	240	0.21	2.50	0.00	0.29
Copper	240	0.02	0.23	0.00	0.04
Cadmium	240	0.06	2.00	0.00	0.24
Nickel	240	0.09	2.08	0.00	0.31
Chromium	240	0.02	0.90	0.00	0.09

Table 3 Descriptive statistics for the water quality data set on each of the three highway sub-catchments

	Tame Close				:Churnet Close				:Twyford Gardens			:
	n	min.	max.	mean	n	min.	max.	mean	n	min.	max.	mean
Temp.	88	2.0	25.0	12.8	88	2.5	25.0	12.7	88	2.5	24.5	12.6
DO	88	0.6	8.5	3.3	88	0.3	8.3	3.6	88	0.2	7.9	3.5
pH	88	5.7	10.7	7.0	88	5.8	11.4	7.1	88	5.5	9.9	7.1
BOD_5	88	0.0	62.0	22.3	88	0.0	62.0	19.5	88	0.0	60.0	16.3
COD	77	0.0	976.0	173.0	75	0.0	537.0	85.9	78	0.0	356.0	57.3
Cond.	88	0.0	93.3	5.7	88	0.0	114.1	5.7	88	0.0	47.6	3.7
SS	72	0.0	610.0	110.0	72	0.0	2449	111.0	72	0.0	1256	121.0
Alk.	80	20.	500.0	158.0	80	20.	320.0	131.3	80	20.	390.0	129.4
TH	80	40.	1220	313.0	80	20.	1240	306.0	80	40.	1060	279.0
Phos.	80	0.0	13.0	2.5	80	0.0	8.2	1.6	80	0.0	5.3	1.3
SO_4	76	0.0	2268	399.0	76	0.0	1710	381.0	76	0.0	1345	350.0
Cl	80	7.0	42894	1922	80	7.0	54593	2268	80	5.0	20916	1235
Nit.	60	0.1	266.0	20.3	60	0.5	109.2	16.1	60	0.3	217.0	19.3
Amm.	80	0.0	23.8	3.0	80	0.0	26.6	2.2	80	0.1	26.6	2.5
Na	80	1.0	22500	2236	80	1.0	45000	1875	80	0.0	12000	677.0
K	80	0.3	45.0	5.5	80	0.4	42.0	5.5	80	0.4	34.0	5.3
Fe	80	0.0	50.0	1.6	80	0.0	17.0	1.3	80	0.0	16.0	0.9
Pb	80	0.0	0.7	0.1	80	0.0	0.8	0.1	80	0.0	0.5	0.1
Ca	80	6.8	460.0	71.9	80	5.0	430.0	78.0	80	0.0	420.0	69.3
Mg	80	0.0	130.0	6.8	80	0.0	115.0	7.2	80	0.0	120.0	8.1
Zn	80	0.0	0.8	0.2	80	0.0	1.2	0.1	80	0.0	0.4	0.1
Mn	80	0.0	1.0	0.2	80	0.0	0.9	0.2	80	0.0	2.5	0.2
Cu	80	0.0	0.2	0.0	80	0.0	0.2	0.0	80	0.0	0.1	0.0
Cd	80	0.0	2.0	0.1	80	0.0	2.0	0.1	80	0.0	1.0	0.0
Ni	80	0.0	2.1	0.1	80	0.0	2.1	0.1	80	0.0	0.8	0.1
Cr	80	0.0	0.8	0.0	80	0.0	0.9	0.0	80	0.0	0.2	0.0

concentrated hydrochloric and nitric acids, and atomic absorption spectrophotometry was used to determine the metal concentrations in the resulting supernatent. The metal concentrations determined are given in Table 4.

A correlation analysis has been carried out to help identify important associations between parameters under study within the gully liquor system to assist in the identification of pollutant sources within the sub-catchments. A summary of the correlation analysis is given in Table 6, where parameters which have correlation coefficients in excess of 0.5 are indicated.

Figure 1 shows plots of some of the quality parameters plotted against time for gully 305.54 on the Churnet Close sub-catchment. The results clearly example the temporal variability of the parameters during periods within the sampling year.

3 Storm runoff sampling

The second part of the field study has been concerned with monitoring the changes in liquor quality during rainstorm events. A number of events have been recorded over the period June 1984 to December 1985 to determine the changes between inflow runoff quality and outflow quality from the gully pot chamber, and to relate such changes to the hydrological conditions and to interactions between inflow, gully liquor and basal sediments.

One gully in each sub-catchment was used for the storm runoff sampling, being one of those at the head of the cul-de-sac where by-passing was not possible and all flow entered the gully (gullies 301.39, 304.104 & 305.53; see Pratt & Henderson (1981)).

The sampling equipment was housed in a steel cabinet bolted to the highway above the gully frame. A small inflow reservoir chamber of some 4 litre capacity was fitted on the

Table 4 Descriptive statistics for the gully pot basal sediment data set on each of the three highway sub-catchments

	Tame Close			:Churnet Close			:Twyford Gardens			:
	n	min.	max.	mean	n	min.	max.	mean	n	min.	max.	mean
Na	24	0.040	24.800	3.400	24	0.100	113.500	6.900	23	0.040	27.030	2.780
K	24	0.000	45.900	4.500	24	0.000	122.100	8.000	23	0.020	5.560	0.700
Fe	24	0.590	10.770	4.270	24	0.390	13.920	13.920	23	0.900	177.800	12.100
Pb	24	0.006	0.820	0.143	24	0.004	0.322	0.094	23	0.002	0.682	0.078
Ca	24	1.800	255.800	38.700	24	1.400	145.300	29.900	23	2.500	201.400	25.800
Mg	24	0.100	88.900	7.100	24	0.000	39.300	8.200	23	0.130	21.940	3.750
Zn	24	0.011	0.737	0.126	24	0.006	0.748	0.103	23	0.014	1.087	0.196
Mn	24	0.049	0.820	0.278	24	0.043	0.405	0.172	23	0.000	4.028	0.481
Cu	24	0.001	0.089	0.013	24	0.002	0.051	0.016	23	0.001	0.247	0.032
Cd	24	0.000	0.010	0.003	24	0.000	0.013	0.002	23	0.000	0.028	0.006
Ni	24	0.003	0.039	0.011	24	0.001	0.047	0.011	23	0.002	0.395	0.041
Cr	24	0.003	0.246	0.053	24	0.000	0.263	0.051	23	0.005	0.528	0.071

Minimum, maximum and mean values in mg/g.

Table 5 Parameters analysed in the storm runoff water quality programme

Suspended solids	Pb
COD	Zn
Total organic carbon	Cu

Table 6 Correlation analysis for the total water quality data set for the gully liquor sampling programme

	pH	TH	Cond.	Cl	SO_4	Na	K	Pb	Ca	Cu	Ni	
Temp:												
DO :												
Alk :												
TH :	*											
Cond:	*	*										
SS :												
BOD_5:												
COD :												
Phos:												
Cl :		*	*									
SO_4 :	*	*	*									
Amm.:												
Nit.:												
Na :		*	*	*	*							
K :												
Fe :												
Pb :		*	*	*	*							
Ca :	*	*	*	*	*	*	*	*				
Mg :												
Zn :												
Mn :												
Cu :	*	*	*	*	*	*		*	*			
Cd :												
Ni :	*	*	*	*	*	*		*	*	*		
Cr :		*	*	*		*			*	*	*	

* indicates correlation coefficent greater than + 0.5

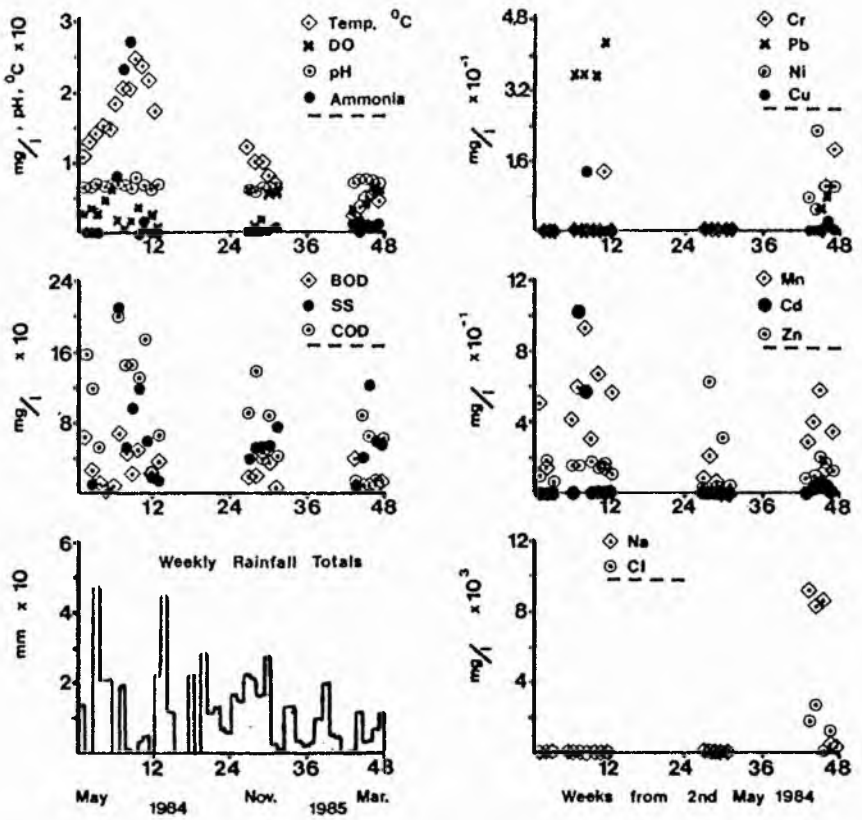

Figure 1 Temporal variation of water quality parameters for gully 305.54

upstream face of the gully pot just below the gully grate. The reservoir chamber contained a float switch and a sampler head which was connected to a 24 bottle vacuum sampler. A hole at the base of the reservoir allowed it to drain during dry weather, but to fill to overflowing during storm runoff from the highway given sufficient inflow rate. Laboratory trials showed that the float switch was activated at flow rates into the reservoir in excess of 0.03 1/s. This value set the minimum threshold for sampling a storm event: once started the sampler was activated for 24 samples regardless

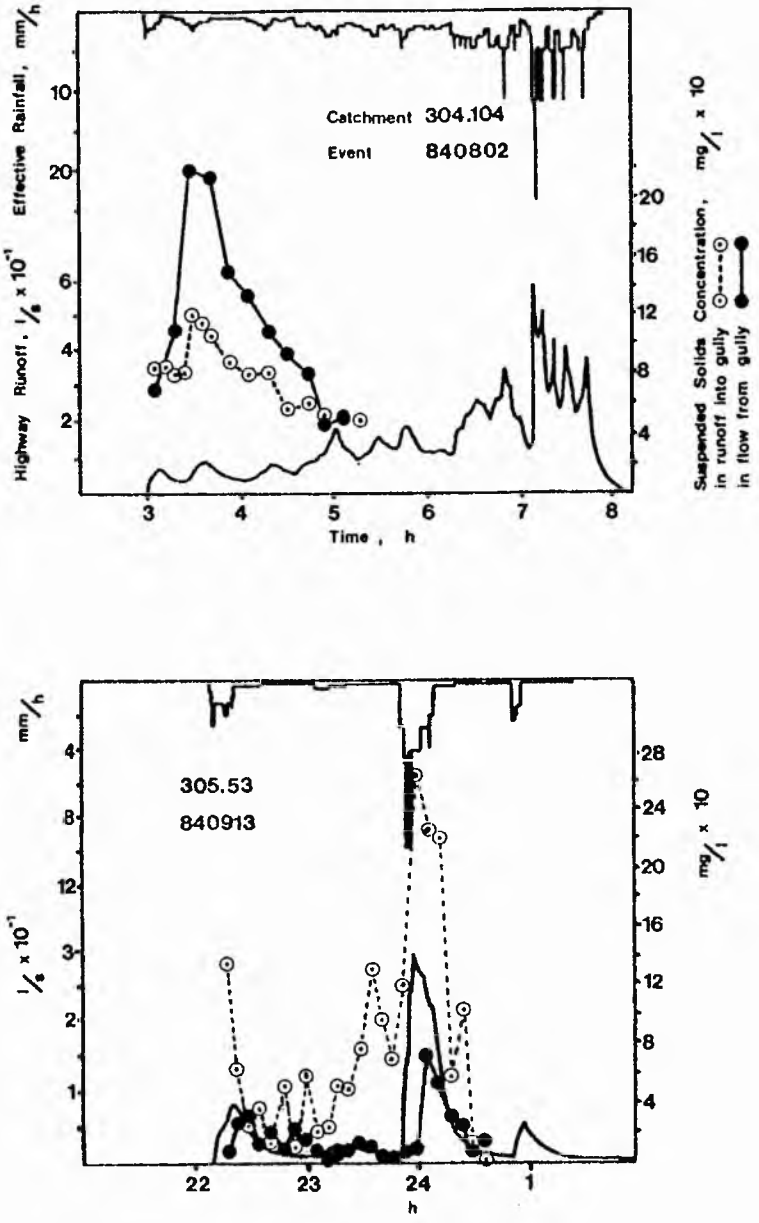

Figure 2 Gully inflow hydrographs and suspended solids concentrations within flows into and from a gully

of subsequent inflow rates. A second sampler collected gully liquor from half depth in the gully pot itself. Once the float switch was activated by storm inflow, simultaneous samples were collected at pre-set time intervals, of either 1 or 6 minutes, from both the inflow waters and from the pot liquor. The pot liquor samples were assumed to be similar in quality to discharge quality from the gully to the downstream sewer. A clock mechanism on samplers recorded the time of first sample, which could be related to observed rainfall. Rainfall was measured using a 0.1mm tipping bucket raingauge, logged at 30s time intervals, and situated within 200m of all sub-catchments.

A previously developed linear reservoir rainfall-runoff model was used to predict inflow hydrographs to each gully. Flow monitoring equipment installed within a gully was thought likely to significantly modify the flow and quality performance of the gully pot. Figure 2 shows the water quality-quantity relationships for two runoff events on two different gully catchments. The figure illustrates the variation in performance which may occur with different storm characteristics. Event 840802 displays a worsening of outflow quality as runoff causes the disturbance of the basal sediments and their resuspension. Effective sedimentation occurred in event 840913 and outflow suspended solids concentrations are markedly reduced. Flow rates during the sampling periods in these events are low: flow rates of the order of design inflow to a gully, about 10 l/s, seem likely to cause considerable worsening of outflow quality.

4 Laboratory studies

Table 7 shows a sample of the results of an experiment conducted to show the influence of sediment size on Zn, Cu and Pb adsorption and release mechanisms for various pH values from 5 to 8. Similar results were found for all three metals.

Table 7 Results of laboratory study of interchange of zinc between liquor and sediments at different pH

Sediment size range (mm)	Concentration of Zn in liquor after :- Day 1	Day 2	Day 3	Day 4	Day 5
pH 5.0					
> 10	2.20	2.20	2.08	2.45	2.70
4 - 10	2.20	2.85	4.20	2.45	2.40
1 - 4	3.10	3.80	4.20	4.20	4.50
0.15 - 1	2.50	3.80	4.00	4.00	4.20
< 0.15	2.80	2.20	2.20	2.45	4.60
pH 8.0					
> 10	0.77	0.33	0.27	0.23	0.08
4 - 10	0.88	0.42	0.38	0.21	0.15
1 - 4	0.68	0.42	0.38	0.19	0.12
0.15 - 1	0.63	0.27	0.27	0.17	0.15
< 0.15	0.43	0.33	0.33	0.25	0.15

Initial liquor Zn concentration 2mg/l in all cases.

Acknowledgements

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Chapter 7 : The Gully Pot Liquor Sampling Programme.

7.1 Introduction.

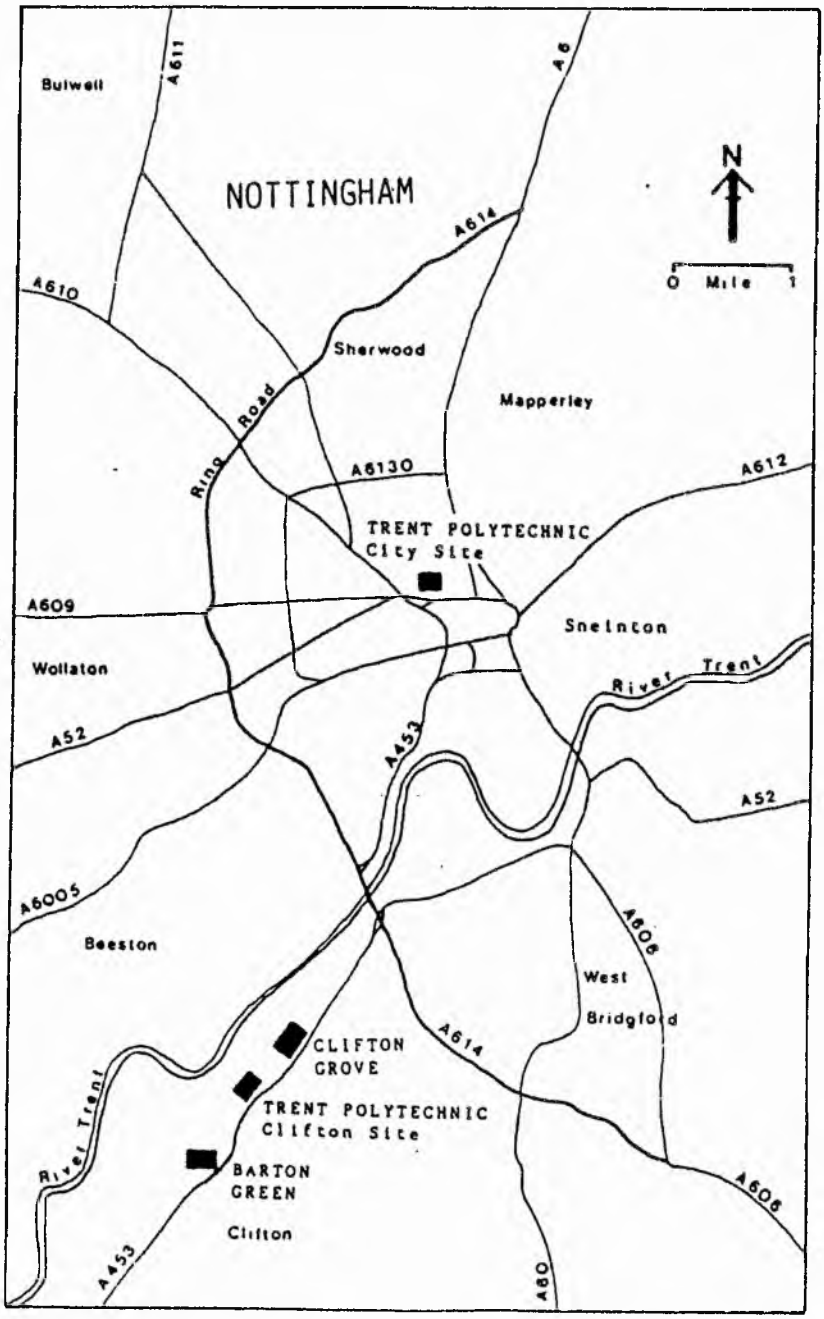
The aim of the research programme was to investigate the influence of gully pots on the quality of urban stormwater discharges from a separately storm sewered urban catchment area. The catchment-based experimental fieldwork concentrated upon two aspects which were studied and will be discussed separately, but which are interrelated. The first part of the programme was to monitor the gully pot standing liquor quality and the deposited basal (bottom) sediments within the gully pot. The second part involved an investigation into the quality of the inflow and outflow stormwater quality within the gully pot system during a storm event. This latter part of the project set out to determine the influence of the highway runoff on the liquor discharging from the gully pot during a storm event and the influence of the gully pot itself could also be ascertained.

The gully pot standing liquor sampling programme set out to investigate the spatial and temporal variations within the standing volume of liquor in the gully pot at a given time. The experimental work was carried out on the Clifton Grove Housing Estate on the southern outskirts of Nottingham (see Figure 7.1). The estate is comprised totally of residential units and there is no commercial area. The catchment is served by a separate storm sewer system and this discharges to the River Trent which flows in a north-easterly direction adjacent to the estate (see Figure 7.1).

The stormwater outfall discharges to the river a few hundred metres upstream of the Clifton Bridge in Nottingham. The separate storm

Map Showing the Location of the Area of Study.

Figure 7.1

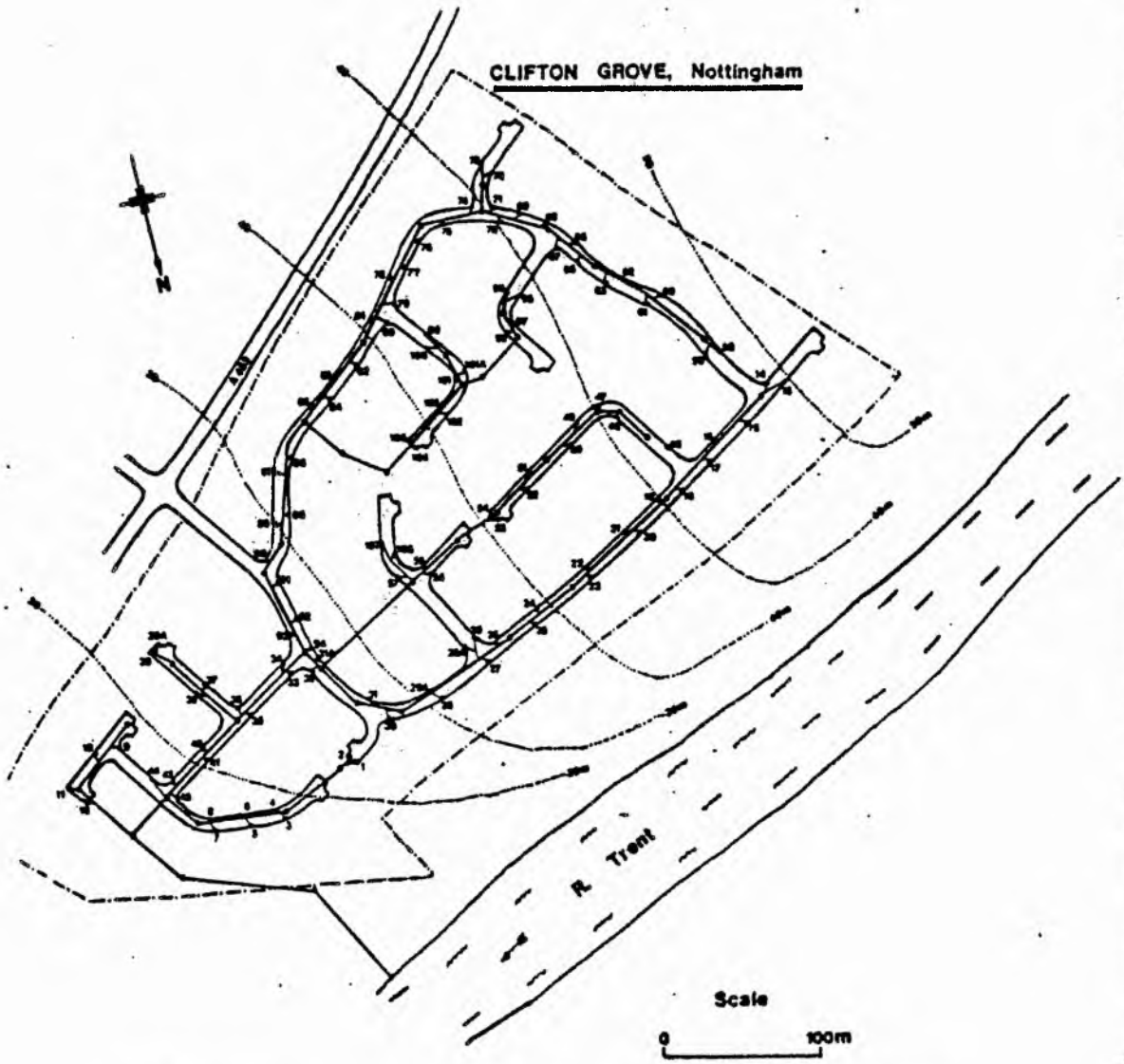


sewer system consists of 108 gully pots and the plan of the estate is based upon a ring road with a number of well-defined cul-de-sacs joining the ring road in a series of arms (see Figure 7.2). The estate was built in the early to middle 1970's and it consists of mainly detached houses and bungalows wih two or three bedrooms. Clifton Grove is a small urban estate with an area of 10.6 hectares of which about 5.5 hectares (or approximately 52%) is impervious.

Three sub-catchment areas on Clifton Grove were chosen for the research study. They were all well-defined cul-de-sac sub-catchments within close proximity, but differing in terms of aspect, slope, size and shape and were collectively highly representative of the Clifton Grove catchment area as a whole. The sub-catchments under study were all similar in land use and had highway slopes which ranged from 0.5% to 5.5%. The three study areas were Tame Close, Churnet Close and Twyford Gardens. The four gully pots at the downslope (or downstream) end (or closed end) of each of the sub-catchments were selected for analysis. All the gully pots chosen were accessible and were considered to be collectively representative of those found in the catchment area. Each gully pot was chosen for its ease of sampling and no noticeable, biased influences operating within the sub-catchment areas were observed during the period the gully pots were studied in the research project. The gully pots were each given a number which described its place within the sub-catchment area, preceded by a combination of letters depicting its sub-catchment location. This was in the form of T = Tame Close, C = Churnet Close and TW = Twyford Gardens. The gully pots were numbered one to four in numerical order going clockwise when looking in a downslope (or down sub-catchment) direction on each sub-catchment. Each sub-catchment

Diagram to Show the Layout of the Clifton Grove Housing Estate.

Figure 7.2



had two gully pots situated at the far end of the road surface which were always numbered two and three respectively and gully pots numbered one and four were situated further upslope on each side of the road (and therefore usually opposite each other). The location of the three sub-catchment areas under study can be seen in Figure 7.3. This coding system for gully pot identification replaced an existing numbering system developed by Fletcher (1981) which can be seen in Figure 7.3. The gully pot identity codes used in this project were as follows :

Sub-catchment:	Gully Pot Code	
Tame Close	T1	(102)*
	T2	(104)*
	T3	(105)*
	T4	(103)*
Churnet Close	C1	(52)*
	C2	(53)*
	C3	(54)*
	C4	(51)*
Twyford Gardens	TW1	(38)*
	TW2	(39)*
	TW3	(39A)*
	TW4	(37)*

* = The figures in brackets refer to the Gully Pot Numbers devised by Fletcher (1981) which can be seen in Figure 7.3.

The gully pot standing liquor sampling programme consisted of a weekly analysis of liquor sampled from each of the twelve gully pots (ie. the four pots on each of the three sub-catchments). The sampling was carried out over a one year period from the summer 1984 to the spring 1985. Data were collected over a twenty-two week period consisting of a twelve week block during the summer of 1984 and two five week blocks

Churnet Close:	C1	52	Gully pot numbers below
*	C2	53	
	C3	54	
	C4	51	
Tame Close:	T1	102	
* *	T2	104	
	T3	105	
	T4	103	
Twyford Gardens:	TW1	38	
* * *	TW2	39	
	TW3	39A	
	TW4	37	

Date samples collected e.g. 84 10 01

** .. .. Year

.. ** .. Month

.. .. ** Day

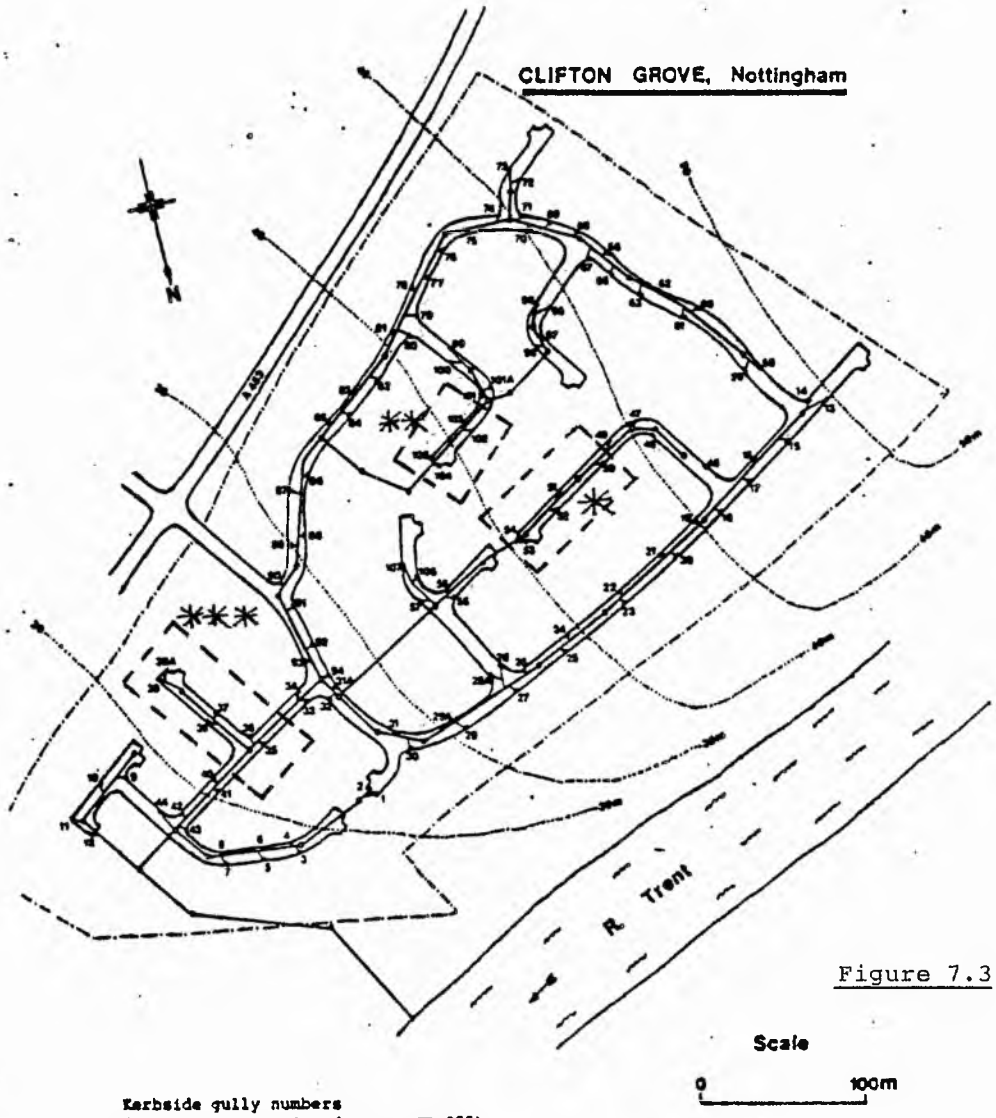


Figure 7.3 Page 228

Kerbside gully numbers
(Gratings: type BS reference GB-325)

TRENT POLYTECHNIC

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Storm Drainage Research Group

Total 108 gullies connected to storm sewer system.

(a) 48, 64 do not exist.

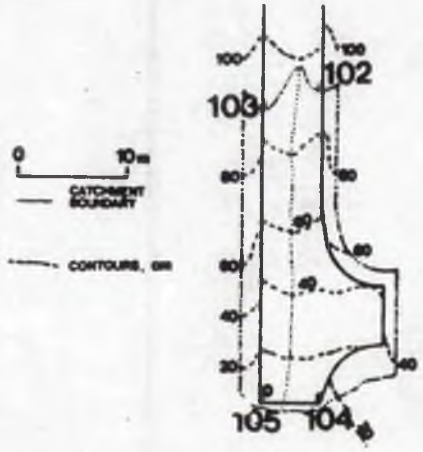
(b) 45, 46 connected to foul sewer system.

(c) 28A, 29A, 31A, 39A, 101A additional to original scheme.

Diagram to Show the Layout of the Tame Close Sub-catchment.

Figure 7.4

Tame Close:	Gully codes	T1	No. 102	Catchments areas 245 m^2
		T2	104	228 m^2
		T3	105	131 m^2
		T4	103	120 m^2



Photograph showing the Layout of the Tame Close Sub-catchment.

Figure 7.5

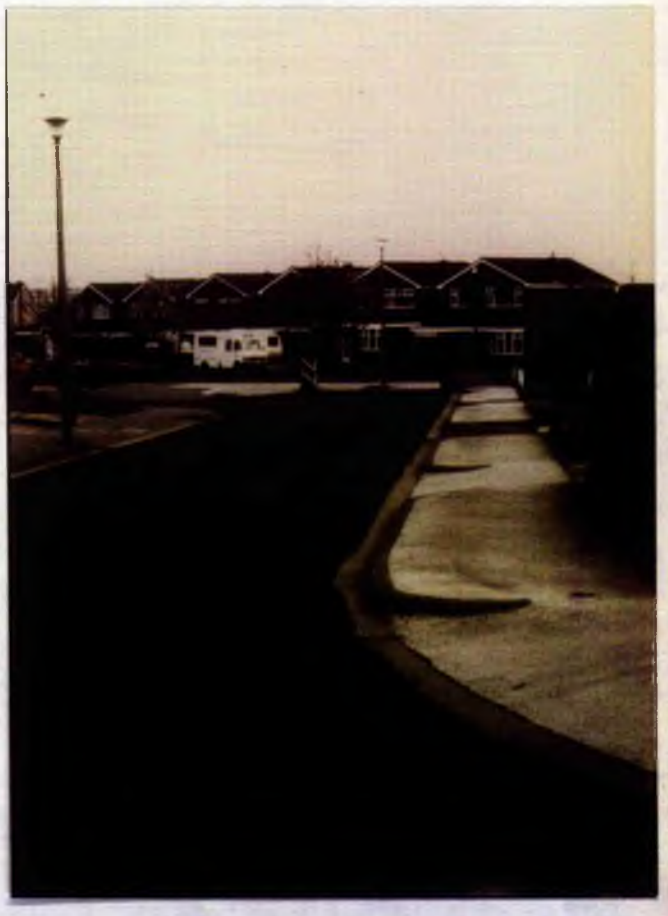


Diagram to Show the Layout of the Churnet Close Sub-catchment.

Churnet Close:	Gully codes	C1	No. 52	Catchment areas	176 m^2
		C2	53		241 m^2
		C3	54		151 m^2
		C4	51		175 m^2

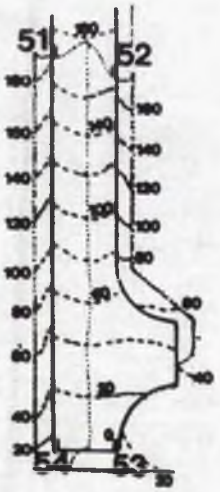


Figure 7.6

Photograph showing the Layout of the Churnet Close Sub-catchment.

Figure 7.7

Diagram to Show the Layout of the Twyford Gardens Sub-catchment.

Twyford Gardens: Gully codes	TW1	No.38	Catchments areas	109 m^2
	TW2	39		382 m^2
	TW3	39a		39 m^2
	TW4	37		150 m^2

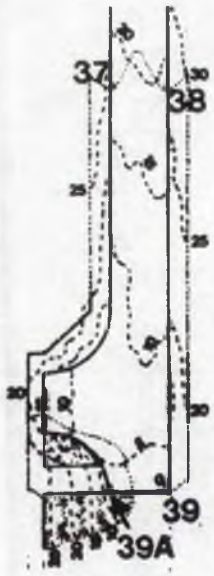


Figure 7.8

Photograph showing the Layout of the Twyford Gardens Sub-catchment.

Figure 7.9

during both the autumn of 1984 and the spring of 1985. This was designed in order to accommodate the influence of seasonality in the analysis. The aim of the exercise was to compile a comprehensive dataset of physical and chemical data for all twelve gully pots under analysis in order to illustrate the temporal and spatial variations in liquor quality. Some preliminary analyses were carried out on samples of gully pot liquor from the Clifton Grove catchment area during the spring of 1984 and these results together with an appreciation of previous work carried out in this field produced an analysis suite of twenty-six physical and chemical determinands which would be measured for all the samples collected over the twenty-two week sampling period. (The results of the preliminary analyses are not reported since they were used only for planning purposes and for laboratory instrumentation calibration). All dates are expressed in the American notation of a six figure code which is as follows:

YYMMDD ... Y = Year, M = Month and D = Day

(eg. the 5th. July 1985 would be 850705).

7.2 The Sampling Programme.

The sampling programme was conducted over a twelve week period from 840509 to 840725 (which is to be known as the 'summer period') and two five week periods from 841031 to 841128 (to be known as the 'autumn period') and from 850220 to 850320 (to be known as the 'winter period'). Samples were taken from all twelve gully pots during the same sampling run and all samples were taken in a consistent chronological order at approximately the same time and on the same day of each week (all samples were taken at approximately 1000 hours on a

Wednesday morning).

A one litre sample was taken from each gully pot standing liquor at a depth of half the standing liquor depth in the pot chamber. A calibrated dipstick was use to measure the standing depth in the pot and a one litre, plastic sample bottle was then gently lowered into the liquor so that the top of the bottle (which was the point of sample entry) was set at a depth equal to half that of the standing liquor. A long piece of thin rubber tubing was attached at one end to a bung which itself was inserted into the top of the bottle. The other end of the tubing was covered by the samplers' finger. Once the bottle was correctly positioned, the finger was removed to allow an easy escape route for the air as the liquor entered through a small orifice in the rubber bung. The sample bottle gradually filled with the pot liquor at the required depth and at all times, there was minimal disruption to the standing liquor which would have yielded an unrepresentative sample. Care was taken not to create any unnecessary turbulence in the pot chamber which could have mobilised any basal sediments into the standing liquor. The sampling was conducted to ensure that the bottle was completely full before removal and thus preventing an air pocket in the top of the sample bottle which could influence the measurement of dissolved oxygen and other parameters in the laboratory analysis. On removing the filled sample bottle, a field thermometer was immediately used to take a temperature reading of the pot liquor. Observations concerning the state of the liquor were also made in a field notebook, which was used as an important source of reference in the analysis of the water quality data. As soon as the temperature had been measured, the bottle was sealed with a screw top lid. Once sealed the samples were immediately returned to

the laboratory for analysis.

All samples were analysed for each of the twenty-six determinands used in the research programme (see Table 5.1) and the analyses were carried out in a strict, sequential order to ensure the validity of the analytical methods employed (see Chapter 5). A priority was assigned to the analyses of dissolved oxygen, pH, BOD, COD, NH3 and SS in the laboratory. This was in keeping with the guidelines set out by the American Standard Methods and the Department of the Environment (United Kingdom) Guidelines.

7.3 The Data Collection Programme.

The gully pot liquor sampling programme set out to investigate the spatial and temporal variations in the pot liquor and these variations, or indeed consistencies, can be deduced from the comprehensive dataset built up of twenty-six physical and chemical determinands over a twenty-two week sampling run during a one year period. The results presented here consist of a review of the results from each of the twelve individual gully pots; a discussion of the results found within each of the three sub-catchments under study in order to identify if there are any differences; and finally by grouping all the data together, it is possible to summarise the findings to give an overall appreciation of the state and temporal variation of the pot liquors found from all twelve gully pots sampled on the Clifton Grove catchment area.

The total dataset (data grouped together from all twelve gully pots) should have two hundred and sixty-four values for each determinand (ie. twelve gully pots with twenty-two weeks of analysis), but there

are some gaps in the datasets when no analysis was carried out. This situation arose for various reasons such as void results which could not be reported, accidental spillage of samples, loss of sample, instrument breakdown etc. It is inevitable that some gaps will appear in any sampling programme of this kind but steps were taken to check the validity of the results obtained and to repeat analysis where necessary, in order to maintain a strict quality control on the data which have been reported.

At the end of each sampling run, the data for all twenty-six determinands for each of the twelve gully pots were entered into a data file on a computer. A series of data files were created on the Trent Polytechnic DEC-20 (Digital Corporation) Mainframe Computer and a suite of programmes were written in the FORTRAN language to produce tables of data and summaries of the data (see Appendices). The twenty-six determinands were split into five groups of interrelated parameters and five tables of results were produced for each sampling run. The tables show the analytical results as well as the time and date of the sampling and the subsequent analysis.

The twenty-six determinands were grouped as follows :

Group	A	Temp	DO	pH	Alk	TH	
Group	B	Cond	SS	BOD	COD		
Group	C	PO4	Cl	SO4	NH3	NO3	
Group	D	Na	K	Fe	Pb	Ca	Mg
Group	E	Zn	Mn	Cu	Cd	Ni	Cr

(The abbreviations for these parameters used in the text are given in Table 5.1).

A number of sorting programmes were written in FORTRAN to produce datasets for each inividual gully pot over the twenty-two week analysis period, grouped data for the sub-catchments and all the data files were concatenated to produce a total dataset for the twenty-two weeks, irrespective of the gully pot location (see Appendices). The MINITAB Statistical Package (Version 8.2 as developed by the Pennsylvannia State University, USA) was used for each of the three series of datasets (ie. individual gully pot, sub-catchment and total dataset) to produce a series of summary statistics and correlation analyses for the gully pot standing liquor quality. This involved setting up the individual datasets in a form which could be accessed by the MINITAB package on the DEC-20 Mainframe system. The programmes run on the MINITAB package can be found in the Appendices.
For each individual gully pot, three tables of statistical results were produced, as follows :

1) Summary of all the data collected over the twenty-two week period.

2) Statistical Summary of the Datasets for each Determinand.

3) A Correlation Coefficient Matrix to Show the Interrelationships between the Individual Water Quality Parameters.

(see Tables 7.1 to 7.36 inclusive)

For each sub-catchment area and for the total dataset (comprising of all three sub-catchments lumped together), two tables of summary data are presented, as follows :

1) Statistical Summary of the Datasets for each Determinand.

2) A Correlation Coefficient Matrix to Show the Interrelationships between the Individual Water Quality Parameters.

(see Tables 7.37 to 7.44 inclusive and see also Table 7.45).

These tables summarised the data given in Tables 7.1 to 7.36 and are presented as Tables 7.37 to 7.44 inclusive.

The Minitab Statistical Package was used to produce summary statistics for all the water quality data for the standing pot liquor and also for other data in the research programme. The statistical summary reports were produced in a standard format and the abbreviations used in these tables can be defined in the following way.

Minitab Description	
Output Name	
N	The number of samples or observations.
MEAN	The mean value
MEDIAN	The median value in the dataset or the 50 th. percentile.
TMEAN	This is a trimmed mean. The smallest 5% (rounded off to the nearest integer) and the largest 5% of the values are trimmed, and the resultant middle 90% are averaged. This summary statistic is particularly relevent if some extreme high or low values (called fliers) are found in the dataset.
STDEV	This is the standard deviation.
SEMEAN	This is the standard error of the mean which is calculated by dividing the standard deviation by the number of observations. (ie. STDEV/N)
MAX	This is the maximum value in the dataset.
MIN	This is the minimum value in the dataset.
Q3	This is the upper quartile value. This is also known as the 75 th. percentile value. It is calculated by ordering the data and the upper quartile lies at the position 3(N+1)/4 in the ordered dataset, where N is the number of observations.
Q1	This is the lower quartile value. This is also known as the 25 th. percentile value. It is calculated by ordering the data and the lower quartile lies at the position (N+1)/4 in the ordered dataset, where N is the number of observations.

7.4 Gully Pot Standing Liquor Sampling: Analysis of the Data.

7.5 TAME 1:

(see Figures 7.10 to 7.35 and Tables 7.1 to 7.3 inclusive).

Relatively low dissolved oxygen values were found during the summer period and this may provide evidence of some oxygen depletion in the pot liquor due to anaerobic or septic conditions operating in the basal sediments. The summer period was also relatively dry with few storm events and so there would have been little 'turn over' of the pot due to storm inflow waters.

The pH values were generally slightly acidic, with most values falling just below the pH 7.0 neutral point. The mean value of pH 7.57 has been influenced by a high pH value of pH 10.7 which was recorded on 850313. This extreme value can be explained by the presence of a highly alkaline caustic substance found both within the liquor and crusted in a crystalline form around the top perimeter of the gully pot. This caustic had presumably come from an individual washing down of a driveway or footpath with a strong cleaning fluid.

The values for conductivity showed a very marked seasonal variation. During the summer and autumn periods, all the values were below 1.0 (x1000) μscm-1 but values in excess of 50.0 (x1000) μscm-1 were found in the dataset going to a maximum of 93.3 (x1000) μscm-1. This was due almost entirely to the winter period when the effects of road salting elevated the concentrations of sodium, calcium and chloride ions in the liquor. This was due to the passage of rock salt from the paved and road areas into the drainage system. As a consequence of

this, the winter values for Total Hardness were increased due to the higher concentrations of the sodium and calcium metals in the pot liquor.

The Suspended Solids (SS) values were quite high in the summer period, perhaps due to the input from gardens and grass cutting. A quantity of builders' sand was delivered to the driveway of a house within the micro-catchment of the Tame 1 gully pot and some of this was certainly windblown into the roadside gutter. The sand was then carried by both aeolian and fluvial processes into the gully pot and a considerable quantity was found in the basal sediments of this gully pot. Particles of rock salt contributed to the elevated SS in the spring period and the enhanced transport of sediments which had naturally built up in the micro-catchment area, since they were effectively locked onto the urban surface during the period of prolonged snowcover in February and March 1985, can also help to explain the higher SS values during the spring period.

The BOD values remained fairly stable throughout the twenty-two week survey but the COD values were enhanced considerably in the summer period to a maximum value of 905 mgl-1 as COD, at a time of severe oxygen depletion. Higher dissolved ammonia concentrations at this time, the maximum value being 8.8 mgl-1 as N, means that one can infer that anaerobic microorganisms were producing a high oxygen demand upon the liquor, which was in a quiescent condition during a warm, dry spell of weather. This may help to explain the high ammonia value in the pot liquor while the mean value was only 2.1 mgl-1 as N.

During the spring period, higher concentrations of nitrates and sulphates were found and this is due to the presence of these anions attached to rock salt.

In an analysis of the twelve metals under consideration, two very

important features stand out. The first is the extremely high sodium concentration in the spring period with a maximum value of 22500 mgl-1. All the values in the five week spring period were well in excess of 10000 mgl-1. This again can be explained by the presence of rock salt. It should be noted that for all the sub-catchment areas during the spring period, that a considerable amount of rock salt was applied to the road surfaces, the driveways and the paved areas by the local residents. The County Council did not salt the roads on the Clifton Grove Estate and so the presence of the rock salt is purely a local influence whereby the residents have taken the task upon themselves. It should also be said that cars will also bring rock salt into the sub-catchment areas from outside, attached to the bodywork and the tyres of the vehicles. The second interesting factor to emerge was the presence (or the detection) of concentrations of copper, cadmium, nickel and chromium in the pot liquor exclusively during the spring period. These heavy metals appear in quite small concentrations within the residential sub-catchment areas but their detection leads to the conclusion that these metals have themselves been derived from rock salt or from increased particulate and atmospheric emissions from motor vehicle engines during the cold weather. The stress to the engine during a cold weather start-up is well known to produce vehicular emissions of this sort. It is also possible that these metals are present within the micro-catchment but it is only because of the snowmelt effect that the metals were able to build up in concentration within the snowcover. This effect tends to amplify the true liquor concentrations but it was enough to make the metals detectable in the gully pot liquor analysis. It is far more likely that the presence of the rock salt and the motor vehicle emissions contributed significantly to the levels found during the

spring period in the Tame 1 gully pot liquor. The higher levels of lead in the spring period from the combustion of alkyl-lead compounds in petrol and diesel fuels, may give further evidence of the influence of the motor vehicle pollutants within an urban environment. It can be stressed that the sub-catchments under study were cul-de-sacs and the movement of cars within the sub-catchments was restricted to those gaining access to individual properties and to cars turning around. The influence of the vehicular pollutants would of course be more pronounced in a busy main road, or even a motorway and some urban stormwater flows in such areas would have enhanced metal concentrations because of this.

Table 7.1

Table of all the Water Quality Data collected over the Twenty-Two Week Period for the Gully Pot Standing Liquor in the Tame 1 Gully Pot.

ROW	DATE	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
1	84Ø5Ø9	11.Ø	1.4	7.Ø	2ØØ	17Ø	Ø.39	*	62	439
2	84Ø516	14.Ø	4.5	6.8	1ØØ	7Ø	Ø.12	69	5	48
3	84Ø523	16.Ø	2.5	7.7	25Ø	31Ø	Ø.1Ø	*	5	53
4	84Ø53Ø	14.5	1.1	6.5	*	*	Ø.27	*	38	*
5	84Ø6Ø6	14.5	7.1	7.Ø	*	*	Ø.19	*	22	*
6	84Ø613	17.Ø	1.8	6.5	43Ø	32Ø	Ø.91	484	41	879
7	84Ø62Ø	2Ø.5	1.4	6.8	5ØØ	22Ø	1.ØØ	432	47	9Ø5
8	84Ø627	2Ø.Ø	1.4	6.6	13Ø	9Ø	Ø.26	39Ø	5	562
9	84Ø7Ø4	23.Ø	2.2	7.6	25Ø	42Ø	Ø.8Ø	3Ø5	35	129
1Ø	84Ø711	23.Ø	1.2	6.8	21Ø	32Ø	Ø.67	56	41	123
11	84Ø718	18.Ø	2.3	6.5	24Ø	17Ø	Ø.1Ø	19	7	54
12	84Ø725	17.5	Ø.9	6.9	19Ø	21Ø	Ø.2Ø	184	41	66
13	841Ø31	12.Ø	6.7	7.3	7Ø	7Ø	Ø.12	18Ø	15	219
14	8411Ø7	1Ø.Ø	3.5	6.1	31Ø	9Ø	Ø.45	9Ø	2	54
15	841114	1Ø.Ø	7.2	7.3	6Ø	5Ø	Ø.ØØ	34	4Ø	17
16	841121	1Ø.Ø	4.9	6.9	6Ø	26Ø	Ø.Ø7	1Ø	11	Ø
17	841128	8.Ø	3.7	7.3	4Ø	26Ø	Ø.22	28	1Ø	93
18	85Ø22Ø	3.Ø	5.3	9.4	75	1Ø65	9Ø.6Ø	4Ø9	21	*
19	85Ø227	4.5	5.2	9.8	1ØØ	1Ø4Ø	93.3Ø	459	25	*
2Ø	85Ø3Ø6	5.5	4.2	9.8	24Ø	122Ø	81.5Ø	455	23	*
21	85Ø313	6.Ø	7.Ø	1Ø.7	13Ø	89Ø	51.ØØ	61Ø	16	5Ø3
22	85Ø32Ø	5.5	5.8	9.3	25Ø	94Ø	52.2Ø	268	32	686

ROW	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
1	7.5	17.7	67	Ø.2	*	12.6	12.2	Ø.5Ø	Ø.ØØ
2	1.9	28.4	26Ø	Ø.1	*	9.2	3.Ø	Ø.4Ø	Ø.ØØ
3	Ø.6	39.Ø	183	Ø.3	*	1.1	Ø.8	Ø.1Ø	Ø.ØØ
4	*	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*	*
6	1Ø.6	284.Ø	1Ø	8.8	3.2	29.Ø	11.2	4.3Ø	Ø.ØØ
7	3.2	149.Ø	Ø	6.2	2.1	58.Ø	6.3	5Ø.ØØ	Ø.ØØ
8	3.8	21.Ø	*	7.Ø	2.5	4Ø.Ø	12.5	2.4Ø	Ø.ØØ
9	3.8	92.Ø	481	Ø.9	4.2	58.Ø	21.Ø	2.ØØ	Ø.ØØ
1Ø	1.9	32.Ø	394	Ø.6	4Ø.6	7.5	3.Ø	Ø.6Ø	Ø.35
11	2.1	234.Ø	567	1.1	Ø.8	7.5	1.2	Ø.3Ø	Ø.34
12	1.8	28.Ø	4Ø4	2.4	82.6	11.7	2.Ø	1.6Ø	Ø.ØØ
13	2.5	28.4	125	Ø.2	Ø.7	2.Ø	Ø.6	Ø.ØØ	Ø.ØØ
14	Ø.9	251.6	29	Ø.2	2.4	3.2	Ø.8	Ø.ØØ	Ø.ØØ
15	Ø.1	21.3	96	Ø.2	2.7	1.4	Ø.7	Ø.ØØ	Ø.ØØ
16	Ø.Ø	7.1	211	Ø.5	Ø.6	8.4	Ø.5	Ø.ØØ	Ø.ØØ
17	1.1	17.7	23Ø	Ø.4	2.9	8.Ø	1.3	Ø.ØØ	Ø.ØØ
18	2.3	42894.Ø	1465	2.8	*	225ØØ.Ø	1Ø.5	1.35	Ø.68
19	2.Ø	4254Ø.Ø	865	4.9	*	196ØØ.Ø	42.Ø	1.58	Ø.6Ø
2Ø	3.7	574.Ø	1778	Ø.8	81.2	183ØØ.Ø	11.5	1.3Ø	Ø.66
21	Ø.Ø	26942.Ø	932	1.5	33.6	133ØØ.Ø	8.7	Ø.9Ø	Ø.28
22	6.9	542.Ø	865	2.6	51.8	112ØØ.Ø	7.5	Ø.71	Ø.28

ROW	Ca	Mg	Zn	Mn	Cu	Cd	Ni	Cr
1	45.Ø	Ø.Ø	Ø.11	Ø.14	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
2	2Ø.Ø	Ø.Ø	Ø.ØØ	Ø.13	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
3	11.3	Ø.Ø	Ø.11	Ø.Ø6	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
4	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*
6	86.Ø	4Ø.Ø	Ø.22	1.ØØ	Ø.Ø6	Ø.ØØ	Ø.ØØ	Ø.Ø
7	1Ø2.5	17.Ø	Ø.35	Ø.85	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
8	55.Ø	6.5	Ø.15	Ø.3Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
9	7Ø.Ø	2.Ø	Ø.2Ø	Ø.15	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
1Ø	31.Ø	2.5	Ø.14	Ø.25	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
11	116.5	36.Ø	Ø.Ø6	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
12	24.4	3.3	Ø.18	Ø.28	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
13	16.Ø	Ø.6	Ø.Ø2	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
14	23.Ø	Ø.8	Ø.18	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
15	14.Ø	Ø.5	Ø.Ø4	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
16	1Ø.5	Ø.3	Ø.Ø4	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
17	22.Ø	1.4	Ø.Ø4	Ø.1Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
18	368.Ø	5.2	Ø.28	Ø.28	Ø.2Ø	Ø.22	1.62	Ø.1
19	42Ø.Ø	4.8	Ø.14	Ø.22	Ø.23	Ø.34	1.55	Ø.8
2Ø	382.Ø	3.5	Ø.11	Ø.18	Ø.22	Ø.36	2.ØØ	Ø.Ø
21	46Ø.Ø	16.4	Ø.16	Ø.1Ø	Ø.22	Ø.19	1.36	Ø.2
22	182.Ø	2.Ø	Ø.Ø7	Ø.Ø7	Ø.18	Ø.25	1.ØØ	Ø.2

Statistical Summary of the Water Quality Data for the Standing Pot Liquor collected in the Tame 1 Gully Pot.

Table 7.2

	TEMP	DO	PH	ALK	TH	COND	SS	BOD
N	22	22	22	2Ø	2Ø	22	18	22
NMISS	Ø	Ø	Ø	2	2	Ø	4	Ø
MEAN	12.89	3.7Ø	7.57	192	4Ø9	17.Ø	249	24.7
MEDIAN	13.ØØ	3.6Ø	7.ØØ	195	26Ø	Ø.3	226	22.5
TMEAN	12.88	3.66	7.49	183	384	14.1	241	24.Ø
STDEV	6.Ø6	2.2Ø	1.31	124	385	32.7	198	16.7
SEMEAN	1.29	Ø.47	Ø.28	28	86	7.Ø	47	3.6
MAX	23.ØØ	7.2Ø	1Ø.7Ø	5ØØ	122Ø	93.3	61Ø	62.Ø
MIN	3.ØØ	Ø.9Ø	6.1Ø	4Ø	5Ø	Ø.1	1Ø	2.Ø
Q3	17.62	5.43	8.1Ø	25Ø	773	13.6	438	4Ø.3
Q1	7.5Ø	1.4Ø	6.75	81	11Ø	Ø.1	51	9.2

	COD	PHOS	CL	SUL	AMM	NIT	Na	K
N	17	2Ø	2Ø	19	2Ø	15	2Ø	2Ø
NMISS	5	2	2	3	2	7	2	2
MEAN	284	2.84	5737	472	2.Ø9	2Ø.8	4258	7.87
MEDIAN	123	2.Ø5	65	26Ø	Ø.85	2.9	12	4.65
TMEAN	262	2.56	3991	423	1.82	17.6	3481	6.38
STDEV	312	2.72	13989	5Ø3	2.6Ø	29.8	7831	9.84
SEMEAN	76	Ø.61	3128	115	Ø.58	7.7	1751	2.2Ø
MAX	9Ø5	1Ø.6Ø	42894	1778	8.8Ø	82.6	225ØØ	42.ØØ
MIN	Ø	Ø.ØØ	7	Ø	Ø.1Ø	Ø.6	1	Ø.5Ø
Q3	532	3.78	478	865	2.75	4Ø.6	8414	11.43
Q1	54	Ø.95	23	96	Ø.22	2.1	8	Ø.9Ø

	Fe	Pb	Ca	Mg	Zn	Mn	Cu	Cd
N	2Ø	2Ø	2Ø	2Ø	2Ø	2Ø	2Ø	2Ø
NMISS	2	2	2	2	2	2	2	2
MEAN	3.4	Ø.16Ø	123	7.1	Ø.134Ø	Ø.2Ø6	Ø.ØØ55	Ø.ØØ68
MEDIAN	Ø.7	Ø.ØØØ	5Ø	2.3	Ø.125Ø	Ø.135	Ø.ØØØØ	Ø.ØØØ
TMEAN	1.Ø	Ø.139	11Ø	5.7	Ø.1283	Ø.173	Ø.ØØ89	Ø.ØØ56
STDEV	11.Ø	Ø.245	153	11.6	Ø.ØØ54	Ø.267	Ø.ØØ29	Ø.126
SEMEAN	2.5	Ø.ØØ55	34	2.6	Ø.ØØ91	Ø.ØØ6Ø	Ø.ØØ28	Ø.ØØ28
MAX	5Ø.Ø	Ø.68Ø	46Ø	4Ø.Ø	Ø.35ØØ	1.ØØØ	Ø.23ØØ	Ø.36Ø
MIN	Ø.Ø	Ø.ØØØ	11	Ø.Ø	Ø.ØØØØ	Ø.ØØØ	Ø.ØØØØ	Ø.ØØØ
Q3	1.6	Ø.325	166	6.2	Ø.18ØØ	Ø.273	Ø.15ØØ	Ø.143
Q1	Ø.Ø	Ø.ØØØ	21	Ø.5	Ø.ØØ625	Ø.Ø15	Ø.ØØØØ	Ø.ØØØ

	Ni	Cr
N	2Ø	2Ø
NMISS	2	2
MEAN	Ø.385	Ø.Ø65
MEDIAN	Ø.ØØØ	Ø.ØØØ
TMEAN	Ø.312	Ø.Ø28
STDEV	Ø.7Ø4	Ø.184
SEMEAN	Ø.157	Ø.Ø41
MAX	2.ØØØ	Ø.8ØØ
MIN	Ø.ØØØ	Ø.ØØØ
Q3	Ø.81Ø	Ø.ØØØ
Q1	Ø.ØØØ	Ø.ØØØ

Table of the Correlation Coefficients between all Twenty-Six Water Quality Parameters for the Standing Pot Liquor in the Tame 1 Gully Pot.

Table 7.3

	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
DO	-0.663								
PH	-0.684	0.525							
ALK	0.455	-0.563	-0.252						
TH	-0.628	0.363	0.914	-0.055					
COND	-0.717	0.395	0.887	-0.184	0.948				
SS	-0.192	0.036	0.623	0.327	0.633	0.595			
BOD	0.192	-0.316	-0.045	0.363	0.042	-0.041	0.253		
COD	0.045	-0.161	0.222	0.614	0.385	0.388	0.817	0.415	
PHOS	0.129	-0.358	-0.089	0.515	0.092	0.011	0.416	0.523	0.781
CL	-0.564	0.488	0.695	-0.315	0.668	0.794	0.521	-0.078	0.192
SUL	-0.539	0.314	0.814	-0.287	0.986	0.881	0.496	-0.125	0.035
AMM	0.283	-0.316	-0.026	0.468	0.118	0.135	0.629	0.214	0.812
NIT	-0.234	-0.062	0.533	0.026	0.657	0.655	0.244	0.313	-0.005
Na	-0.721	0.468	0.893	-0.288	0.946	0.996	0.685	-0.038	0.366
K	-0.185	0.011	0.479	0.004	0.541	0.598	0.682	0.219	0.499
Fe	0.311	-0.289	-0.144	0.622	-0.094	-0.106	0.293	0.338	0.567
Pb	-0.581	0.269	0.717	-0.148	0.852	0.898	0.398	-0.032	0.057
Ca	-0.603	0.489	0.899	-0.079	0.984	0.921	0.748	-0.021	0.436
Mg	0.258	-0.245	-0.121	0.519	-0.012	-0.062	0.388	0.068	0.479
Zn	0.246	-0.415	0.045	0.617	0.281	0.184	0.597	0.339	0.581
Mn	0.346	-0.466	-0.161	0.677	0.017	-0.038	0.527	0.456	0.752
Cu	-0.789	0.492	0.928	-0.183	0.956	0.958	0.689	-0.004	0.467
Cd	-0.781	0.452	0.893	-0.124	0.951	0.967	0.588	-0.011	0.386
Ni	-0.712	0.467	0.916	-0.152	0.961	0.976	0.621	-0.048	0.359
Cr	-0.465	0.342	0.599	-0.198	0.572	0.673	0.488	0.004	0.375

	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
CL	-0.188								
SUL	-0.048	0.559							
AMM	0.542	0.196	-0.012						
NIT	0.065	0.131	0.715	-0.134					
Na	-0.011	0.818	0.893	0.128	0.648				
K	0.267	0.687	0.378	0.422	0.092	0.548			
Fe	0.096	-0.479	-0.211	0.458	-0.164	-0.111	0.018		
Pb	-0.041	0.683	0.895	0.037	0.611	0.888	0.454	-0.143	
Ca	-0.011	0.795	0.833	0.288	0.475	0.931	0.582	-0.089	0.838
Mg	0.486	0.025	-0.043	0.571	-0.226	-0.052	0.032	0.258	0.078
Zn	0.238	0.318	0.182	0.583	0.038	0.285	0.278	0.644	0.134
Mn	0.581	0.015	-0.142	0.834	-0.052	-0.035	0.287	0.638	-0.064
Cu	0.097	0.735	0.843	0.191	0.579	0.958	0.546	-0.117	0.817
Cd	0.066	0.646	0.871	0.188	0.664	0.949	0.577	-0.113	0.858
Ni	0.085	0.693	0.923	0.075	0.647	0.977	0.498	-0.114	0.872
Cr	-0.058	0.742	0.343	0.254	0.298	0.631	0.803	-0.078	0.527

	Ca	Mg	Zn	Mn	Cu	Cd	Ni
Mg	0.169						
Zn	0.272	0.298					
Mn	0.057	0.576	0.723				
Cu	0.950	0.166	0.163	0.027			
Cd	0.895	-0.074	0.071	-0.066	0.959		
Ni	0.937	-0.047	0.142	-0.056	0.978	0.975	
Cr	0.637	-0.031	0.039	-0.031	0.651	0.667	0.564

Graphs of Gully Pot Liquor Quality for Tame 1 Gully Pot.

NOTE: In Figures 7.10 to 7.321 inclusive, the X axis represents the time in weeks from May 1984 to May 1985 which was the period covered by the Gully Pot Liquor Monitoring Programme.

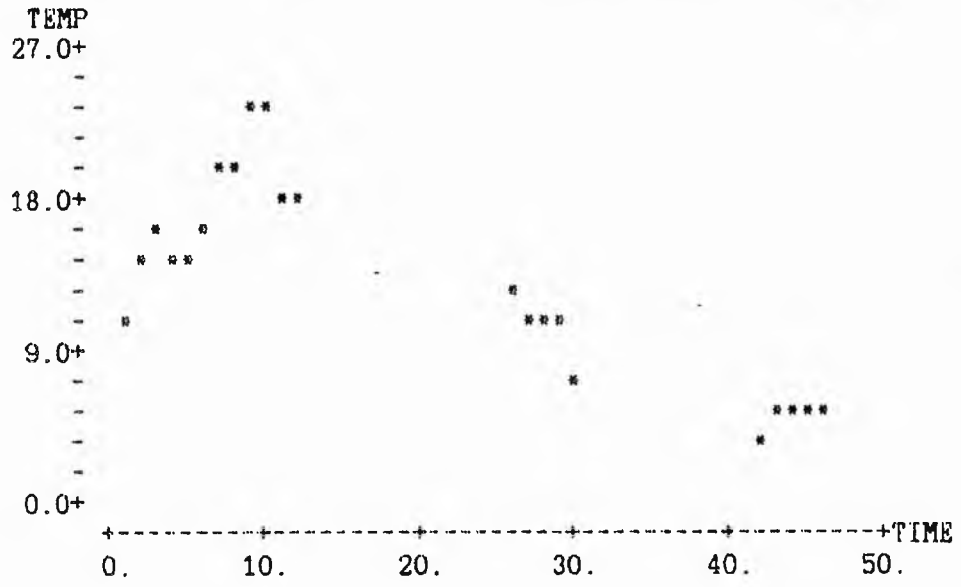


Figure 7.10

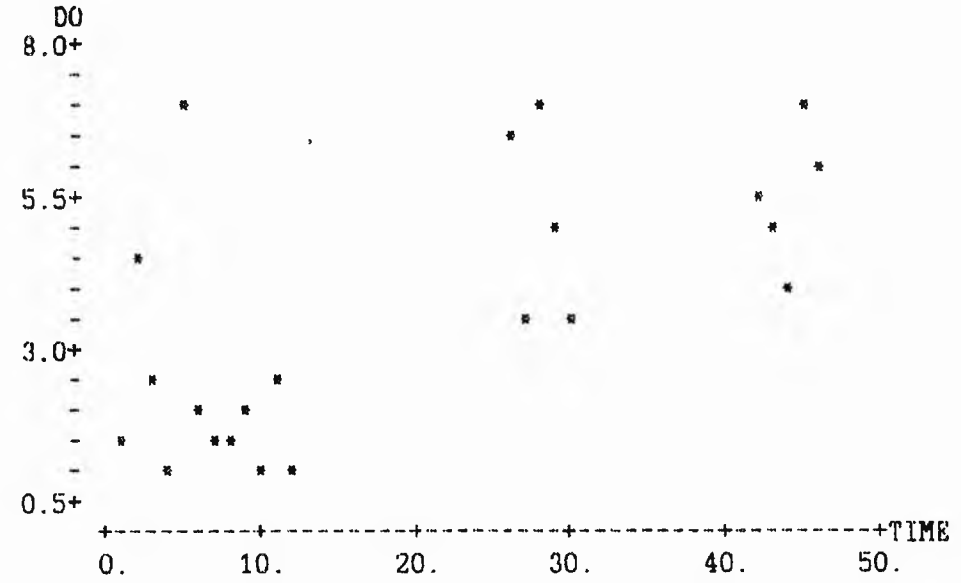


Figure 7.11

Graphs of Gully Pot Liquor Quality for Tame 1 Gully Pot.

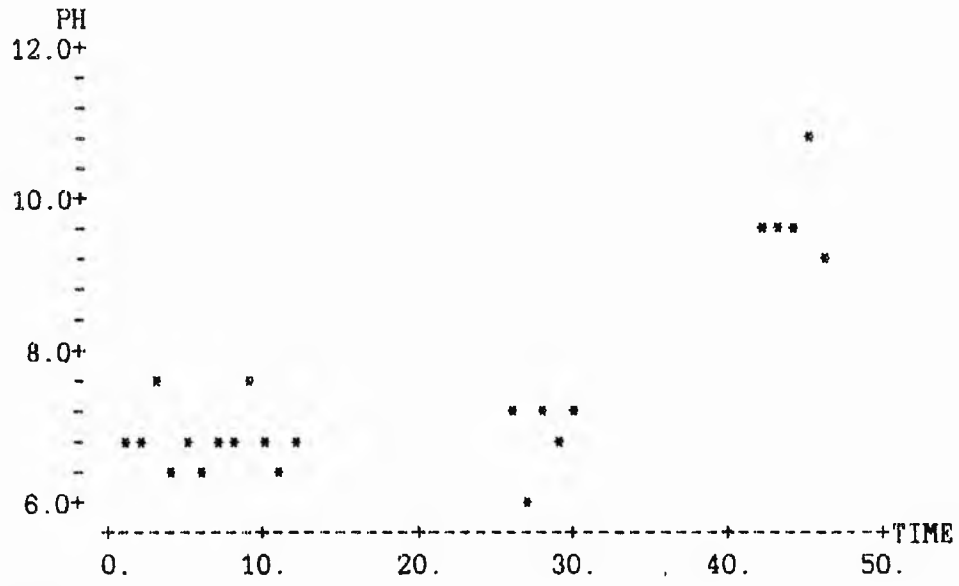
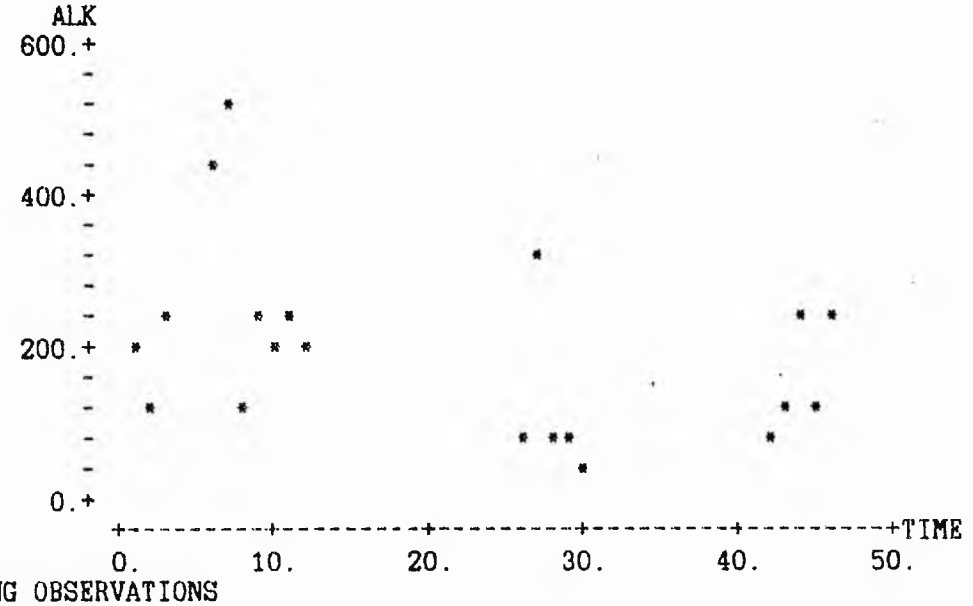


Figure 7.12



2 MISSING OBSERVATIONS

Figure 7.13

Graphs of Gully Pot Liquor Quality for Tame 1 Gully Pot.

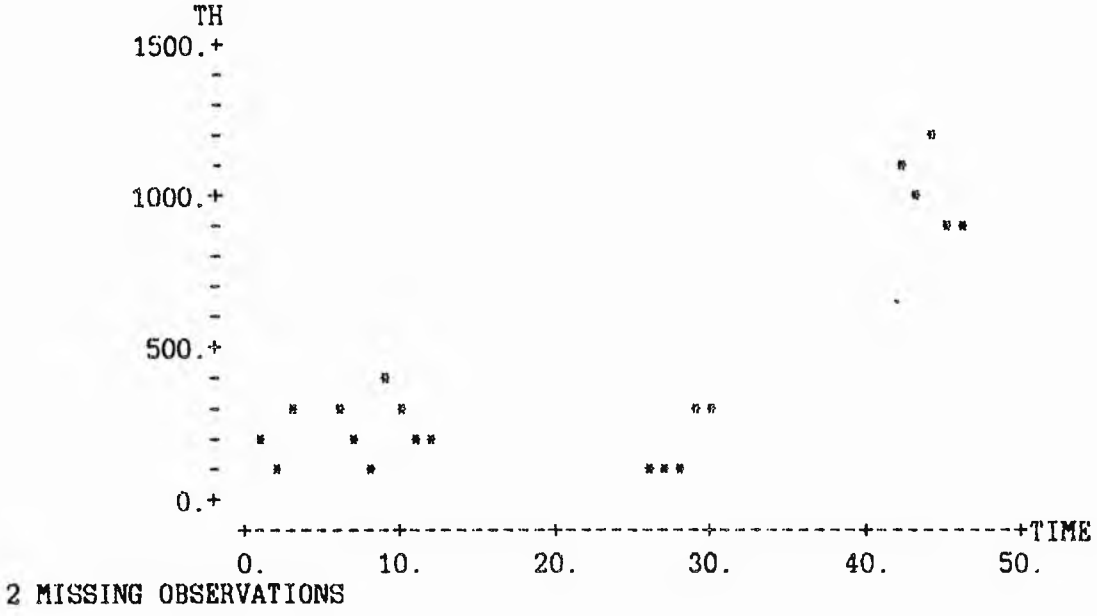


Figure 7.14

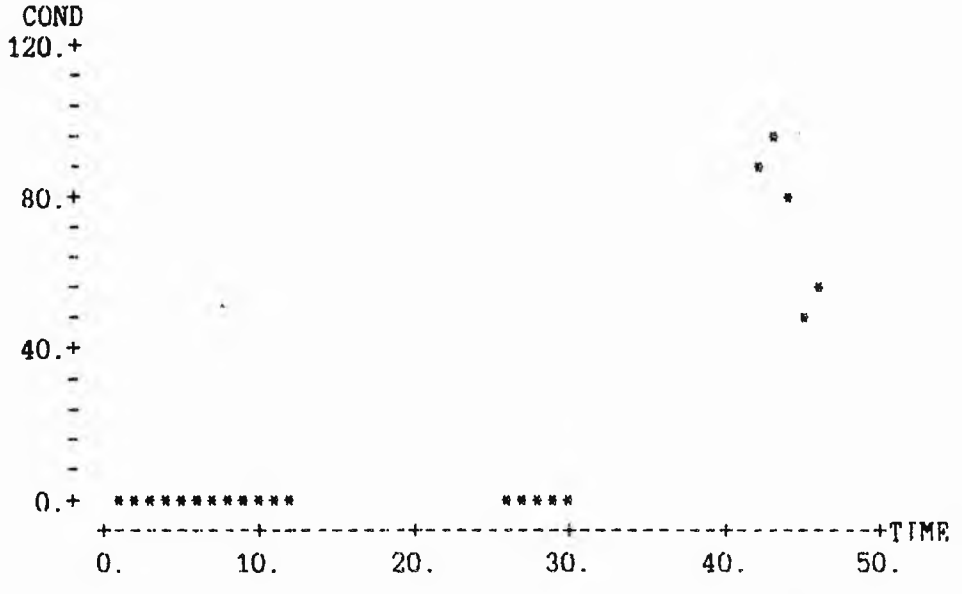
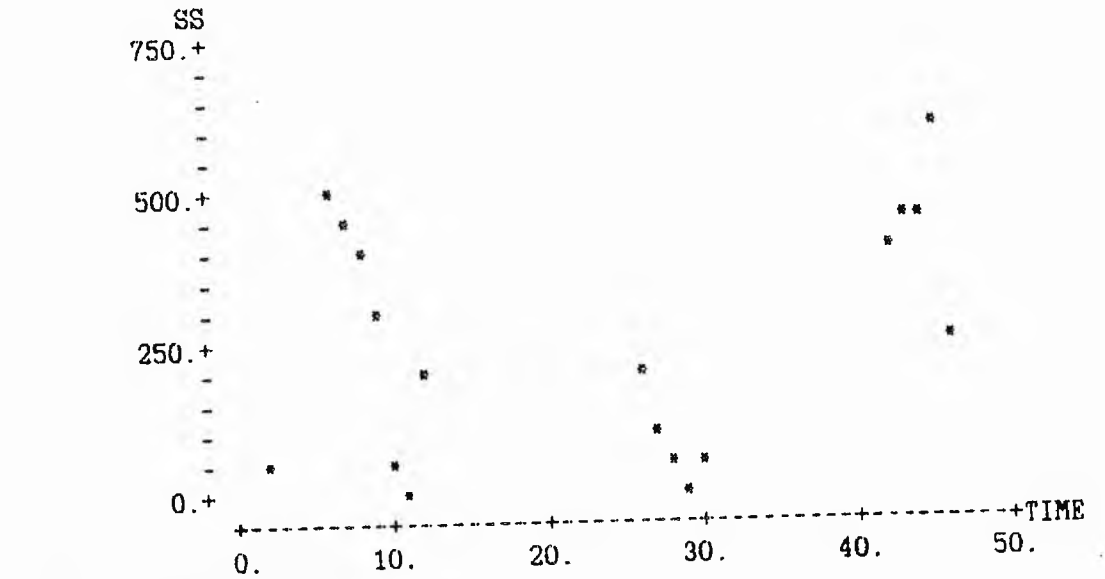


Figure 7.15

Graphs of Gully Pot Liquor Quality for Tame 1 Gully Pot.



4 MISSING OBSERVATIONS

Figure 7.16

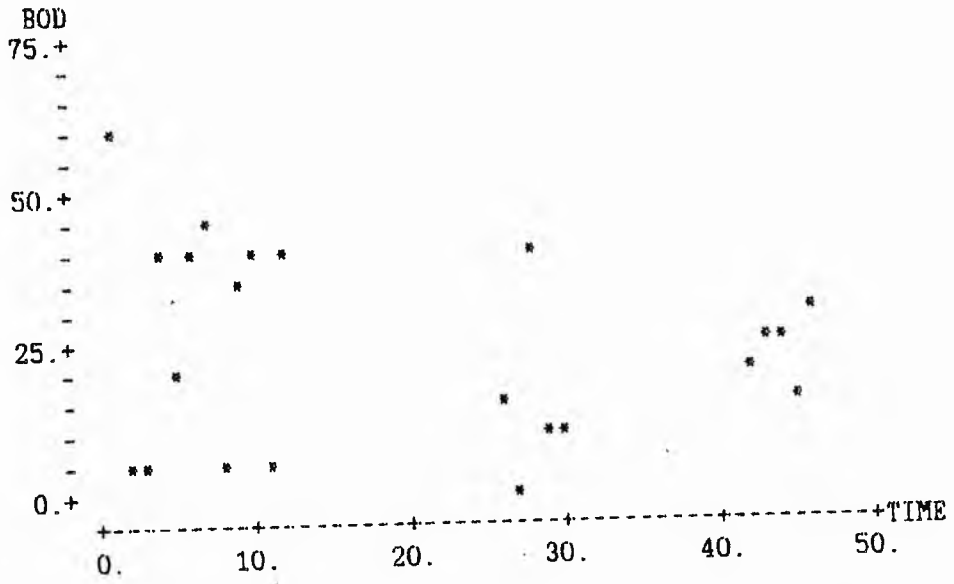
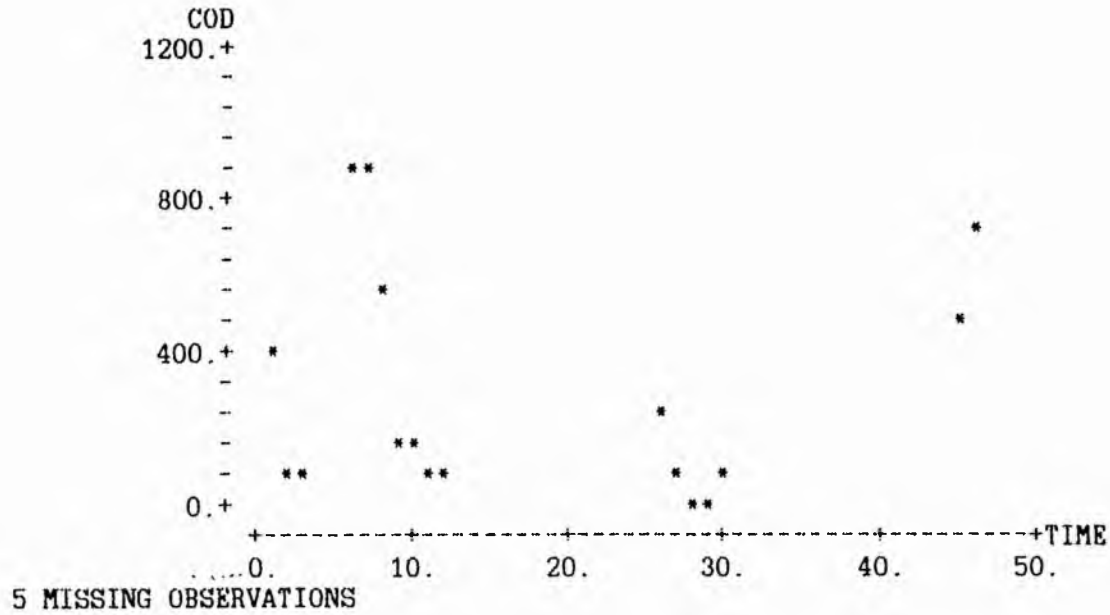


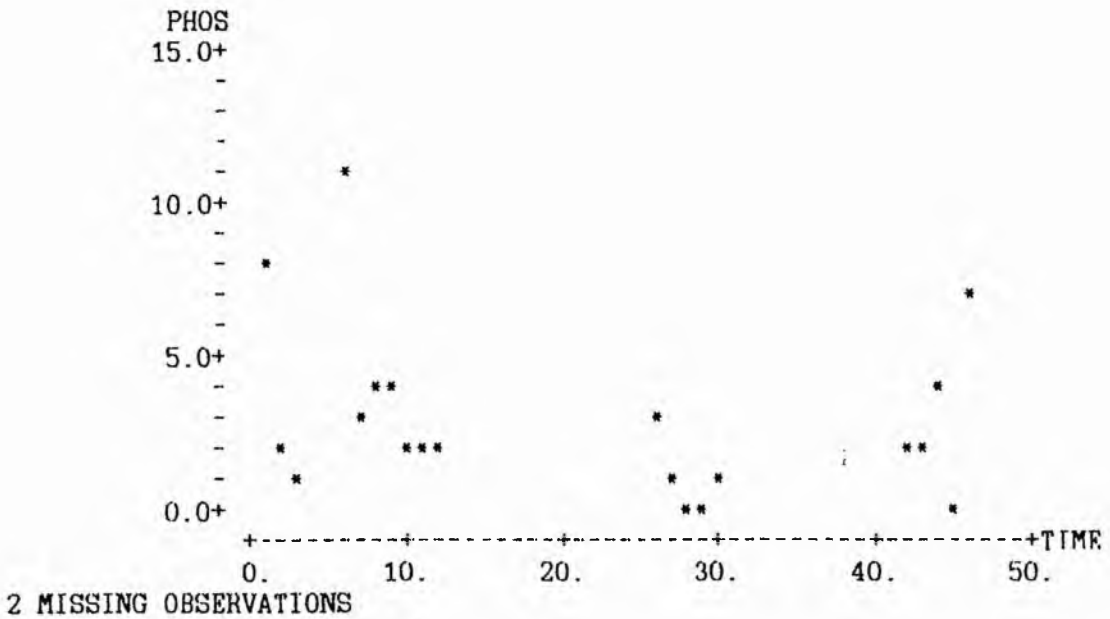
Figure 7.17

Graphs of Gully Pot Liquor Quality for Tame 1 Gully Pot.



5 MISSING OBSERVATIONS

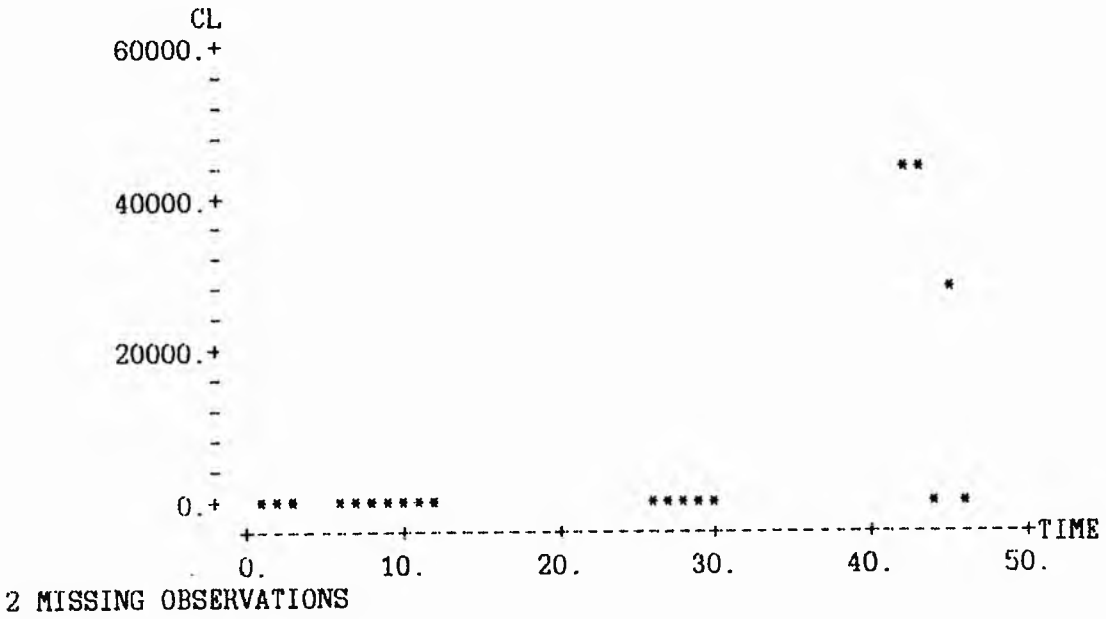
Figure 7.18



2 MISSING OBSERVATIONS

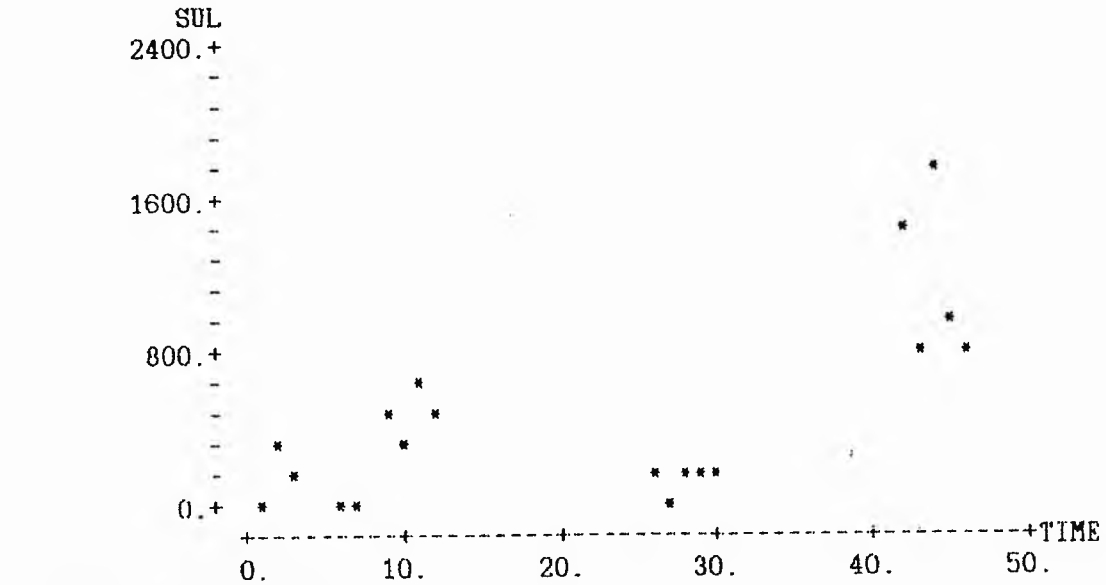
Figure 7.19

Graphs of Gully Pot Liquor Quality for Tame 1 Gully Pot.



2 MISSING OBSERVATIONS

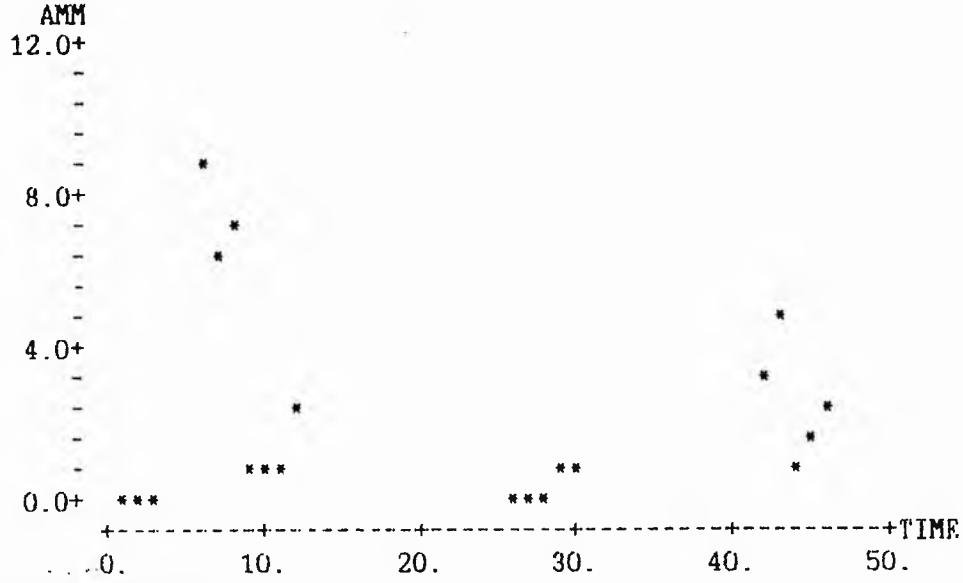
Figure 7.20



3 MISSING OBSERVATIONS

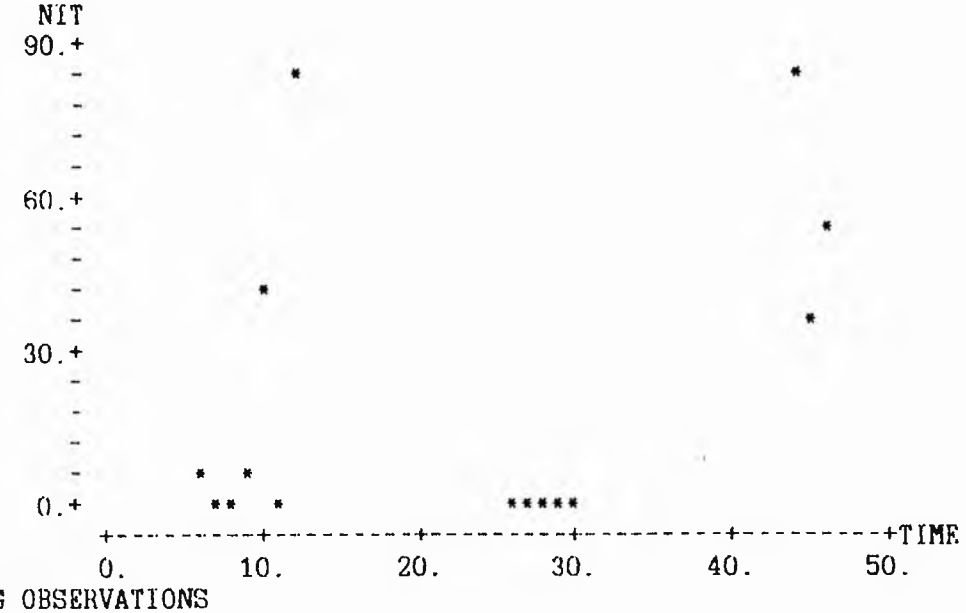
Figure 7.21

Graphs of Gully Pot Liquor Quality for Tame 1 Gully Pot.



2 MISSING OBSERVATIONS

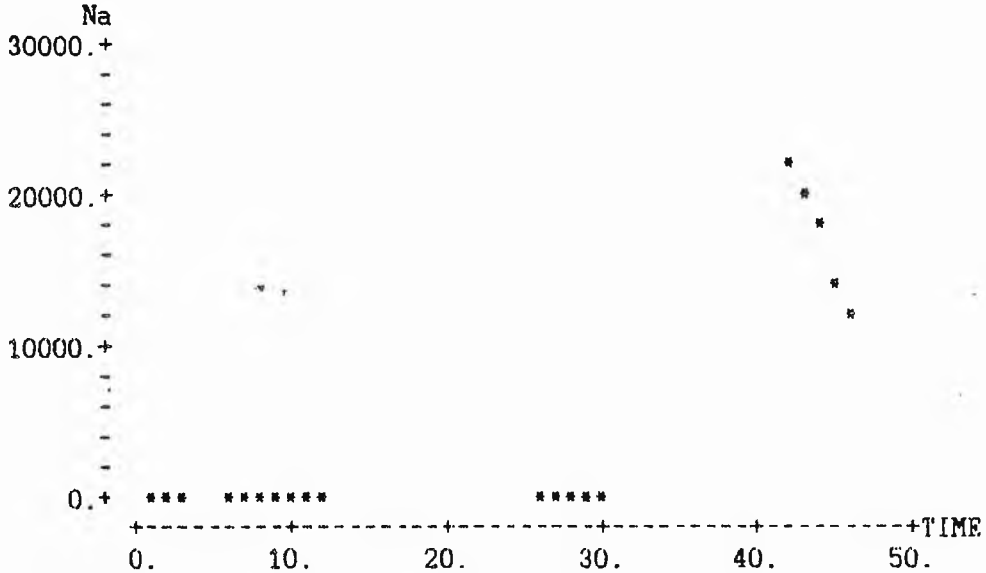
Figure 7.22



7 MISSING OBSERVATIONS

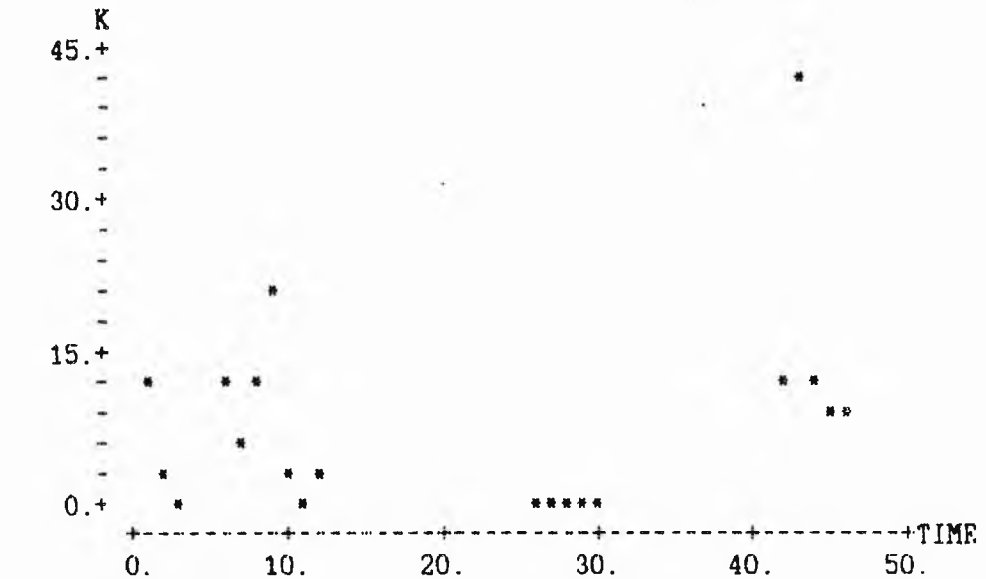
Figure 7.23

Graphs of Gully Pot Liquor Quality for Tame 1 Gully Pot.



2 MISSING OBSERVATIONS

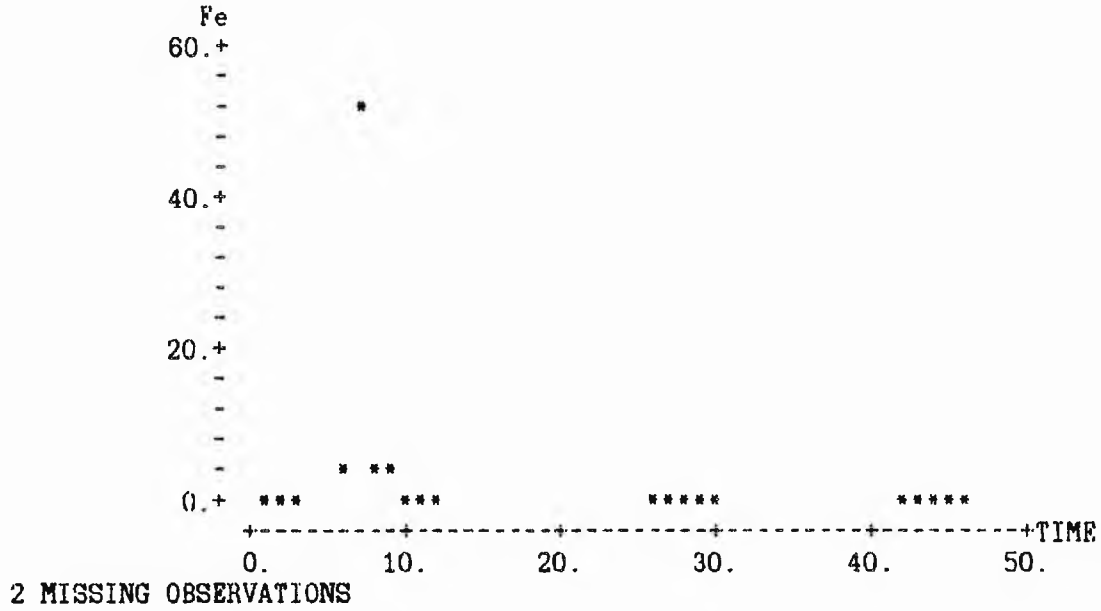
Figure 7.24



2 MISSING OBSERVATIONS

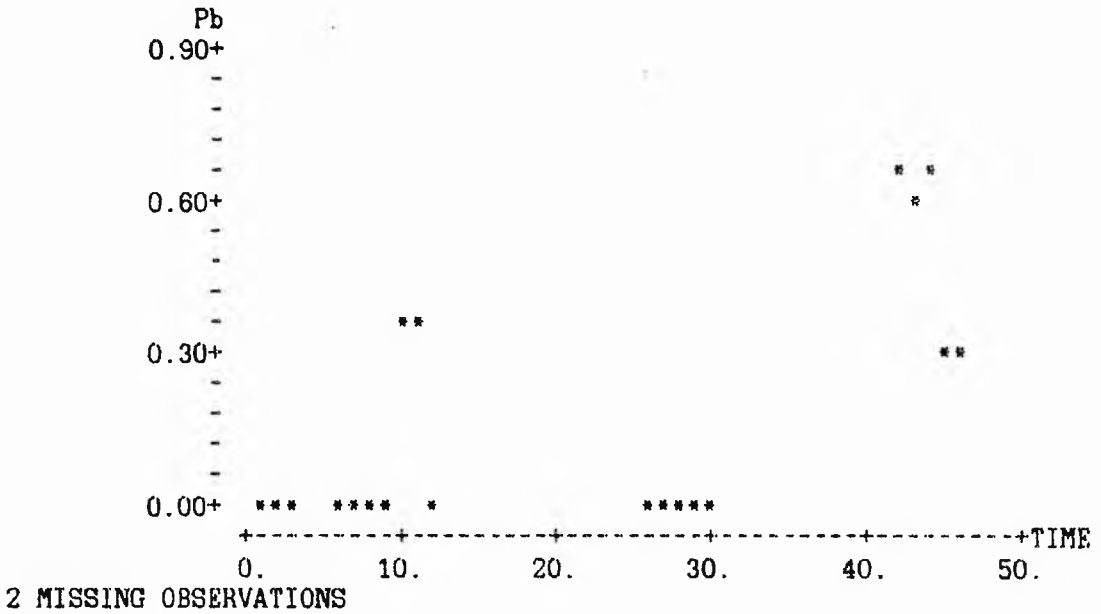
Figure 7.25

Graphs of Gully Pot Liquor Quality for Tame 1 Gully Pot.



2 MISSING OBSERVATIONS

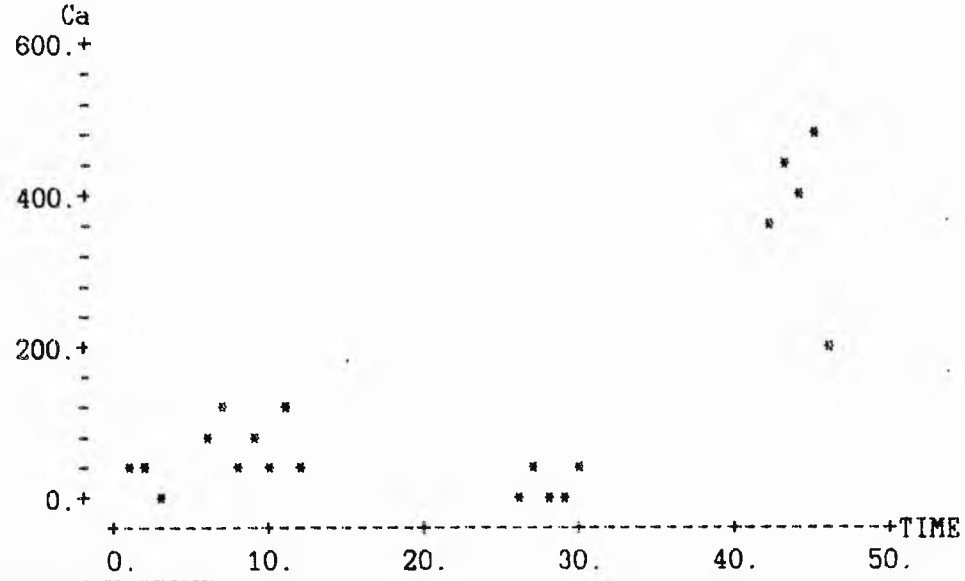
Figure 7.26



2 MISSING OBSERVATIONS

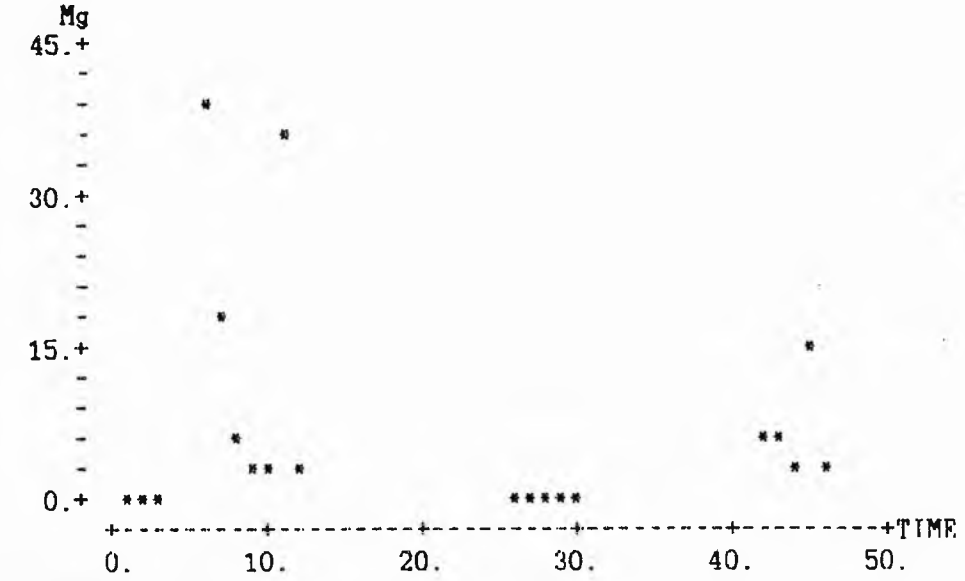
Figure 7.27

Graphs of Gully Pot Liquor Quality for Tame 1 Gully Pot.



2 MISSING OBSERVATIONS

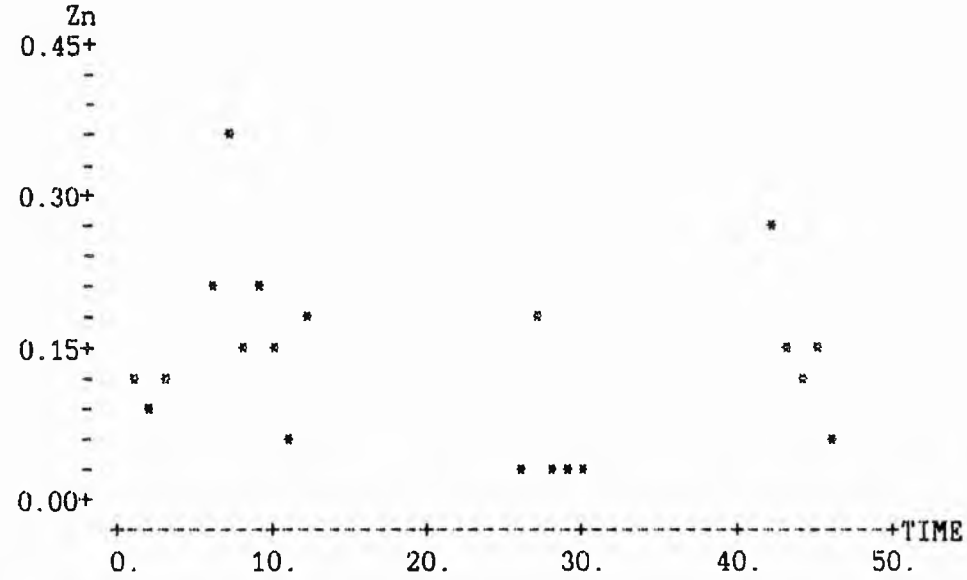
Figure 7.28



2 MISSING OBSERVATIONS

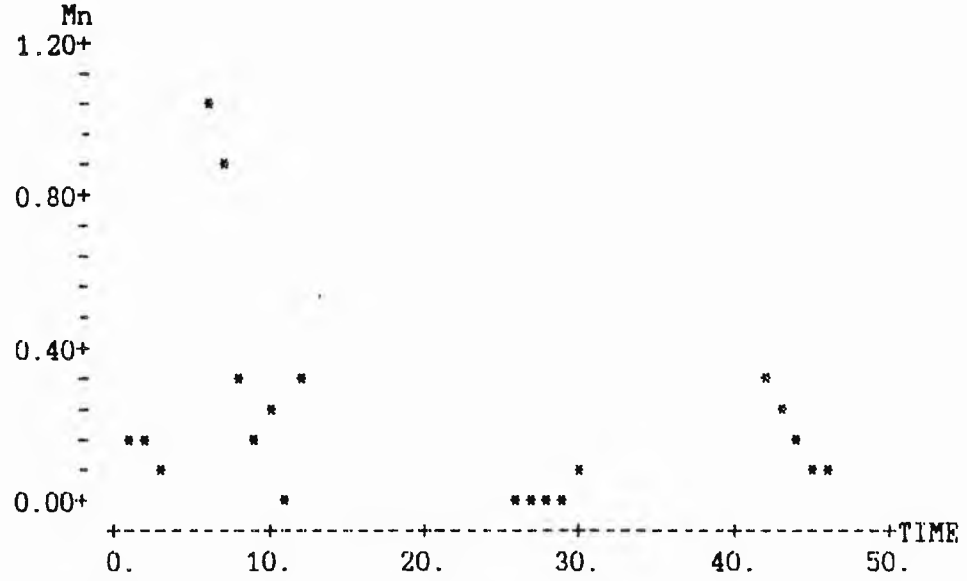
Figure 7.29

Graphs of Gully Pot Liquor Quality for Tame 1 Gully Pot.



2 MISSING OBSERVATIONS

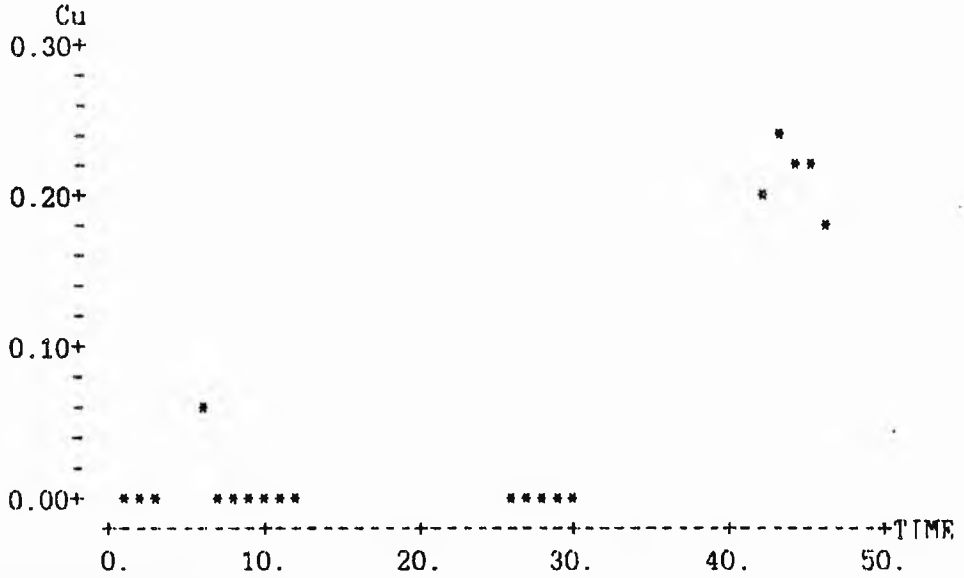
Figure 7.30



2 MISSING OBSERVATIONS

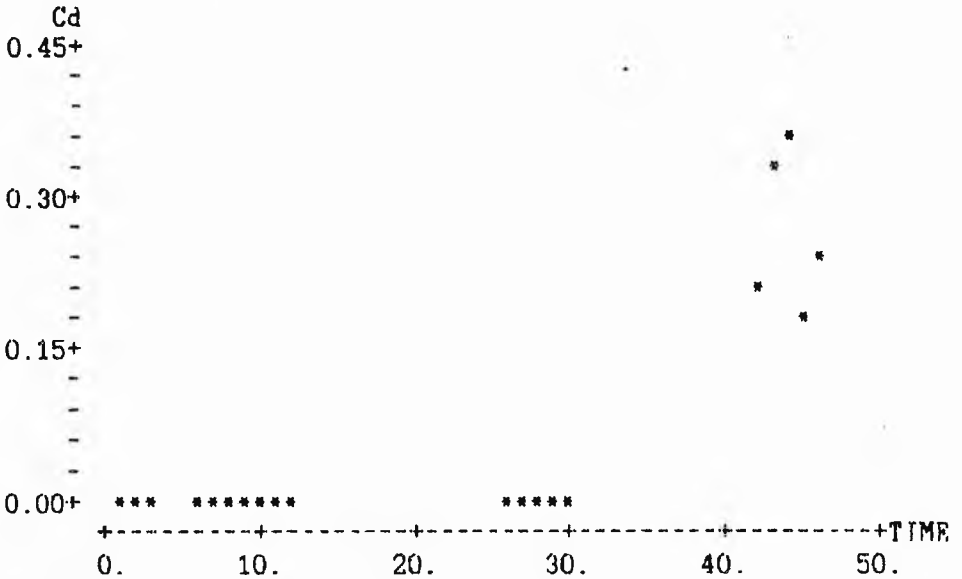
Figure 7.31

Graphs of Gully Pot Liquor Quality for Tame 1 Gully Pot.



2 MISSING OBSERVATIONS

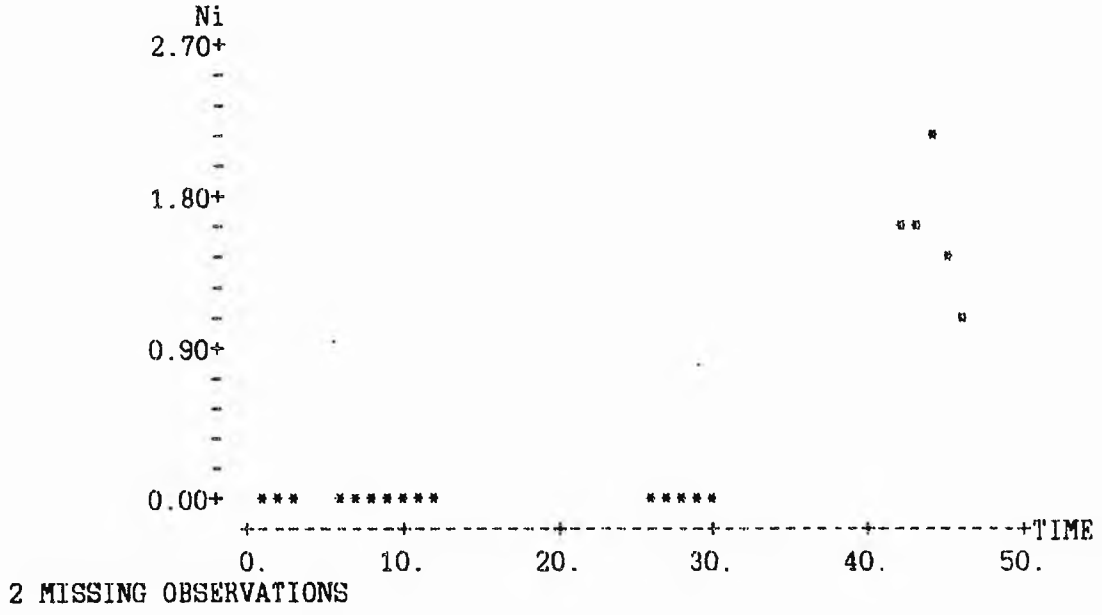
Figure 7.32



2 MISSING OBSERVATIONS

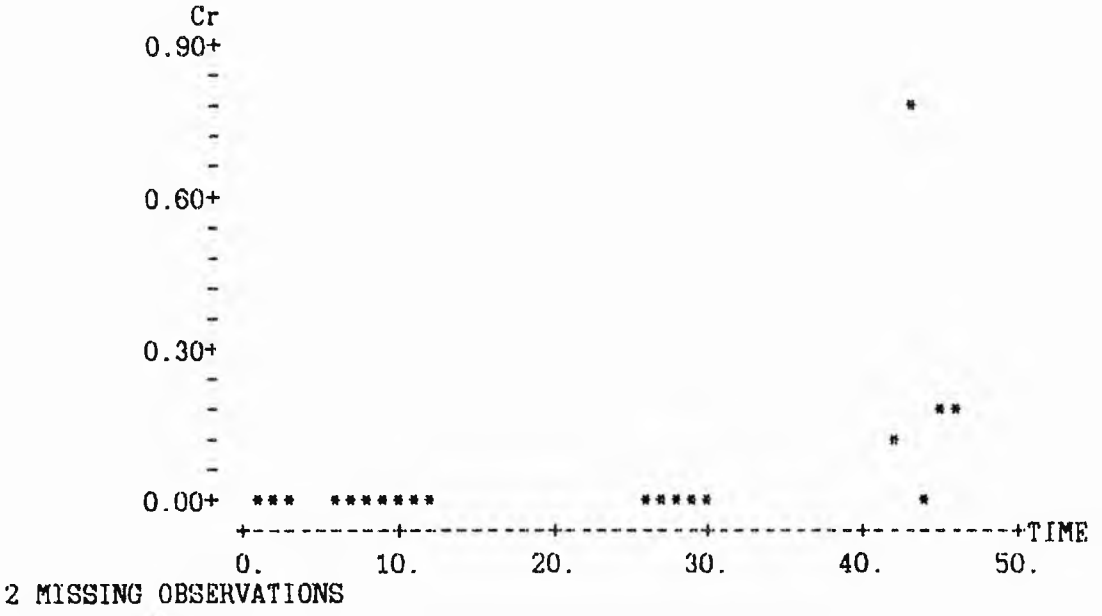
Figure 7.33

Graphs of Gully Pot Liquor Quality for Tame 1 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.34



2 MISSING OBSERVATIONS

Figure 7.35

7.6 TAME 2:

(see Figures 7.36 to 7.61 and Tables 7.4 to 7.6 inclusive).

The dissolved oxygen (DO) and pH values were fairly consistent throughout the twenty-two week period of study and no real temporal trend could be detected. There was a slight decrease in the pH values during the autumn period and this may have been due to increased quantities of organic matter reaching the gully pot from leaf fall and vegetation decay, which would produce acidic humic acids in the pot liquor, thus reducing the pH. The SS values were relatively low in comparison with data derived from the other gully pots, since there was a lack of any vegetated or loose soil areas adjacent to this gully pot, whose drainage would therefore be influenced. No real temporal pattern emerged from the SS dataset although peak values occurred in each of the three time periods, perhaps for differing reasons. The reason for these peaks is probably due to the seasonal changes within the sub-catchment itself, such as the influence of the supply of organic matter, grass cutting and increased anthropogenic activity during the summer months: higher SS values were seen in the autumn due to leaf fall and the influence of rock salt and the generally wetter conditions, with an increased mobility of sediment washoff from the urban surfaces into the gully pot drainage system during the winter months.

The dataset for Tame 2 gully pot shows enhanced values in the spring period for conductivity, sodium and chloride up to maxima of 17.3 (x1000) μscm-1, 14800 mgl-1 and 7090 mgl-1 as Cl^- respectively. These maxima are interrelated due to the presence of rock salt. Associated trends were also observed in the calcium values and this explains the

higher values for Total Hardness, with perhaps calcium making up most of the Total Hardness in preference to the lower concentrations of magnesium within the urban environment.

The values for alkalinity and phosphate showed no temporal variation and the same can also be said for the ammonia and nitrate levels, although a notable maximum ammonia value of 13.6 mgl-1 as N was observed in the summer period. This high ammonia concentration occurred at the same time as the maximum found in the Tame 1 dataset (in the same sub-catchment) and this is indicative of oxygen depletion in the pot with subsequent denitrification during a warm, dry period. The pot liquor temperatures were in excess of 20'C for most of this period and this warm, constant temperature would do much to enhance the denitrification process.

In the analysis of the soluble metals values in the dataset, similar trends to those found for Tame 1 gully pot can be seen. The high values for sodium have been explained above. Another interesting feature within the data, is the presence of copper and nickel during the spring period. Chromium was not detected at all in this gully pot liquor. Heavy metals derived from rock salt and vehicular emissions invariably explain the values found during the spring period although a cadmium concentration of 2.00 mgl-1 was measured early in the summer period. This can be described as either a freak result or due to the local dumping of a material into the pot such as brake fluid, (although there were no visible signs of any immiscible fluids within or on top of the pot liquor during the field inspection just prior to the sample being taken).

The values obtained for phosphate, sulphate, BOD and COD show no temporal variablity and they all retain fairly consistent levels throughout the whole study period.

Table 7.4

Table of all the Water Quality Data collected over the Twenty-Two Week Period for the Gully Pot Standing Liquor in the Tame 2 Gully Pot.

ROW	DATE	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
1	840509	11.0	2.1	7.3	170	220	0.55	*	9	119
2	840516	14.0	4.0	6.5	80	90	0.11	5	5	43
3	840523	14.5	3.2	7.4	170	290	0.09	*	5	42
4	840530	14.5	4.1	6.5	*	*	0.08	*	4	*
5	840606	14.5	6.4	6.7	*	*	0.14	*	4	*
6	840613	17.0	2.1	6.8	90	120	0.12	0	55	5
7	840620	19.5	1.1	7.0	100	260	0.18	21	14	79
8	840627	21.0	1.9	6.4	220	210	0.95	84	26	351
9	840704	25.0	3.4	7.5	170	220	0.25	110	19	666
10	840711	22.5	0.7	6.9	170	270	0.26	23	30	139
11	840718	20.0	2.5	6.7	80	270	0.12	24	11	5
12	840725	17.5	1.9	6.7	110	220	0.13	29	11	27
13	841031	12.0	6.4	5.7	30	40	0.08	9	6	60
14	841107	10.0	4.6	6.0	140	50	0.11	66	11	64
15	841114	10.0	5.3	6.2	50	40	0.05	30	54	0
16	841121	10.0	8.2	6.1	50	140	0.04	27	6	0
17	841128	8.0	4.9	6.7	30	180	0.05	141	8	99
18	850220	3.5	2.3	7.2	80	435	17.30	27	7	30
19	850227	4.0	2.3	7.2	90	360	14.52	87	9	173
20	850306	5.5	4.0	7.8	150	710	14.32	81	5	98
21	850313	6.0	2.0	7.3	100	660	12.73	125	11	35
22	850320	5.0	5.9	7.4	240	670	9.58	71	32	113

ROW	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
1	0.5	17.7	135	0.2	*	38.0	3.9	0.20	0.00
2	1.4	24.8	260	0.2	*	8.6	3.0	0.30	0.00
3	0.6	60.3	0	0.2	*	1.1	0.7	0.10	0.00
4	*	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*	*
6	2.0	18.0	346	13.6	3.9	8.0	1.0	0.60	0.00
7	1.4	28.0	452	5.0	2.5	7.5	2.5	10.50	0.20
8	5.6	160.0	*	8.7	0.1	10.0	10.0	2.70	0.00
9	5.7	32.0	192	0.2	8.4	30.0	17.0	2.00	0.00
10	0.9	21.0	365	1.1	7.7	7.0	1.5	0.80	0.45
11	3.0	18.0	577	0.5	0.9	10.0	1.3	0.30	0.54
12	0.6	21.0	567	1.1	19.6	6.8	1.5	1.00	0.00
13	1.4	35.5	211	0.3	1.2	1.8	0.5	0.00	0.00
14	0.3	39.0	48	0.2	1.7	3.6	0.5	0.00	0.00
15	0.3	17.7	154	0.2	2.1	1.7	0.5	0.00	0.00
16	0.0	7.1	115	0.2	1.0	4.5	0.4	0.00	0.00
17	1.6	10.6	192	0.2	1.4	4.0	0.4	0.00	0.00
18	1.9	7090.0	418	3.1	*	7000.0	4.2	0.39	0.13
19	1.7	7090.0	481	7.3	*	9000.0	45.0	0.45	0.10
20	0.2	113.0	1076	1.3	16.8	14800.0	5.3	1.12	0.16
21	0.5	5317.5	663	3.5	8.4	6500.0	5.5	0.96	0.15
22	1.8	298.0	529	4.9	30.1	1580.0	2.6	0.96	0.28

ROW	Ca	Mg	Zn	Mn	Cu	Cd	Ni	Cr
1	48.0	0.00	0.31	0.06	0.00	0.00	0.00	0
2	19.0	0.00	0.84	0.09	0.00	0.00	0.00	0
3	10.5	0.00	0.00	0.06	0.00	0.00	0.00	0
4	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*
6	19.0	0.90	0.20	0.15	0.00	0.00	0.00	0
7	30.0	0.50	0.45	0.15	0.00	2.00	0.00	0
8	27.5	2.00	0.10	0.35	0.00	0.00	0.00	0
9	102.5	5.00	0.20	0.00	0.00	0.00	0.00	0
10	30.0	5.00	0.20	0.50	0.00	0.00	0.00	0
11	107.5	48.50	0.06	0.13	0.00	0.00	0.00	0
12	20.5	2.30	0.26	0.18	0.00	0.00	0.00	0
13	12.8	0.80	0.05	0.03	0.00	0.00	0.00	0
14	13.0	1.10	0.09	0.00	0.00	0.00	0.00	0
15	10.0	0.70	0.05	0.00	0.00	0.00	0.00	0
16	7.0	0.40	0.04	0.00	0.00	0.00	0.00	0
17	6.8	0.60	0.02	0.10	0.00	0.00	0.00	0
18	158.0	4.00	0.63	0.70	0.00	0.00	0.22	0
19	158.0	3.00	0.37	0.50	0.00	0.06	0.13	0
20	195.0	4.20	0.58	0.57	0.02	0.03	0.23	0
21	250.0	5.50	0.53	0.62	0.04	0.03	0.25	0
22	83.5	3.28	0.23	0.44	0.00	0.03	0.25	0

Statistical Summary of the Water Quality Data for the Standing Pot Liquor collected in the Tame 2 Gully Pot.

Table 7.5

	TEMP	DO	PH	ALK	TH	COND	SS	BOD
N	22	22	22	2Ø	2Ø	22	18	22
NMISS	Ø	Ø	Ø	2	2	Ø	4	Ø
MEAN	12.95	3.6Ø	6.818	116.Ø	273	3.26	53.3	15.5
MEDIAN	13.ØØ	3.3Ø	6.75Ø	1ØØ.Ø	22Ø	Ø.14	29.5	1Ø.Ø
TMEAN	12.83	3.52	6.825	113.9	261	2.72	51.2	14.1
STDEV	6.29	1.96	Ø.541	6Ø.2	2Ø3	5.92	43.3	15.Ø
SEMEAN	1.34	Ø.42	Ø.115	13.5	45	1.26	1Ø.2	3.2
MAX	25.ØØ	8.2Ø	7.8ØØ	24Ø.Ø	71Ø	17.3Ø	141.Ø	55.Ø
MIN	3.5Ø	Ø.7Ø	5.7ØØ	3Ø.Ø	4Ø	Ø.Ø4	Ø.Ø	4.Ø
Q3	18.ØØ	5.ØØ	7.3ØØ	17Ø.Ø	342	3.11	84.7	2Ø.7
Q1	7.5Ø	2.Ø7	6.475	8Ø.Ø	125	Ø.Ø9	22.5	5.7

	COD	PHOS	CL	SUL	AMM	NIT	Na	K
N	2Ø	2Ø	2Ø	19	2Ø	15	2Ø	2Ø
NMISS	2	2	2	3	2	7	2	2
MEAN	1Ø7	1.57	1Ø21	357	2.6Ø	7.Ø5	1951	5.4
MEDIAN	62	1.4Ø	3Ø	346	Ø.8Ø	2.5Ø	8	2.Ø
TMEAN	82	1.43	74Ø	336	2.12	5.82	1346	3.4
STDEV	154	1.59	2385	26Ø	3.66	8.7Ø	4Ø89	1Ø.2
SEMEAN	34	Ø.36	533	6Ø	Ø.82	2.25	914	2.3
MAX	666	5.7Ø	7Ø9Ø	1Ø76	13.6Ø	3Ø.1Ø	148ØØ	45.Ø
MIN	Ø	Ø.ØØ	7	Ø	Ø.2Ø	Ø.1Ø	1	Ø.4
Q3	117	1.88	148	529	4.55	8.4Ø	1195	5.Ø
Q1	28	Ø.5Ø	18	154	Ø.2Ø	1.2Ø	4	Ø.6

	Fe	Pb	Ca	Mg	Zn	Mn	Cu	Cd
N	2Ø	2Ø	2Ø	2Ø	2Ø	2Ø	2Ø	2Ø
NMISS	2	2	2	2	2	2	2	2
MEAN	1.12	Ø.1ØØ	65.4	4.4	Ø.264	Ø.231	Ø.ØØ3ØØ	Ø.1Ø7
MEDIAN	Ø.42	Ø.ØØØ	28.8	1.5	Ø.2ØØ	Ø.14Ø	Ø.ØØØØØ	Ø.ØØØ
TMEAN	Ø.66	Ø.Ø82	58.4	2.2	Ø.246	Ø.218	Ø.ØØ111	Ø.ØØØ
STDEV	2.32	Ø.16Ø	72.7	1Ø.5	Ø.233	Ø.237	Ø.ØØ979	Ø.446
SEMEAN	Ø.52	Ø.Ø36	16.3	2.4	Ø.Ø52	Ø.Ø53	Ø.ØØ219	Ø.1ØØ
MAX	1Ø.5Ø	Ø.54Ø	25Ø.Ø	48.5	Ø.84Ø	Ø.7ØØ	Ø.Ø4ØØØ	2.ØØØ
MIN	Ø.ØØ	Ø.ØØØ	6.8	Ø.Ø	Ø.Ø2Ø	Ø.ØØØ	Ø.ØØØØØ	Ø.ØØØ
Q3	Ø.99	Ø.158	1Ø6.3	4.1	Ø.43Ø	Ø.485	Ø.ØØØØØ	Ø.Ø22
Q1	Ø.Ø2	Ø.ØØØ	12.9	Ø.5	Ø.Ø65	Ø.Ø38	Ø.ØØØØØ	Ø.ØØØ

	Ni	Cr
N	2Ø	2Ø
NMISS	2	2
MEAN	Ø.Ø54Ø	Ø
MEDIAN	Ø.ØØØØ	Ø
TMEAN	Ø.Ø461	Ø
STDEV	Ø.Ø986	Ø
SEMEAN	Ø.Ø221	Ø
MAX	Ø.25ØØ	Ø
MIN	Ø.ØØØØ	Ø
Q3	Ø.Ø975	Ø
Q1	Ø.ØØØØ	Ø

Table of the Correlation Coefficients between all Twenty-Six Water Quality Parameters for the Standing Pot Liquor in the Tame 2 Gully Pot.

Table 7.6

	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
DO	-0.351								
PH	-0.140	-0.441							
ALK	0.229	-0.302	0.494						
TH	-0.439	-0.183	0.769	0.414					
COND	-0.703	-0.154	0.560	0.086	0.795				
SS	-0.262	0.006	0.425	0.255	0.429	0.325			
BOD	0.204	-0.147	-0.071	0.137	-0.171	-0.153	-0.215		
COD	0.447	-0.155	0.288	0.479	0.016	-0.060	0.483	0.032	
PHOS	0.533	-0.237	0.091	0.330	-0.073	-0.106	0.249	0.160	0.787
CL	-0.554	-0.264	0.302	-0.171	0.429	0.809	0.241	-0.216	-0.061
SUL	-0.211	-0.306	0.499	0.142	0.758	0.630	0.162	-0.078	-0.088
AMM	0.036	-0.370	0.129	0.182	0.141	0.224	-0.057	0.510	0.047
NIT	-0.300	0.002	0.618	0.558	0.698	0.599	0.144	0.028	0.039
Na	-0.602	-0.103	0.545	0.024	0.729	0.886	0.326	-0.273	-0.045
K	-0.156	-0.223	0.305	0.088	0.181	0.449	0.364	-0.117	0.450
Fe	0.359	-0.386	0.163	0.133	0.081	-0.088	-0.070	0.015	0.181
Pb	0.156	-0.323	0.260	0.176	0.427	0.194	-0.131	0.041	-0.130
Ca	-0.427	-0.262	0.629	0.099	0.808	0.854	0.448	-0.240	0.111
Mg	0.247	-0.170	0.035	-0.088	0.115	-0.023	-0.096	-0.082	-0.083
Zn	-0.277	-0.337	0.446	0.016	0.442	0.561	-0.074	-0.289	-0.083
Mn	-0.404	-0.403	0.531	0.256	0.796	0.859	0.247	-0.059	-0.039
Cu	-0.341	-0.128	0.359	0.004	0.641	0.509	0.452	-0.163	-0.108
Cd	0.219	-0.285	0.084	-0.057	0.010	-0.103	-0.171	-0.046	-0.042
Ni	-0.689	-0.004	0.570	0.208	0.901	0.931	0.362	-0.120	-0.095

	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
CL	-0.027								
SUL	-0.030	0.265							
AMM	0.326	0.258	0.261						
NIT	-0.139	0.081	0.559	0.028					
Na	-0.189	0.595	0.738	0.126	0.384				
K	0.317	0.592	0.163	0.317	0.101	0.436			
Fe	0.200	-0.100	0.198	0.264	-0.063	-0.069	0.018		
Pb	0.037	0.069	0.488	-0.028	0.196	0.136	-0.047	0.151	
Ca	0.046	0.696	0.712	0.115	0.358	0.819	0.426	-0.029	0.337
Mg	0.253	-0.016	0.306	-0.119	-0.119	-0.015	-0.037	-0.086	0.717
Zn	-0.130	0.448	0.492	0.084	0.460	0.544	0.176	0.209	0.051
Mn	-0.009	0.686	0.707	0.338	0.517	0.737	0.306	0.024	0.429
Cu	-0.238	0.347	0.567	0.015	0.182	0.577	0.002	-0.015	0.107
Cd	-0.030	-0.076	0.109	0.166	-0.129	-0.085	-0.040	0.953	0.153
Ni	-0.146	0.628	0.668	0.178	0.679	0.786	0.222	-0.075	0.258

	Ca	Mg	Zn	Mn	Cu	Cd
Mg	0.266					
Zn	0.526	-0.153				
Mn	0.751	0.030	0.526			
Cu	0.737	0.021	0.391	0.587		
Cd	-0.090	-0.088	0.200	-0.059	-0.056	
Ni	0.828	-0.016	0.514	0.823	0.619	-0.103

Graph of Gully Pot Liquor Quality for Tame 2 Gully Pot.

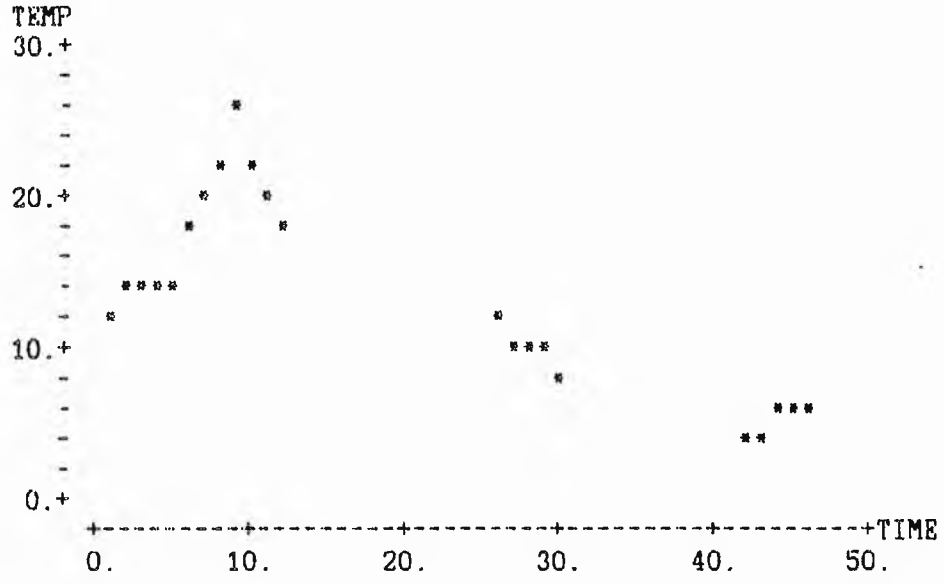


Figure 7.36

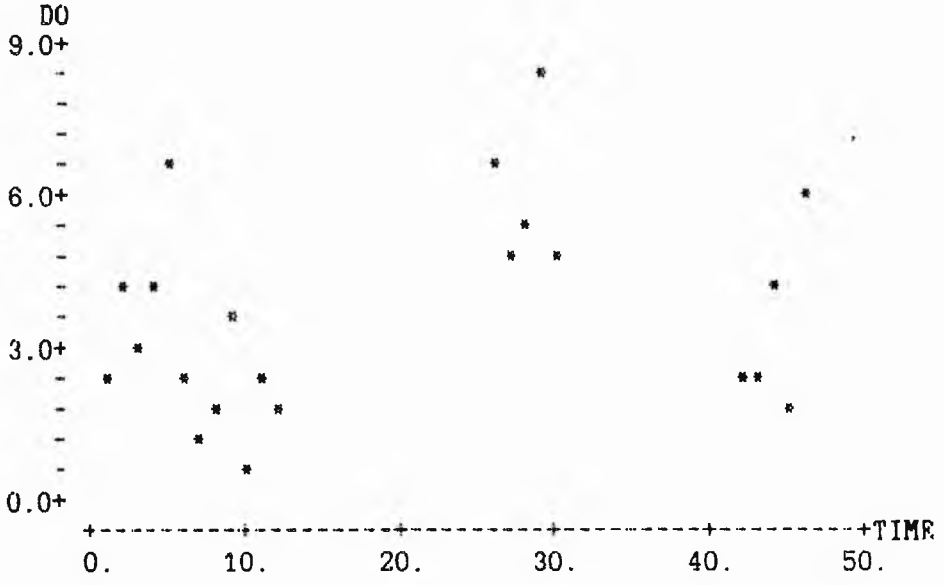


Figure 7.37

Graph of Gully Pot Liquor Quality for Tame 2 Gully Pot.

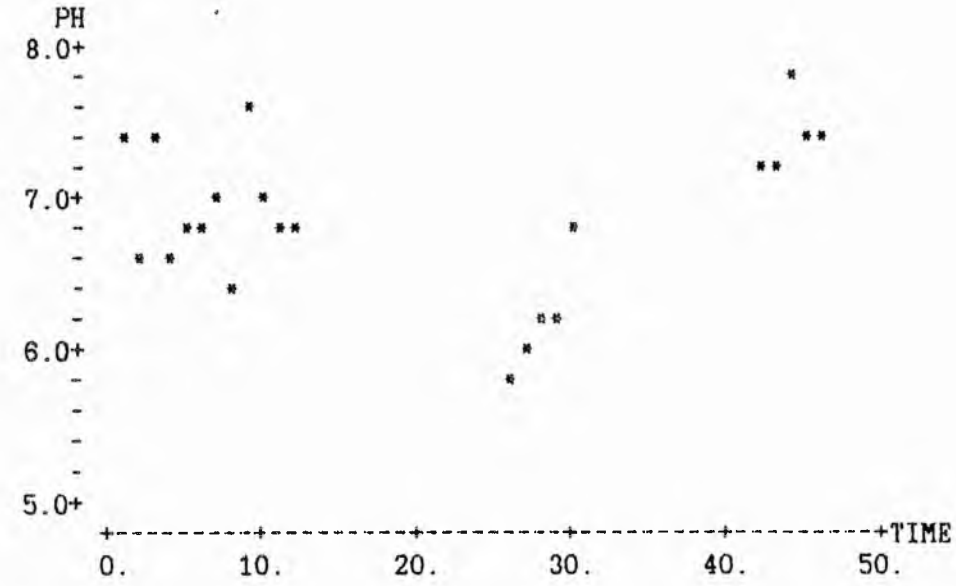
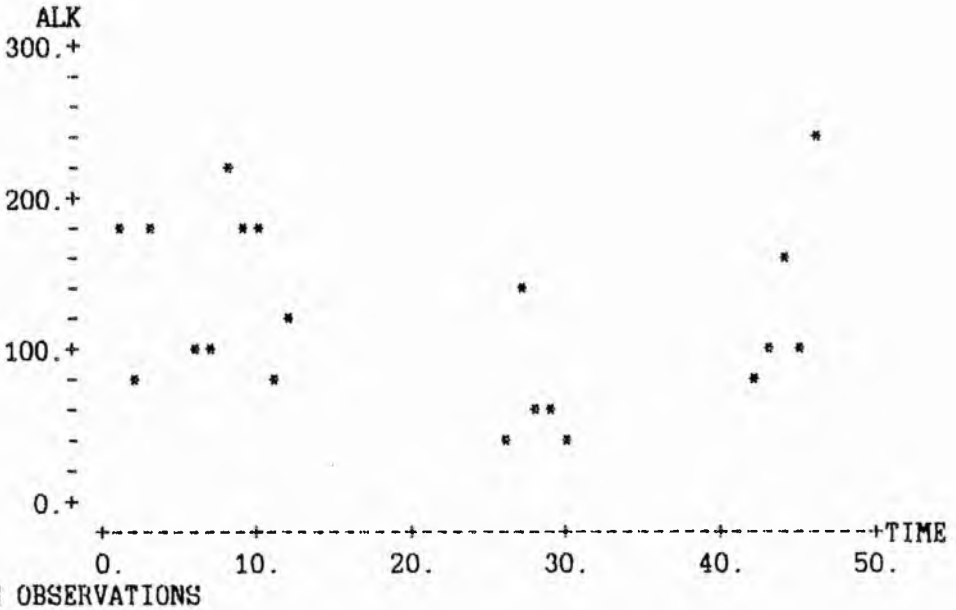


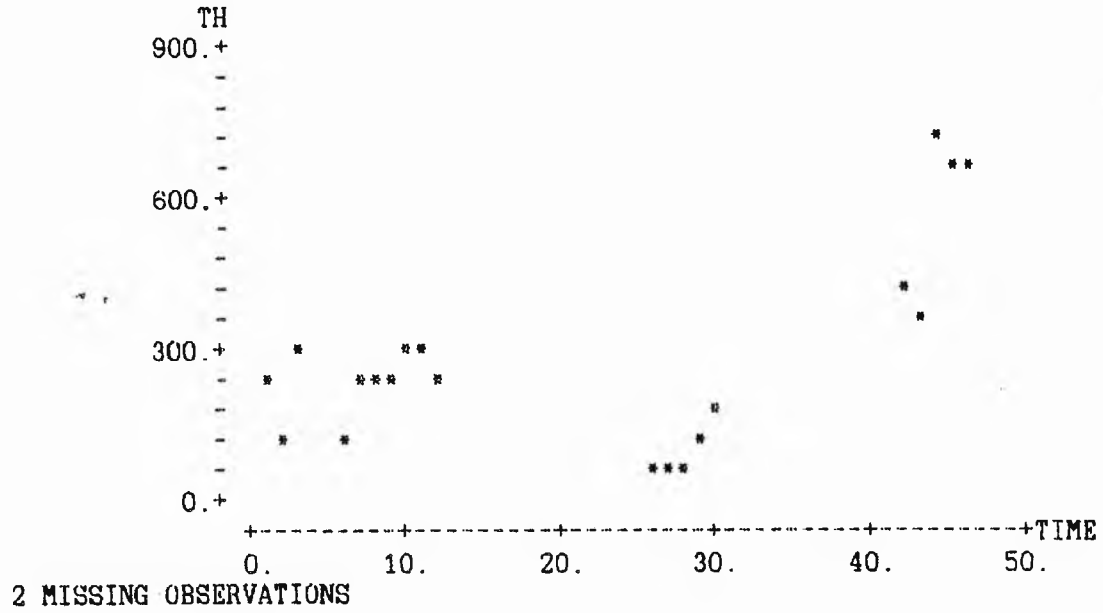
Figure 7.38



2 MISSING OBSERVATIONS

Figure 7.39

Graph of Gully Pot Liquor Quality for Tame 2 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.40

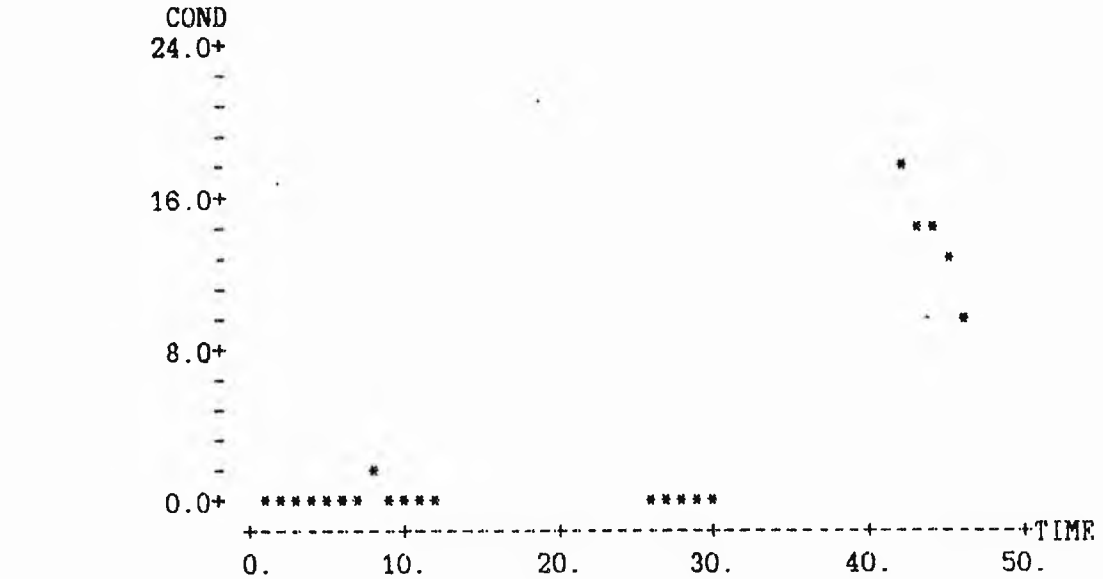
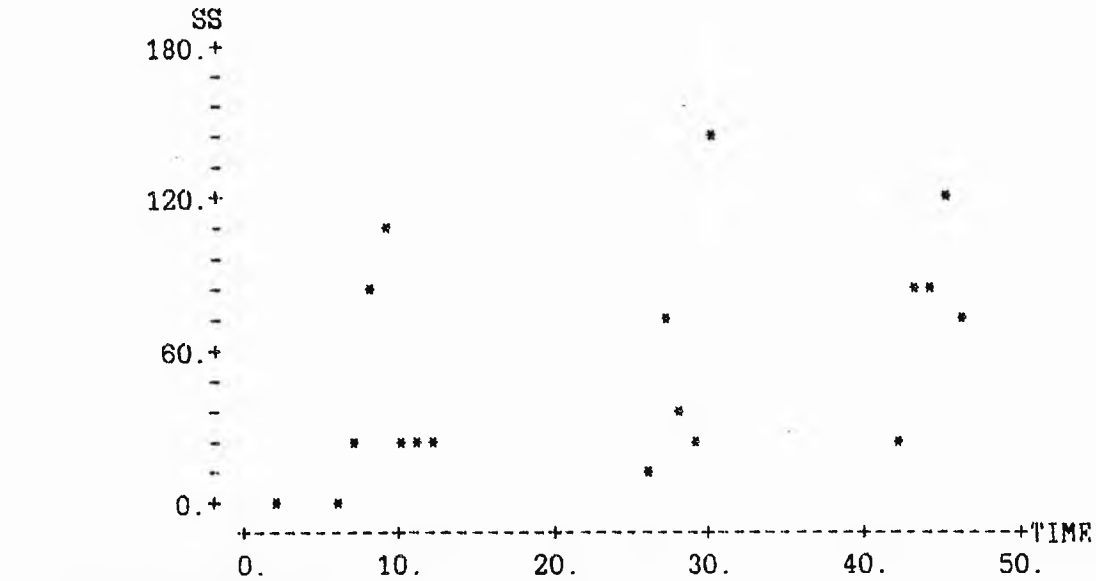


Figure 7.41

Graph of Gully Pot Liquor Quality for Tame 2 Gully Pot.



4 MISSING OBSERVATIONS

Figure 7.42

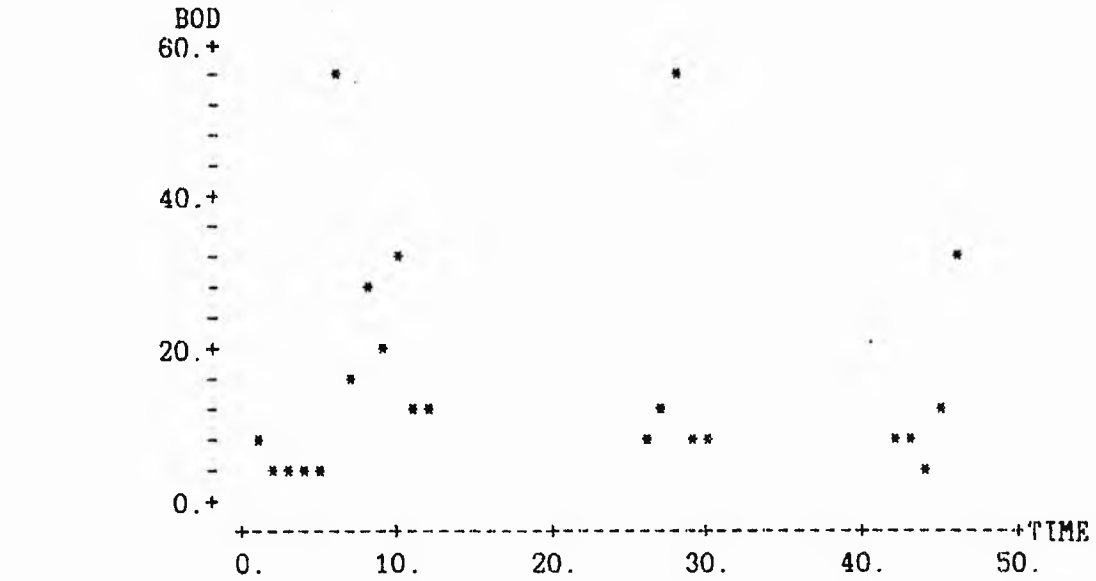
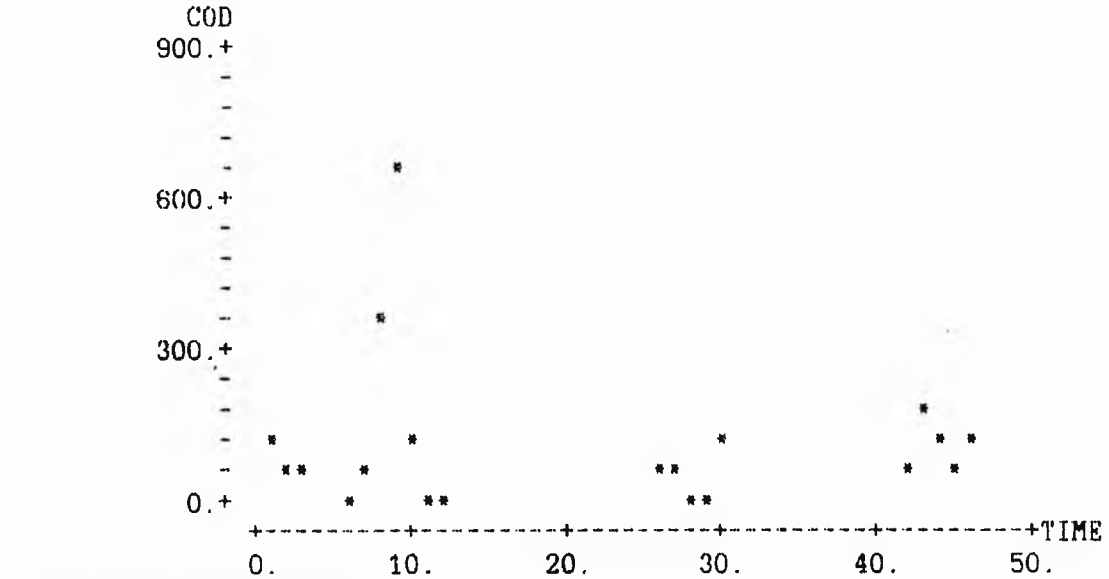


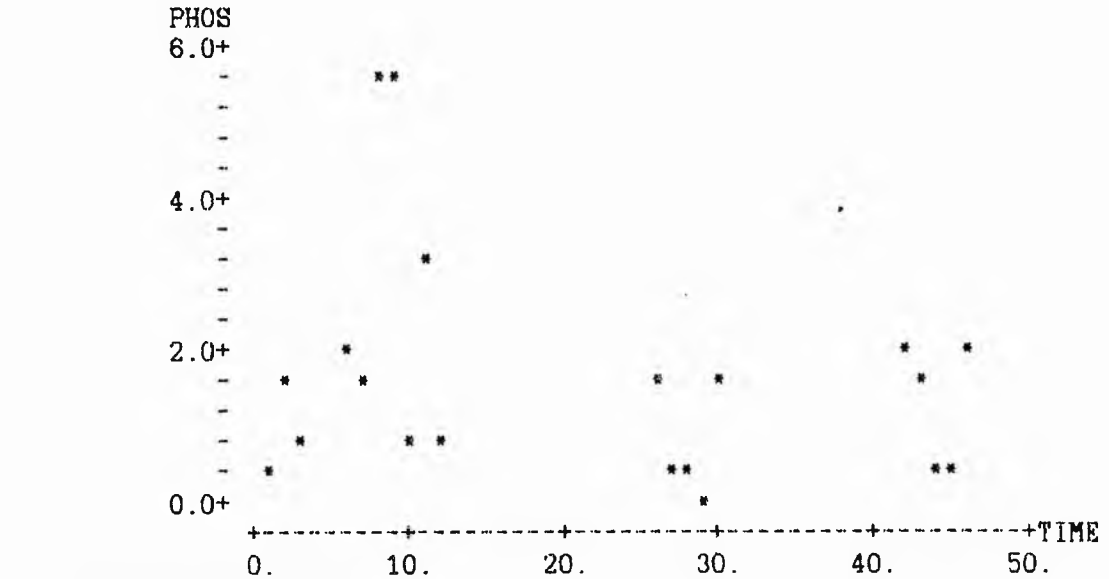
Figure 7.43

Graph of Gully Pot Liquor Quality for Tame 2 Gully Pot.



2 MISSING OBSERVATIONS

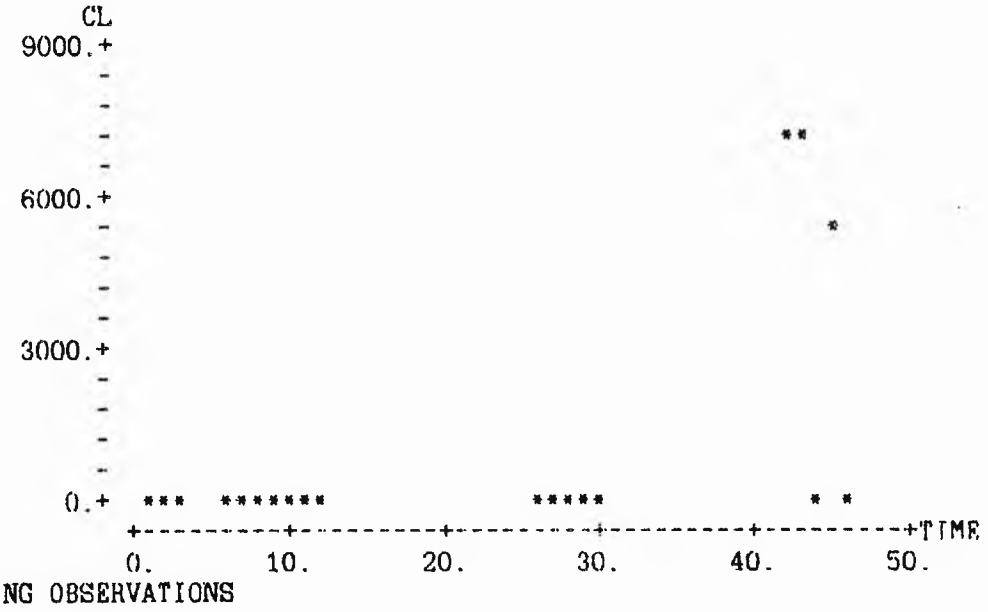
Figure 7.44



2 MISSING OBSERVATIONS

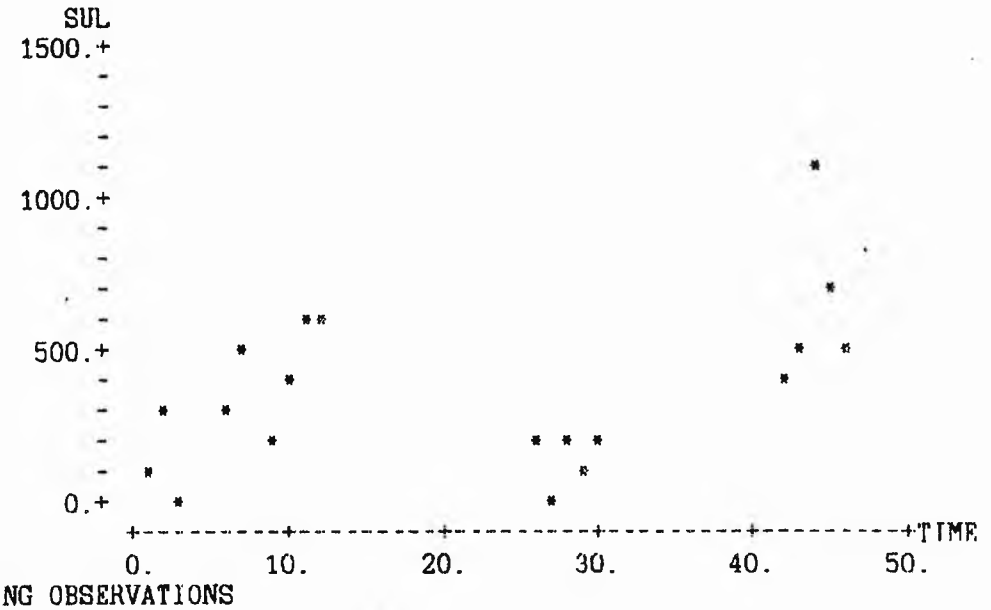
Figure 7.45

Graph of Gully Pot Liquor Quality for Tame 2 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.46



3 MISSING OBSERVATIONS

Figure 7.47

Graph of Gully Pot Liquor Quality for Tame 2 Gully Pot.

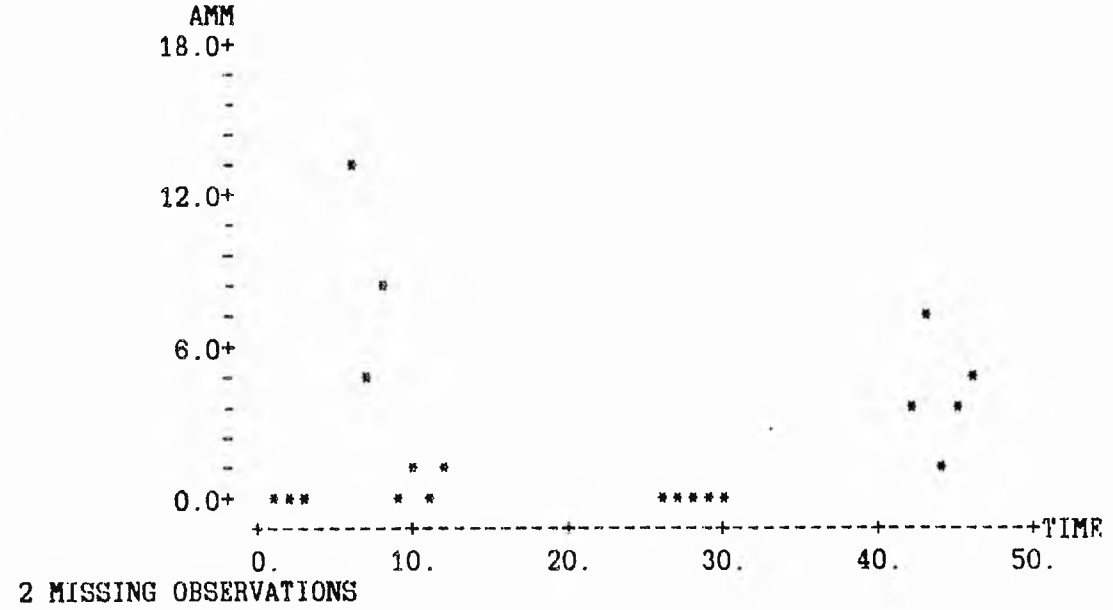


Figure 7.48

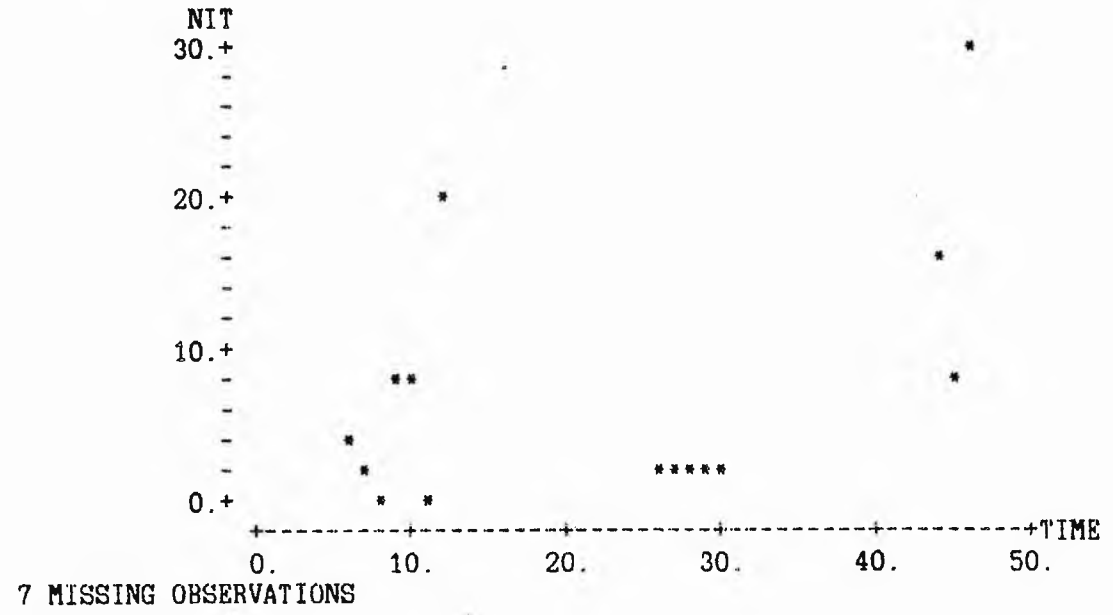
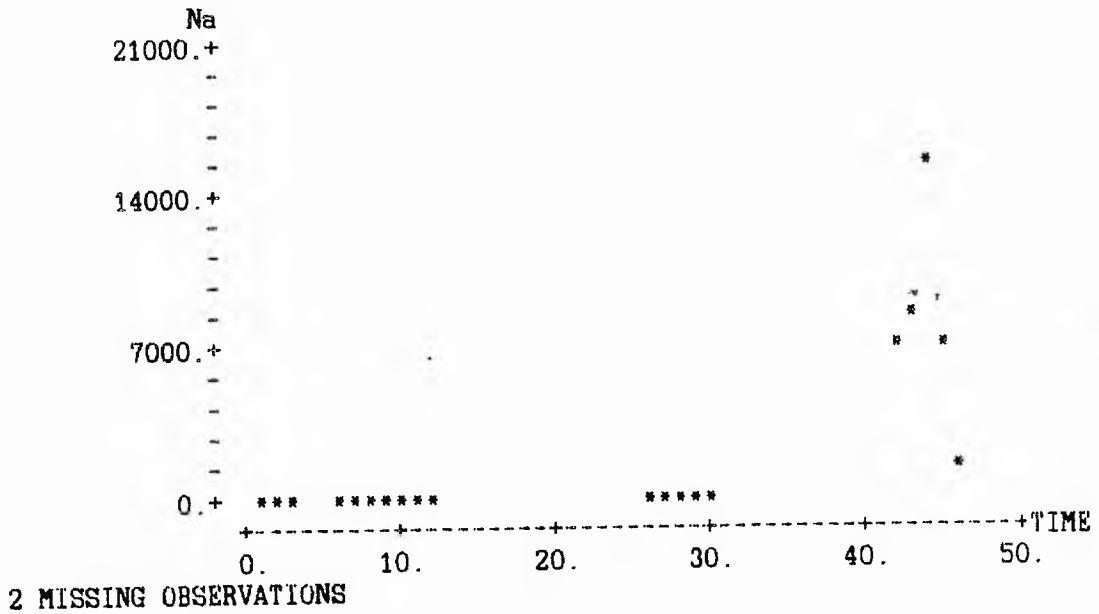


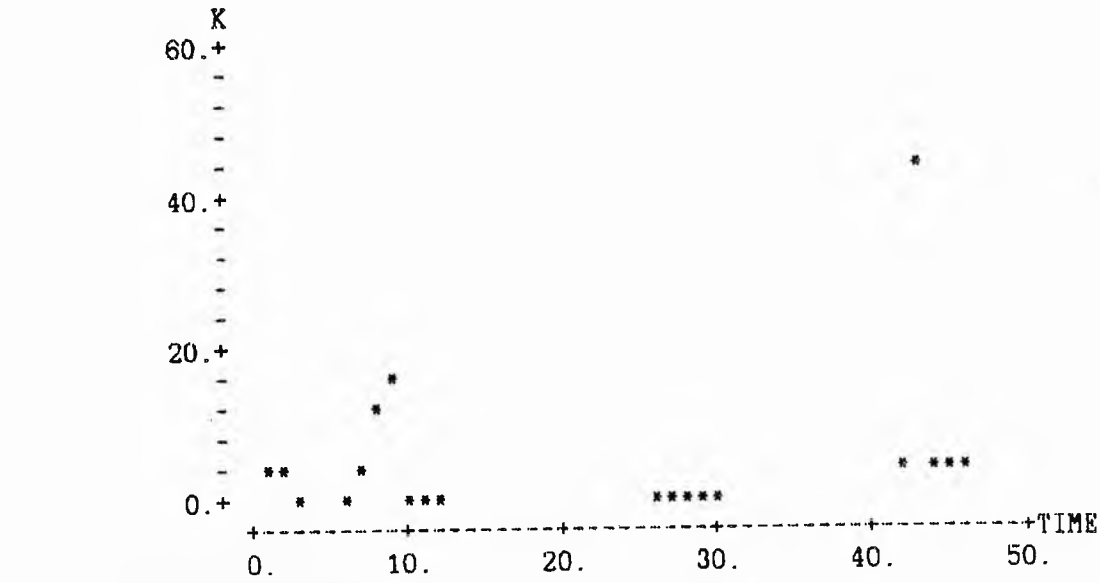
Figure 7.49

Graph of Gully Pot Liquor Quality for Tame 2 Gully Pot.



2 MISSING OBSERVATIONS

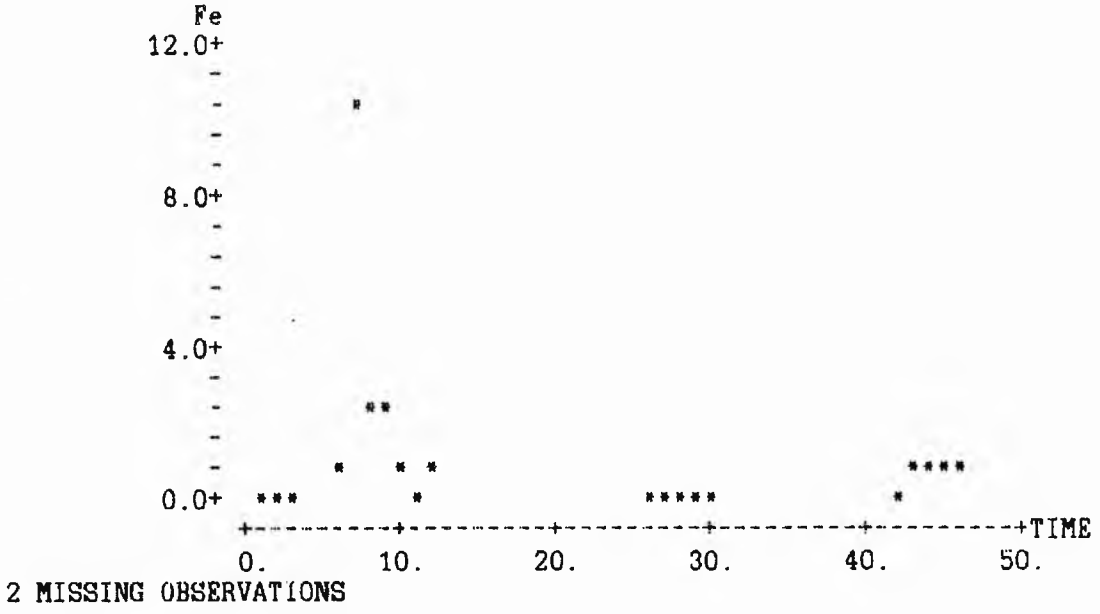
Figure 7.50



2 MISSING OBSERVATIONS

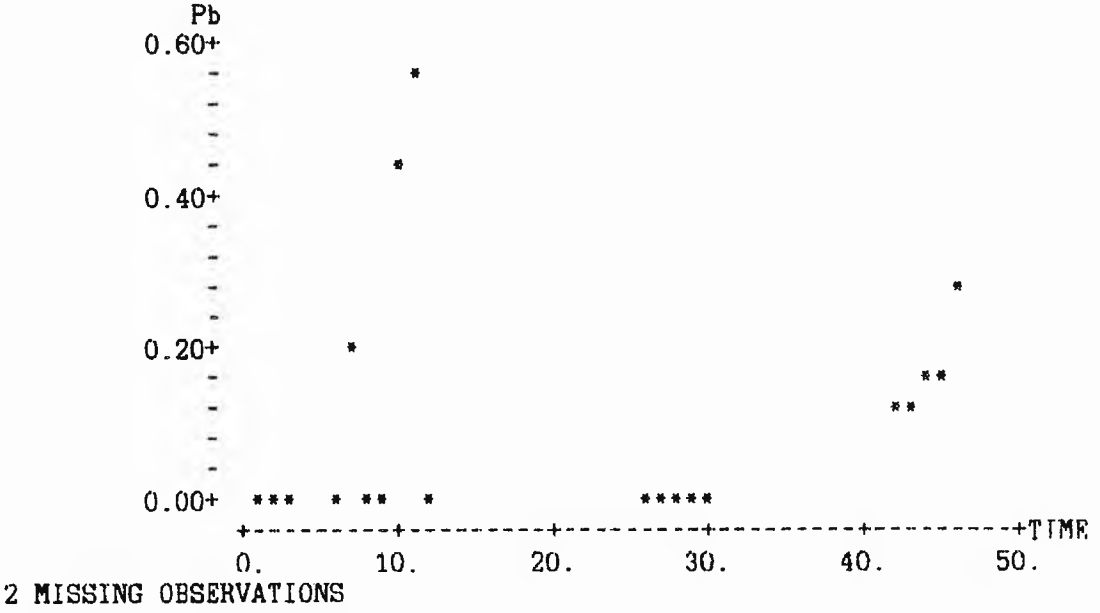
Figure 7.51

Graph of Gully Pot Liquor Quality for Tame 2 Gully Pot.



2 MISSING OBSERVATIONS

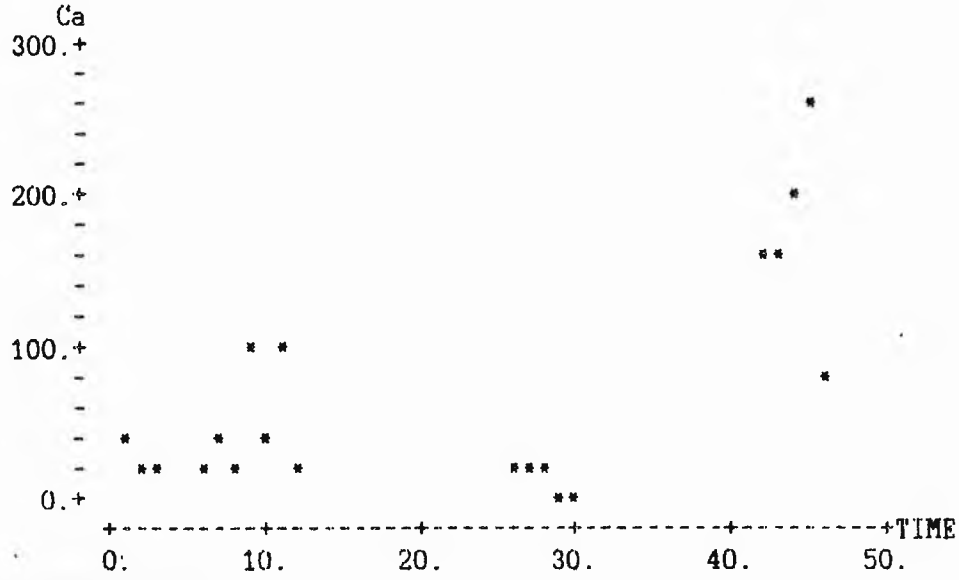
Figure 7.52



2 MISSING OBSERVATIONS

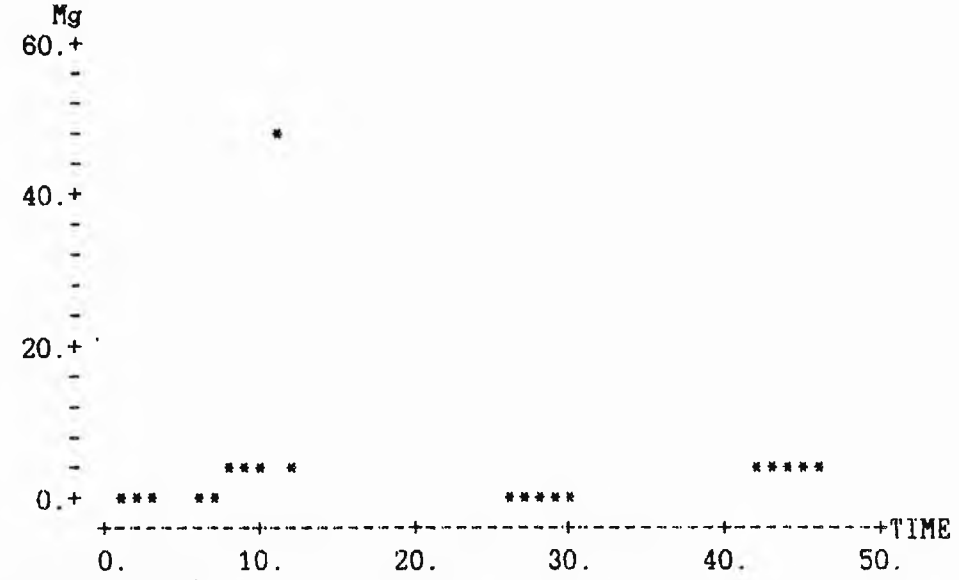
Figure 7.53

Graph of Gully Pot Liquor Quality for Tame 2 Gully Pot.



2 MISSING OBSERVATIONS

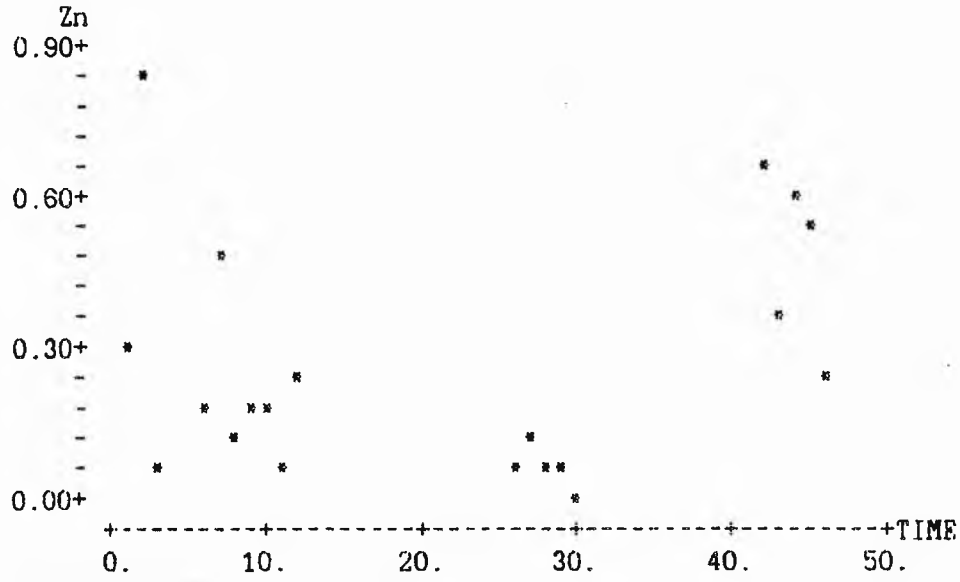
Figure 7.54



2 MISSING OBSERVATIONS

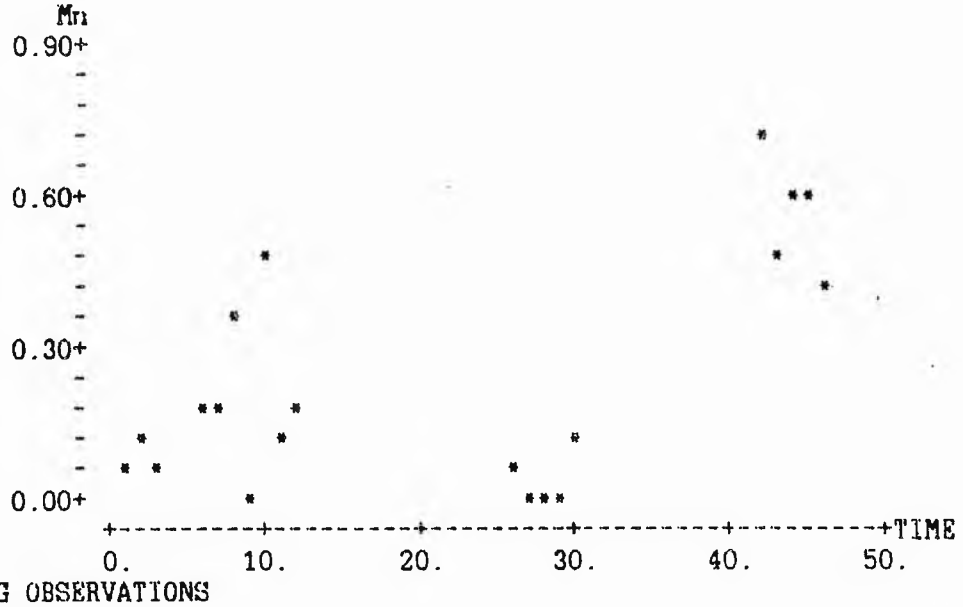
Figure 7.55

Graph of Gully Pot Liquor Quality for Tame 2 Gully Pot.



2 MISSING OBSERVATIONS

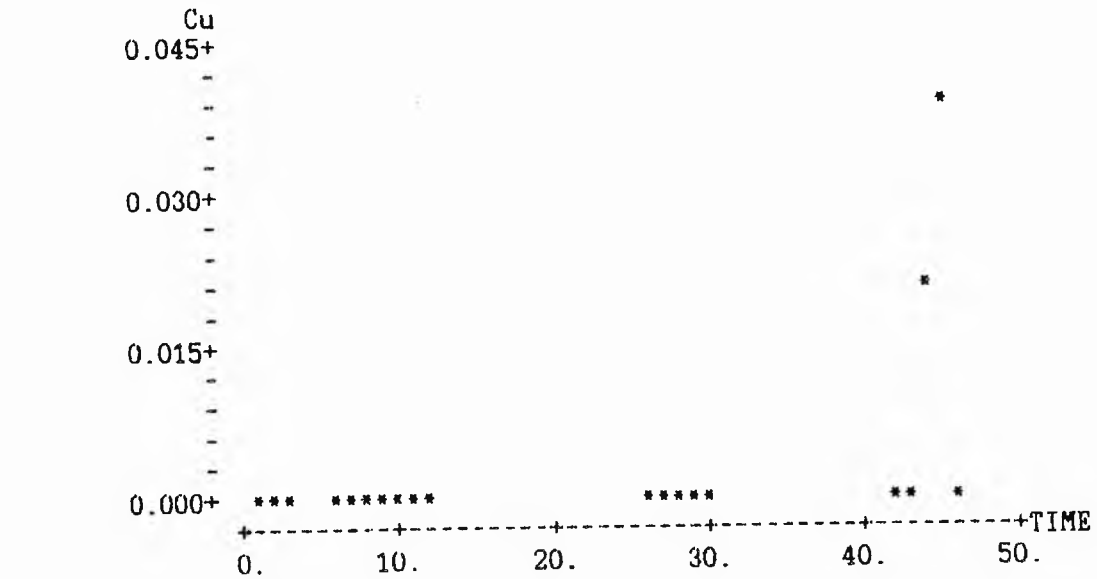
Figure 7.56



2 MISSING OBSERVATIONS

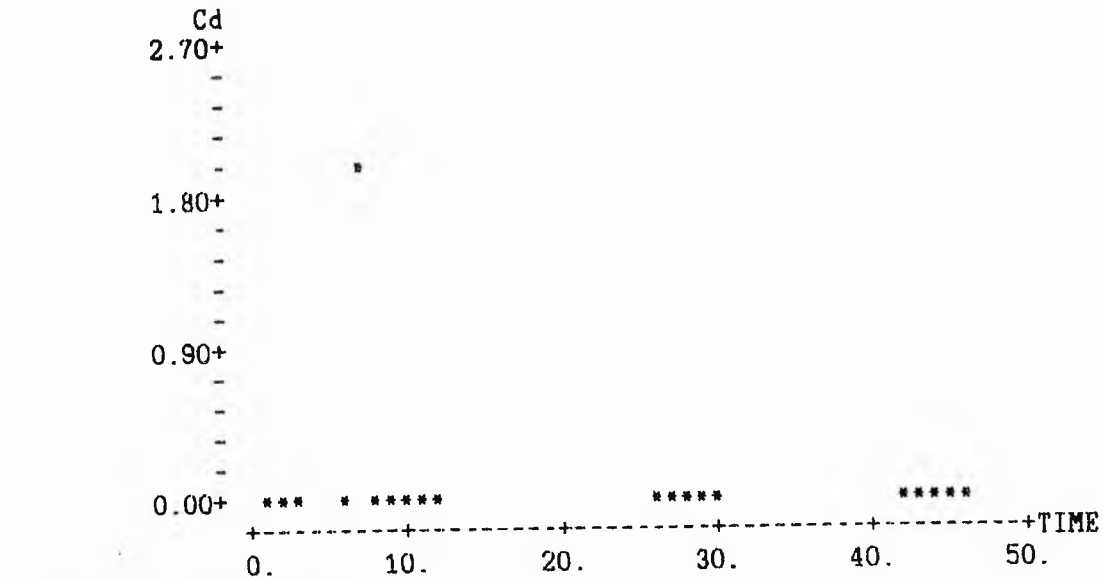
Figure 7.57

Graph of Gully Pot Liquor Quality for Tame 2 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.58



2 MISSING OBSERVATIONS

Figure 7.59

Graph of Gully Pot Liquor Quality for Tame 2 Gully Pot.

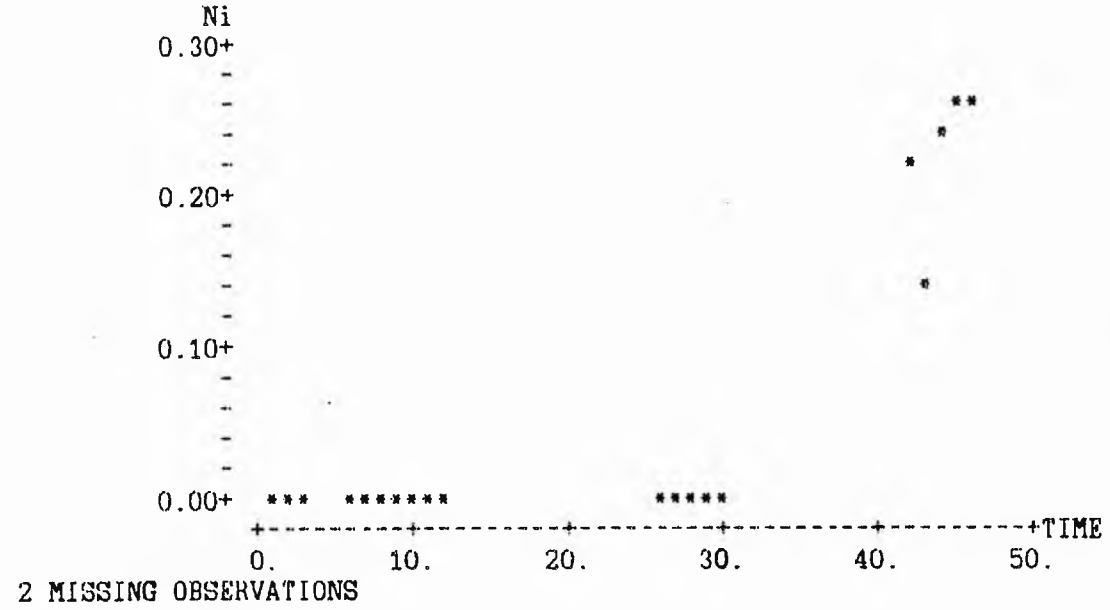


Figure 7.60

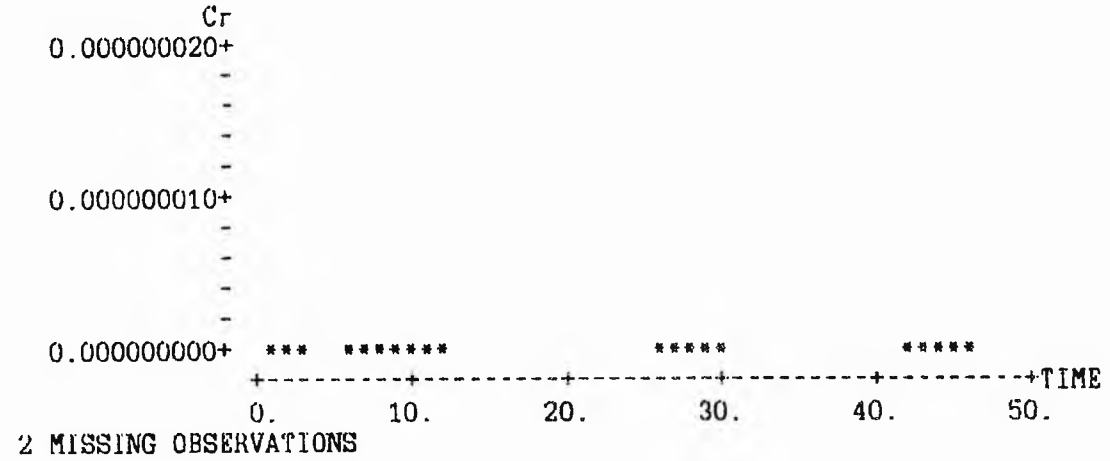


Figure 7.61

7.7 TAME 3:

(see Figures 7.62 to 7.87 and Tables 7.7 to 7.9 inclusive).

The pH values showed a noticeable variation with a range from pH 5.8 to pH 8.4. The values were at the lower end of this range in the autumn period and this was again probably due to the formation of organic, humic acids through leaf fall, vegetation decay and other organic matter decaying after the summer period. The higher incidence of rainstorm events at this time of the year may also have acted so as to reduce the pH by the greater incidence and inflow of acidic rainfall (see Table 7.7). Rainfall is generally well carbonated during its passage through the atmosphere and it has a pH around 4.0. The short residence time of the rainfall on an urban surface (since the rainfall-runoff process is hydrologically a quick response) means that the acidic nature of the rainfall has little time to be changed and so there is a greater probability that the pot liquor will be composed of recently fallen precipitation water during a period of heavier rainfall and this may help to explain the reduced pH values in the pot liquor. The pH values increased to a maximum of pH 8.0 in the spring period and this was due to the buffering capacity of increased concentrations of chloride, nitrate and sulphate salts from the rock salt source, which directly entered the gully pot through snowmelt runoff and also as highway runoff during the days and weeks after the snowmelt had taken place.

It was again observed that the levels of conductivity, sodium and chloride increased during the summer period although not to such a degree as for some of the other gully pot liquors. The conductivity reached a maximum value of 9.42 (x1000) μscm^{-1}, sodium reached a

concentration of 18200.0 mgl-1 and the maximum chloride value was 4609.0 mgl-1 as Cl. It seems that the influence of rock salt in this micro-catchment has been damped or suppressed in some way, because the concentrations of the above parameters do not increase by similar orders of magnitude as experienced in some of the other gully pot liquors. The fact that the area draining to an individual gully pot is really quite small (ie. of the order of 200 m^2, see Table 4.1), means that the activity of just a few householders may have a marked effect upon the resultant liquor quality. It can be inferred that these residents were not as active in applying rock salt to their premises and adjacent roadways and pavements as some of their neighbours.

The values for SS and BOD do not seem to show any significant temporal variations and one can deduce from this that the concentrations of these parameters within the pot liquor may be influenced by storm conditions which can not be accommodated within an analysis of data from a systematic sampling programme. The concentrations of these parameters may be dictated heavily by the input into and discharge from the gully pot under storm conditions. The values for SS will reflect changes, influences and events within the micro-catchment (ie. the area draining to one gully pot) and the sub-catchment areas, but the influence of the resuspension of basal sediment material can not be dismissed. This factor is particularly relevent if a rainstorm closely preceded the time when a sample was taken.

Another interesting observation from this dataset is the higher values found for ammonia during the summer period. A maximum value of 23.8 mgl-1 as N on the 840613 was observed and this may have arisen through denitrification in the basal sediments of the gully pot chamber.

The heavy metals (copper, nickel and chromium) only appeared during

the spring period, with chromium only being detected on three occasions. The concentration of nickel reached a maximum of 0.13 mgl-1. It should also be noted that levels of cadmium were observed during the summer period (with values in excess of 1.00 mgl-1) and it again reappeared during the spring period. The high value found during the summer was probably due to some material such as brake fluid being poured into the gully pot, as the storm sewer is often used in this way as a convenient means of disposal.

The ammonia and nitrate levels were generally enhanced during the summer months and both parameters showed low concentrations during the autumn period.

Two samples taken during the summer period showed that lead was present but the concentrations during the summer and autumn were low. Higher levels of lead were found during the spring period which was consistent with the findings in the datasets for gully pots Tame 1 and Tame 2. This increase is almost certainly due to increased particulate and gaseous vehicular emissions in the winter period, caused by the start-up and subsequent stress on the engine during the warm-up period for the engine, before the vehicle is actually made to move. Air temperatures were low at this time of year and for many days during the spring period the maximum daytime air temperatures did not get much above 0'C. This factor should not be ignored in the circumstances prevailing at the time the sampling programme for the spring period was being carried out.

Levels of zinc, manganese, calcium and magnesium showed no real temporal variation although as a general rule, the values for each of these determinands tended to be lower during the autumn period.

Table 7.7

Table of all the Water Quality Data collected over the Twenty-Two Week Period for the Gully Pot Standing Liquor in the Tame 3 Gully Pot.

ROW	DATE	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
1	840509	10.5	2.0	7.0	360	310	0.68	*	61	279
2	840516	13.5	3.6	6.8	100	60	0.12	64	23	64
3	840523	14.0	4.1	6.9	270	240	0.06	*	3	5
4	840530	15.0	3.1	6.5	*	*	0.08	*	0	*
5	840606	14.0	5.6	6.8	*	*	0.13	*	11	*
6	840613	17.0	1.1	8.4	220	250	0.72	192	48	345
7	840620	19.5	1.2	7.5	310	530	0.80	166	56	374
8	840627	19.5	1.0	6.1	160	90	0.25	201	45	268
9	840704	24.5	3.4	7.4	220	310	0.33	230	59	913
10	840711	23.0	0.6	6.3	400	530	0.63	52	43	976
11	840718	21.0	0.6	6.1	130	240	0.12	26	19	75
12	840725	17.0	0.7	6.7	140	270	0.19	53	25	99
13	841031	12.0	4.2	5.8	40	40	0.09	18	8	114
14	841107	10.0	1.1	6.2	120	70	0.12	147	8	119
15	841114	10.0	4.5	5.9	50	50	0.06	39	56	0
16	841121	10.0	8.5	6.2	50	100	0.05	43	10	5
17	841128	8.0	4.5	6.6	60	240	0.15	159	10	148
18	850220	2.5	2.4	7.3	110	320	9.42	144	27	15
19	850227	4.0	1.4	7.5	130	240	5.06	40	8	117
20	850306	5.0	3.8	7.8	340	760	4.77	34	10	83
21	850313	5.5	3.5	8.0	100	450	3.33	36	7	40
22	850320	5.0	5.3	7.5	460	670	2.05	29	14	149

ROW	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
1	5.4	17.7	288	9.0	*	38.8	11.4	0.80	0.00
2	1.6	24.8	48	7.6	*	7.2	3.9	0.40	0.00
3	0.7	67.4	77	9.2	*	0.7	0.8	0.10	0.00
4	*	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*	*
6	2.7	89.0	327	23.8	9.1	57.0	4.0	0.60	0.00
7	5.3	131.0	490	13.6	7.6	62.5	5.0	5.00	0.00
8	4.5	39.0	*	16.8	10.4	15.0	5.0	2.70	0.00
9	5.2	32.0	279	0.2	42.0	22.5	17.0	0.00	0.00
10	1.0	245.0	10	1.2	266.0	10.0	3.0	3.80	0.35
11	1.1	25.0	365	1.0	4.9	5.8	1.4	0.30	0.54
12	1.5	21.0	423	1.4	46.2	7.0	1.2	1.00	0.00
13	1.1	31.9	96	0.3	0.9	1.8	0.8	0.20	0.00
14	0.5	42.5	48	0.2	2.0	3.0	0.8	0.00	0.00
15	0.0	21.3	67	0.2	0.3	1.5	0.5	0.00	0.00
16	0.0	7.1	67	0.1	0.7	3.7	0.5	0.00	0.00
17	0.4	17.7	288	0.5	0.6	3.4	1.0	0.00	0.00
18	5.9	4609.0	288	2.0	*	1100.0	4.2	0.13	0.11
19	3.4	2836.0	356	3.4	*	1820.0	13.0	0.53	0.00
20	2.5	67.0	1547	0.1	7.3	1300.0	4.0	0.52	0.05
21	0.9	1276.2	750	1.2	4.0	620.0	3.8	0.18	0.00
22	4.3	223.0	375	1.7	69.3	610.0	2.7	0.18	0.00

ROW	Ca	Mg	Zn	Mn	Cu	Cd	Ni	Cr
1	58.0	0.00	0.10	0.32	0.00	0.00	0.00	0.0
2	17.0	0.00	0.46	0.14	0.00	0.00	0.00	0.0
3	9.2	0.00	0.07	0.10	0.00	0.00	0.00	0.0
4	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*
6	63.0	10.00	0.20	0.12	0.00	0.00	0.00	0.0
7	87.5	5.00	0.25	0.00	0.00	1.00	0.00	0.0
8	45.0	3.00	0.25	0.10	0.00	0.15	0.00	0.0
9	70.0	3.00	0.16	0.00	0.00	0.00	0.00	0.0
10	62.5	3.00	0.35	0.75	0.00	0.03	0.00	0.0
11	150.0	45.00	0.20	0.25	0.00	0.00	0.00	0.0
12	30.5	2.60	0.26	0.10	0.00	0.00	0.00	0.0
13	13.0	0.70	0.05	0.07	0.00	0.00	0.00	0.0
14	15.0	1.00	0.14	0.10	0.00	0.00	0.00	0.0
15	10.0	0.70	0.07	0.10	0.00	0.00	0.00	0.0
16	8.2	0.50	0.22	0.00	0.00	0.00	0.00	0.0
17	16.6	1.20	0.13	0.20	0.00	0.00	0.00	0.0
18	95.0	3.95	0.00	0.63	0.00	0.02	0.13	0.1
19	95.0	6.60	0.28	0.34	0.00	0.06	0.05	0.0
20	110.0	4.80	0.16	0.27	0.03	0.00	0.11	0.0
21	56.0	3.50	0.14	0.27	0.00	0.02	0.00	0.1
22	45.5	2.15	0.12	0.21	0.00	0.03	0.00	0.1

Statistical Summary of the Water Quality Data for the Standing Pot Liquor collected in the Tame 3 Gully Pot.

Table 7.8

	TEMP	DO	PH	ALK	TH	COND	SS	BOD
N	22	22	22	20	20	22	18	22
NMISS	0	0	0	2	2	0	4	0
MEAN	12.75	3.01	6.877	188	289	1.33	92.9	25.0
MEDIAN	12.75	3.25	6.800	135	245	0.22	52.5	16.5
TMEAN	12.67	2.85	6.855	182	276	0.99	89.1	24.5
STDEV	6.37	2.02	0.720	127	207	2.35	72.2	20.7
SEMEAN	1.36	0.43	0.154	28	46	0.50	17.0	4.4
MAX	24.50	8.50	8.400	460	760	9.42	230.0	61.0
MIN	2.50	0.60	5.800	40	40	0.05	18.0	0.0
Q3	17.62	4.27	7.500	300	418	1.11	160.8	45.7
Q1	7.37	1.10	6.200	100	92	0.11	35.5	8.0

	COD	PHOS	CL	SUL	AMM	NIT	Na	K
N	20	20	20	19	20	15	20	20
NMISS	2	2	2	3	2	7	2	2
MEAN	209	2.40	491	326	4.68	31.4	1553	4.20
MEDIAN	115	1.55	41	288	1.30	7.3	13	3.40
TMEAN	178	2.34	289	272	3.87	15.8	715	3.69
STDEV	274	2.02	1175	351	6.67	68.1	4537	4.52
SEMEAN	61	0.45	263	81	1.49	17.6	1014	1.01
MAX	976	5.90	4609	1547	23.80	266.0	18200	17.00
MIN	0	0.00	7	10	0.10	0.3	1	0.50
Q3	276	4.45	200	375	8.65	42.0	473	4.80
Q1	46	0.75	22	67	0.22	0.9	3	0.85

	Fe	Pb	Ca	Mg	Zn	Mn	Cu	Cd
N	20	20	20	20	20	20	20	20
NMISS	2	2	2	2	2	2	2	2
MEAN	0.82	0.061	52.8	4.83	0.189	0.204	0.0055	0.066
MEDIAN	0.25	0.000	50.8	2.80	0.170	0.130	0.0000	0.000
TMEAN	0.64	0.037	49.9	2.87	0.181	0.184	0.0017	0.017
STDEV	1.38	0.139	39.7	9.78	0.101	0.196	0.0188	0.223
SEMEAN	0.31	0.031	8.9	2.19	0.023	0.044	0.0042	0.050
MAX	5.00	0.540	150.0	45.00	0.460	0.750	0.0800	1.000
MIN	0.00	0.000	8.2	0.00	0.050	0.000	0.0000	0.000
Q3	0.75	0.072	83.1	4.59	0.250	0.270	0.0000	0.028
Q1	0.02	0.000	15.4	0.70	0.123	0.100	0.0000	0.000

	Ni	Cr
N	20	20
NMISS	2	2
MEAN	0.0145	0.0150
MEDIAN	0.0000	0.0000
TMEAN	0.0089	0.0111
STDEV	0.0379	0.0366
SEMEAN	0.0085	0.0082
MAX	0.1300	0.1000
MIN	0.0000	0.0000
Q3	0.0000	0.0000
Q1	0.0000	0.0000

Table of the Correlation Coefficients between all Twenty-Six Water Quality Parameters for the Standing Pot Liquor in the Tame 3 Gully Pot.

Table 7.9

	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
DO	-0.388								
PH	-0.258	-0.181							
ALK	0.162	-0.196	0.484						
TH	-0.129	-0.068	0.689	0.773					
COND	-0.638	-0.098	0.488	0.041	0.395				
SS	0.388	-0.293	0.217	0.027	-0.131	-0.073			
BOD	0.485	-0.367	0.092	0.287	0.014	-0.137	0.555		
COD	0.671	-0.336	0.094	0.473	0.277	-0.213	0.428	0.583	
PHOS	0.036	-0.299	0.463	0.457	0.358	0.448	0.518	0.511	0.388
CL	-0.528	-0.138	0.382	-0.179	0.081	0.988	0.005	-0.162	-0.193
SUL	-0.381	-0.048	0.579	0.284	0.784	0.448	-0.134	-0.151	-0.137
AMM	0.321	-0.367	0.349	0.219	-0.082	-0.163	0.539	0.437	0.186
NIT	0.386	-0.278	-0.075	0.591	0.382	-0.024	-0.147	0.228	0.712
Na	-0.448	-0.092	0.336	0.049	0.243	0.524	-0.269	-0.382	-0.139
K	0.136	-0.219	0.424	0.253	0.156	0.218	0.482	0.443	0.586
Fe	0.588	-0.484	-0.001	0.431	0.317	-0.128	0.225	0.476	0.581
Pb	0.314	-0.331	-0.218	0.166	0.235	0.037	-0.322	-0.041	0.286
Ca	0.094	-0.482	0.395	0.383	0.517	0.495	0.000	0.147	0.184
Mg	0.388	-0.369	-0.065	-0.058	0.048	-0.021	-0.152	-0.041	-0.054
Zn	0.377	-0.328	0.023	0.114	-0.007	-0.177	-0.028	0.182	0.386
Mn	-0.284	-0.319	0.094	0.292	0.381	0.584	-0.221	-0.011	0.233
Cu	-0.384	-0.124	0.288	-0.003	0.139	0.447	-0.248	-0.276	-0.114
Cd	0.255	-0.236	0.172	0.232	0.264	-0.041	0.288	0.347	0.156
Ni	-0.535	-0.023	0.334	0.039	0.358	0.982	-0.051	-0.198	-0.222
Cr	-0.533	0.181	0.481	0.118	0.398	0.617	-0.148	-0.238	-0.222

	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
CL	0.385								
SUL	0.228	0.058							
AMM	0.362	-0.129	-0.055						
NIT	0.018	0.065	-0.236	-0.132					
Na	0.136	0.425	0.455	-0.131	-0.097				
K	0.674	0.235	0.126	0.118	0.087	0.484			
Fe	0.311	-0.125	0.038	0.486	0.462	-0.082	0.055		
Pb	-0.144	0.043	0.006	-0.248	0.448	-0.095	-0.175	0.155	
Ca	0.478	0.363	0.536	0.041	0.079	0.418	0.379	0.227	0.688
Mg	-0.056	-0.007	0.133	-0.002	-0.182	0.034	-0.067	-0.028	0.797
Zn	0.034	-0.123	-0.091	0.245	0.599	0.136	0.187	0.462	0.149
Mn	0.147	0.574	0.056	-0.283	0.821	0.217	0.068	0.165	0.525
Cu	0.115	0.417	0.321	-0.181	-0.098	0.985	0.433	-0.066	-0.184
Cd	0.389	-0.041	0.115	0.367	-0.079	-0.043	0.071	0.768	-0.186
Ni	0.354	0.716	0.534	-0.191	-0.098	0.531	0.129	-0.139	0.022
Cr	0.277	0.567	0.184	-0.197	0.031	-0.074	-0.068	-0.286	0.091

	Ca	Mg	Zn	Mn	Cu	Cd	Ni
Mg	0.784						
Zn	0.116	0.061					
Mn	0.482	0.095	0.137				
Cu	0.359	0.048	0.179	0.185			
Cd	0.228	-0.004	0.177	-0.222	-0.038		
Ni	0.485	-0.004	-0.173	0.493	0.422	-0.083	
Cr	0.137	-0.072	-0.319	0.366	-0.126	-0.082	0.328

Graphs of Gully Pot Liquor Quality for Tame 3 Gully Pot.

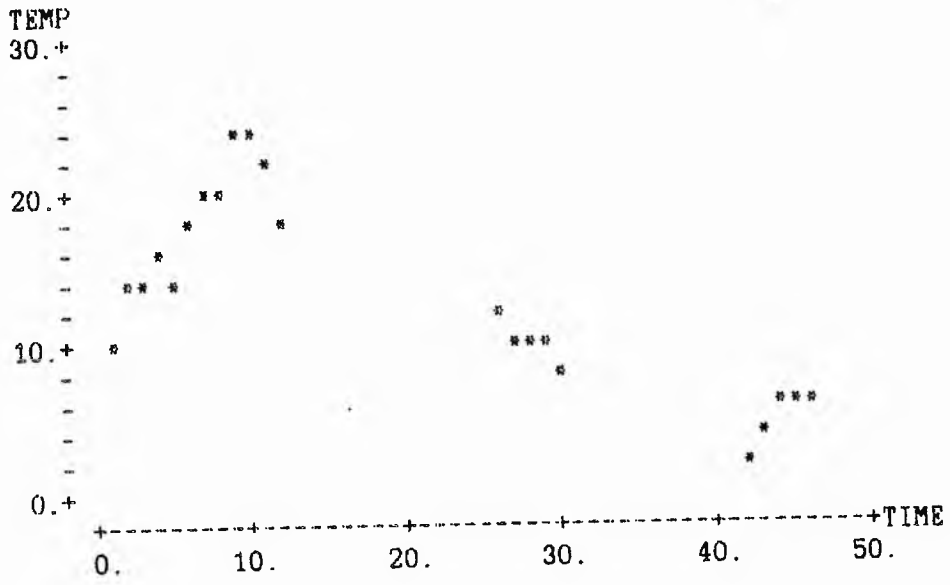


Figure 7.62

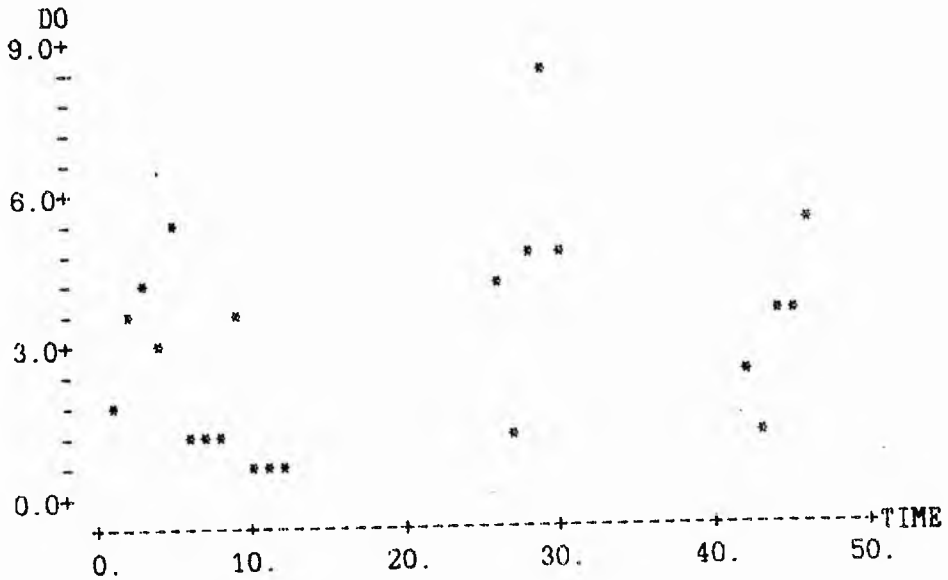


Figure 7.63

Graphs of Gully Pot Liquor Quality for Tame 3 Gully Pot.

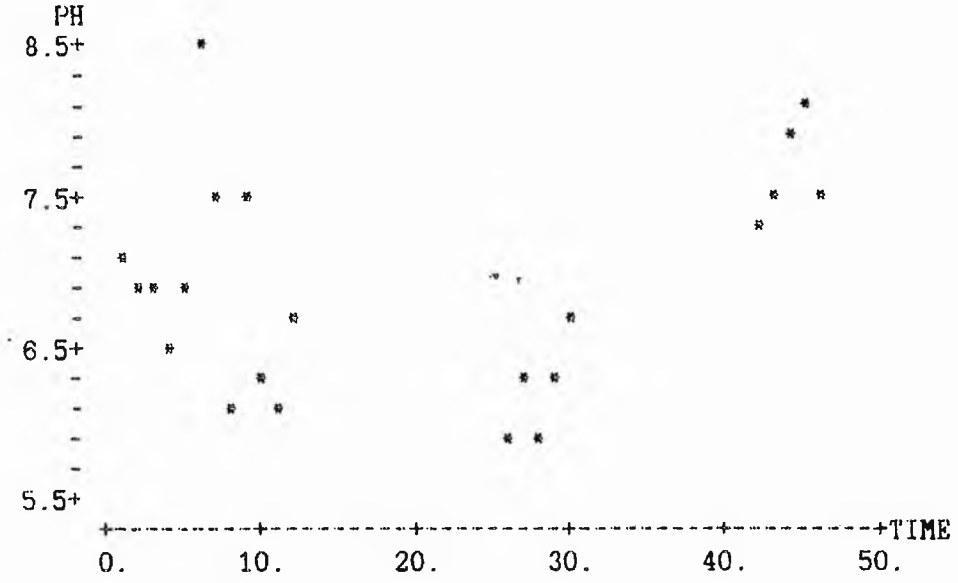
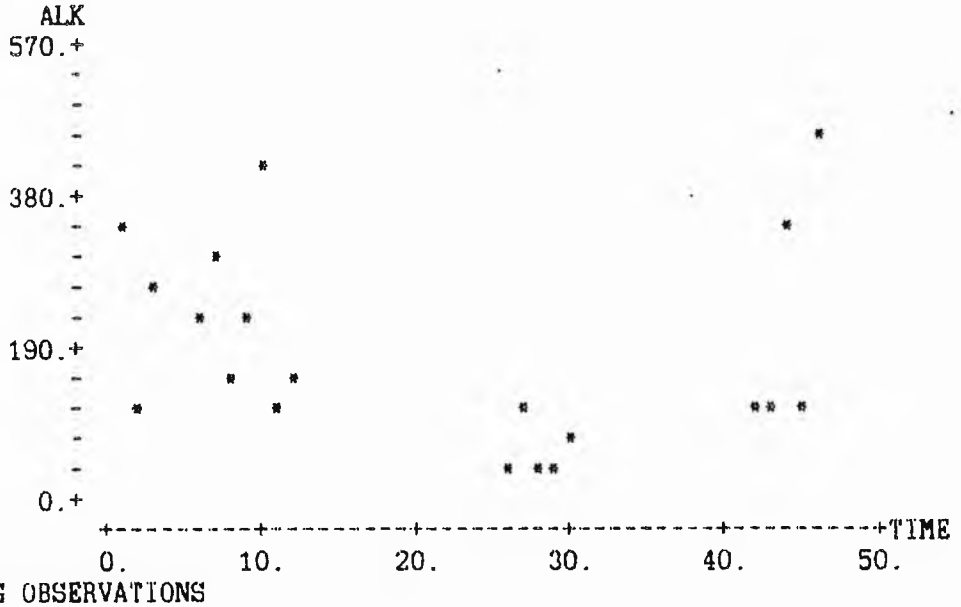


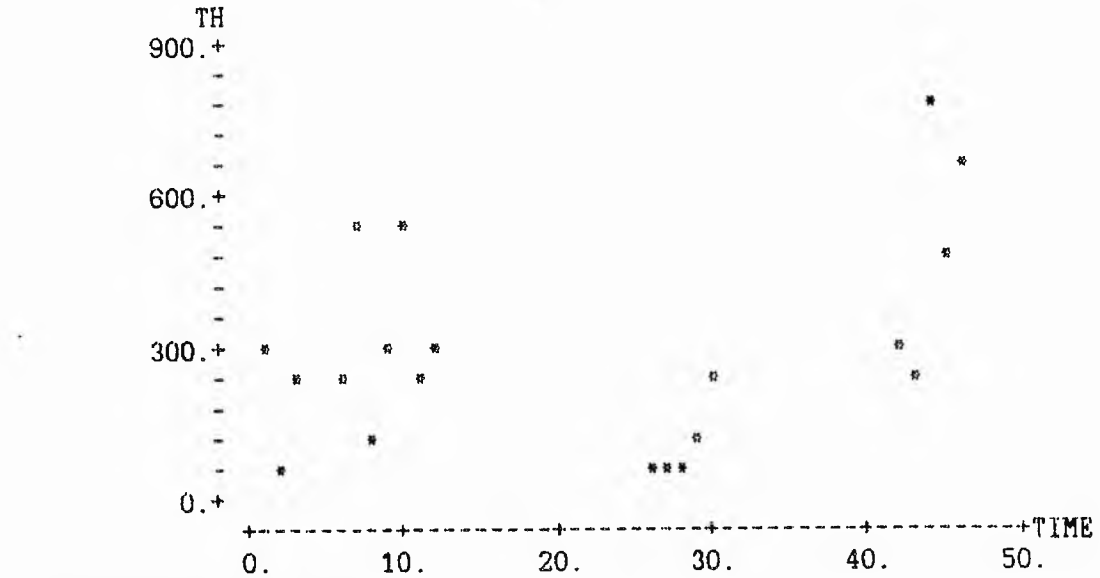
Figure 7.64



2 MISSING OBSERVATIONS

Figure 7.65

Graphs of Gully Pot Liquor Quality for Tame 3 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.66

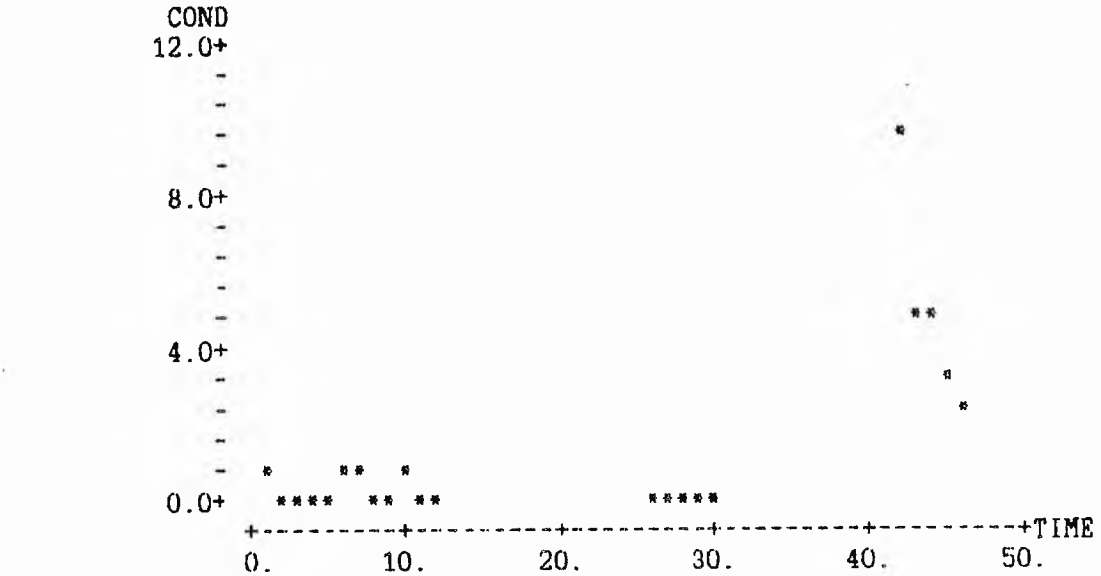
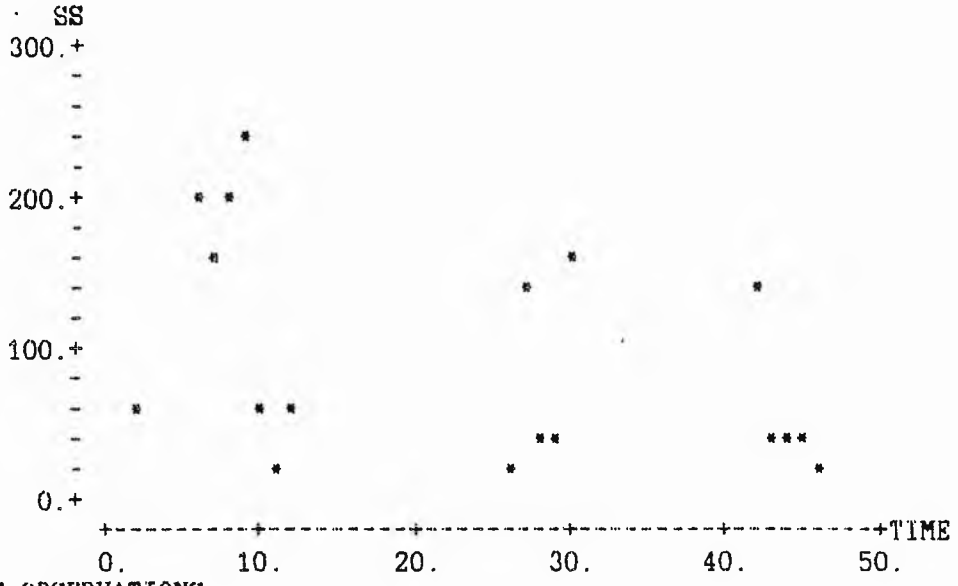


Figure 7.67

Graphs of Gully Pot Liquor Quality for Tame 3 Gully Pot.



4 MISSING OBSERVATIONS

Figure 7.68

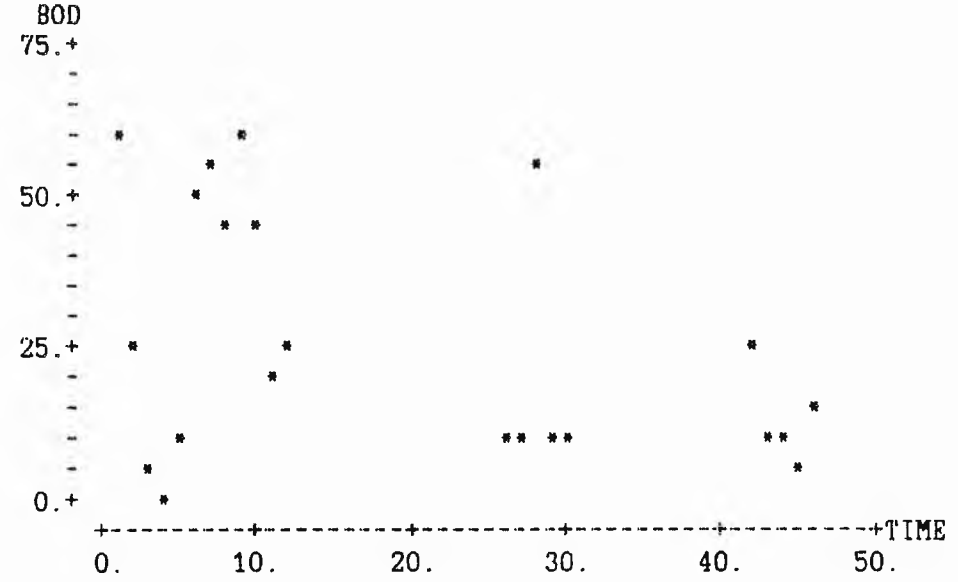
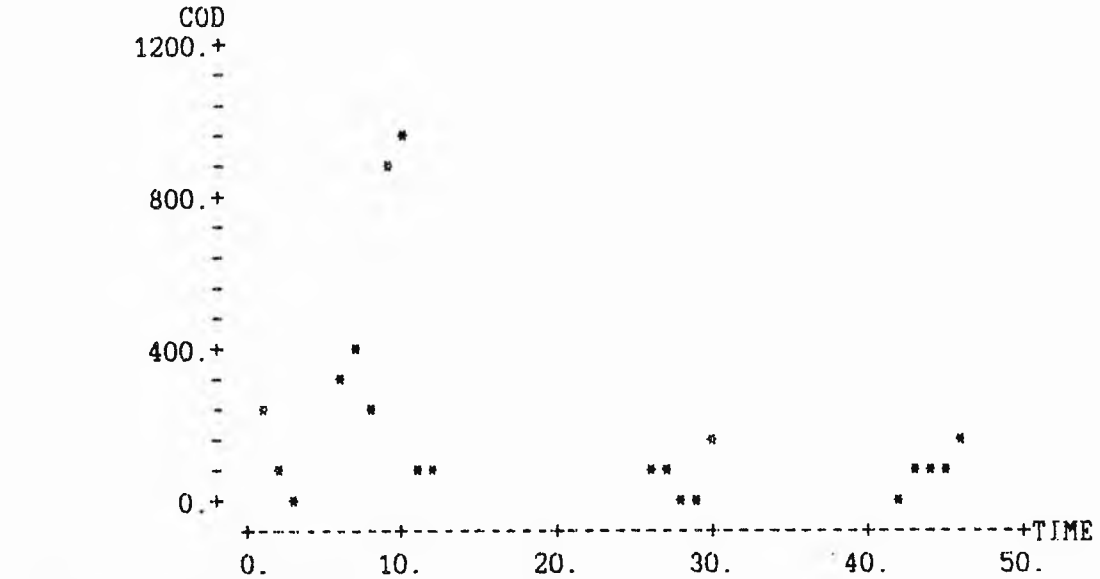


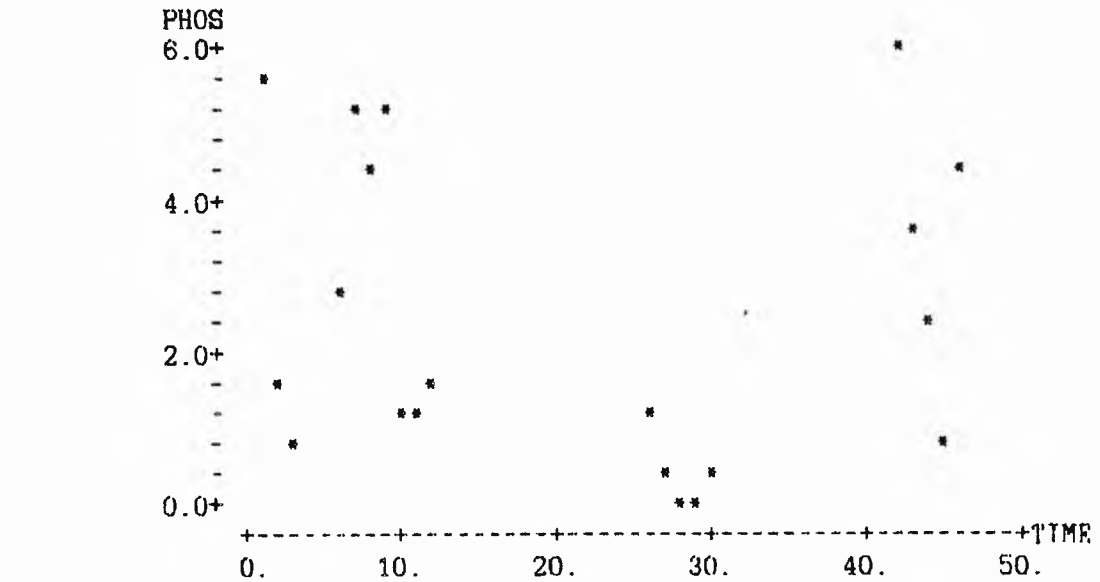
Figure 7.69

Graphs of Gully Pot Liquor Quality for Tame 3 Gully Pot.



2 MISSING OBSERVATIONS

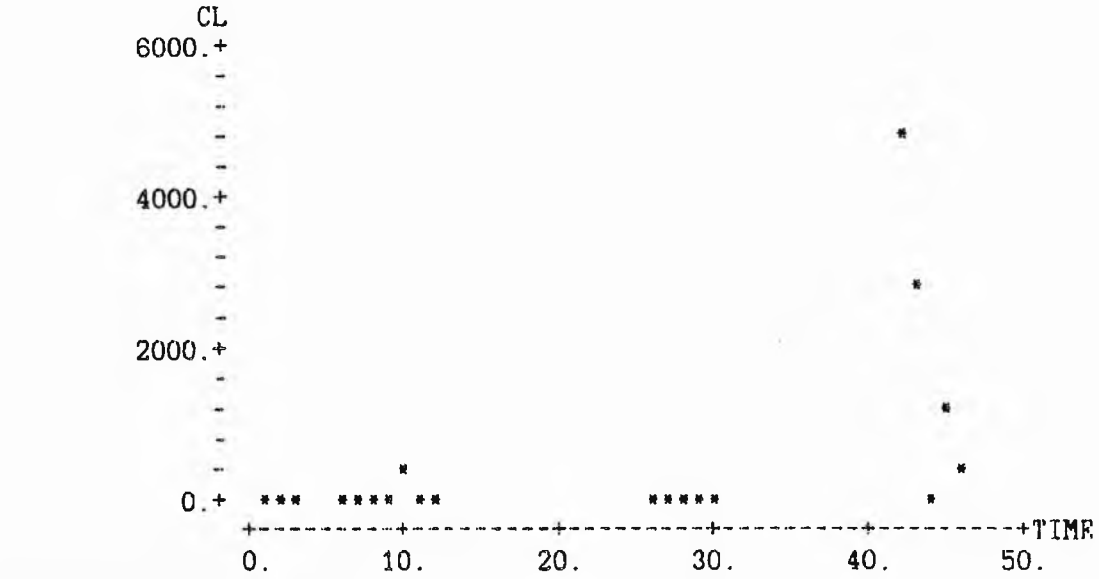
Figure 7.70



2 MISSING OBSERVATIONS

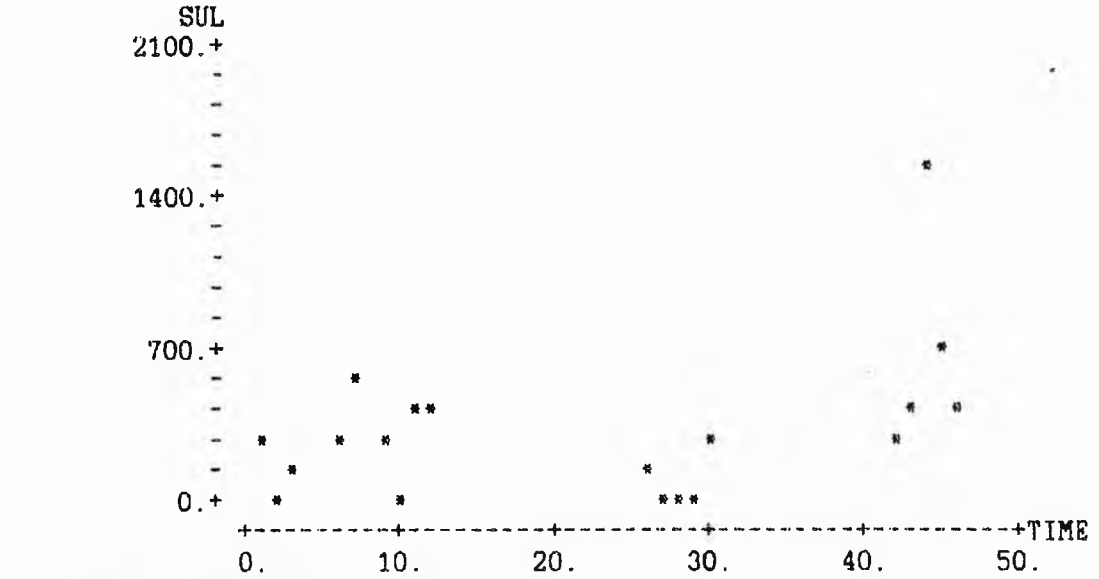
Figure 7.71

Graphs of Gully Pot Liquor Quality for Tame 3 Gully Pot.



2 MISSING OBSERVATIONS

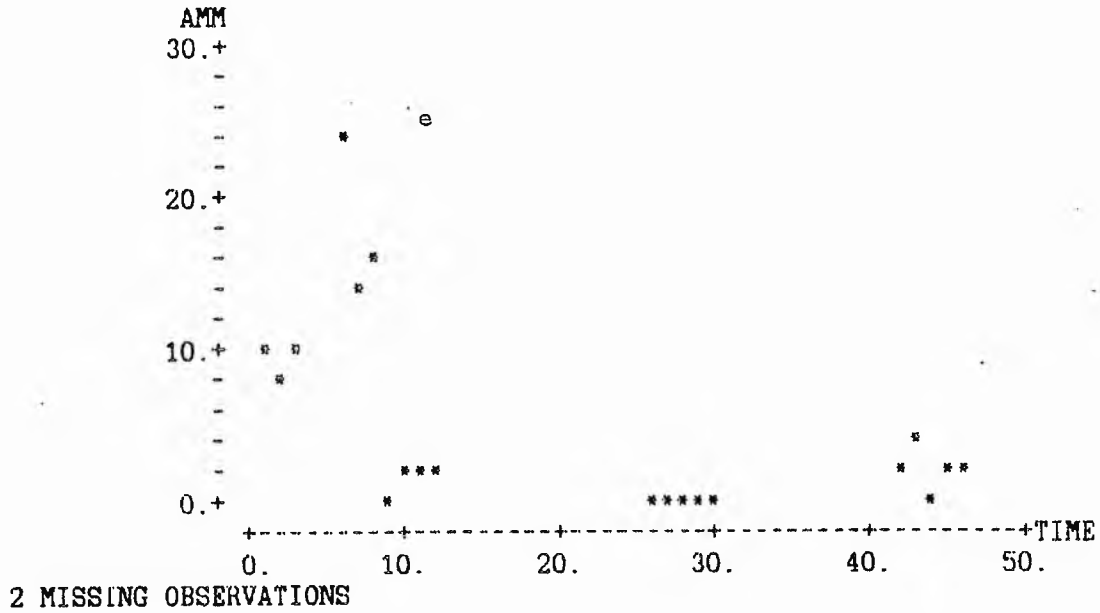
Figure 7.72



3 MISSING OBSERVATIONS

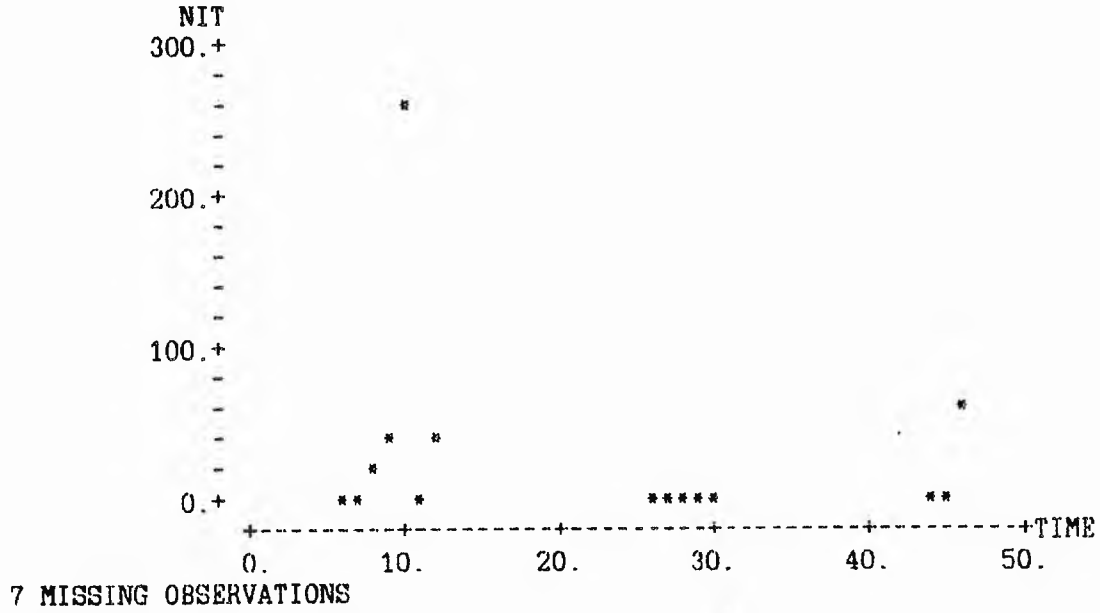
Figure 7.73

Graphs of Gully Pot Liquor Quality for Tame 3 Gully Pot.



2 MISSING OBSERVATIONS

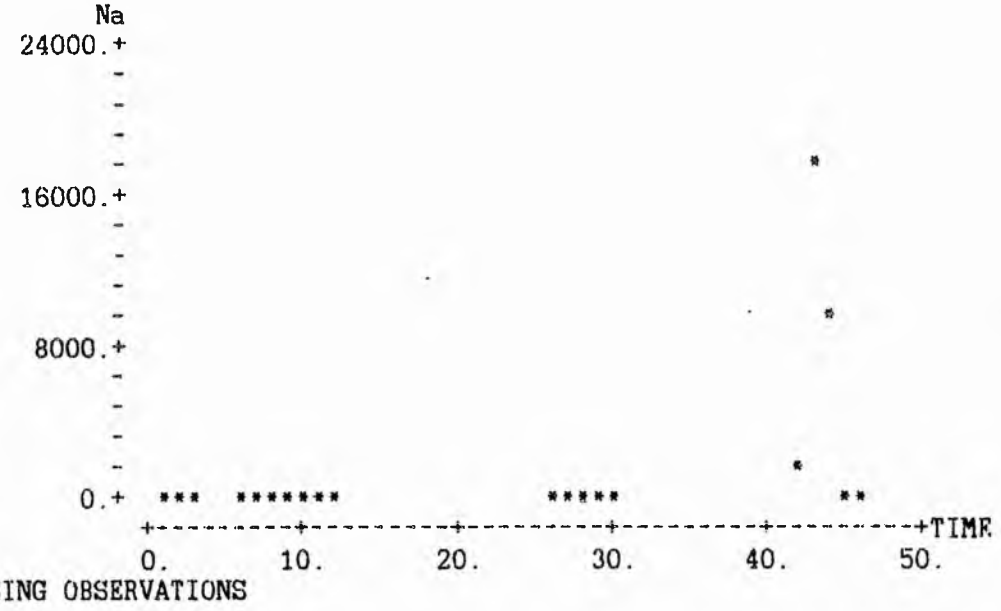
Figure 7.74



7 MISSING OBSERVATIONS

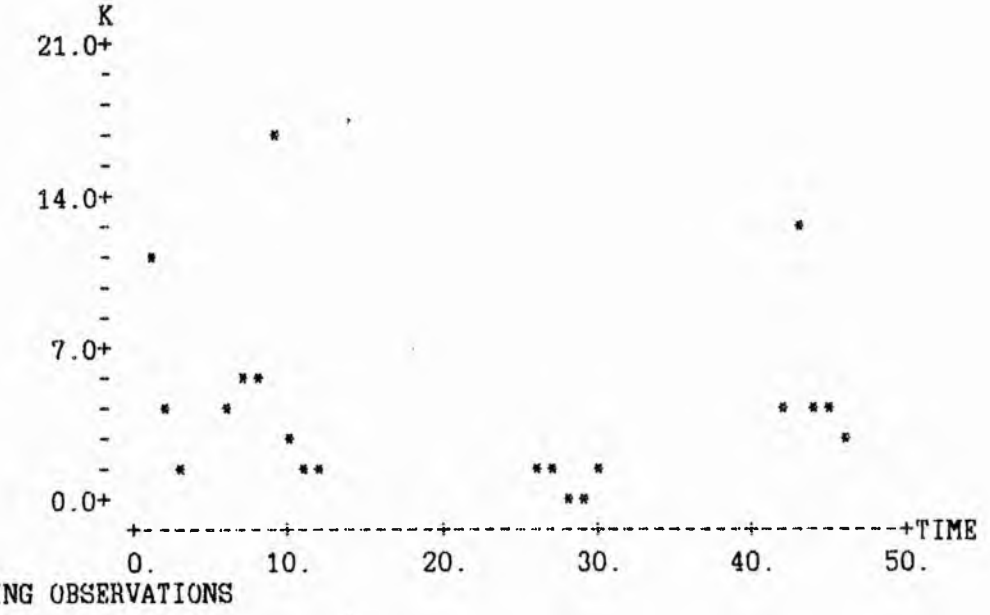
Figure 7.75

Graphs of Gully Pot Liquor Quality for Tame 3 Gully Pot.



2 MISSING OBSERVATIONS

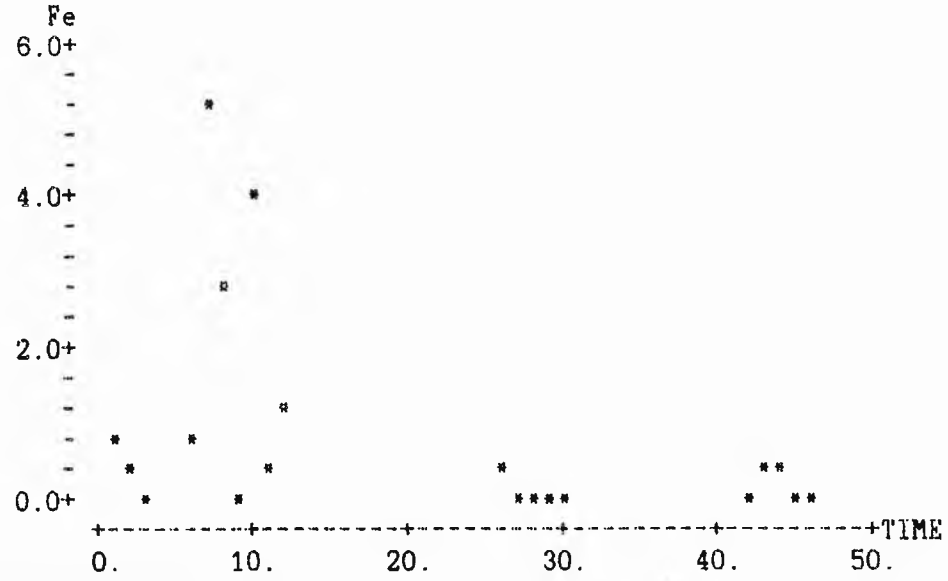
Figure 7.76



2 MISSING OBSERVATIONS

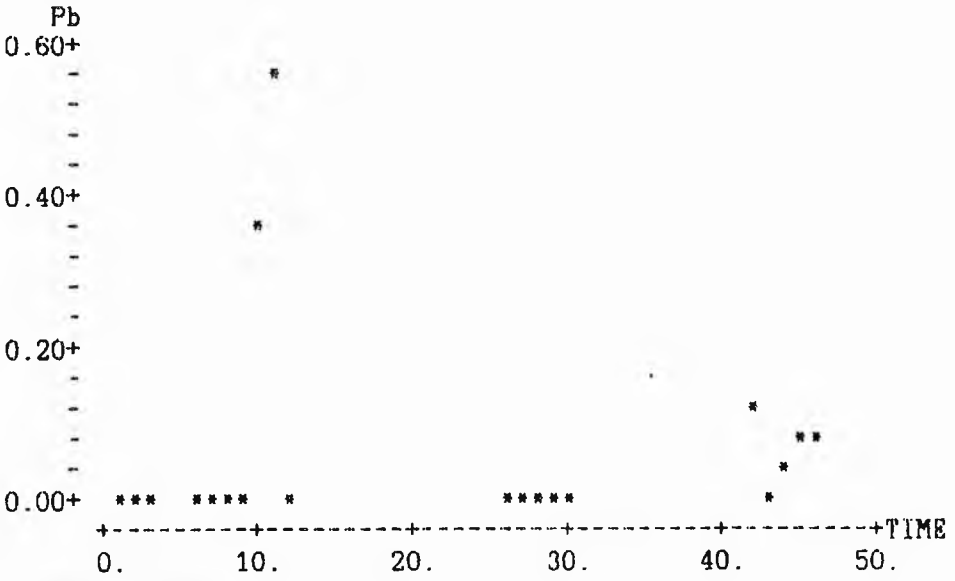
Figure 7.77

Graphs of Gully Pot Liquor Quality for Tame 3 Gully Pot.



2 MISSING OBSERVATIONS

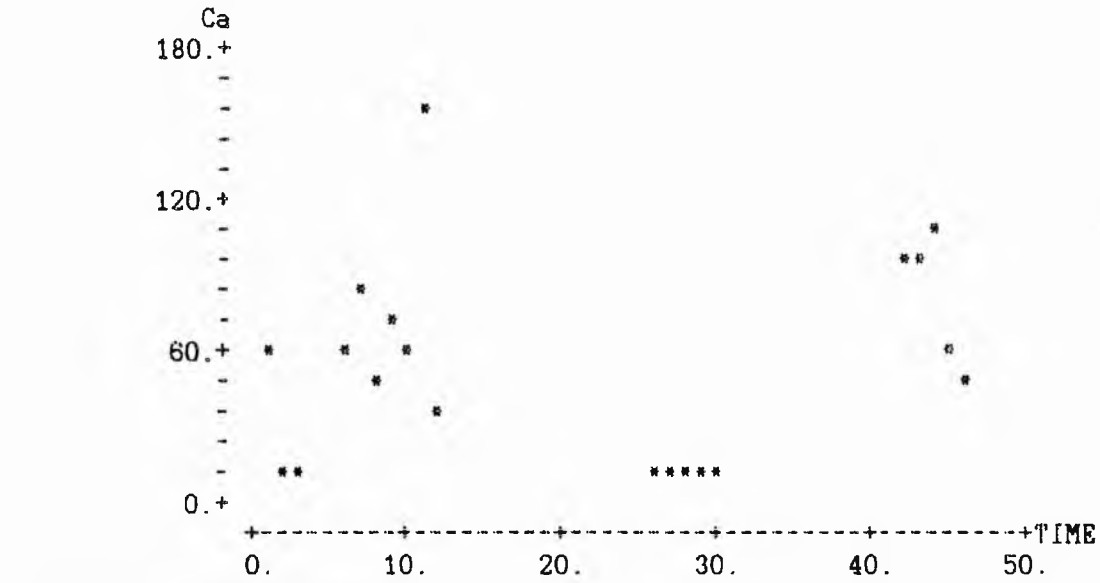
Figure 7.78



2 MISSING ORSERVATIONS

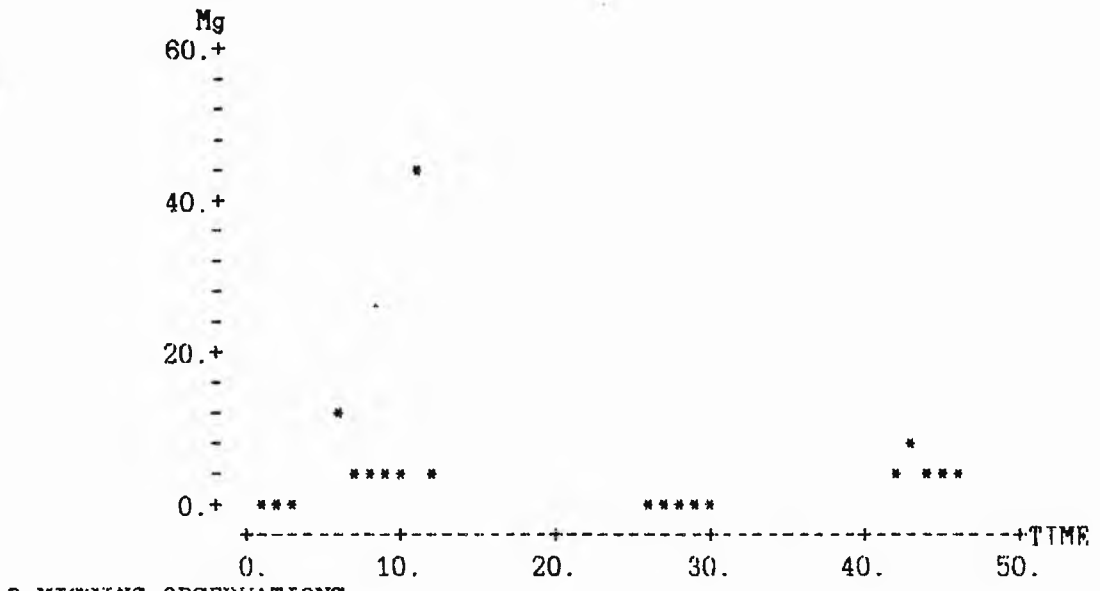
Figure 7.79

Graphs of Gully Pot Liquor Quality for Tame 3 Gully Pot.



2 MISSING OBSERVATIONS

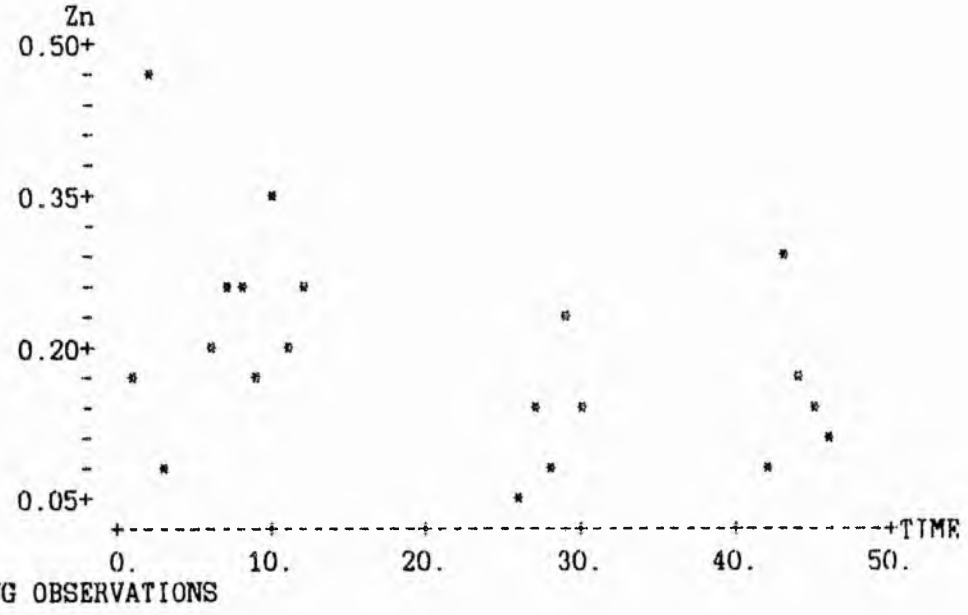
Figure 7.80



2 MISSING OBSERVATIONS

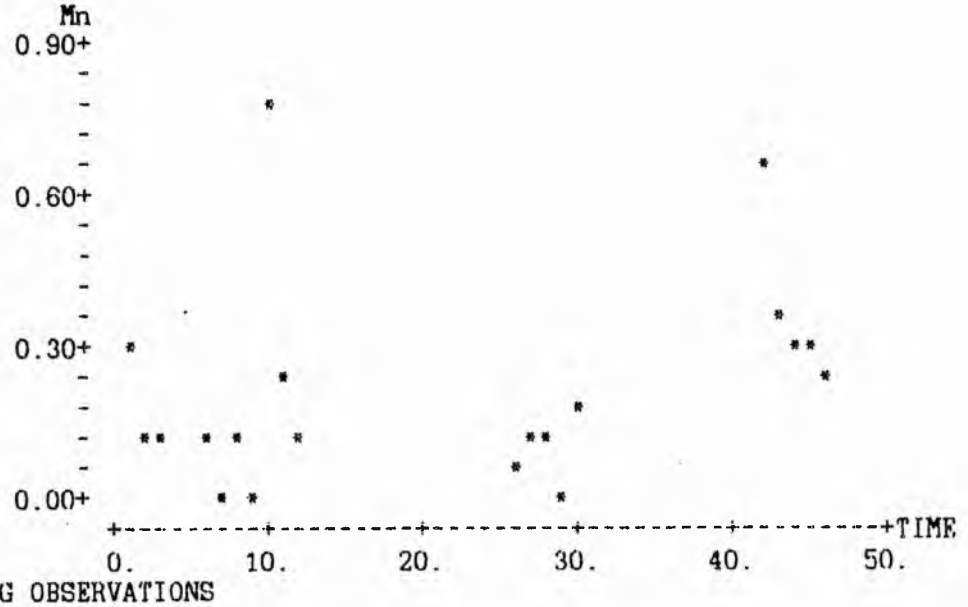
Figure 7.81

Graphs of Gully Pot Liquor Quality for Tame 3 Gully Pot.



2 MISSING OBSERVATIONS

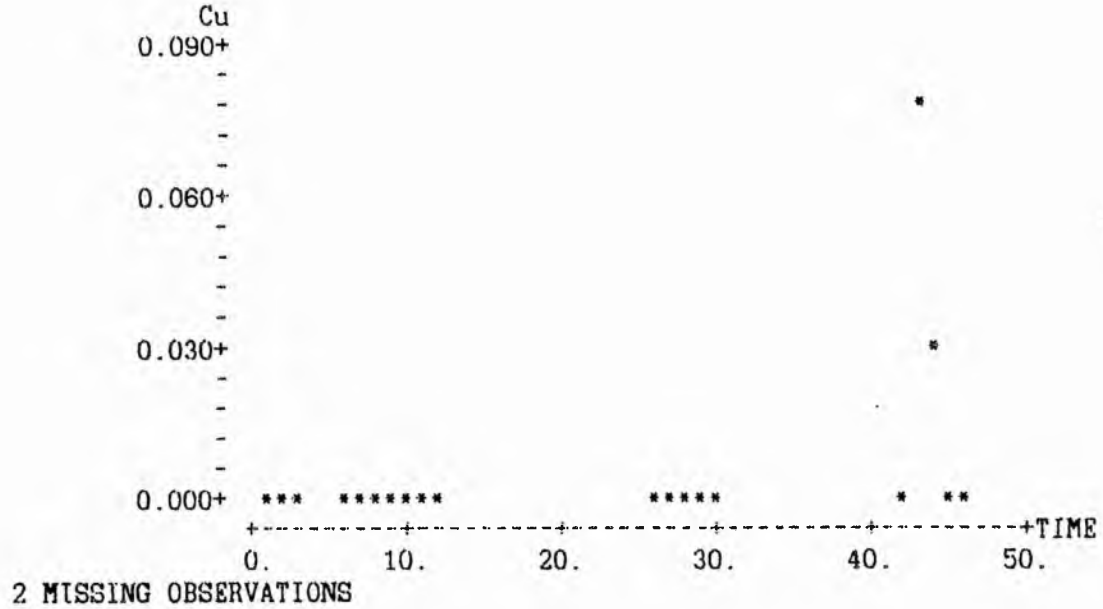
Figure 7.82



2 MISSING OBSERVATIONS

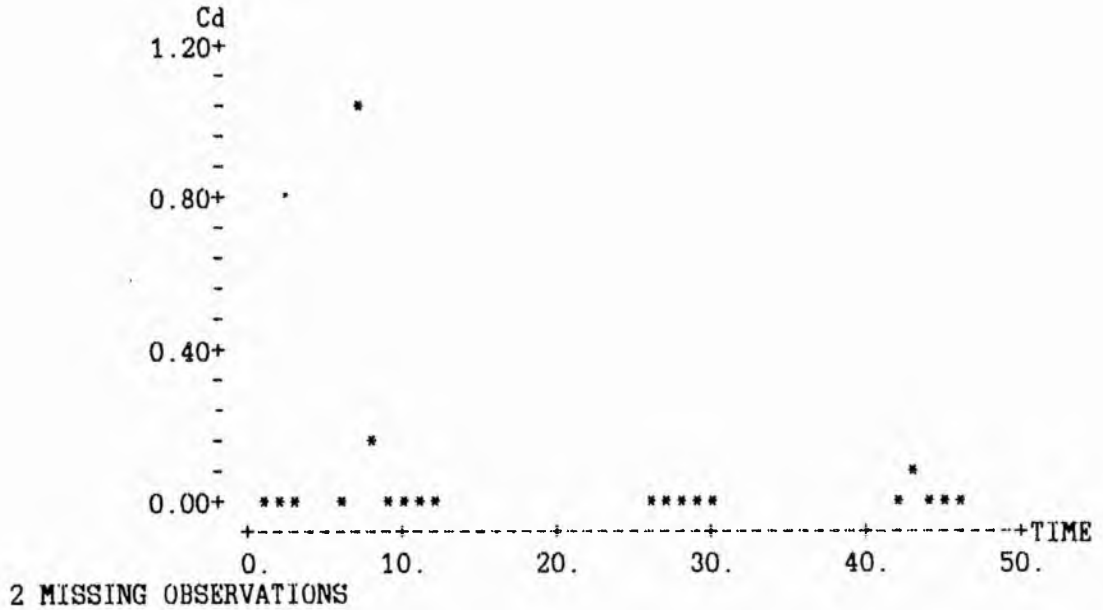
Figure 7.83

Graphs of Gully Pot Liquor Quality for Tame 3 Gully Pot.



2 MISSING OBSERVATIONS

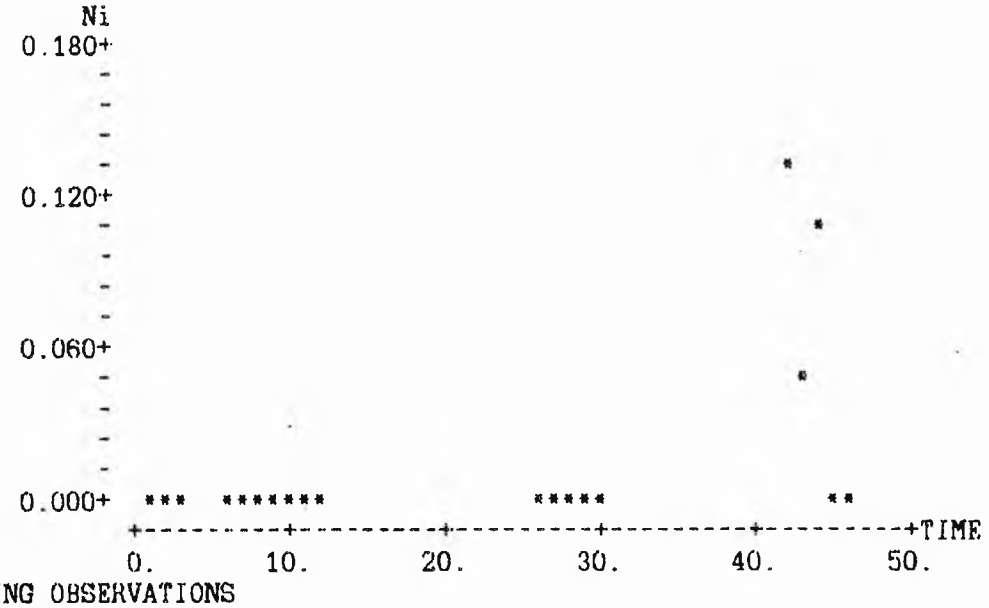
Figure 7.84



2 MISSING OBSERVATIONS

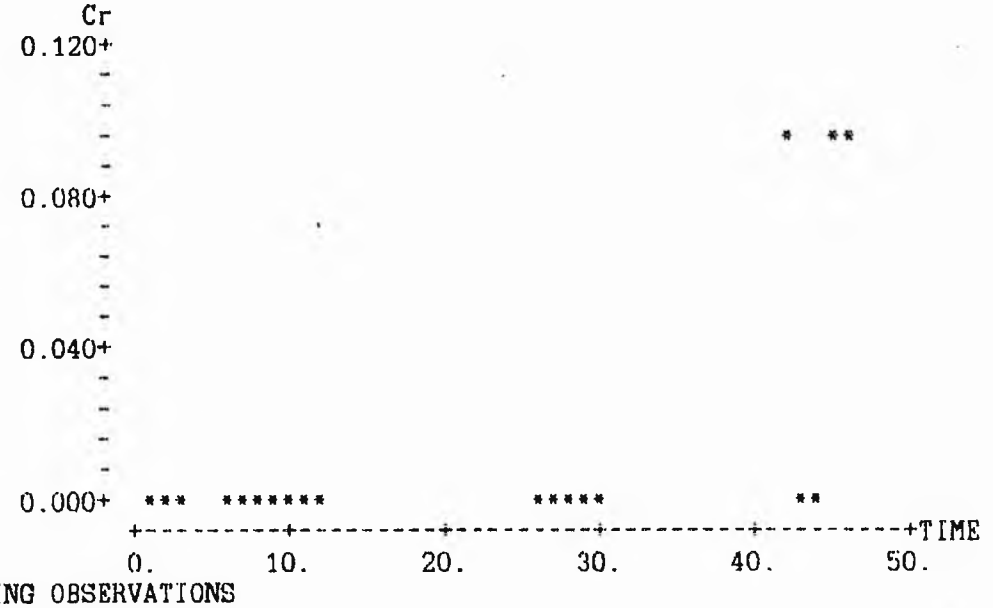
Figure 7.85

Graphs of Gully Pot Liquor Quality for Tame 3 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.86



2 MISSING OBSERVATIONS

Figure 7.87

7.8 TAME 4:

(see Figures 7.88 to 7.113 and Tables 7.10 to 7.12 inclusive).

The pH values tended to be quite low for this gully pot liquor especially during the summer period and the overall mean value for the whole study period was pH 6.9. Higher pH values were again observed during the spring period with much lower pH values for the autumn period, which contributed to a pH range of pH 5.8-8.6 for the whole period. This is one of the largest pH ranges found amongst the twelve gully pots under analysis.

The values for alkalinity, SS, BOD and COD all showed some degree of variation throughout the twenty-two week period but no recognisable, temporal trend could really be observed.

The spring period once again had high values for the Conductivity, sodium and chloride concentrations as a direct result of the presence of rock salt. The concentrations found were not as large as those measured in the pot liquor at Tame 1 and Tame 2 gully pots, within the same sub-catchment. The maxima for Conductivity, sodium and chloride were 5.42 (x1000) μscm-1, 19100.0 mgl-1 and 3013.0 mgl-1 as Cl^-, respectively. It may tentatively be concluded from this, that perhaps the effects of road salting carried out by the local residents was more marked on one side of the road than on the other. This is an unsubstantiated hypothesis but it may help to explain the spatial differences between the gully pot liquors in the same sub-catchment areas, for the parameters as outlined above. This type of observation is a good example of local (or anthropogenic) sources operating within a micro-catchment or at least part of a sub-catchment area.

The effects of rock salt also help to explain the higher levels of

calcium in the pot liquor. The value for Total Hardness is influenced in a similar way. The effect was not nearly as marked as found in the Tame 1 and Tame 2 gully pots but the distinctive characteristic was again well illustrated.

Cadmium was detected during the summer period with an observation of 1.00 mgl-1 on 840620 and it was not detected again until the end of the spring period. The heavy metals copper, nickel and chromium were detected exclusively during the spring period with maximum concentrations of 0.02, 0.11 and 0.10 mgl-1, respectively.

The BOD and COD values showed no real temporal variation with mean values of 24 mgl-1 as BOD and 106 mgl-1 as COD, respectively.

It should be noted that there are a number of missing values found in the dataset for the Tame 4 gully pot. The SS and nitrate determinations have been particularly effected in this way and the explanation is that some problems were encountered with laboratory equipment and a sample was accidently knocked over in the laboratory on two occasions.

Table 7.10

Table of all the Water Quality Data collected over the Twenty-Two Week Period for the Gully Pot Standing Liquor in the Tame 4 Gully Pot.

ROW	DATE	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
1	840509	11.5	2.0	6.6	240	270	0.46	*	24	413
2	840516	13.5	2.0	6.5	90	110	0.12	53	19	75
3	840523	15.0	3.2	7.0	220	210	0.00	*	8	53
4	840530	14.5	4.1	6.6	*	*	0.07	*	0	*
5	840606	14.5	5.4	6.6	*	*	0.12	*	5	*
6	840613	18.0	0.9	7.5	180	220	0.49	98	33	21
7	840620	19.0	1.2	7.1	280	420	0.65	43	59	162
8	840627	19.5	1.7	6.4	100	110	0.16	50	9	294
9	840704	24.0	3.7	7.1	190	280	0.32	77	29	98
10	840711	23.0	0.9	6.9	290	500	0.58	49	45	134
11	840718	20.0	1.8	6.5	90	260	0.10	19	17	21
12	840725	17.5	0.6	7.1	160	260	0.17	21	44	49
13	841031	12.0	5.0	5.8	30	40	0.00	45	14	114
14	841107	10.0	1.4	6.3	20	60	0.09	26	9	54
15	841114	10.0	4.1	6.2	50	50	0.06	57	55	23
16	841121	10.0	5.5	6.0	40	130	0.03	14	15	0
17	841128	8.0	7.0	6.7	50	210	0.10	19	6	0
18	850220	2.0	2.2	7.4	100	180	5.42	40	47	76
19	850227	3.5	0.6	7.6	100	190	5.20	55	18	234
20	850306	5.0	2.9	7.6	170	580	5.17	39	22	44
21	850313	5.5	3.5	8.6	120	440	4.59	30	23	151
22	850320	4.5	5.6	7.9	190	1090	4.27	38	27	103

ROW	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
1	1.4	21.3	192	0.3	*	23.2	5.00	0.10	0.00
2	1.6	24.8	192	0.3	*	3.9	9.80	0.20	0.00
3	1.2	42.5	106	0.3	*	0.8	0.60	0.10	0.00
4	*	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*	*
6	2.0	39.0	260	9.8	8.4	24.0	3.00	0.60	0.00
7	6.3	67.0	0	10.6	4.2	22.5	5.00	10.50	0.00
8	6.0	25.0	*	15.4	12.0	30.0	4.50	2.70	0.00
9	4.7	46.0	29	0.5	12.0	17.5	9.00	2.70	0.00
10	1.1	130.0	461	1.1	109.2	21.0	7.50	0.80	0.00
11	2.5	14.0	846	0.3	1.8	8.4	1.35	0.30	0.34
12	2.0	18.0	673	5.2	18.2	7.1	1.50	1.00	0.00
13	1.8	31.9	192	0.4	1.4	1.8	0.50	0.00	0.00
14	0.5	113.4	19	0.3	3.6	1.8	0.50	0.00	0.00
15	0.0	21.3	86	0.2	1.7	1.6	0.50	0.00	0.00
16	0.0	10.6	29	0.1	0.7	7.2	0.30	0.00	0.00
17	1.0	10.6	202	0.5	0.7	7.2	1.00	0.00	0.00
18	13.0	3013.0	317	1.0	*	1910.0	2.10	0.22	0.11
19	6.9	2836.0	567	4.2	*	1700.0	21.00	0.66	0.09
20	5.6	99.0	2268	0.0	6.3	1280.0	4.00	0.23	0.05
21	4.4	1737.1	644	2.0	11.9	800.0	4.50	0.18	0.15
22	5.1	468.0	1345	1.7	138.6	580.0	6.20	0.33	0.08

ROW	Ca	Mg	Zn	Mn	Cu	Cd	Ni	Cr
1	54.0	0.00	0.14	0.00	0.00	0.00	0.00	0.0
2	19.0	0.00	0.31	0.22	0.00	0.00	0.00	0.0
3	11.3	0.00	0.00	0.06	0.00	0.00	0.00	0.0
4	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*
6	48.0	130.00	0.17	0.22	0.00	0.00	0.00	0.0
7	70.0	14.00	0.26	0.15	0.00	1.00	0.00	0.0
8	37.5	2.00	0.15	0.10	0.00	0.22	0.00	0.0
9	70.0	5.00	0.20	0.15	0.00	0.00	0.00	0.0
10	62.5	2.50	0.14	0.50	0.00	0.03	0.00	0.0
11	100.0	45.50	0.20	0.13	0.00	0.00	0.00	0.0
12	16.3	1.30	0.36	0.28	0.00	0.00	0.00	0.0
13	13.8	0.70	0.05	0.07	0.00	0.00	0.00	0.0
14	10.0	0.70	0.15	0.00	0.00	0.00	0.00	0.0
15	10.0	0.60	0.07	0.00	0.00	0.00	0.00	0.0
16	7.0	0.30	0.17	0.00	0.00	0.00	0.00	0.0
17	13.0	0.80	0.11	0.10	0.00	0.00	0.00	0.0
18	28.0	2.90	0.16	0.22	0.00	0.00	0.10	0.0
19	105.0	3.90	0.40	0.26	0.00	0.06	0.05	0.0
20	100.0	3.30	0.17	0.17	0.02	0.00	0.11	0.0
21	100.0	3.50	0.16	0.16	0.02	0.06	0.10	0.1
22	50.0	2.53	0.00	0.16	0.00	0.01	0.10	0.0

Statistical Summary of the Water Quality Data for the Standing Pot Liquor collected in the Tame 4 Gully Pot.

Table 7.11

	TEMP	DO	PH	ALK	TH	COND	SS	BOD
N	22	22	22	20	20	22	18	22
NMISS	0	0	0	2	2	0	4	0
MEAN	12.75	2.97	6.909	135.5	281	1.29	42.9	24.0
MEDIAN	12.75	2.55	6.800	110.0	215	0.17	41.5	20.5
TMEAN	12.73	2.89	6.880	133.3	249	1.14	41.3	23.5
STDEV	6.40	1.88	0.668	82.4	242	2.04	21.3	16.8
SEMEAN	1.36	0.40	0.142	18.4	54	0.43	5.0	3.6
MAX	24.00	7.00	8.600	290.0	1090	5.42	98.0	59.0
MIN	2.00	0.60	5.800	20.0	40	0.03	14.0	0.0
Q3	18.25	4.33	7.425	190.0	385	1.55	53.5	35.7
Q1	7.37	1.35	6.475	60.0	115	0.09	24.8	9.0

	COD	PHOS	CL	SUL	AMM	NIT	Na	K
N	20	20	20	19	20	15	20	20
NMISS	2	2	2	3	2	7	2	2
MEAN	106	3.35	439	444	2.71	22.0	1182	4.39
MEDIAN	76	2.00	41	202	0.50	6.3	19	3.50
TMEAN	95	3.01	319	362	2.16	14.7	252	3.70
STDEV	105	3.18	934	561	4.31	42.0	4245	4.88
SEMEAN	24	0.71	209	129	0.96	10.9	949	1.09
MAX	413	13.00	3013	2268	15.40	138.6	19100	21.00
MIN	0	0.00	11	0	0.00	0.7	1	0.30
Q3	147	5.48	130	644	3.65	12.0	443	5.90
Q1	28	1.13	21	86	0.30	1.7	5	0.70

	Fe	Pb	Ca	Mg	Zn	Mn	Cu	Cd
N	20	20	20	20	20	20	20	20
NMISS	2	2	2	2	2	2	2	2
MEAN	1.03	0.0410	46.3	11.0	0.1765	0.148	0.00200	0.069
MEDIAN	0.23	0.0000	42.7	2.3	0.1600	0.150	0.00000	0.000
TMEAN	0.56	0.0267	45.2	5.0	0.1711	0.136	0.00111	0.021
STDEV	2.37	0.0838	34.9	29.8	0.0931	0.121	0.00616	0.225
SEMEAN	0.53	0.0187	7.8	6.7	0.0208	0.027	0.00138	0.050
MAX	10.50	0.3400	105.0	130.0	0.4000	0.500	0.02000	1.000
MIN	0.00	0.0000	7.0	0.0	0.0500	0.000	0.00000	0.000
Q3	0.77	0.0725	70.0	3.8	0.2000	0.220	0.00000	0.025
Q1	0.02	0.0000	13.2	0.6	0.1175	0.063	0.00000	0.000

	Ni	Cr
N	20	20
NMISS	2	2
MEAN	0.0230	0.0050
MEDIAN	0.0000	0.0000
TMEAN	0.0194	0.0000
STDEV	0.0423	0.0224
SEMEAN	0.0095	0.0050
MAX	0.1100	0.1000
MIN	0.0000	0.0000
Q3	0.0375	0.0000
Q1	0.0000	0.0000

Table of the Correlation Coefficients between all Twenty-Six Water Quality Parameters for the Standing Pot Liquor in the Tame 4 Gully Pot.

Table 7.12

	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
DO	-0.386								
PH	-0.328	-0.187							
ALK	0.411	-0.376	0.424						
TH	-0.160	0.150	0.637	0.550					
COND	-0.719	-0.082	0.759	0.059	0.494				
SS	0.312	-0.296	0.166	0.343	-0.065	-0.026			
BOD	0.189	-0.481	0.247	0.447	0.194	0.173	0.270		
COD	0.032	-0.328	0.075	0.352	0.053	0.121	0.212	-0.032	
PHOS	-0.327	-0.214	0.514	0.138	0.238	0.730	0.121	0.268	0.237
CL	-0.684	-0.179	0.530	-0.128	0.026	0.787	0.006	0.127	0.184
SUL	-0.341	0.006	0.493	0.150	0.660	0.621	-0.166	-0.058	-0.073
AMM	0.351	-0.434	0.115	0.223	-0.037	-0.095	0.340	0.168	0.340
NIT	-0.030	0.037	0.352	0.523	0.784	0.354	0.049	0.208	0.212
Na	-0.438	-0.085	0.225	-0.100	-0.056	0.541	-0.032	0.291	-0.046
K	-0.081	-0.351	0.372	0.231	0.175	0.418	0.377	0.014	0.448
Fe	0.405	-0.274	0.070	0.468	0.125	-0.125	0.139	0.464	0.223
Pb	-0.144	-0.088	0.289	-0.143	0.201	0.367	-0.314	-0.085	-0.103
Ca	-0.005	-0.328	0.612	0.377	0.445	0.546	0.142	0.087	0.308
Mg	0.288	-0.297	0.171	0.129	-0.031	-0.124	0.547	0.106	-0.229
Zn	0.088	-0.602	0.223	0.089	-0.108	0.157	0.021	0.163	0.120
Mn	0.233	-0.469	0.435	0.469	0.336	0.281	0.245	0.387	-0.011
Cu	-0.374	0.075	0.572	0.039	0.325	0.564	-0.144	-0.078	-0.027
Cd	0.252	-0.244	0.064	0.394	0.117	-0.068	0.020	0.422	0.242
Ni	-0.716	0.130	0.741	0.036	0.593	0.951	-0.120	0.077	0.009
Cr	-0.249	0.090	0.563	-0.044	0.155	0.356	-0.152	-0.046	0.101

	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
CL	0.731								
SUL	0.285	0.081							
AMM	0.283	-0.036	-0.116						
NIT	0.139	0.156	0.317	-0.093					
Na	0.760	0.714	0.018	-0.098	0.173				
K	0.333	0.473	0.115	0.125	0.553	-0.038			
Fe	0.297	-0.118	-0.199	0.590	-0.099	-0.094	0.131		
Pb	0.296	0.359	0.379	-0.174	0.002	0.224	0.045	-0.158	
Ca	0.400	0.336	0.535	0.104	0.121	-0.048	0.548	0.216	0.586
Mg	-0.067	-0.116	-0.017	0.375	-0.133	-0.077	-0.085	0.030	0.169
Zn	0.234	0.304	0.042	0.257	-0.218	-0.002	0.620	0.274	0.106
Mn	0.275	0.275	0.264	0.149	0.570	0.167	0.468	0.083	0.084
Cu	0.177	0.176	0.636	-0.136	-0.125	-0.011	-0.010	-0.119	0.241
Cd	0.276	-0.063	-0.180	0.579	-0.111	-0.080	0.084	0.964	-0.115
Ni	0.653	0.630	0.699	-0.163	0.353	0.507	0.191	-0.180	0.373
Cr	0.077	0.327	0.086	-0.039	-0.067	-0.021	0.005	-0.085	0.306

	Ca	Mg	Zn	Mn	Cu	Cd	Ni
Mg	0.179						
Zn	0.334	0.036					
Mn	0.365	0.148	0.429				
Cu	0.526	-0.087	-0.042	0.050			
Cd	0.195	-0.001	0.221	0.020	-0.059		
Ni	0.455	-0.150	-0.033	0.184	0.663	-0.120	
Cr	0.362	-0.059	-0.042	0.024	0.688	-0.009	0.428

Graphs of Gully Pot Liquor Quality for Tame 4 Gully Pot.

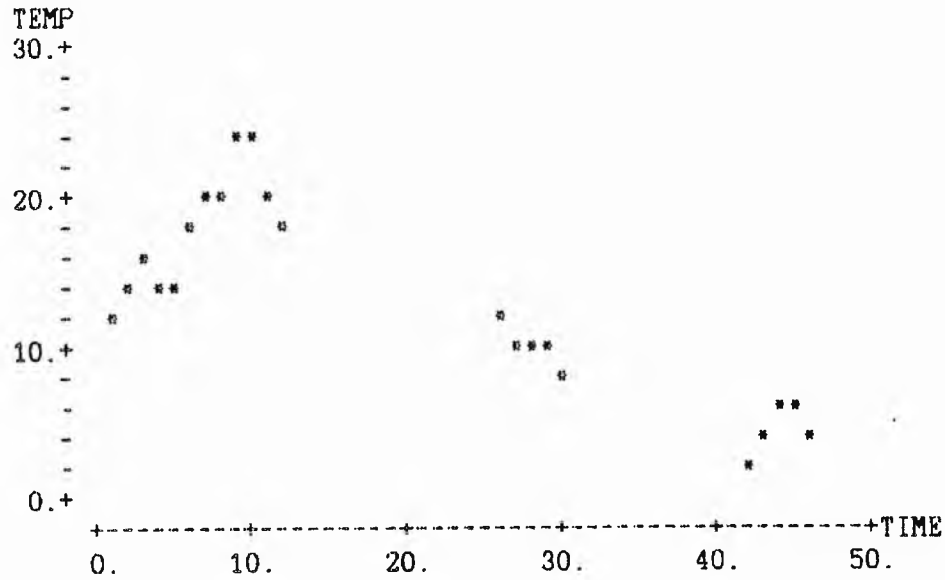


Figure 7.88

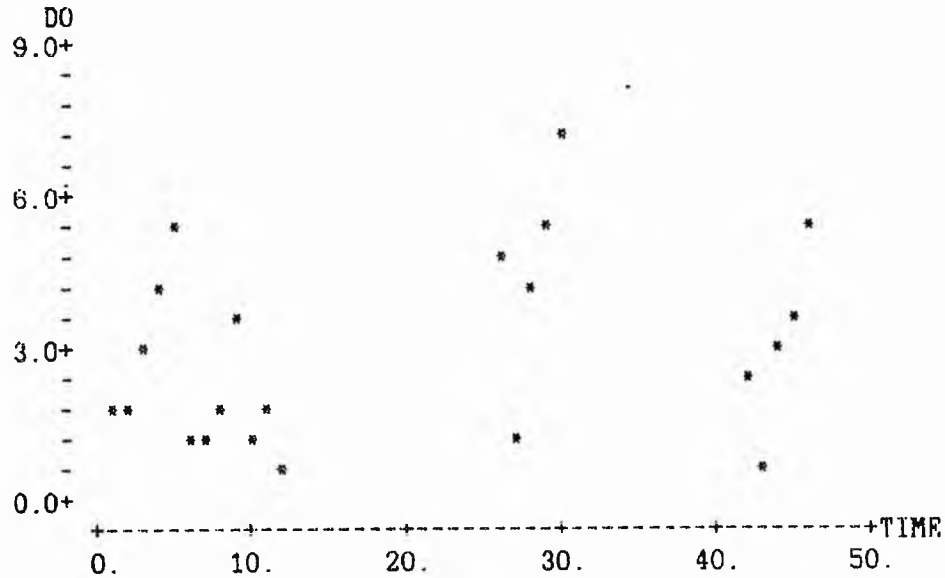


Figure 7.89

Graphs of Gully Pot Liquor Quality for Tame 4 Gully Pot.

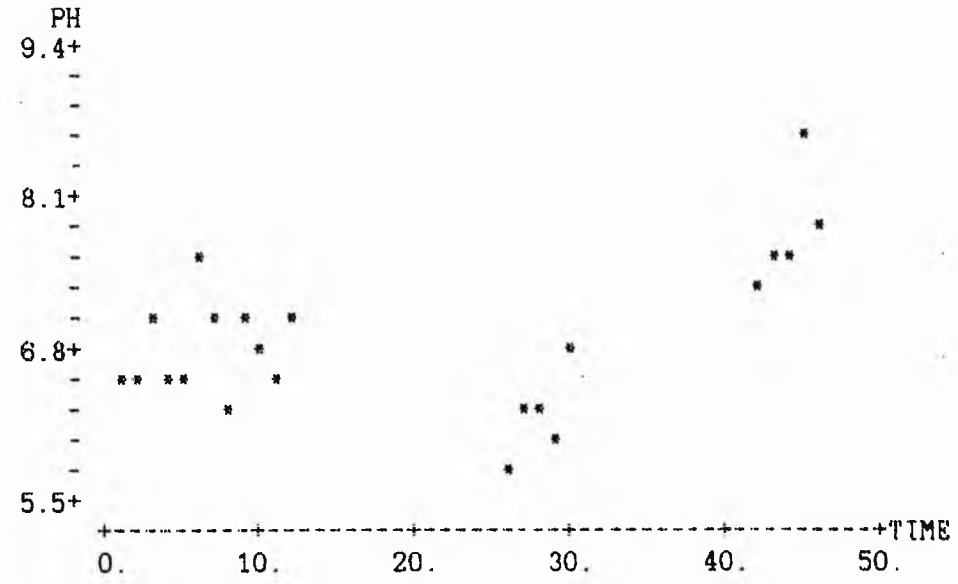
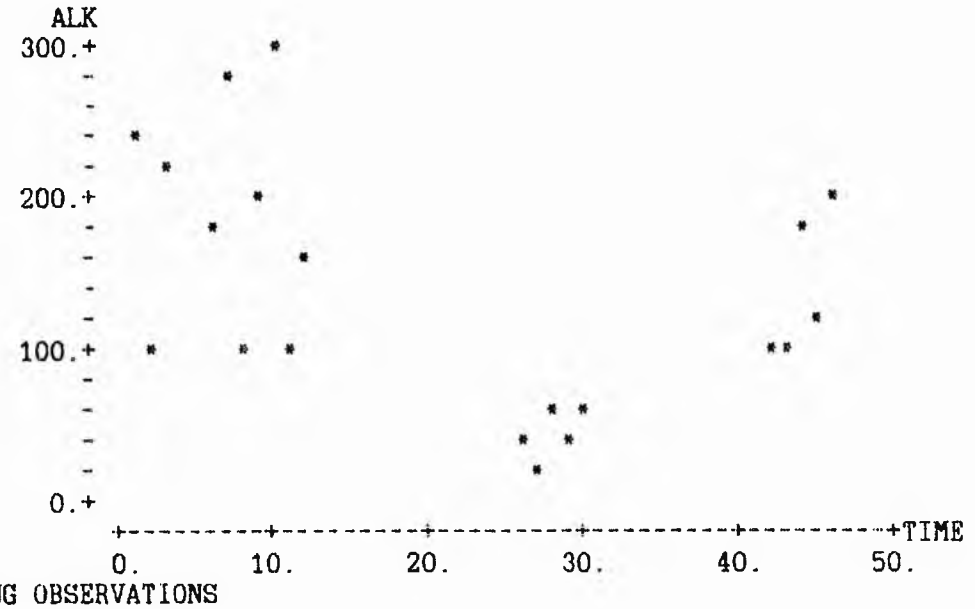


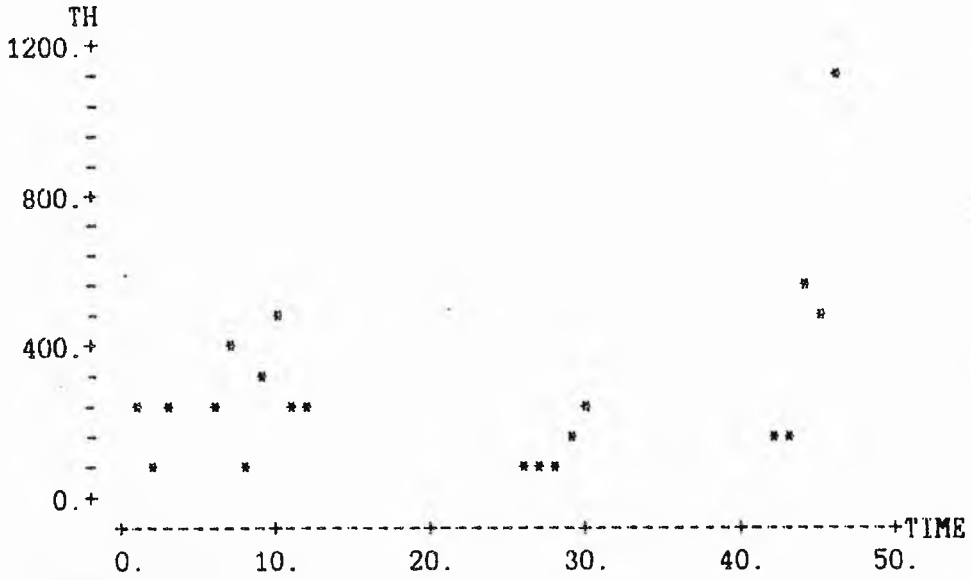
Figure 7.90



2 MISSING OBSERVATIONS

Figure 7.91

Graphs of Gully Pot Liquor Quality for Tame 4 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.92

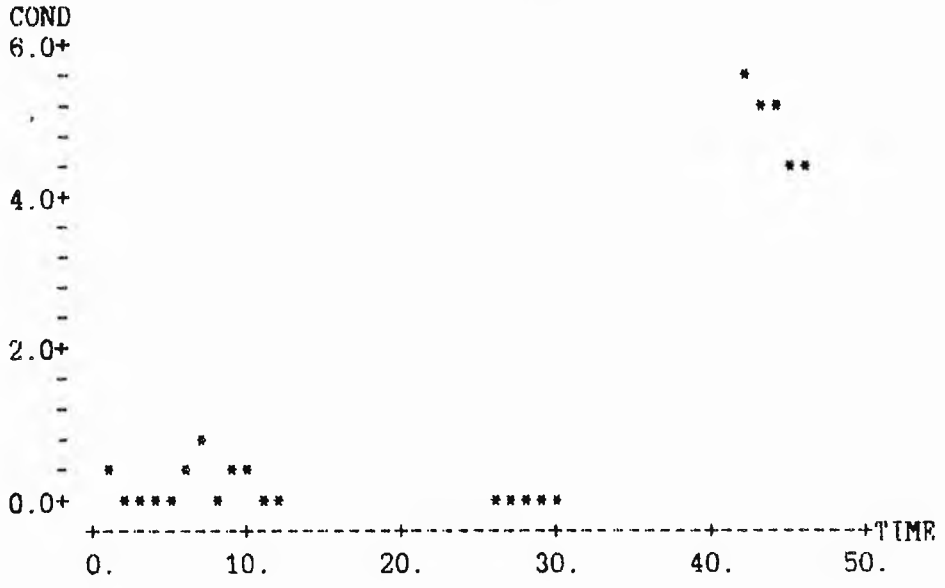


Figure 7.93

Graphs of Gully Pot Liquor Quality for Tame 4 Gully Pot.

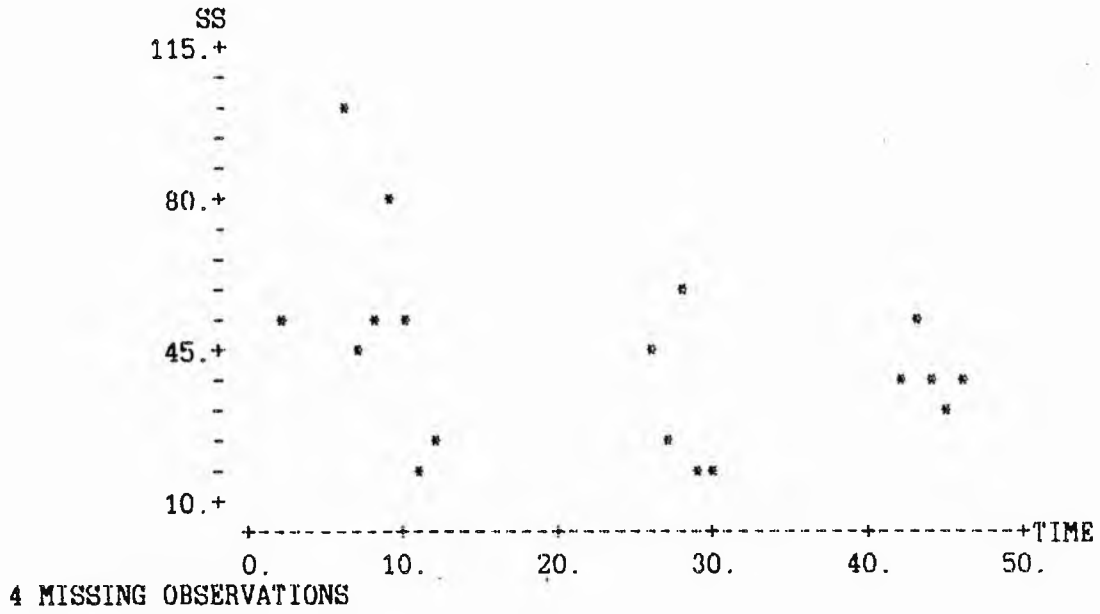


Figure 7.94

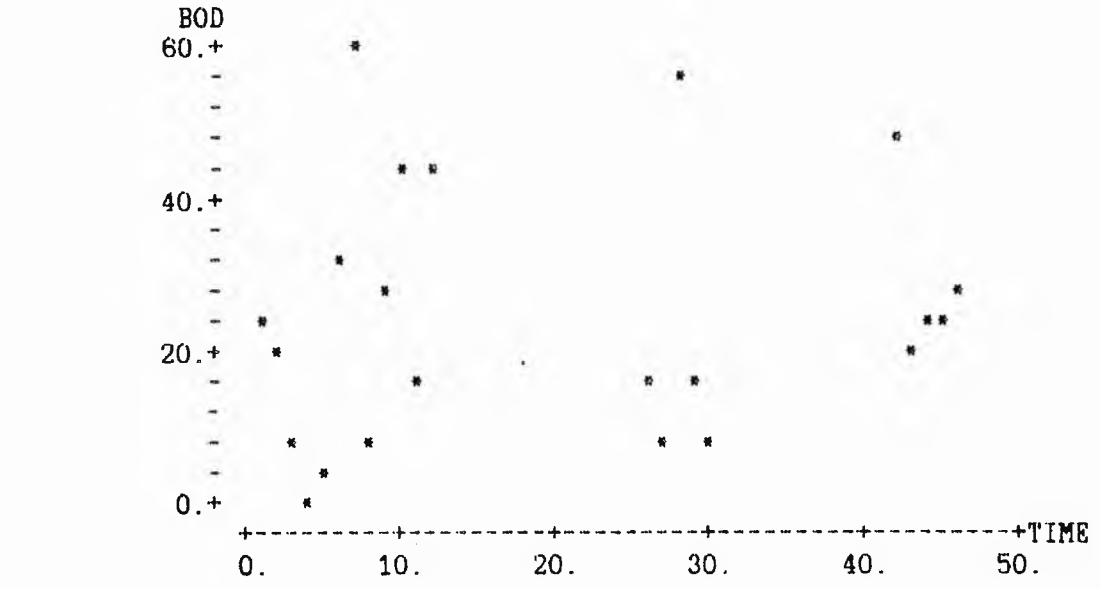
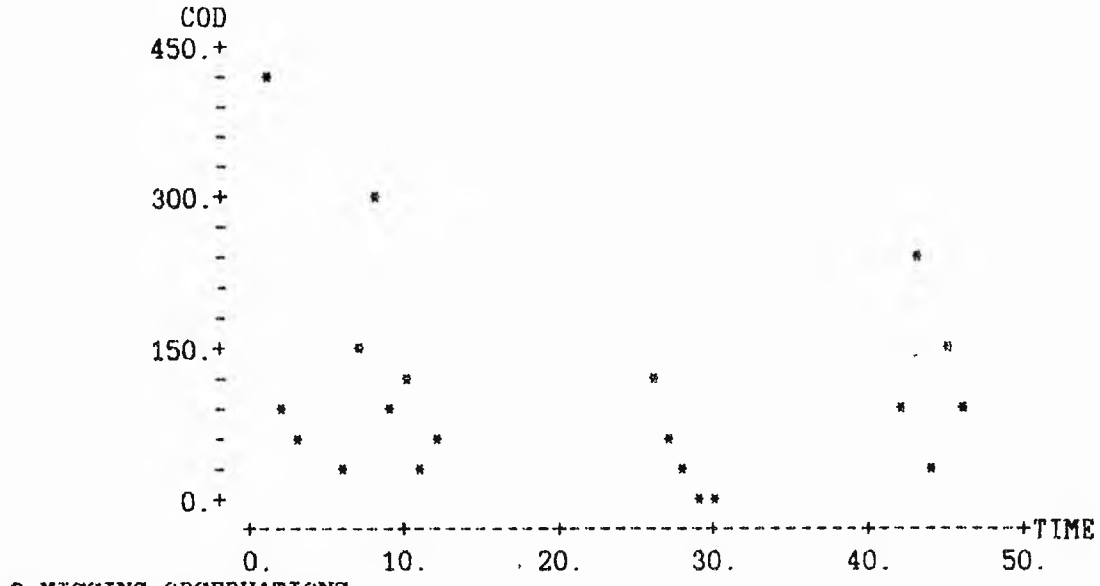


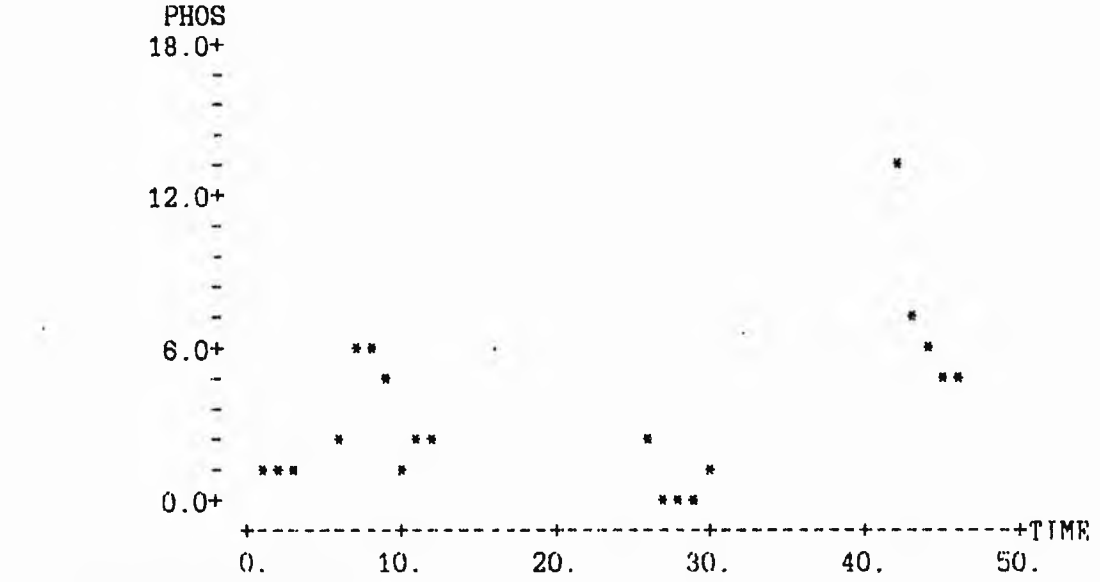
Figure 7.95

Graphs of Gully Pot Liquor Quality for Tame 4 Gully Pot.



2 MISSING OBSERVATIONS

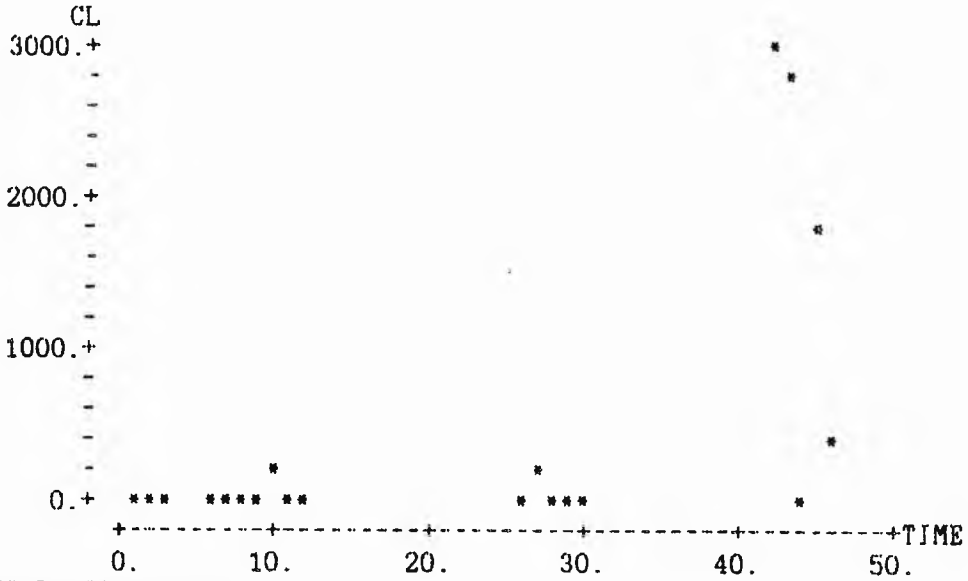
Figure 7.96



2 MISSING OBSERVATIONS

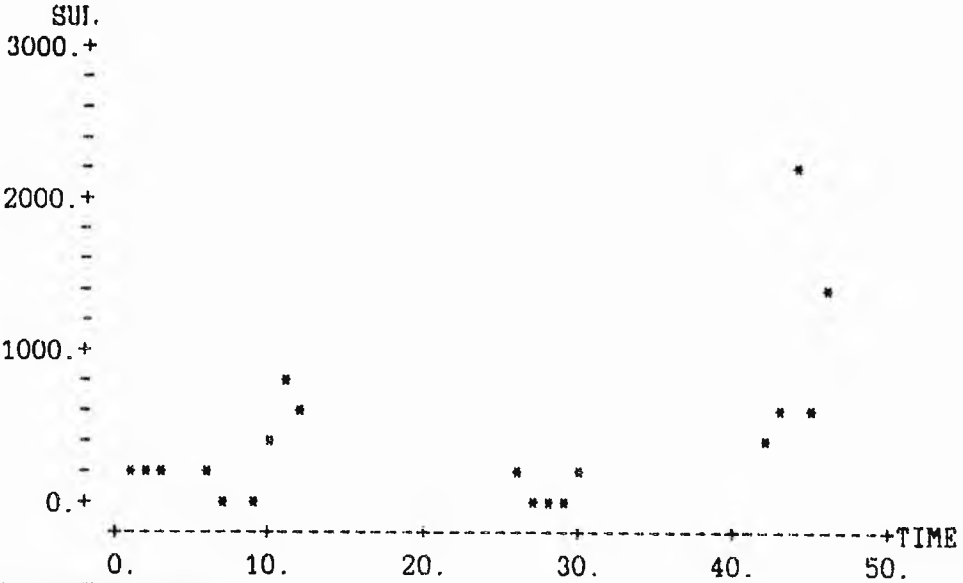
Figure 7.97

Graphs of Gully Pot Liquor Quality for Tame 4 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.98



3 MISSING OBSERVATIONS

Figure 7.99

Graphs of Gully Pot Liquor Quality for Tame 4 Gully Pot.

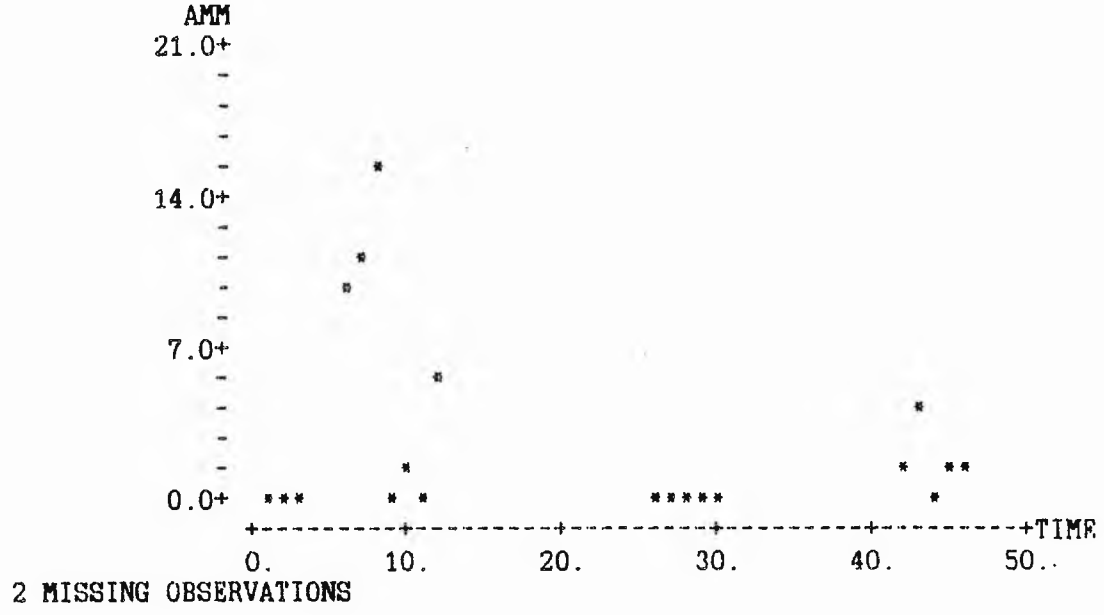


Figure 7.100

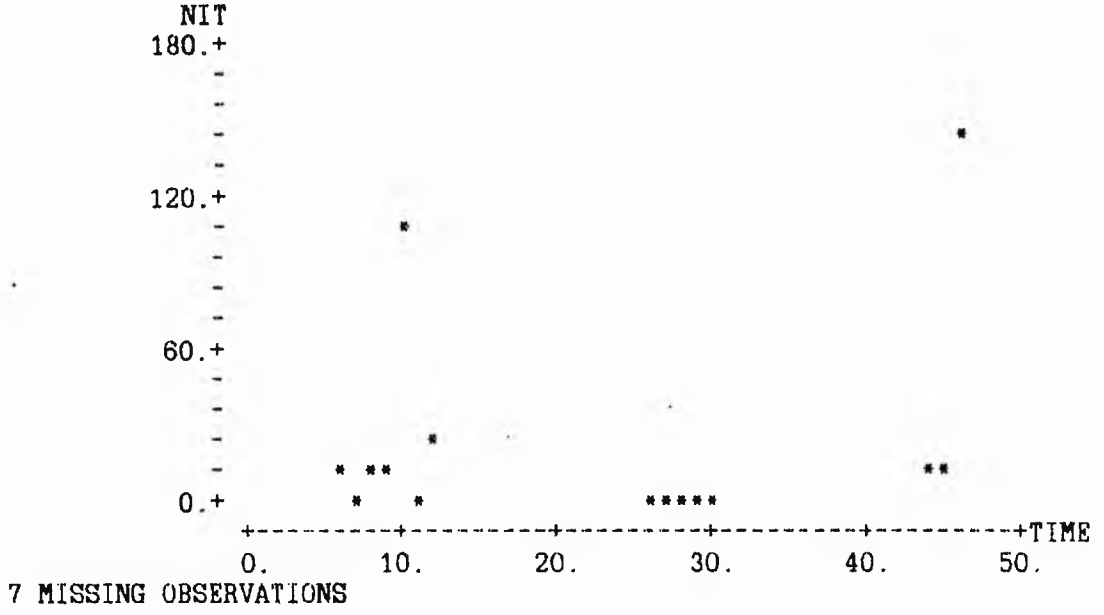


Figure 7.101

Graphs of Gully Pot Liquor Quality for Tame 4 Gully Pot.

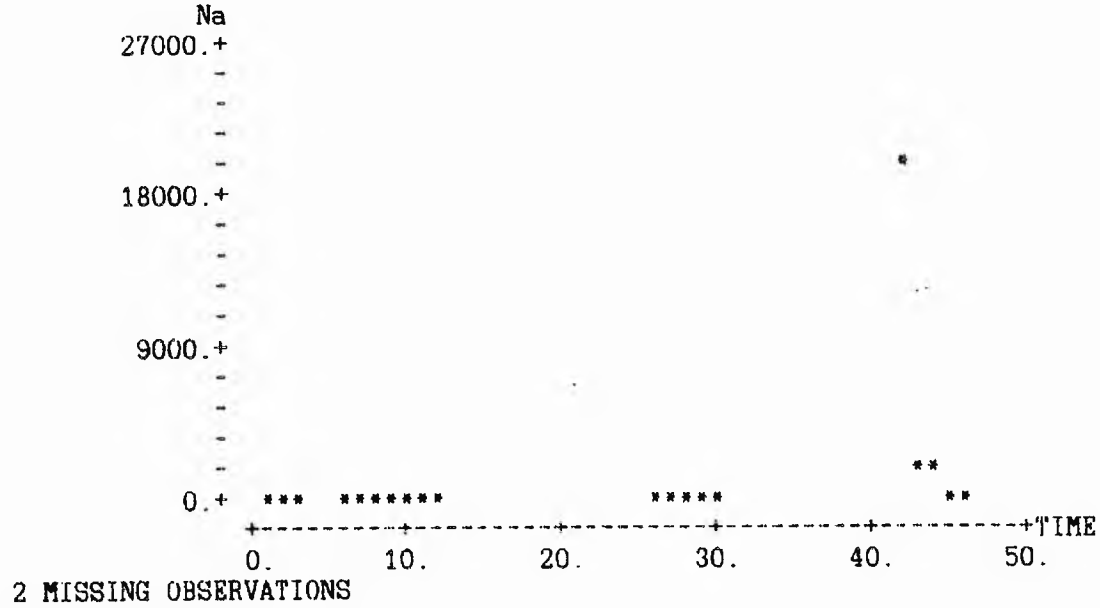


Figure 7.102

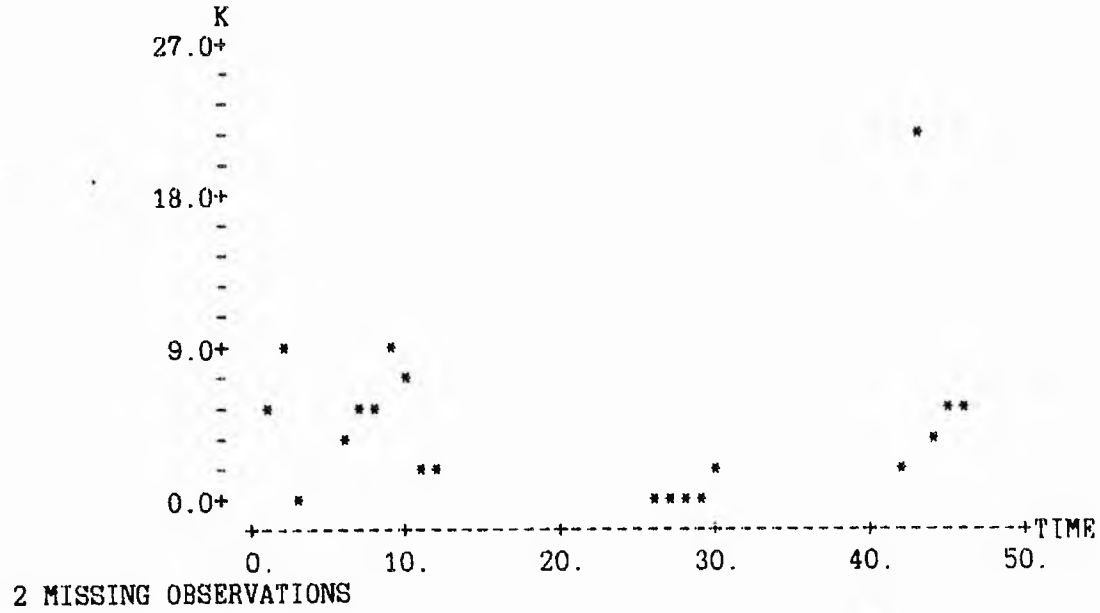
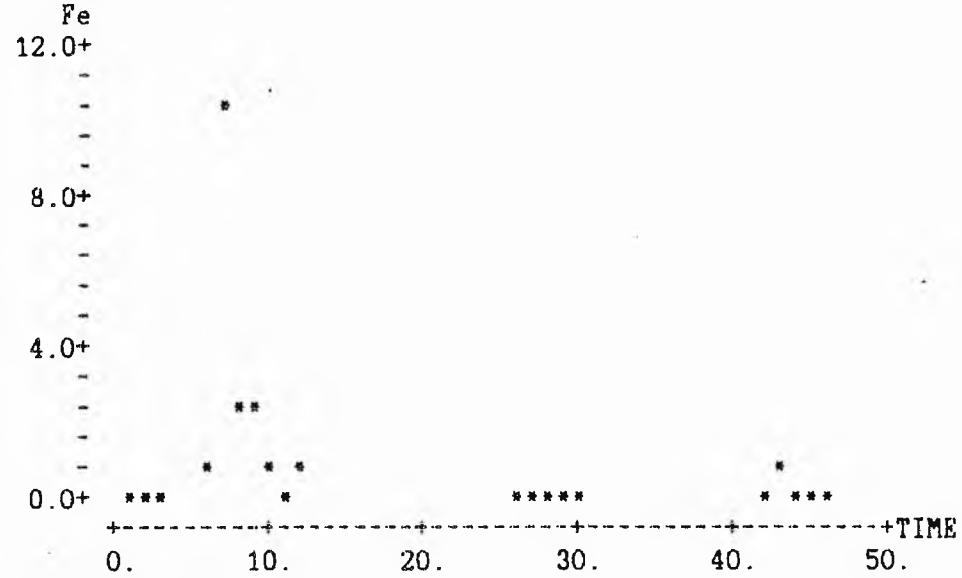


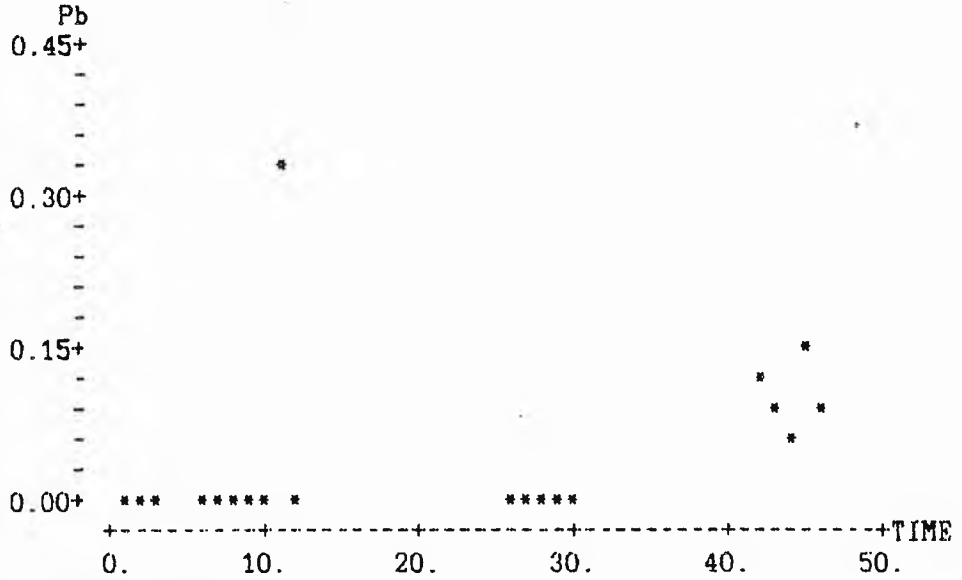
Figure 7.103

Graphs of Gully Pot Liquor Quality for Tame 4 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.104



2 MISSING OBSERVATIONS

Figure 7.105

Graphs of Gully Pot Liquor Quality for Tame 4 Gully Pot.

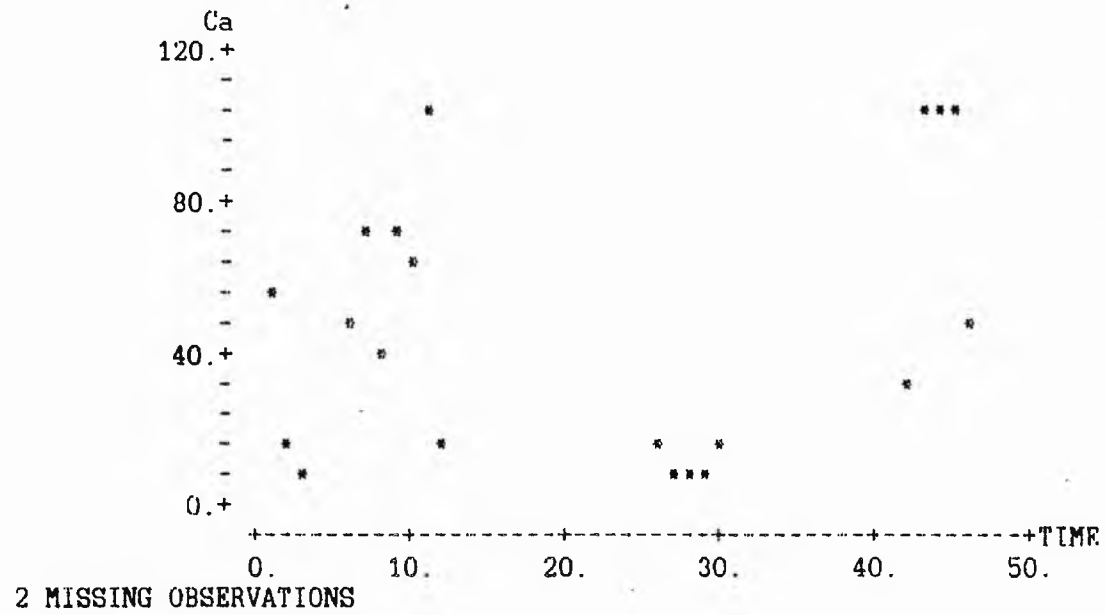


Figure 7.106

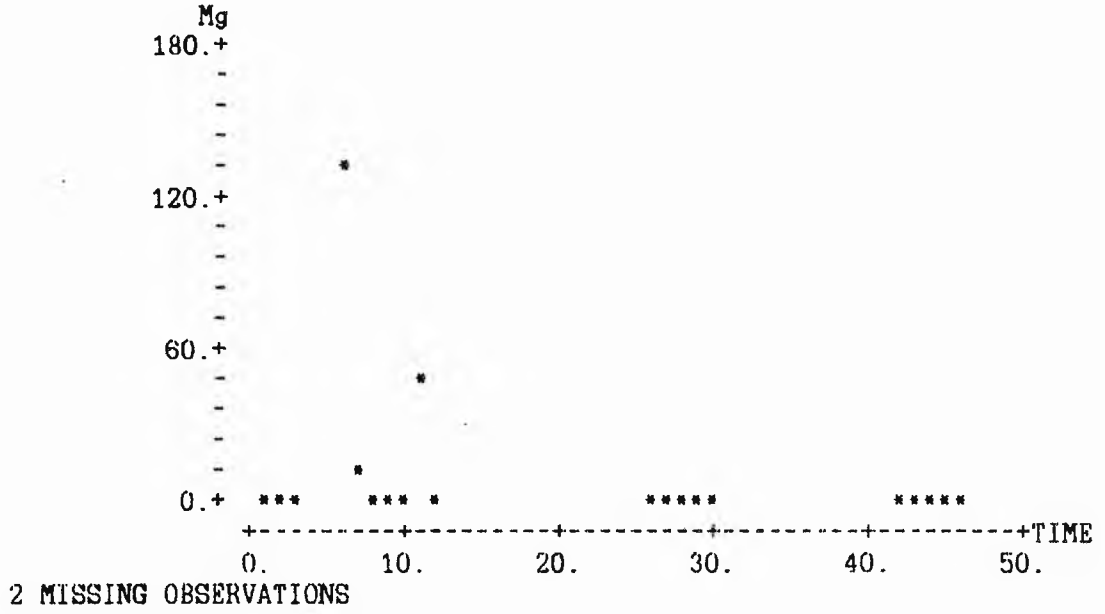
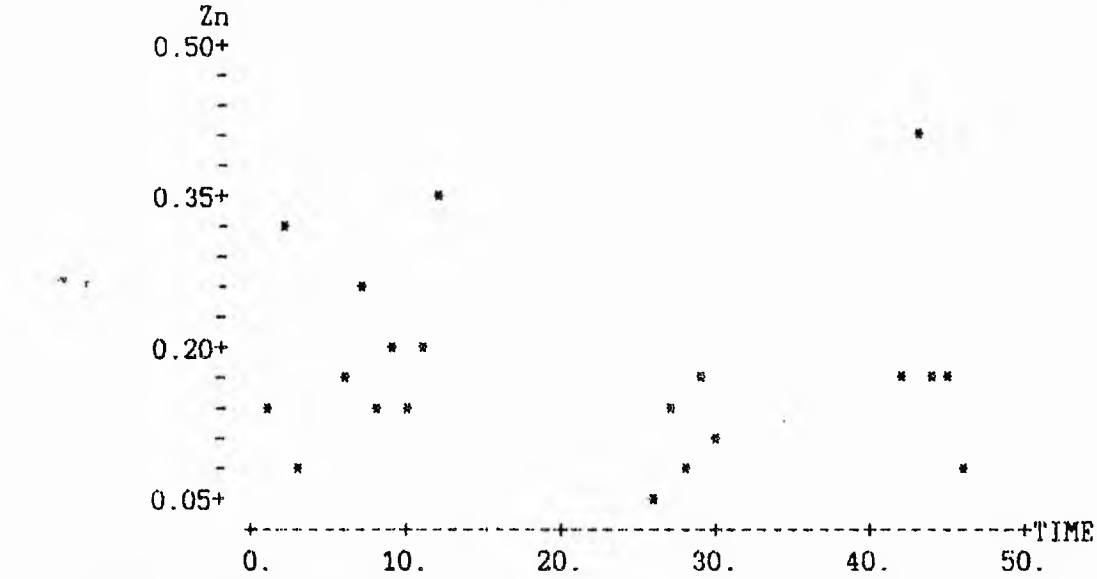


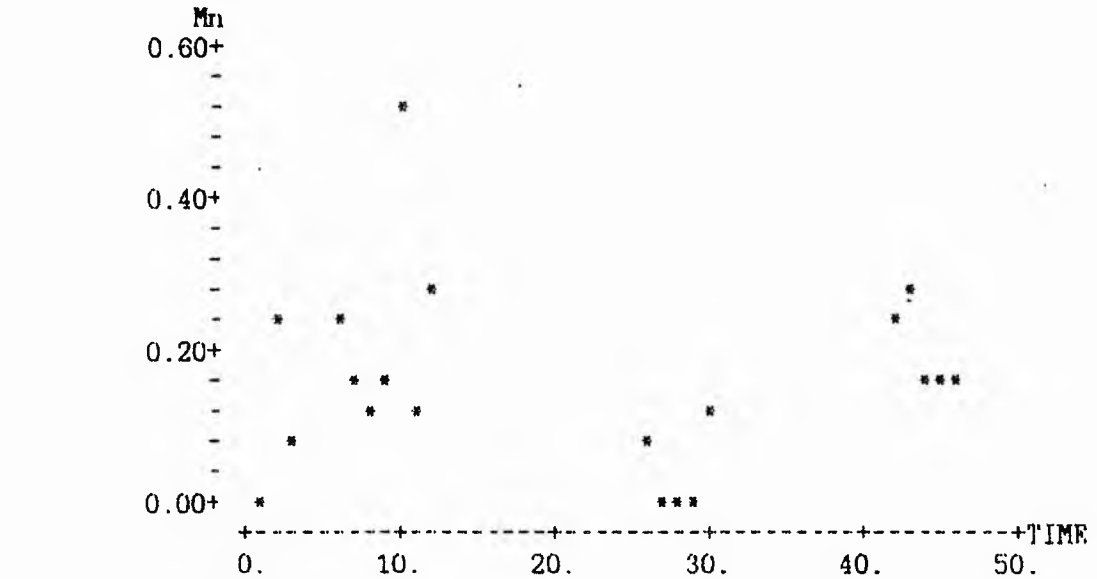
Figure 7.107

Graphs of Gully Pot Liquor Quality for Tame 4 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.108



2 MISSING OBSERVATIONS

Figure 7.109

Graphs of Gully Pot Liquor Quality for Tame 4 Gully Pot.

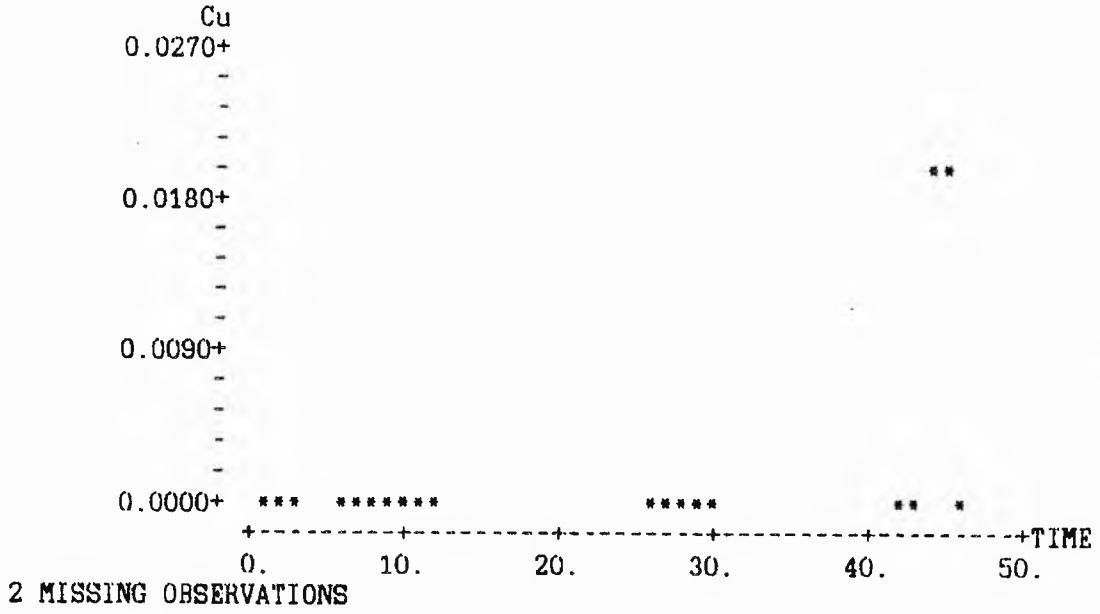


Figure 7.110

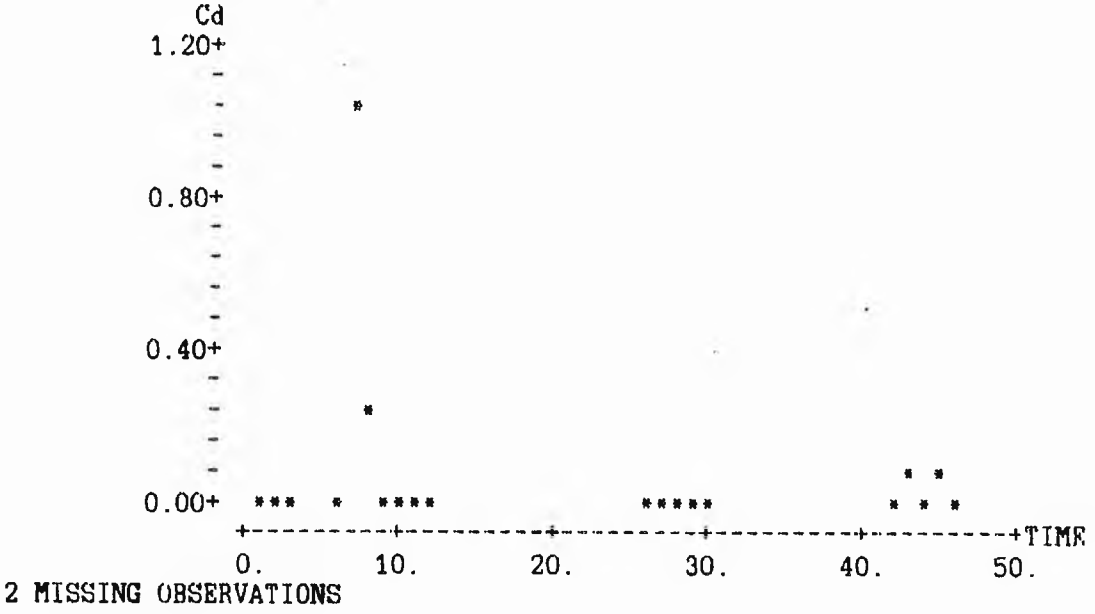
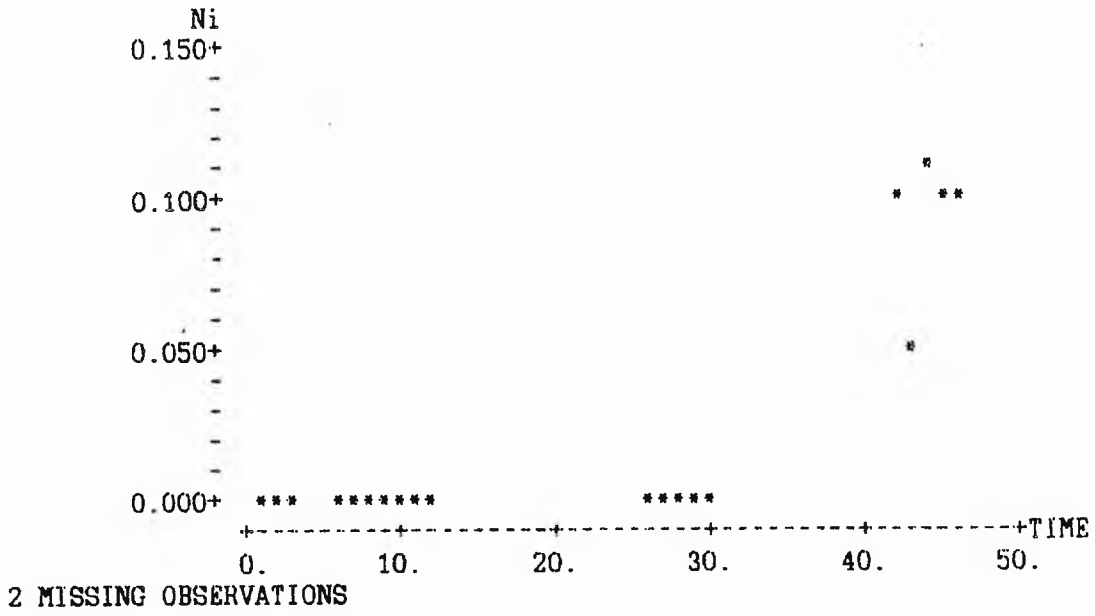


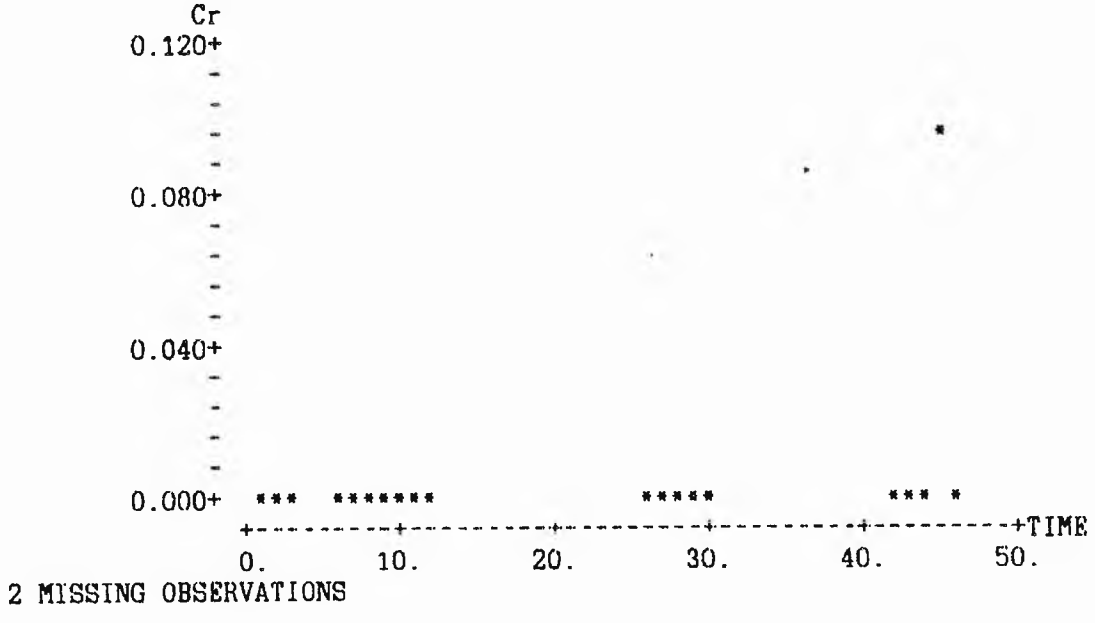
Figure 7.111

Graphs of Gully Pot Liquor Quality for Tame 4 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.112



2 MISSING OBSERVATIONS

Figure 7.113

7.9 CHURNET 1:

(see Figures 7.114 to 7.139 and Tables 7.13 to 7.15 inclusive).

The pH values stayed around or just below the pH 7.0 neutral point for the summer period, but showed a marked increase during the spring period. All values obtained during the autumn period were within the range pH 6.1-6.7, but during the spring period the values were much higher and fell within the range of pH 7.8-9.8, with the maximum value of pH 9.8 observed on the 850313. This may be explained by the increased concentration of alkaline salts associated with the rock salt used in road salting. This source of nitrates, chlorides and carbonates (not under study) and the other associated anions had shifted the pH to a higher, more alkaline condition.

The influence of road salting was again well illustrated with the trends shown over the twenty-two week period for the values for Conductivity, sodium and chloride. The Conductivity measurements for the summer and autumn periods were all less than 0.60 (x1000) μscm-1, but rose dramatically to around 37.4 (x1000) μscm-1 during the spring period. The maximum Conductivity value of 114.1 (x1000) μscm-1 was obtained on the 850220. The same trend was detected in the sodium and chloride determinations which both had average background concentrations in the summer and autumn periods, but whose values rose in the spring period. The maxima for sodium and chloride were 45000.0 mgl-1 and 54593.0 mgl-1 as Cl^- respectively, which both occurred on the 850220. These concentrations for Conductivity, sodium and chloride were the highest measured in any of the gully pot liquors under study, throughout the whole of the study period. It seemed certain that a large quantity of rock salt was applied to the road surface or to an

adjacent paved area, which was easily flushed into the Churnet 1 gully pot. This assertion was supported by the elevated SS concentrations found during the spring period which rose to a maximum of 482.0 mgl-1. The BOD and COD parameters again showed no temporal pattern or relationship although interestingly, both maximum values occurred in the summer period. A number of void results were obtained for the COD analysis on the Churnet 1 pot liquor due to the extremely high concentration of chloride found in the sample. Mercuric sulphate was used in the Method for determining COD as a means of reducing the chloride interference factor within the test (see Chapter 5) but it was impossible to produce a dilution that rendered a test and credible result. Some COD data were therefore declared void and were not presented in the dataset.

As a further consequence of the rock salt, higher values were again found for Total Hardness and calcium. The calcium may have been chiefly in the form of calcium sulphate (since the sulphate levels also increased during the same period) and this salt is naturally occurring and is often found attached to and forms part of the rock salt crystalline structure. The sulphate ion concentration peaked to a maximum of 1710.0 mgl-1 as SO_4^{2-} on the 850220, which was the same day that the Total Hardness value reached its maximum value for this gully pot, at 1240.0 mgl-1 as $CaCO_3$. It can therefore be inferred that the increased Total Hardness values were almost certainly explained by the increased calcium metal (and to a much lesser extent the sodium metal), predominantly in the form of calcium sulphate.

The ammonia concentrations rose during the summer period with higher ambient temperatures, which would promote the microbial breakdown of organic matter, producing ammonia gas in the dissolved phase as a by-product. This anaerobic action within the gully pot liquor would

probably act along a biochemical gradient set up within the liquor and so much higher levels of ammonia and more oxygen depletion would be expected near to the base of the pot where the source of anaerobic microbes within the basal sediments was at its highest and the influence of the air-water interface at the surface of the pot liquor was at a minimum.

It should also be noted that the heavy metals, copper, cadmium, nickel and chromium all showed a characteristic trend, similar to that found to the pot liquors analysed in the Tame sub-catchment. Cadmium had its maximum value of 2.00 mgl-1 during the summer period. This result may be explained by an abnormal source operating within the micro-catchment, such as the local dumping of material down the gully pot. Further analysis of the cadmium data for all twelve gully pots on the three sub-catchments for the summer period, may lead to the conclusion that this was (along with others) a freak result caused by an instrumentation problem or by contamination of the standard solutions or the samples themselves. Notes made in the laboratory at the time of the analysis did not reveal any observable abnormality in the sample analysis for cadmium, and so the cadmium data were accepted to be true results and were therefore left on the dataset for the pot liquor analysis. The levels of copper, nickel and chromium were only detected during the spring period and reached maxima of 0.22, 2.05 and 0.90 mgl-1, respectively.

Table 7.13

Table of all the Water Quality Data collected over the Twenty-Two Week Period for the Gully Pot Standing Liquor in the Churnet 1 Gully Pot.

ROW	DATE	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
1	840509	12.0	4.1	7.0	190	280	0.47	*	16	243
2	840516	13.5	3.6	6.9	80	70	0.12	84	15	32
3	840523	14.0	1.9	7.3	220	300	0.08	*	7	16
4	840530	15.0	4.0	6.7	*	*	0.09	*	3	*
5	840606	15.0	5.7	6.8	*	*	0.16	*	5	*
6	840613	17.5	2.9	6.8	240	210	0.39	49	50	229
7	840620	20.0	0.6	7.3	240	400	0.59	62	16	153
8	840627	19.5	0.9	6.1	100	50	0.19	55	3	144
9	840704	25.0	5.1	7.2	270	310	0.33	81	11	67
10	840711	22.5	1.1	7.0	170	350	0.31	32	19	129
11	840718	20.0	2.3	6.7	160	220	0.12	47	9	21
12	840725	17.0	0.5	6.7	190	140	0.19	333	27	77
13	841031	12.0	6.4	6.1	40	50	0.09	64	26	35
14	841107	10.0	0.9	6.7	170	40	0.08	56	18	84
15	841114	10.0	4.8	6.5	50	40	0.08	17	45	0
16	841121	8.0	6.2	6.3	30	120	0.06	21	28	0
17	841128	7.0	7.1	6.4	20	150	0.03	40	2	0
18	850220	3.0	6.6	8.2	45	1240	114.10	27	26	*
19	850227	4.5	3.3	7.8	60	1060	95.00	482	10	*
20	850306	5.5	2.8	8.9	190	840	37.40	167	6	74
21	850313	6.0	4.6	9.8	90	1000	56.20	479	7	*
22	850320	5.0	6.0	8.5	220	850	42.00	195	17	*

ROW	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
1	1.4	24.8	135	2.1	*	16.8	6.2	0.70	0.00
2	1.6	39.0	288	1.7	*	7.4	3.0	0.60	0.00
3	0.9	39.0	135	2.2	*	4.0	1.6	0.20	0.00
4	*	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*	*
6	5.2	32.0	202	4.2	4.9	13.0	3.8	2.60	0.00
7	1.7	71.0	211	6.2	2.9	22.0	3.0	10.50	0.35
8	1.2	21.0	*	7.0	6.3	25.0	3.5	5.80	0.35
9	0.6	113.0	567	0.0	18.2	22.5	11.0	2.00	0.00
10	0.7	28.0	394	1.2	85.4	12.2	3.0	0.30	0.20
11	2.2	32.0	202	0.3	0.8	8.5	1.7	0.50	0.17
12	0.7	21.0	423	2.1	10.5	8.3	1.5	3.10	0.00
13	1.3	28.4	0	0.1	1.5	3.7	1.3	0.20	0.00
14	0.7	42.5	0	0.2	2.0	3.0	1.1	0.00	0.00
15	1.0	21.3	115	0.2	2.5	2.7	1.1	0.00	0.00
16	0.3	7.1	48	0.1	1.3	3.2	1.0	0.00	0.00
17	0.4	10.6	135	0.5	0.7	3.6	0.7	0.00	0.00
18	5.2	54593.0	1710	1.5	*	45000.0	10.5	1.80	0.78
19	1.7	43249.0	1124	0.4	*	18700.0	18.0	1.64	0.62
20	0.8	216.0	1326	0.5	33.6	1620.0	10.0	0.42	0.24
21	0.0	29424.0	961	1.2	70.0	14600.0	9.0	0.96	0.40
22	3.7	429.0	721	1.4	39.2	8000.0	7.5	0.60	0.28

ROW	Ca	Mg	Zn	Mn	Cu	Cd	Ni	Cr
1	50.0	0.00	0.10	0.03	0.00	0.00	0.00	0.0
2	18.0	0.00	0.10	0.16	0.00	0.00	0.00	0.0
3	15.0	0.00	0.04	0.04	0.00	0.00	0.00	0.0
4	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*
6	48.0	115.00	0.17	0.70	0.00	0.00	0.00	0.0
7	70.0	12.00	0.20	0.30	0.00	2.00	0.00	0.0
8	55.0	3.00	0.00	0.00	0.00	0.30	0.00	0.0
9	102.5	3.00	0.17	0.30	0.00	0.00	0.00	0.0
10	42.5	2.50	0.20	0.50	0.00	0.00	0.00	0.0
11	150.0	40.00	0.16	0.00	0.00	0.00	0.00	0.0
12	36.5	2.60	0.13	0.38	0.00	0.00	0.00	0.0
13	12.5	0.90	0.05	0.08	0.00	0.00	0.00	0.0
14	10.0	1.10	0.05	0.00	0.00	0.00	0.00	0.0
15	12.5	1.10	0.05	0.00	0.00	0.00	0.00	0.0
16	8.3	0.60	0.06	0.00	0.00	0.00	0.00	0.0
17	4.6	0.40	0.04	0.00	0.00	0.00	0.00	0.0
18	410.0	7.00	0.34	0.62	0.22	0.28	2.05	0.3
19	430.0	8.00	0.28	0.52	0.16	0.37	1.55	0.9
20	250.0	3.10	0.08	0.14	0.08	0.11	0.66	0.0
21	410.0	5.50	0.13	0.22	0.18	0.22	1.36	0.1
22	168.0	2.53	0.12	0.22	0.10	0.12	0.10	0.1

Statistical Summary of the Water Quality Data for the Standing Pot Liquor collected in the Churnet 1 Gully Pot.

Table 7.14

	TEMP	DO	PH	ALK	TH	COND	SS	BOD
N	22	22	22	20	20	22	18	22
NMISS	0	0	0	2	2	0	4	0
MEAN	12.82	3.70	7.168	138.7	386	15.8	127	16.6
MEDIAN	12.75	3.80	6.850	165.0	250	0.2	59	15.5
TMEAN	12.70	3.69	7.090	138.1	358	11.7	112	15.7
STDEV	6.33	2.14	0.940	81.8	385	33.0	150	12.9
SEMEAN	1.35	0.46	0.200	18.3	86	7.0	35	2.8
MAX	25.00	7.10	9.800	270.0	1240	114.1	482	50.0
MIN	3.00	0.50	6.100	20.0	40	0.0	17	2.0
Q3	18.00	5.77	7.425	212.5	730	9.8	174	26.0
Q1	6.75	1.70	6.650	52.5	83	0.1	38	6.7

	COD	PHOS	CL	SUL	AMM	NIT	Na	K
N	16	20	20	19	20	15	20	20
NMISS	6	2	2	3	2	7	2	2
MEAN	81.5	1.56	6422	458	1.66	18.7	4404	4.93
MEDIAN	70.5	1.10	36	211	1.20	4.9	13	3.00
TMEAN	75.8	1.45	4102	411	1.45	14.9	2393	4.43
STDEV	78.3	1.48	16046	491	1.98	27.0	10922	4.66
SEMEAN	19.6	0.33	3588	113	0.44	7.0	2442	1.04
MAX	243.0	5.20	54593	1710	7.00	85.4	45000	18.00
MIN	0.0	0.00	7	0	0.00	0.7	3	0.70
Q3	140.2	1.70	190	721	2.10	33.6	1221	8.63
Q1	17.3	0.70	22	135	0.22	1.5	4	1.35

	Fe	Pb	Ca	Mg	Zn	Mn	Cu	Cd
N	20	20	20	20	20	20	20	20
NMISS	2	2	2	2	2	2	2	2
MEAN	1.60	0.170	115	10.4	0.1235	0.211	0.0370	0.170
MEDIAN	0.60	0.000	49	2.6	0.1100	0.150	0.0000	0.000
TMEAN	1.19	0.145	104	5.2	0.1183	0.195	0.0289	0.078
STDEV	2.53	0.233	144	26.2	0.0862	0.228	0.0709	0.447
SEMEAN	0.57	0.052	32	5.8	0.0193	0.051	0.0158	0.100
MAX	10.50	0.780	430	115.0	0.3400	0.700	0.2200	2.000
MIN	0.00	0.000	5	0.0	0.0000	0.000	0.0000	0.000
Q3	1.95	0.333	163	6.6	0.1700	0.360	0.0600	0.195
Q1	0.20	0.000	13	0.7	0.0500	0.000	0.0000	0.000

	Ni	Cr
N	20	20
NMISS	2	2
MEAN	0.286	0.070
MEDIAN	0.000	0.000
TMEAN	0.204	0.028
STDEV	0.618	0.208
SEMEAN	0.138	0.047
MAX	2.050	0.900
MIN	0.000	0.000
Q3	0.075	0.000
Q1	0.000	0.000

Table of the Correlation Coefficients between all Twenty-Six Water Quality Parameters for the Standing Pot Liquor in the Churnet 1 Gully Pot.

Table 7.15

	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
DO	-0.512								
PH	-0.479	0.092							
ALK	0.543	-0.518	0.170						
TH	-0.557	0.238	0.867	-0.028					
COND	-0.657	0.272	0.684	-0.290	0.925				
SS	-0.345	-0.093	0.609	-0.099	0.553	0.507			
BOD	-0.012	0.051	-0.219	-0.024	-0.222	-0.053	-0.281		
COD	0.350	-0.411	0.143	0.555	0.206	-0.011	0.056	0.175	
PHOS	-0.131	0.166	0.128	0.144	0.354	0.416	-0.188	0.449	0.541
CL	-0.531	0.273	0.525	-0.397	0.801	0.936	0.471	-0.057	0.037
SUL	-0.475	0.179	0.783	-0.085	0.923	0.897	0.454	-0.224	0.063
AMM	0.390	-0.507	-0.123	0.304	-0.118	-0.165	-0.110	-0.017	0.607
NIT	-0.042	-0.079	0.660	0.167	0.682	0.600	0.482	-0.239	0.249
Na	-0.547	0.358	0.524	-0.334	0.806	0.927	0.269	0.012	-0.013
K	-0.337	0.180	0.658	0.051	0.817	0.792	0.602	-0.254	0.341
Fe	0.413	-0.463	-0.049	0.321	0.005	-0.054	-0.011	-0.049	0.450
Pb	-0.367	0.038	0.568	-0.207	0.834	0.875	0.378	-0.233	0.284
Ca	-0.507	0.192	0.793	-0.164	0.933	0.927	0.645	-0.244	0.112
Mg	0.250	-0.139	-0.083	0.314	-0.066	-0.087	-0.129	0.502	0.448
Zn	-0.038	0.026	0.395	0.098	0.670	0.680	0.250	0.131	0.397
Mn	0.064	-0.084	0.309	0.222	0.506	0.503	0.254	0.363	0.525
Cu	-0.665	0.331	0.792	-0.270	0.943	0.970	0.574	-0.144	-0.026
Cd	0.143	-0.300	0.151	0.202	0.201	0.105	0.034	-0.117	0.275
Ni	-0.600	0.265	0.671	-0.352	0.879	0.961	0.519	-0.122	-0.026
Cr	-0.443	0.114	0.315	-0.296	0.638	0.777	0.594	-0.115	******

	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
CL	0.352								
SUL	0.333	0.773							
AMM	0.257	-0.126	-0.098						
NIT	-0.164	0.532	0.614	-0.123					
Na	0.518	0.941	0.806	-0.099	0.600				
K	0.217	0.698	0.805	-0.141	0.508	0.603			
Fe	0.142	-0.008	0.027	0.830	-0.204	-0.017	0.024		
Pb	0.392	0.841	0.833	0.195	0.512	0.834	0.676	0.314	
Ca	0.274	0.872	0.891	-0.147	0.582	0.804	0.840	0.000	0.853
Mg	0.618	-0.055	-0.101	0.284	-0.183	-0.064	-0.047	0.142	-0.075
Zn	0.543	0.714	0.656	-0.021	0.410	0.708	0.621	0.225	0.688
Mn	0.599	0.519	0.526	0.168	0.398	0.515	0.493	0.246	0.478
Cu	0.347	0.904	0.890	-0.163	0.618	0.897	0.751	-0.075	0.845
Cd	0.084	0.118	0.084	0.589	-0.103	0.096	0.098	0.871	0.417
Ni	0.302	0.968	0.875	-0.157	0.574	0.918	0.746	-0.042	0.849
Cr	0.217	0.777	0.559	-0.159	0.542	0.612	0.766	-0.006	0.677

	Ca	Mg	Zn	Mn	Cu	Cd	Ni
Mg	-0.016						
Zn	0.657	0.235					
Mn	0.451	0.479	0.823				
Cu	0.948	-0.096	0.603	0.446			
Cd	0.144	-0.017	0.315	0.176	0.092		
Ni	0.936	-0.075	0.658	0.481	0.955	0.106	
Cr	0.712	-0.043	0.605	0.448	0.665	0.120	0.718

Graphs of Gully Pot Liquor Quality for Churnet 1 Gully Pot.

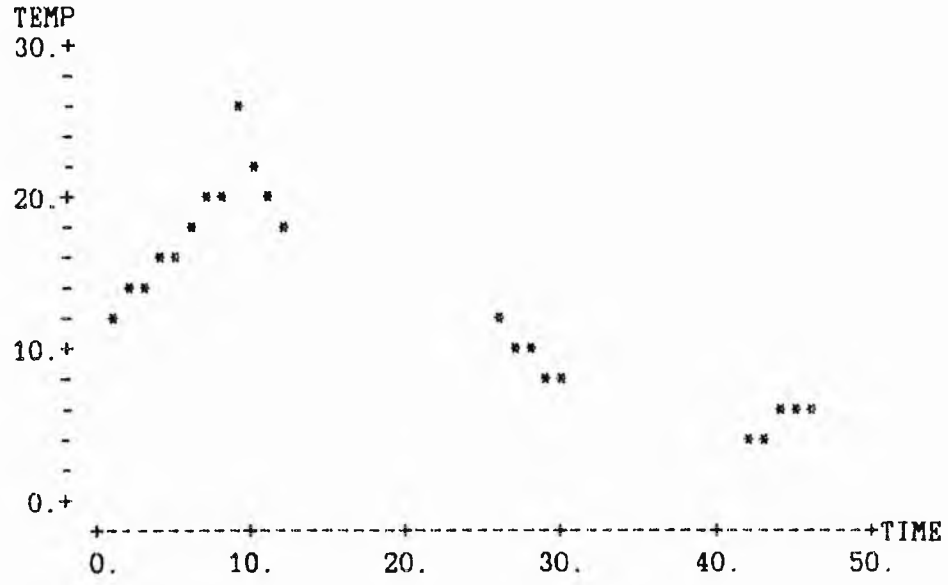


Figure 7.114

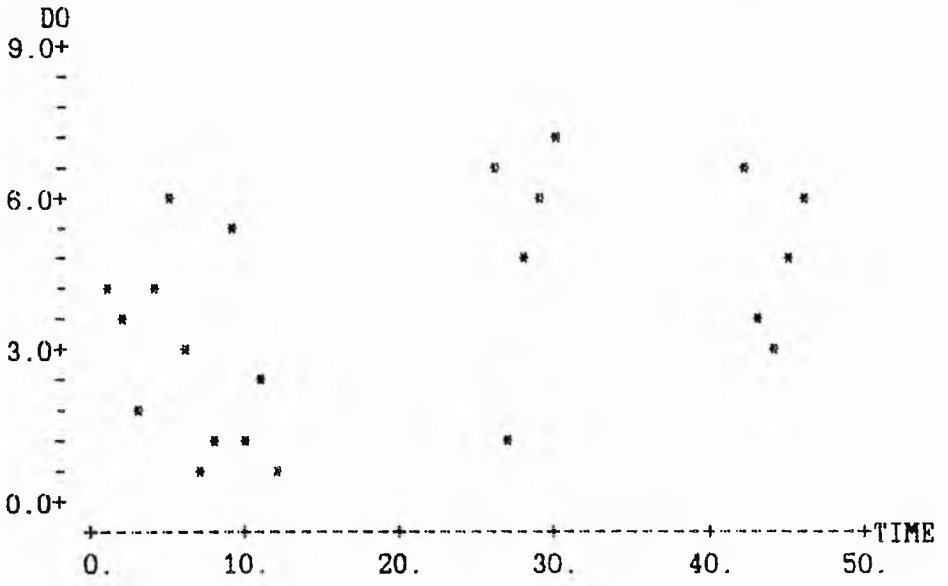


Figure 7.115

Graphs of Gully Pot Liquor Quality for Churnet 1 Gully Pot.

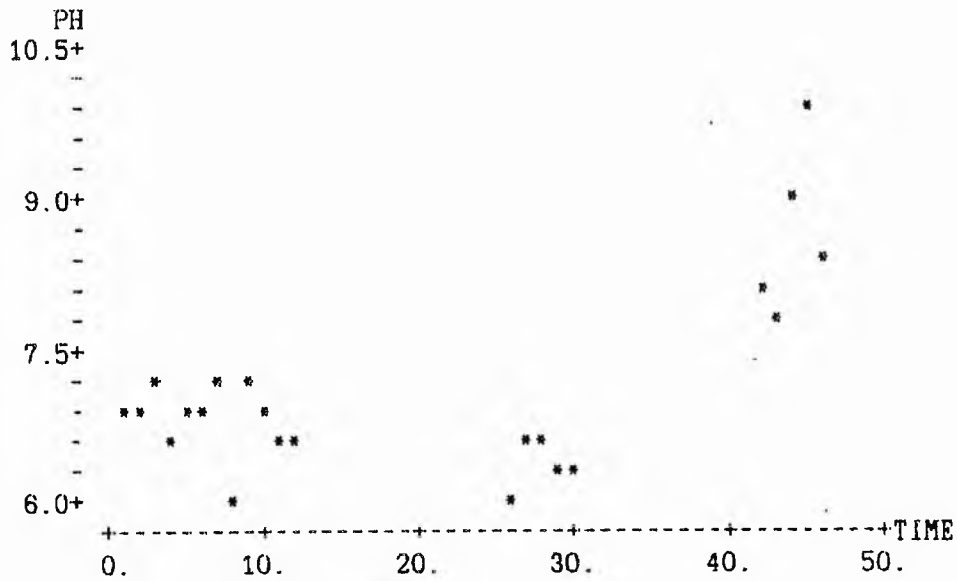
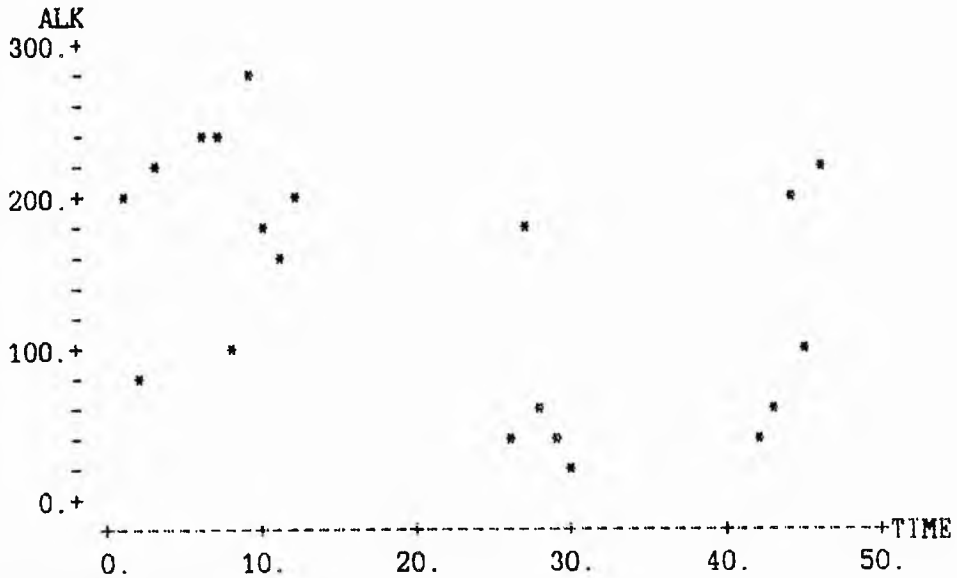


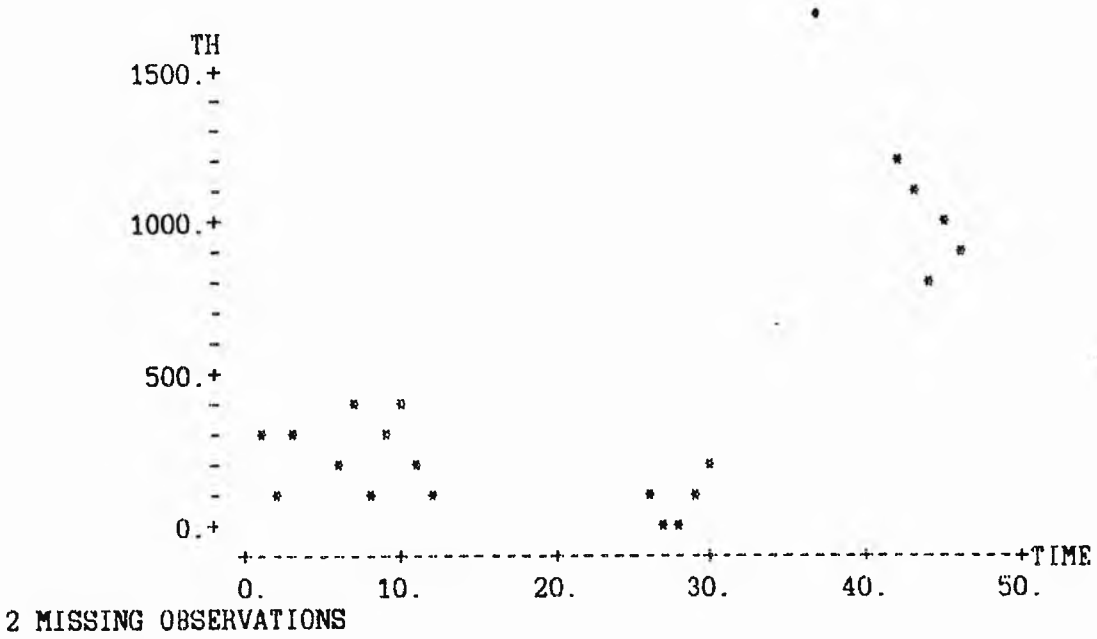
Figure 7.116



2 MISSING OBSERVATIONS

Figure 7.117

Graphs of Gully Pot Liquor Quality for Churnet 1 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.118

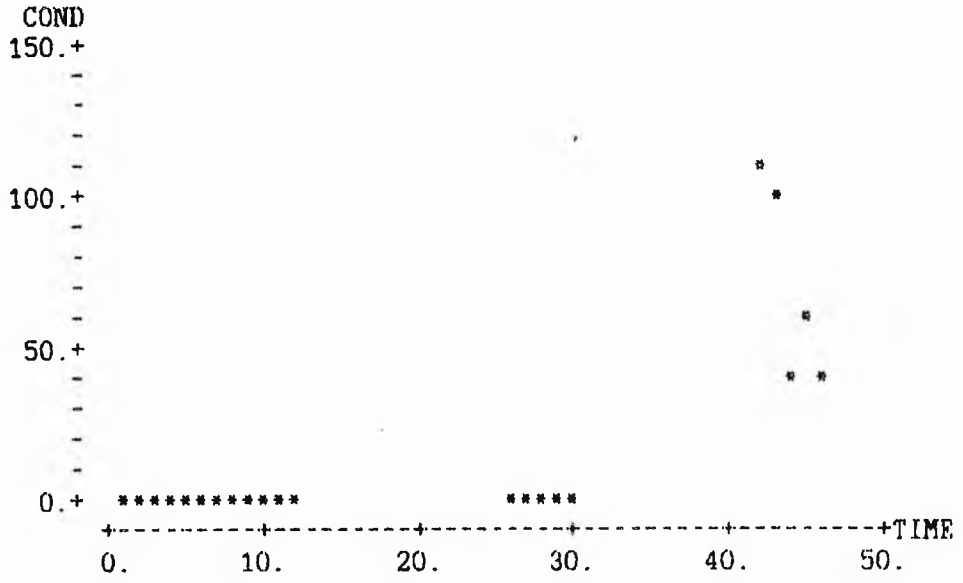
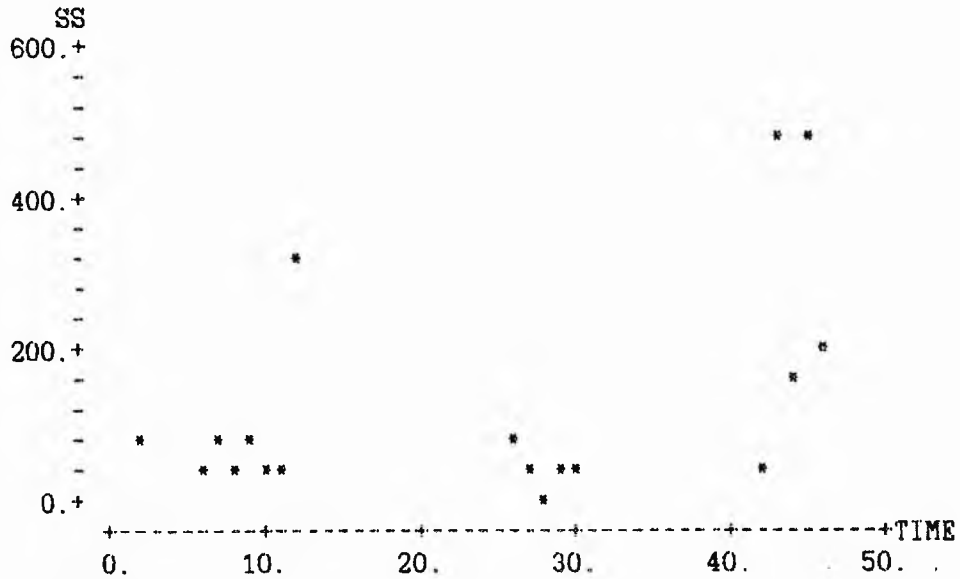


Figure 7.119

Graphs of Gully Pot Liquor Quality for Churnet 1 Gully Pot.



4 MISSING OBSERVATIONS

Figure 7.120

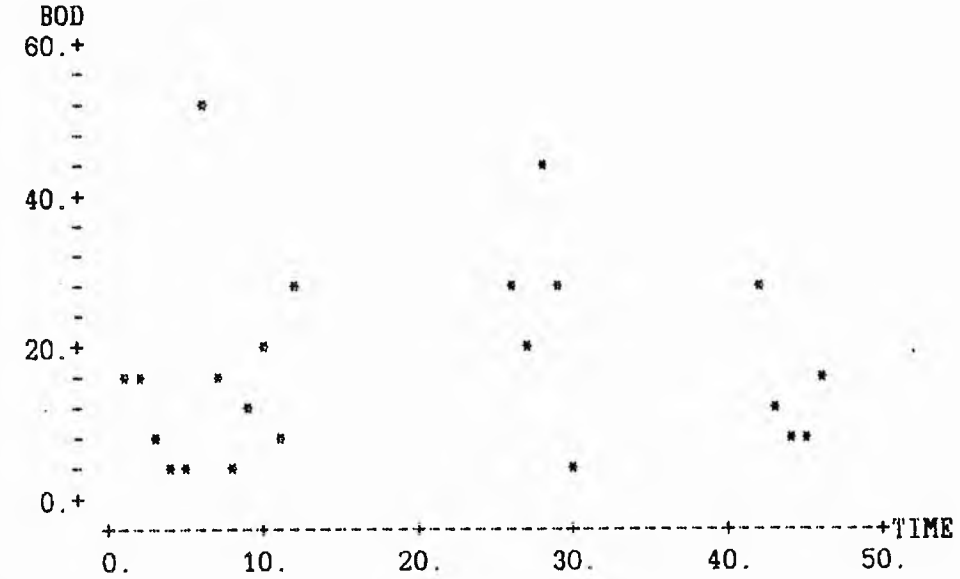
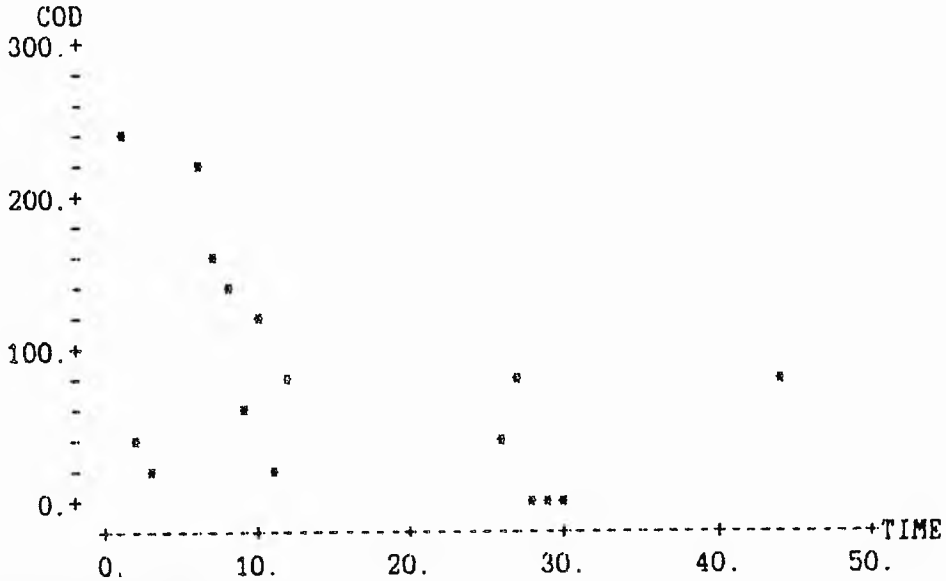


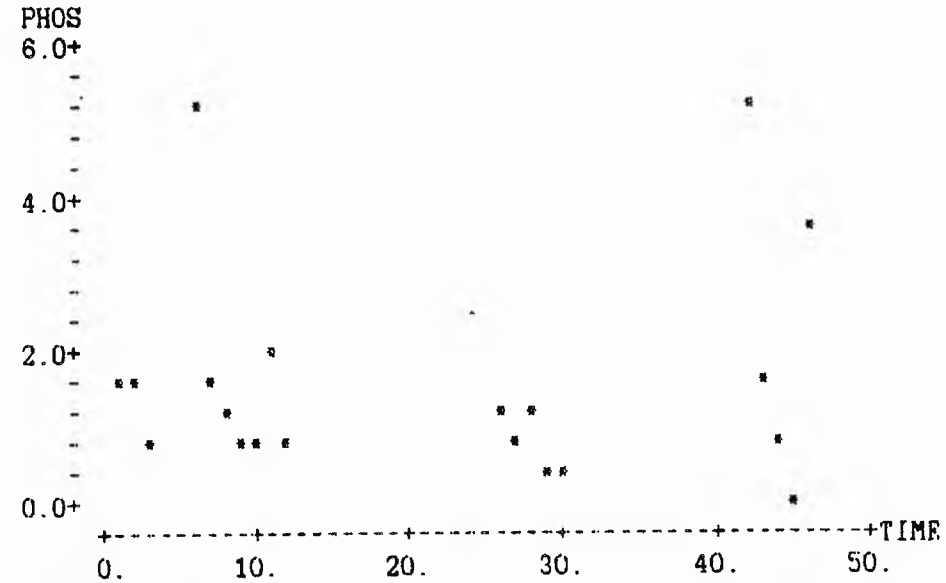
Figure 7.121

Graphs of Gully Pot Liquor Quality for Churnet 1 Gully Pot.



6 MISSING OBSERVATIONS

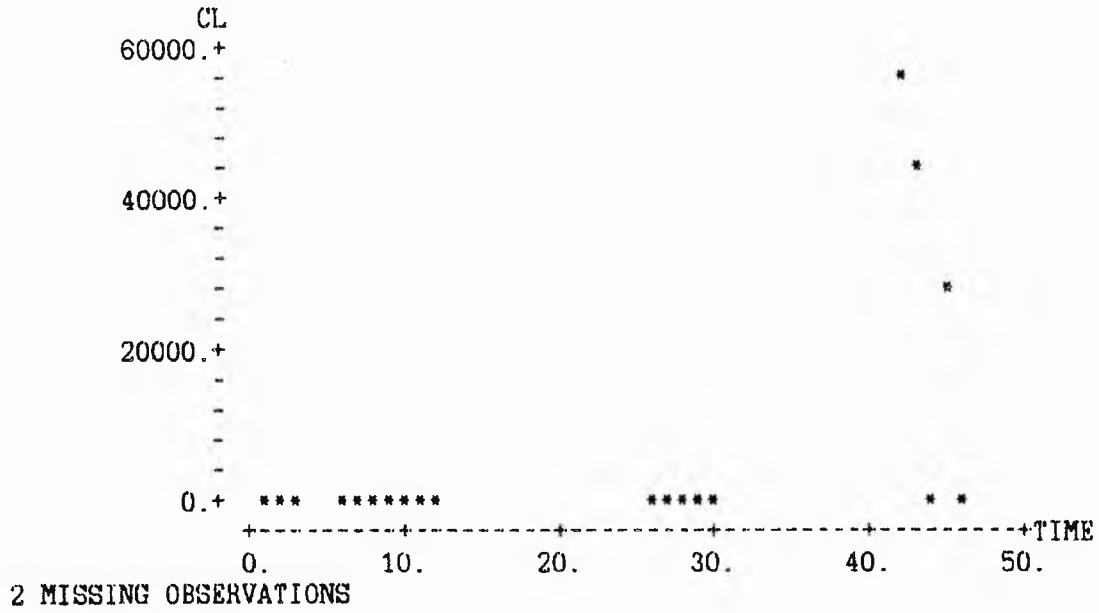
Figure 7.122



2 MISSING OBSERVATIONS

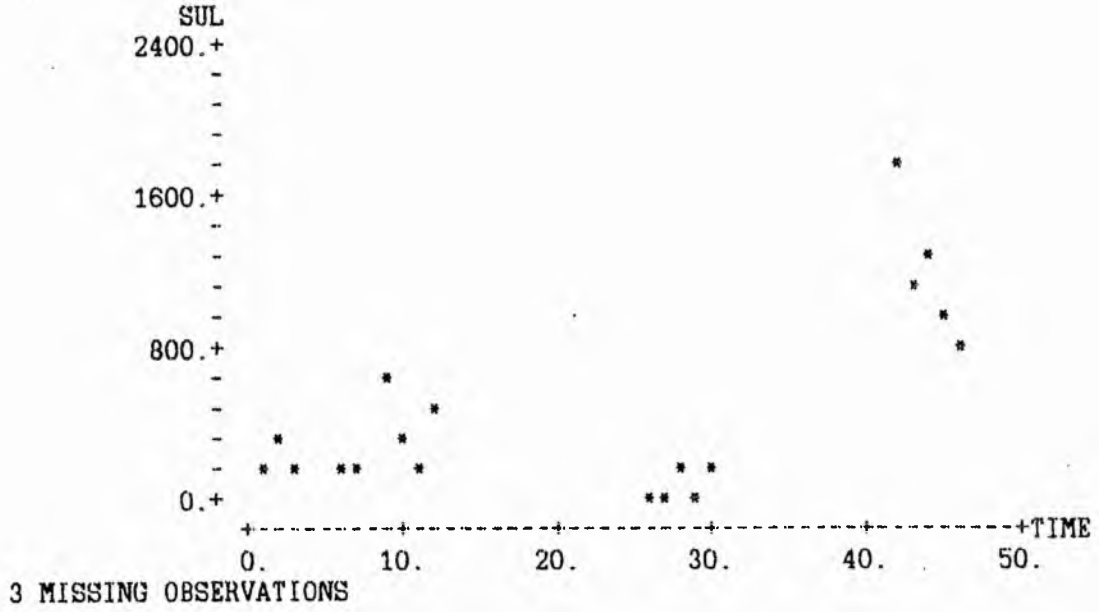
Figure 7.123

Graphs of Gully Pot Liquor Quality for Churnet 1 Gully Pot.



2 MISSING OBSERVATIONS

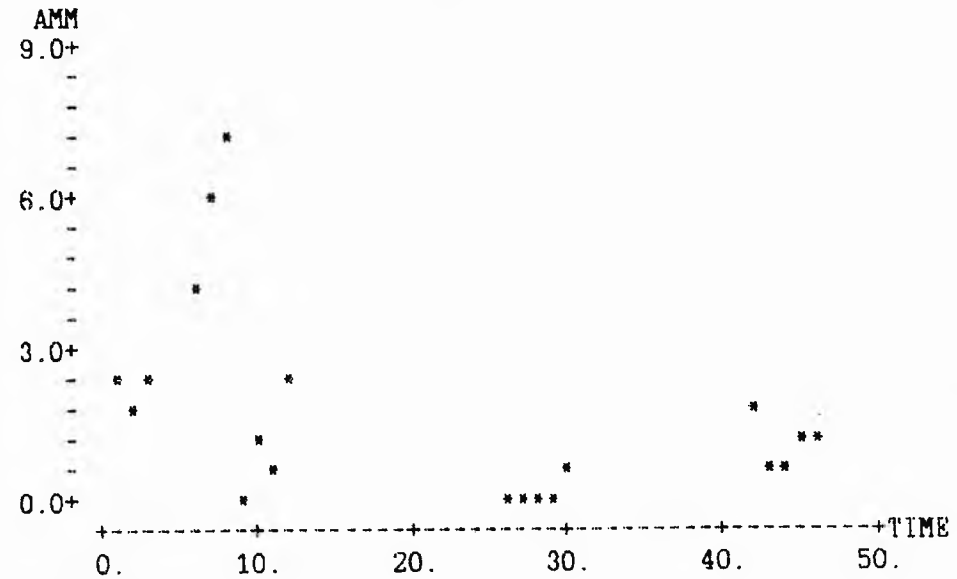
Figure 7.124



3 MISSING OBSERVATIONS

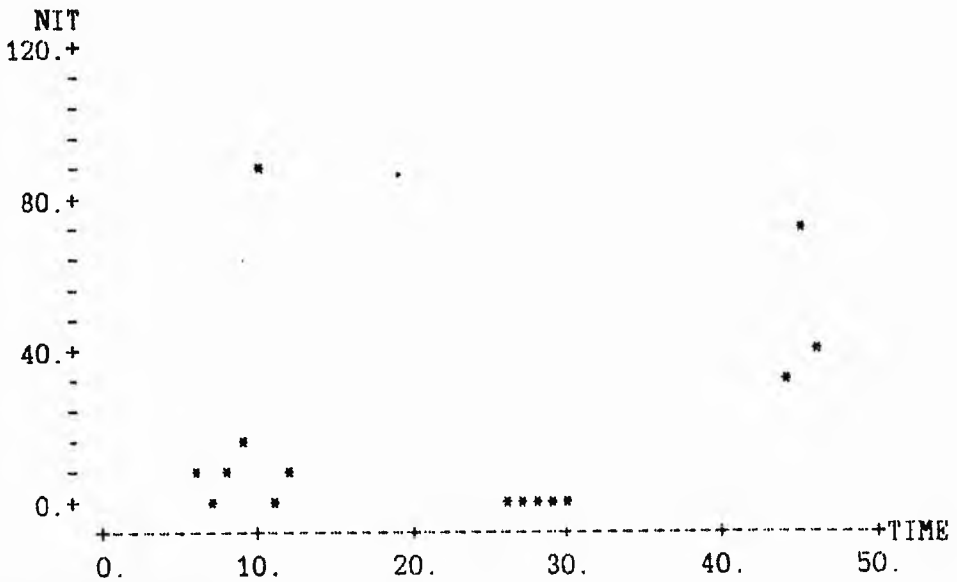
Figure 7.125

Graphs of Gully Pot Liquor Quality for Churnet 1 Gully Pot.



2 MISSING OBSERVATIONS

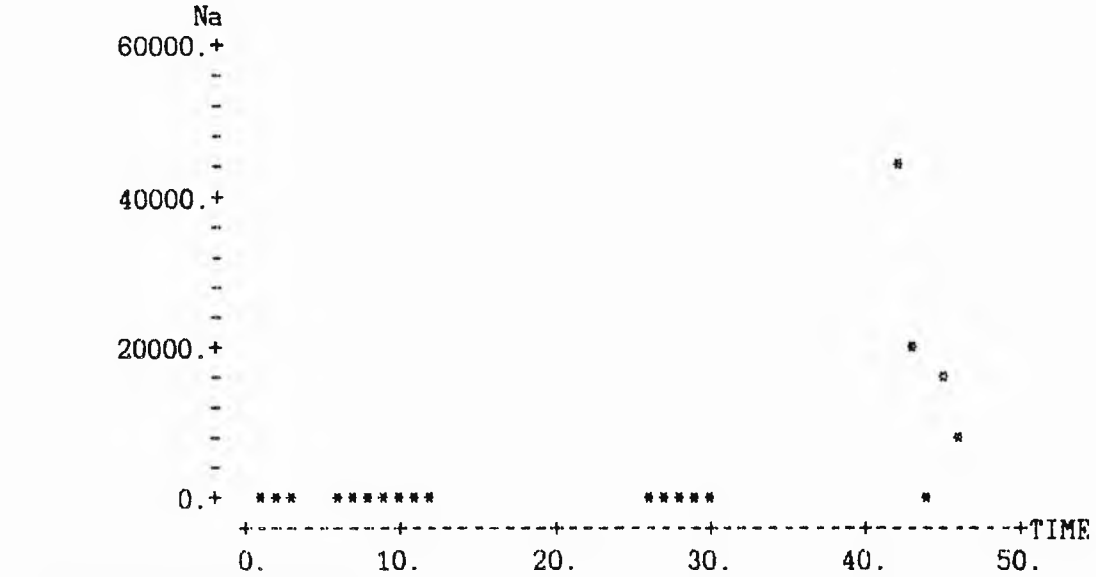
Figure 7.126



7 MISSING OBSERVATIONS

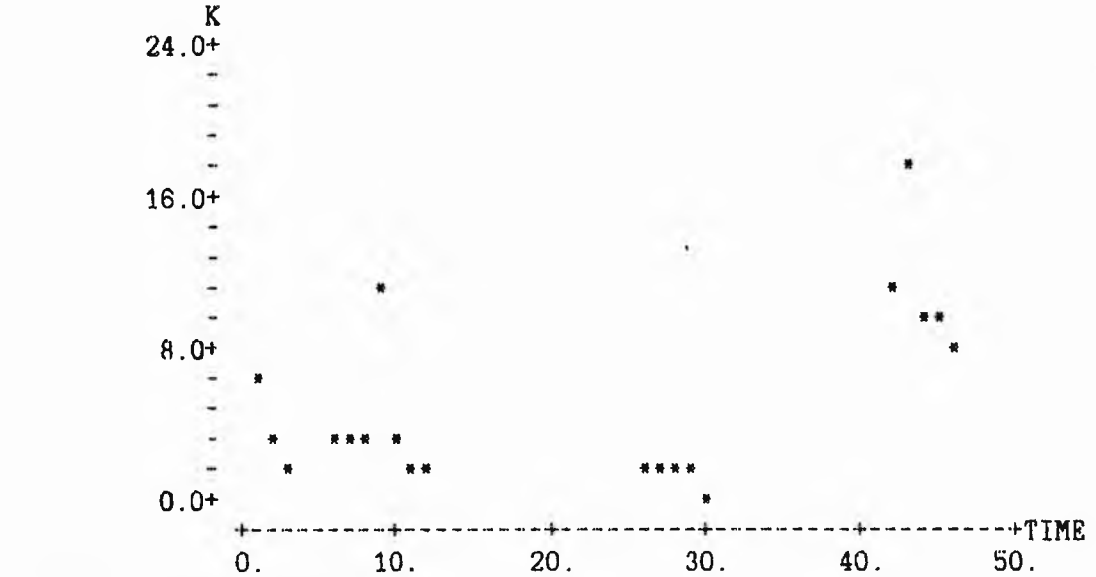
Figure 7.127

Graphs of Gully Pot Liquor Quality for Churnet 1 Gully Pot.



2 MISSING OBSERVATIONS

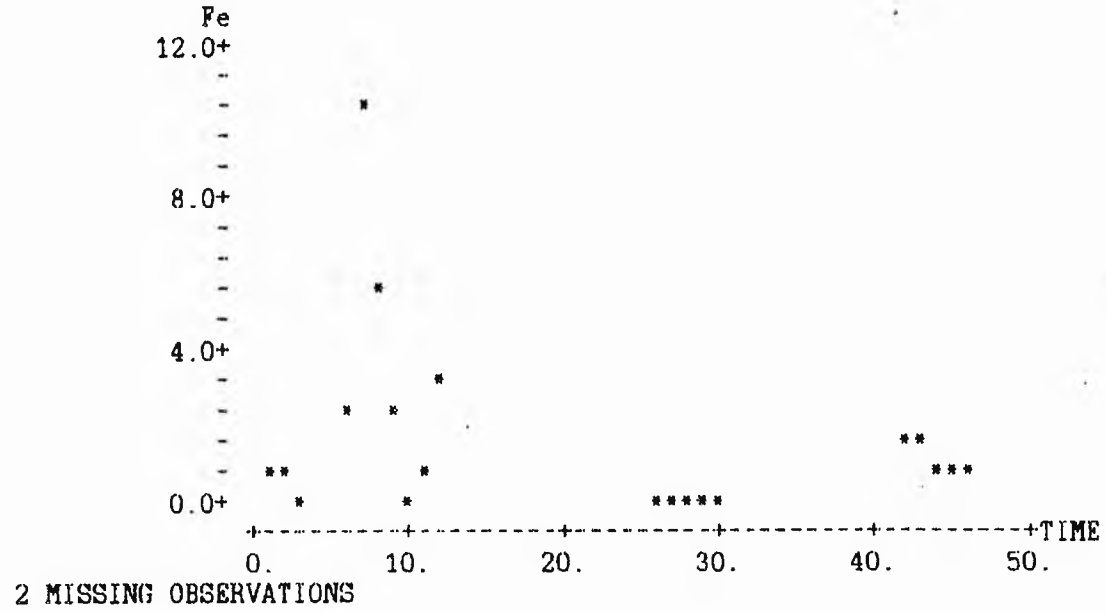
Figure 7.128



2 MISSING OBSERVATIONS

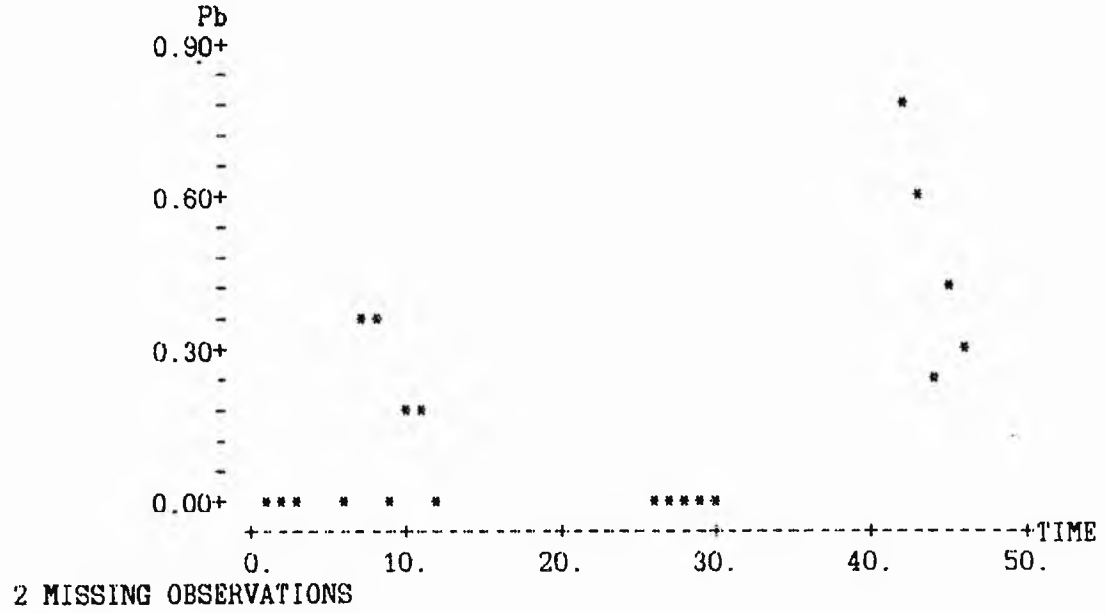
Figure 7.129

Graphs of Gully Pot Liquor Quality for Churnet 1 Gully Pot.



2 MISSING OBSERVATIONS

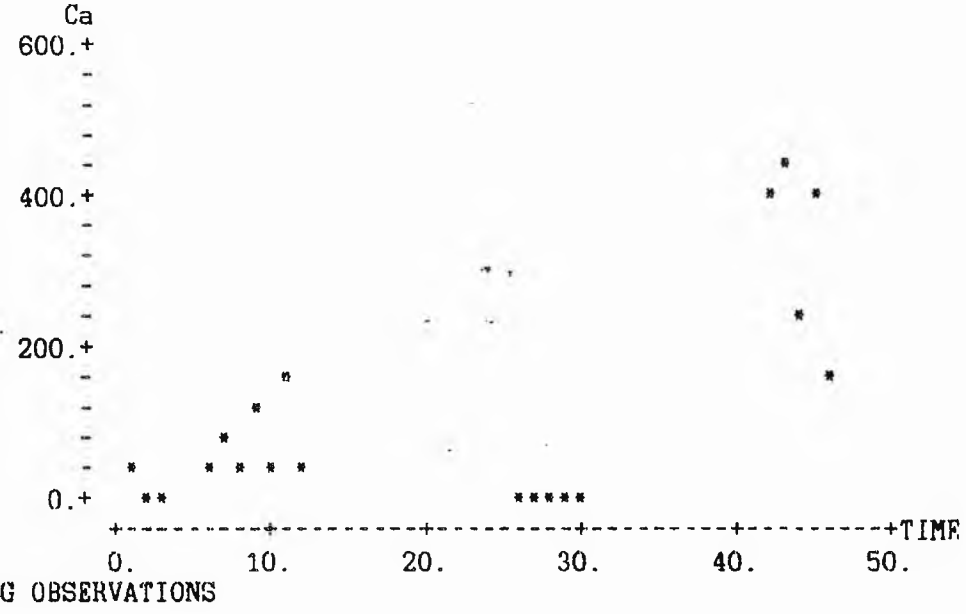
Figure 7.130



2 MISSING OBSERVATIONS

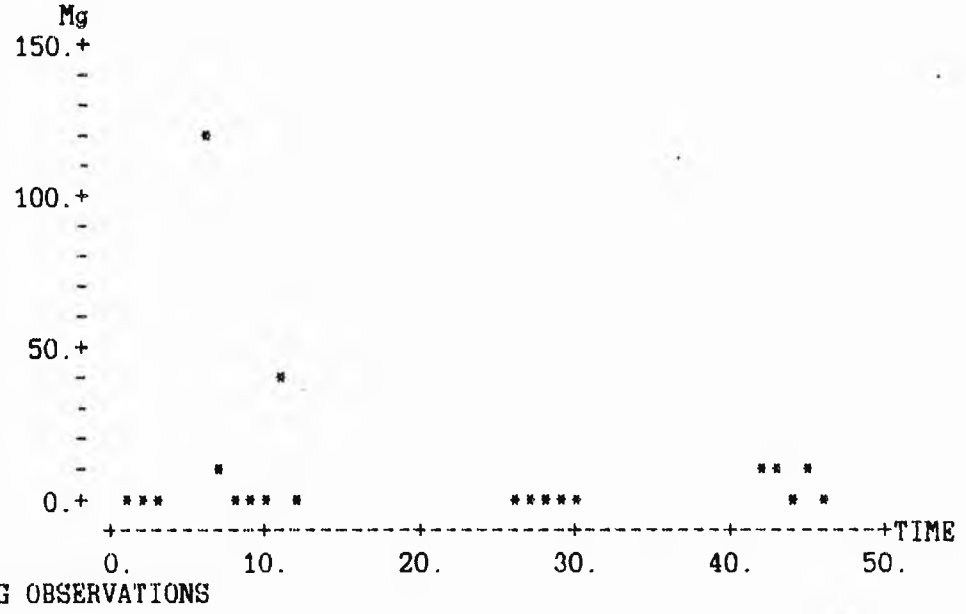
Figure 7.131

Graphs of Gully Pot Liquor Quality for Churnet 1 Gully Pot.



2 MISSING OBSERVATIONS

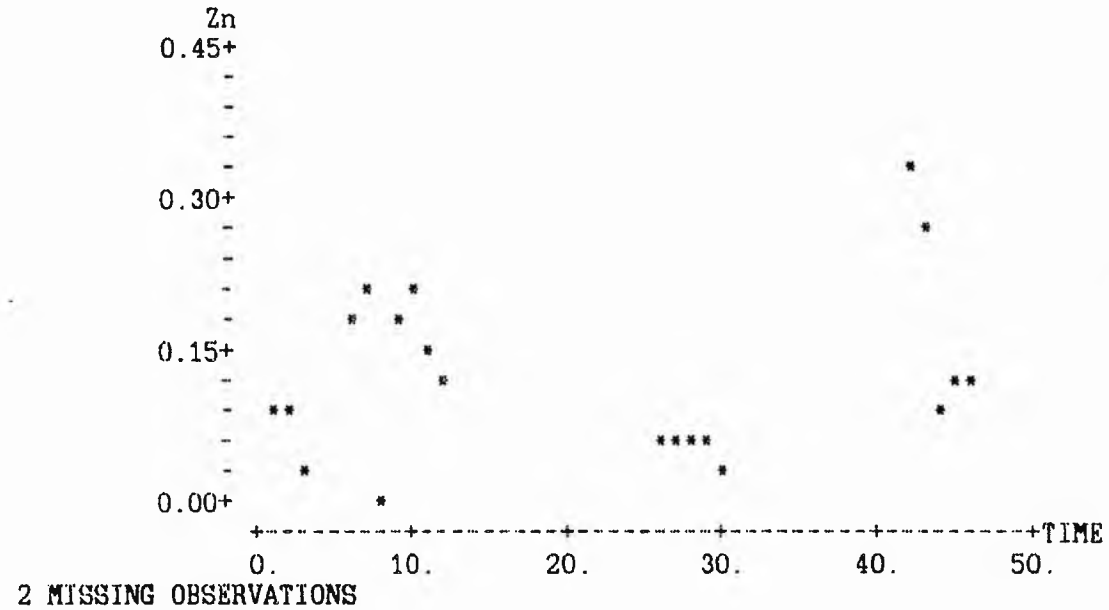
Figure 7.132



2 MISSING OBSERVATIONS

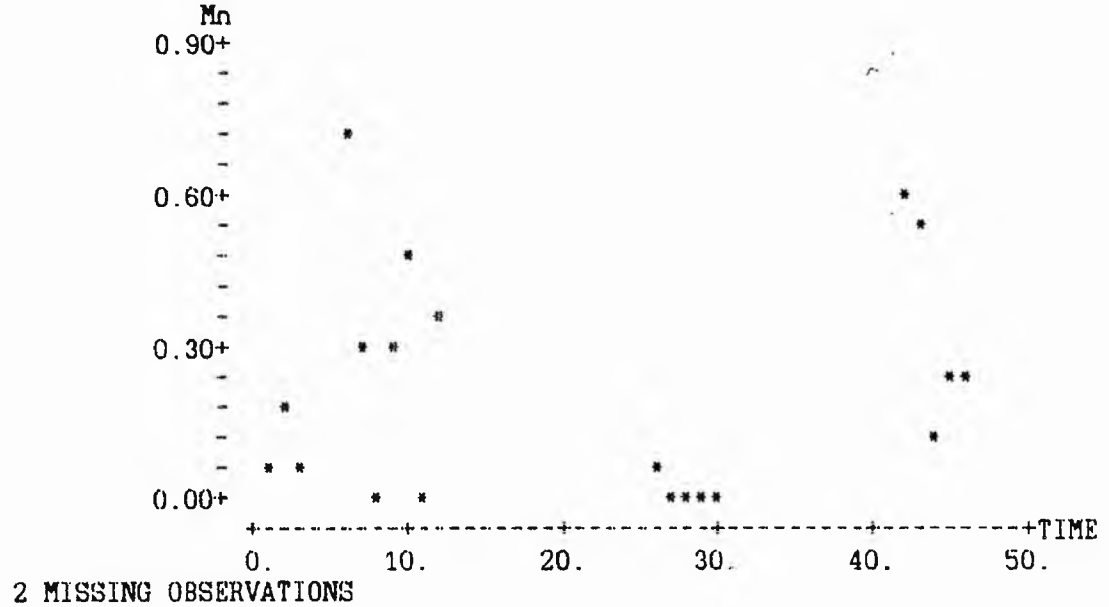
Figure 7.133

Graphs of Gully Pot Liquor Quality for Churnet 1 Gully Pot.



2 MISSING OBSERVATIONS

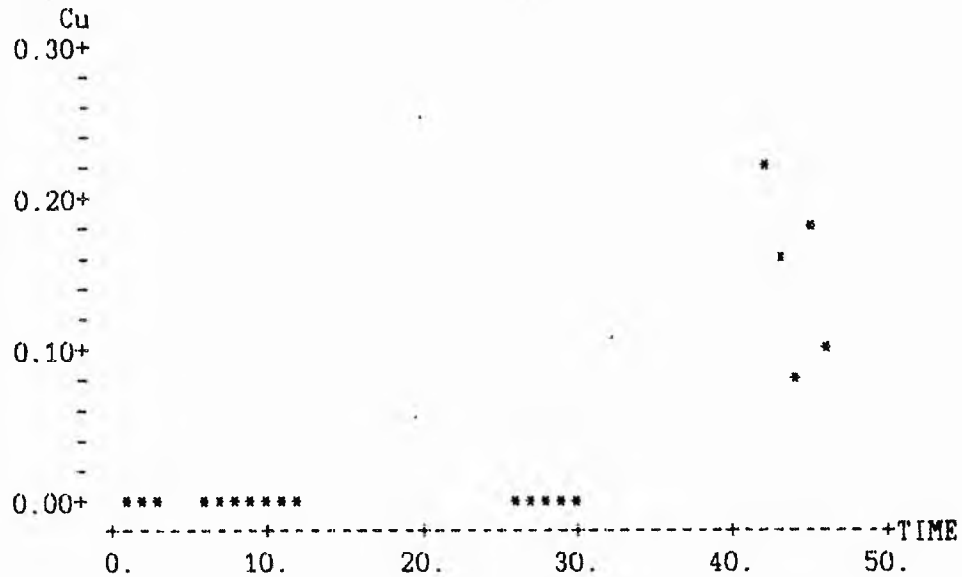
Figure 7.134



2 MISSING OBSERVATIONS

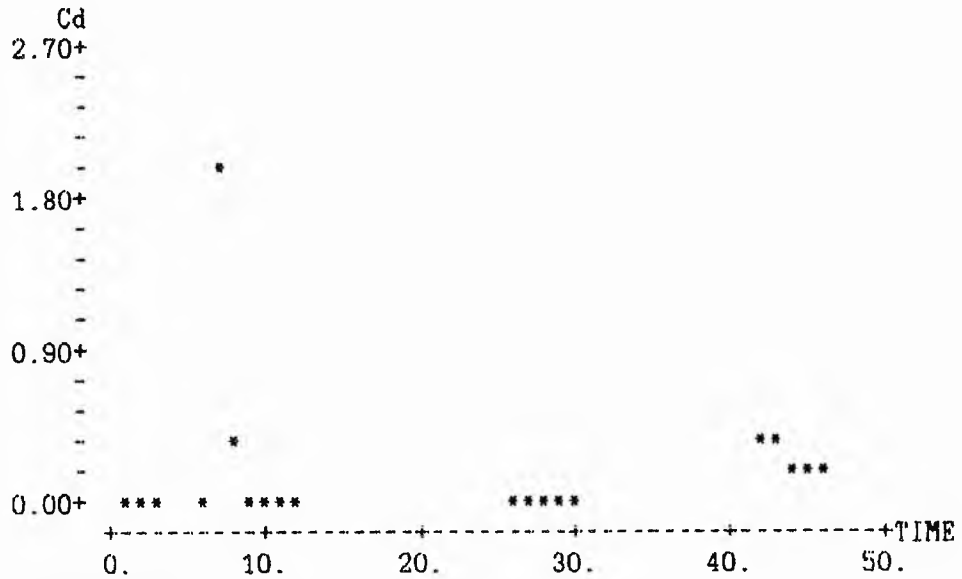
Figure 7.135

Graphs of Gully Pot Liquor Quality for Churnet 1 Gully Pot.



2 MISSING OBSERVATIONS

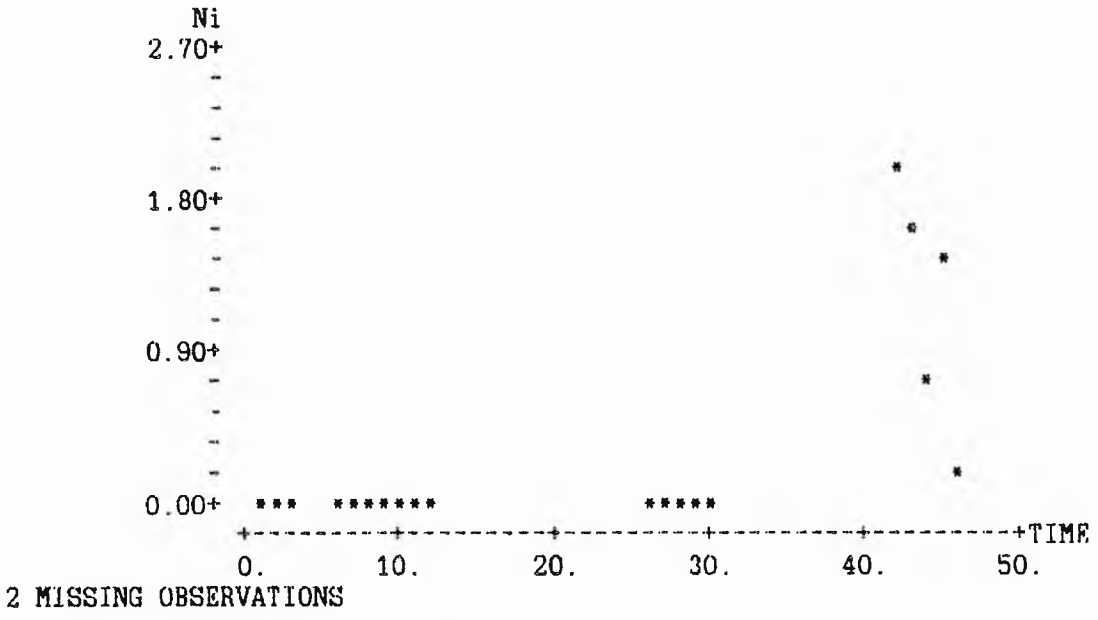
Figure 7.136



2 MISSING OBSERVATIONS

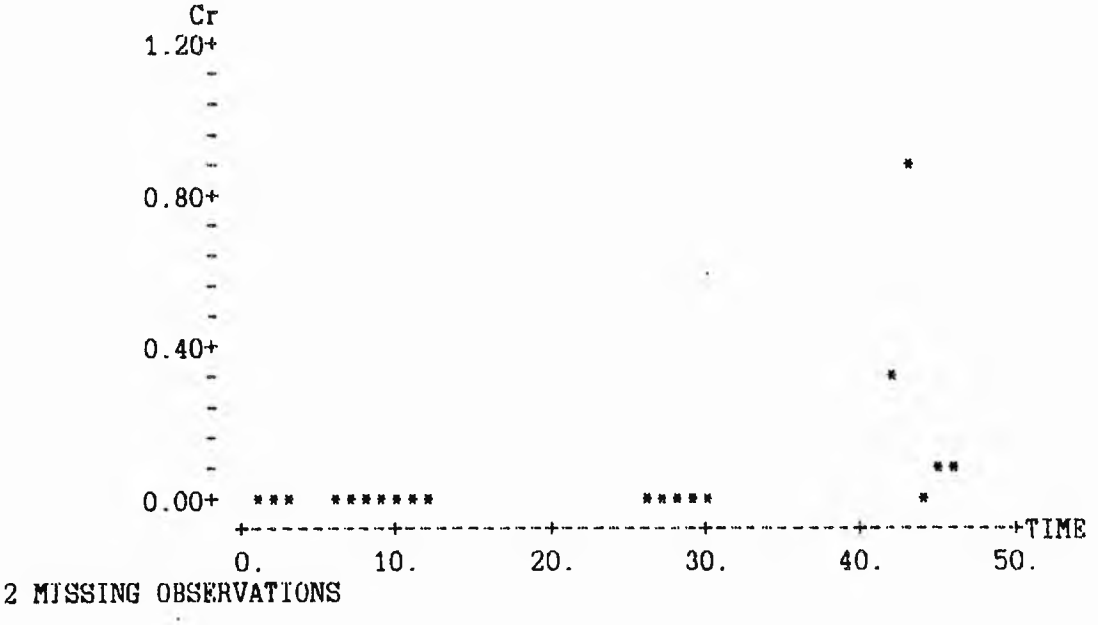
Figure 7.137

Graphs of Gully Pot Liquor Quality for Churnet 1 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.138



2 MISSING OBSERVATIONS

Figure 7.139

7.10 CHURNET 2:

(see Figures 7.140 to 7.165 and Tables 7.16 to 7.18 inclusive).

The pH values were shown to vary throughout the summer period within the range of pH 6.2-7.6 which is quite a large range in comparison to some of the other pots liquors. All the autumn period values were below the pH 7.0 neutral point but they did increase in the spring period. The acidic values found in the autumn were most likely to have been maintained by the influx into the pot of decaying vegetation through leaf fall and other organic matter, whose decomposition on the road surface and within the pot chamber itself, would produce humic acids (whose pH was generally around pH 3.8). The higher, spring period values led to a maximum value of pH 9.9 and this trend was consistent with results derived from the other gully pots under study. Churnet 2 gully liquor clearly illustrated the trends for Conductivity, sodium and chloride as found in the Tame gully pots, during the spring period. The effect was not as marked as that found in the Churnet 1 gully pot and the maxima obtained were a Conductivity of 39.9 (x1000) μscm-1, a sodium value of 13000.0 mgl-1 and a chloride concentration of 17547.0 mgl-1 as Cl^-.

The associated effect of higher calcium values due to the rock salting can also be seen for the Churnet 2 gully pot liquor. The sulphate concentration was also seen to dramatically rise to a maximum of 1115.0 mgl-1 as SO_4^{2-}, in the spring period and the maximum Total Hardness value of 970.0 mgl-1 as $CaCO_3$ is explained by the increased inflow of calcium in the meltwaters, predominantly in the form of calcium sulphate. Further evidence of this important chemical association was provided by the correlation analysis (Table 7.18) of

all the parameters under study. The value for the correlation coefficient between the calcium and sulphate concentrations for the Churnet 2 gully pot liquor over the whole study period, was r = +0.852. This highly significant correlation result adds weight to the argument that the calcium was essentially in the form of a sulphate within the pot liquor.

The SS values increased during the spring period to a maximum of 230 mgl-1 but no coherent, temporal pattern for the SS determinations was evident. The same can also be said for the values obtained for BOD and COD which varied greatly throughout the study period, but no seasonal fluctuations could be detected.

During the summer period, high ammonia values were measured but these concentrations decreased during the autumn period. These findings were consistent with those obtained from other pot liquors.

The four heavy metals, copper, cadmium, nickel and chromium all showed detectable concentrations in the spring period with no detection during the autumn period. One interesting observation made in the analysis of the data for the Churnet 2 gully pot, was that all four metals listed above were measured at varying times during the summer period. Nickel and chromium were both measured in the liquor sampled on the 840718 in concentrations of 0.15 and 0.13 mgl-1, respectively. Such a presence was probably due to a local source of these metals within the micro-catchment or by the specific dumping of a material such as brake fluid, engine oil or paint for example, either directly into or adjacent to the gully pot.

One marked characteristic of the Churnet 2 gully pot liquor is the extreme pH values observed during the spring period. pH values of 9.6 and 9.9 were found in the pot liquor, and the field notes kept during the sampling procedure do not reveal the presence of any cleaning

fluids (ie. caustic materials), nor any indication of highly alkaline conditions in and around the pot. The high pH values for a naturally occurring water would do much to change the chemical equilibrium found within the pot liquor and the interaction between the liquor and the basal sediments found in the pot is likely to be enhanced.

Table 7.16

Table of all the Water Quality Data collected over the Twenty-Two Week Period for the Gully Pot Standing Liquor in the Churnet 2 Gully Pot.

ROW	DATE	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
1	84Ø5Ø9	11.Ø	3.1	7.5	21Ø	21Ø	Ø.55	*	5	289
2	84Ø516	14.Ø	2.1	6.2	5Ø	7Ø	Ø.1Ø	3	16	7Ø
3	84Ø523	14.Ø	1.7	6.9	18Ø	29Ø	Ø.ØØ	*	Ø	42
4	84Ø53Ø	15.Ø	4.9	6.7	*	*	Ø.ØØ	*	Ø	*
5	84Ø6Ø6	15.Ø	7.6	6.8	*	*	Ø.16	*	5	*
6	84Ø613	17.5	3.2	6.5	5Ø	2Ø	Ø.Ø7	Ø	59	1Ø
7	84Ø62Ø	19.Ø	Ø.9	6.5	8Ø	34Ø	Ø.16	17	18	34
8	84Ø627	21.Ø	2.2	5.9	12Ø	9Ø	Ø.32	28	6	17Ø
9	84Ø7Ø4	24.5	5.Ø	7.6	25Ø	27Ø	Ø.23	5Ø	37	93
1Ø	84Ø711	22.5	1.4	6.9	16Ø	24Ø	Ø.24	21	13	75
11	84Ø718	2Ø.Ø	2.9	6.4	18Ø	24Ø	Ø.1Ø	28	18	11
12	84Ø725	16.Ø	2.9	6.6	11Ø	23Ø	Ø.12	14	2Ø	49
13	841Ø31	12.Ø	7.2	6.1	3Ø	5Ø	Ø.Ø7	44	22	8Ø
14	841Ø7	1Ø.Ø	3.3	6.4	7Ø	5Ø	Ø.1Ø	26	11	25
15	841114	1Ø.Ø	4.Ø	6.4	4Ø	3Ø	Ø.Ø5	11	39	51
16	841121	8.Ø	6.7	6.7	3Ø	17Ø	Ø.Ø4	26	28	Ø
17	841128	7.Ø	5.9	6.6	2Ø	12Ø	Ø.Ø4	28	3	Ø
18	85Ø22Ø	2.5	5.7	7.3	7Ø	97Ø	38.9Ø	124	4Ø	126
19	85Ø227	4.5	1.4	7.2	8Ø	92Ø	39.9Ø	23Ø	7	*
2Ø	85Ø3Ø6	5.Ø	4.3	9.6	14Ø	59Ø	8.88	71	8	118
21	85Ø313	5.5	5.9	9.9	9Ø	62Ø	9.49	124	5	45
22	85Ø32Ø	4.5	7.6	7.6	19Ø	63Ø	5.21	48	23	77

ROW	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
1	Ø.3	14.2	2Ø2	Ø.6	*	32.8	5.ØØ	Ø.5Ø	Ø.ØØ
2	1.4	21.3	115	Ø.5	*	5.3	3.ØØ	Ø.3Ø	Ø.ØØ
3	Ø.5	49.6	173	Ø.7	*	1.7	1.2Ø	Ø.2Ø	Ø.ØØ
4	*	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*	*
6	1.5	7.Ø	288	2.9	6.9	4.Ø	1.2Ø	Ø.2Ø	Ø.ØØ
7	1.1	18.Ø	673	4.5	11.7	2.5	1.2Ø	16.ØØ	Ø.35
8	1.Ø	57.Ø	*	6.9	4.5	2.5	6.5Ø	1.2Ø	Ø.35
9	Ø.5	128.Ø	452	Ø.1	11.2	57.Ø	18.ØØ	1.8Ø	Ø.ØØ
1Ø	1.Ø	18.Ø	394	2.1	7Ø.Ø	8.7	1.5Ø	Ø.3Ø	Ø.ØØ
11	2.6	35.Ø	144	Ø.2	Ø.9	8.2	1.65	Ø.5Ø	Ø.34
12	Ø.8	21.Ø	471	Ø.5	9.1	8.Ø	1.2Ø	Ø.5Ø	Ø.ØØ
13	1.1	31.9	1Ø	Ø.3	1.7	1.8	Ø.8Ø	Ø.2Ø	Ø.ØØ
14	Ø.1	24.8	48	Ø.2	2.4	2.8	Ø.9Ø	Ø.ØØ	Ø.ØØ
15	Ø.8	17.7	77	Ø.2	2.1	1.9	Ø.7Ø	Ø.ØØ	Ø.ØØ
16	Ø.Ø	7.1	115	Ø.1	1.1	3.5	Ø.8Ø	Ø.ØØ	Ø.ØØ
17	Ø.6	14.2	58	Ø.4	1.Ø	2.7	Ø.8Ø	Ø.ØØ	Ø.ØØ
18	1.9	17547.Ø	1115	1.3	*	13ØØØ.Ø	14.1Ø	Ø.28	Ø.32
19	2.1	16662.Ø	1Ø95	Ø.2	*	97ØØ.Ø	3Ø.ØØ	Ø.75	Ø.3Ø
2Ø	8.2	64.Ø	759	Ø.5	1Ø.9	81Ø.Ø	5.8Ø	Ø.2Ø	Ø.Ø5
21	Ø.3	3899.5	894	1.4	16.1	182Ø.Ø	5.7Ø	Ø.33	Ø.15
22	4.Ø	5ØØ.Ø	413	1.4	69.3	78Ø.Ø	3.8Ø	Ø.28	Ø.28

ROW	Ca	Mg	Zn	Mn	Cu	Cd	Ni	Cr
1	57.Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
2	13.Ø	Ø.ØØ	Ø.42	Ø.Ø9	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
3	11.3	Ø.ØØ	Ø.ØØ	Ø.Ø4	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
4	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*
6	13.Ø	7.ØØ	Ø.16	Ø.1Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
7	3Ø.Ø	2.ØØ	Ø.1Ø	Ø.3Ø	Ø.ØØ	1.ØØ	Ø.ØØ	Ø.ØØ
8	37.5	2.ØØ	Ø.Ø5	Ø.2Ø	Ø.13	Ø.4Ø	Ø.ØØ	Ø.ØØ
9	8Ø.Ø	6.5Ø	Ø.16	Ø.48	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
1Ø	37.5	1.45	Ø.14	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
11	116.5	37.5Ø	Ø.16	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.15	Ø.13
12	16.3	Ø.82	Ø.Ø5	Ø.1Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
13	1Ø.8	Ø.8Ø	Ø.Ø4	Ø.Ø3	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
14	9.Ø	Ø.9Ø	Ø.12	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
15	9.5	Ø.8Ø	Ø.Ø4	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
16	8.6	Ø.6Ø	Ø.22	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
17	4.6	Ø.5Ø	Ø.Ø3	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
18	262.Ø	8.ØØ	Ø.16	Ø.62	Ø.1Ø	Ø.Ø6	Ø.52	Ø.ØØ
19	34Ø.Ø	6.9Ø	Ø.16	Ø.62	Ø.Ø9	Ø.13	Ø.47	Ø.1Ø
2Ø	142.Ø	1.4Ø	Ø.Ø4	Ø.Ø4	Ø.Ø8	Ø.ØØ	Ø.19	Ø.ØØ
21	314.Ø	3Ø.ØØ	Ø.Ø7	Ø.Ø7	Ø.Ø5	Ø.Ø5	Ø.1Ø	Ø.2Ø
22	51.Ø	1.5Ø	Ø.Ø7	Ø.1Ø	Ø.Ø2	Ø.Ø1	Ø.25	Ø.2Ø

Statistical Summary of the Water Quality Data for the Standing Pot Liquor collected in the Churnet 2 Gully Pot.

Table 7.17

	TEMP	DO	PH	ALK	TH	COND	SS	BOD
N	22	22	22	20	20	22	18	22
NMISS	0	0	0	2	2	0	4	0
MEAN	12.66	4.09	7.01	107.6	307	4.8	49.6	17.4
MEDIAN	13.00	3.65	6.70	85.0	235	0.1	28.0	14.5
TMEAN	12.58	4.07	6.93	104.4	287	3.2	41.4	16.2
STDEV	6.43	2.13	1.00	67.9	288	11.6	57.3	15.3
SEMEAN	1.37	0.45	0.21	15.2	64	2.5	13.5	3.3
MAX	24.50	7.60	9.90	250.0	970	39.9	230.0	59.0
MIN	2.50	0.90	5.90	20.0	20	0.0	0.0	0.0
Q3	17.87	5.90	7.35	175.0	527	1.7	55.3	24.3
Q1	6.62	2.17	6.40	50.0	75	0.1	16.3	5.0

	COD	PHOS	CL	SUL	AMM	NIT	Na	K
N	19	20	20	19	20	15	20	20
NMISS	3	2	2	3	2	7	2	2
MEAN	71.8	1.49	1957	395	1.25	14.6	1313	5.19
MEDIAN	51.0	1.00	28	288	0.50	6.9	7	1.58
TMEAN	63.3	1.20	1199	375	1.00	11.4	736	4.06
STDEV	69.3	1.84	5254	356	1.73	22.9	3503	7.45
SEMEAN	15.9	0.41	1175	82	0.39	5.9	783	1.67
MAX	289.0	8.20	17547	1115	6.90	70.0	13000	30.00
MIN	0.0	0.00	7	10	0.10	0.9	2	0.70
Q3	93.0	1.80	112	673	1.40	11.7	599	5.76
Q1	25.0	0.50	18	115	0.20	1.7	3	0.96

	Fe	Pb	Ca	Mg	Zn	Mn	Cu	Cd
N	20	20	20	20	20	20	20	20
NMISS	2	2	2	2	2	2	2	2
MEAN	1.18	0.107	78	5.4	0.1175	0.144	0.0235	0.082
MEDIAN	0.29	0.000	34	1.4	0.0900	0.075	0.0000	0.000
TMEAN	0.42	0.099	68	4.0	0.1056	0.125	0.0189	0.036
STDEV	3.52	0.150	105	10.1	0.0900	0.201	0.0418	0.235
SEMEAN	0.79	0.034	24	2.3	0.0201	0.045	0.0094	0.052
MAX	16.00	0.350	340	37.5	0.4200	0.620	0.1300	1.000
MIN	0.00	0.000	5	0.0	0.0300	0.000	0.0000	0.000
Q3	0.50	0.295	107	6.8	0.1600	0.175	0.0425	0.041
Q1	0.20	0.000	11	0.6	0.0500	0.000	0.0000	0.000

	Ni	Cr
N	20	20
NMISS	2	2
MEAN	0.084	0.0315
MEDIAN	0.000	0.0000
TMEAN	0.064	0.0239
STDEV	0.159	0.0677
SEMEAN	0.036	0.0151
MAX	0.520	0.2000
MIN	0.000	0.0000
Q3	0.138	0.0000
Q1	0.000	0.0000

Table of the Correlation Coefficients between all Twenty-Six Water Quality Parameters for the Standing Pot Liquor in the Churnet 2 Gully Pot.

Table 7.18

	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
DO	-0.427								
PH	-0.447	0.237							
ALK	0.375	-0.163	0.304						
TH	-0.559	0.124	0.591	0.176					
COND	-0.571	-0.017	0.294	-0.123	0.867				
SS	-0.544	0.048	0.483	0.035	0.843	0.898			
BOD	0.095	0.126	-0.175	-0.189	-0.184	0.076	-0.255		
COD	-0.025	-0.089	0.192	0.456	0.192	0.213	0.374	-0.222	
PHOS	-0.304	0.181	0.477	0.195	0.426	0.237	0.187	-0.042	0.122
CL	-0.500	0.003	0.179	-0.166	0.807	0.984	0.855	0.079	0.169
SUL	-0.341	-0.088	0.591	0.096	0.986	0.818	0.785	-0.015	0.215
AMM	0.396	-0.342	-0.203	-0.006	-0.088	-0.188	-0.183	-0.012	0.199
NIT	0.014	0.016	0.217	0.487	0.490	0.253	0.183	-0.085	0.223
Na	-0.515	0.049	0.181	-0.151	0.814	0.978	0.800	0.127	0.190
K	-0.194	-0.093	0.260	0.203	0.676	0.785	0.843	-0.002	0.431
Fe	0.295	-0.359	-0.116	-0.022	0.040	-0.090	-0.118	-0.010	-0.085
Pb	-0.068	-0.126	0.013	0.110	0.560	0.488	0.423	-0.079	0.095
Ca	-0.462	0.051	0.614	0.058	0.854	0.836	0.923	-0.129	0.175
Mg	0.056	0.056	0.314	0.169	0.247	0.143	0.262	0.000	-0.224
Zn	0.137	-0.216	-0.222	-0.122	-0.043	0.095	-0.052	0.217	-0.146
Mn	-0.086	-0.116	0.082	0.111	0.663	0.774	0.667	0.216	0.281
Cu	-0.317	-0.028	0.301	-0.023	0.602	0.664	0.621	-0.175	0.415
Cd	0.266	-0.403	-0.173	-0.094	0.065	-0.006	-0.040	-0.103	0.011
Ni	-0.583	0.138	0.324	0.017	0.985	0.938	0.814	0.061	0.158
Cr	-0.322	0.293	0.457	0.225	0.485	0.235	0.433	-0.166	-0.145

	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
CL	0.077								
SUL	0.344	0.762							
AMM	-0.049	-0.092	0.287						
NIT	0.215	0.097	0.288	0.106					
Na	0.133	0.989	0.757	-0.085	0.255				
K	0.127	0.769	0.689	-0.095	0.040	0.721			
Fe	-0.059	-0.076	0.221	0.473	-0.036	-0.080	-0.053		
Pb	0.237	0.480	0.604	0.503	0.129	0.481	0.370	0.412	
Ca	0.241	0.806	0.852	-0.102	0.067	0.767	0.734	-0.082	0.500
Mg	0.039	0.162	0.238	-0.071	-0.127	0.128	0.104	-0.063	0.422
Zn	-0.126	0.138	-0.051	-0.156	0.034	0.130	0.151	-0.039	-0.052
Mn	0.022	0.796	0.741	0.128	-0.018	0.789	0.868	0.251	0.510
Cu	0.382	0.611	0.860	0.432	-0.035	0.620	0.564	-0.094	0.598
Cd	-0.063	0.010	0.299	0.697	-0.073	-0.001	0.009	0.936	0.571
Ni	0.439	0.894	0.761	-0.136	0.411	0.910	0.692	-0.119	0.602
Cr	0.198	0.195	0.319	-0.081	0.396	0.147	0.192	-0.106	0.481

	Ca	Mg	Zn	Mn	Cu	Cd	Ni
Mg	0.537						
Zn	0.017	0.052					
Mn	0.609	0.023	0.177				
Cu	0.632	0.096	-0.143	0.531			
Cd	-0.017	-0.073	-0.098	0.296	0.180		
Ni	0.794	0.247	0.063	0.677	0.633	-0.055	
Cr	0.537	0.650	-0.080	0.022	0.152	-0.089	0.408

Graphs of Gully Pot Liquor Quality for Churnet 2 Gully Pot.

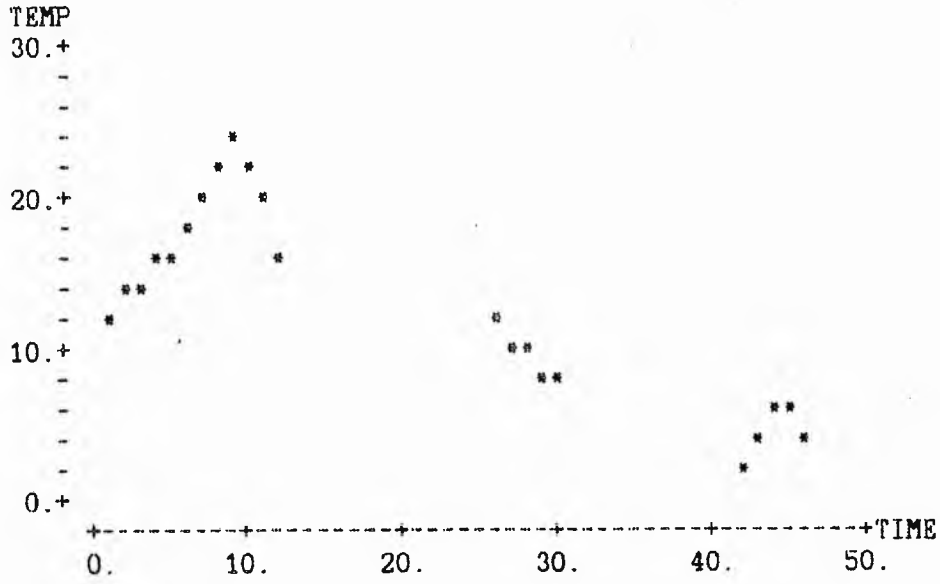


Figure 7.140

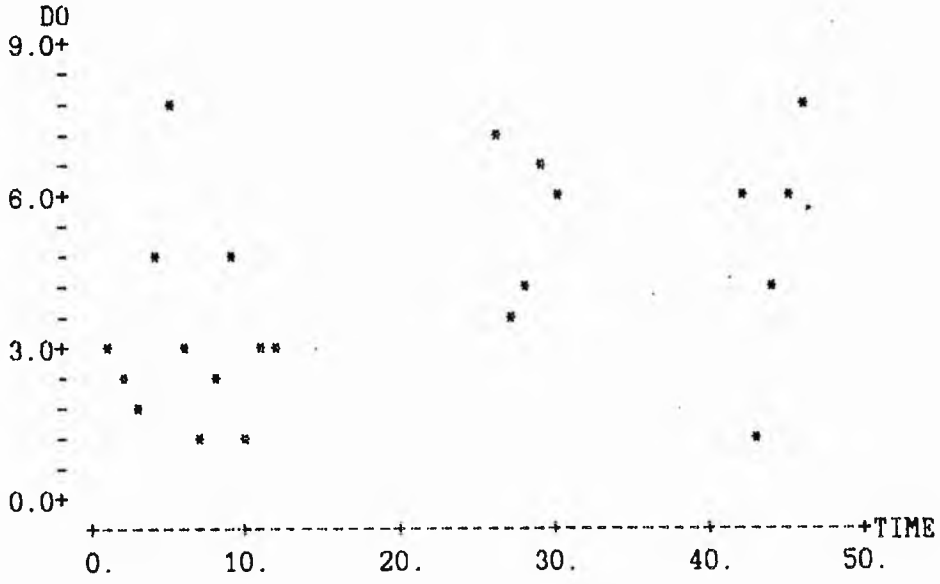


Figure 7.141

Graphs of Gully Pot Liquor Quality for Churnet 2 Gully Pot.

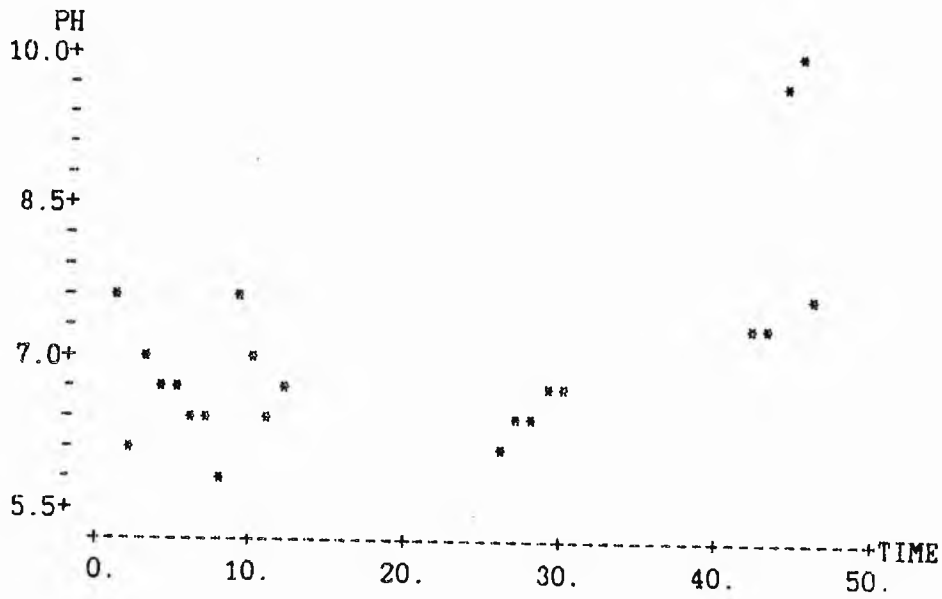
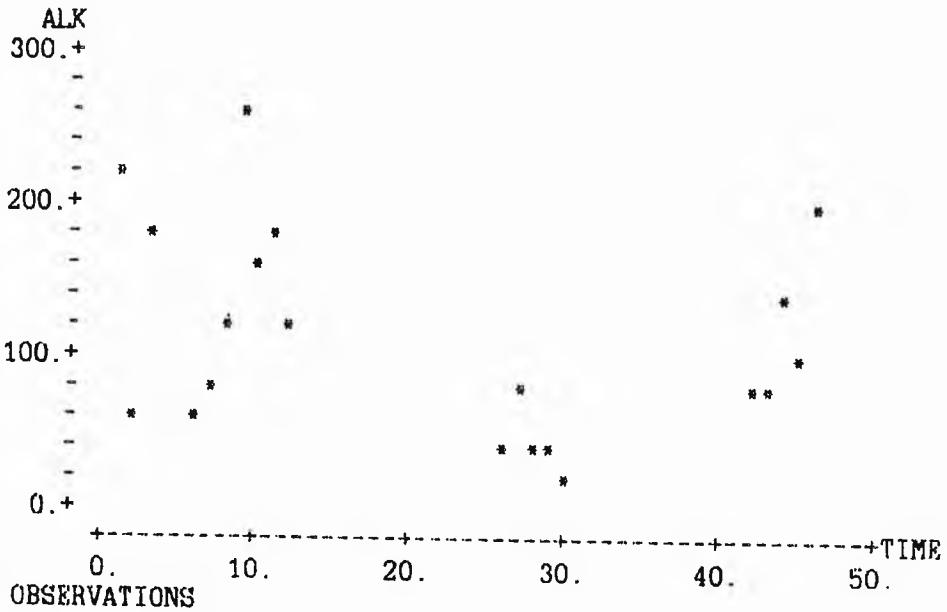


Figure 7.142



2 MISSING OBSERVATIONS

Figure 7.143

Graphs of Gully Pot Liquor Quality for Churnet 2 Gully Pot.

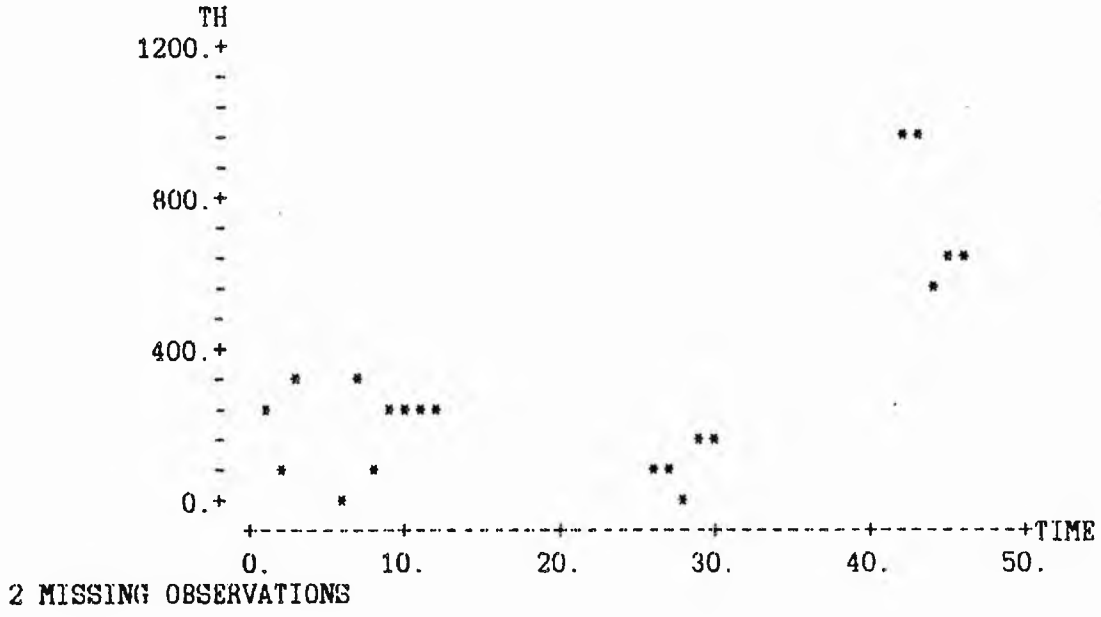


Figure 7.144

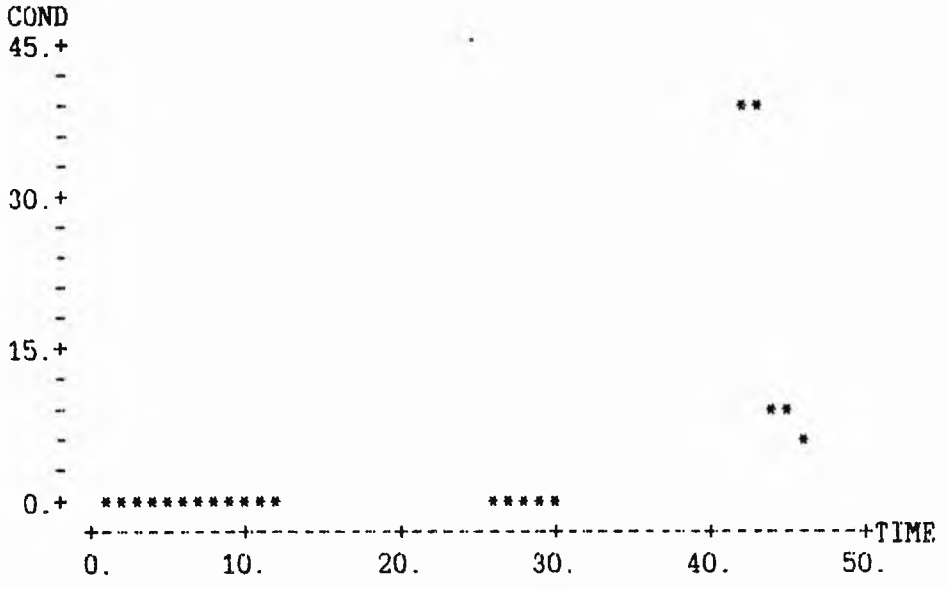
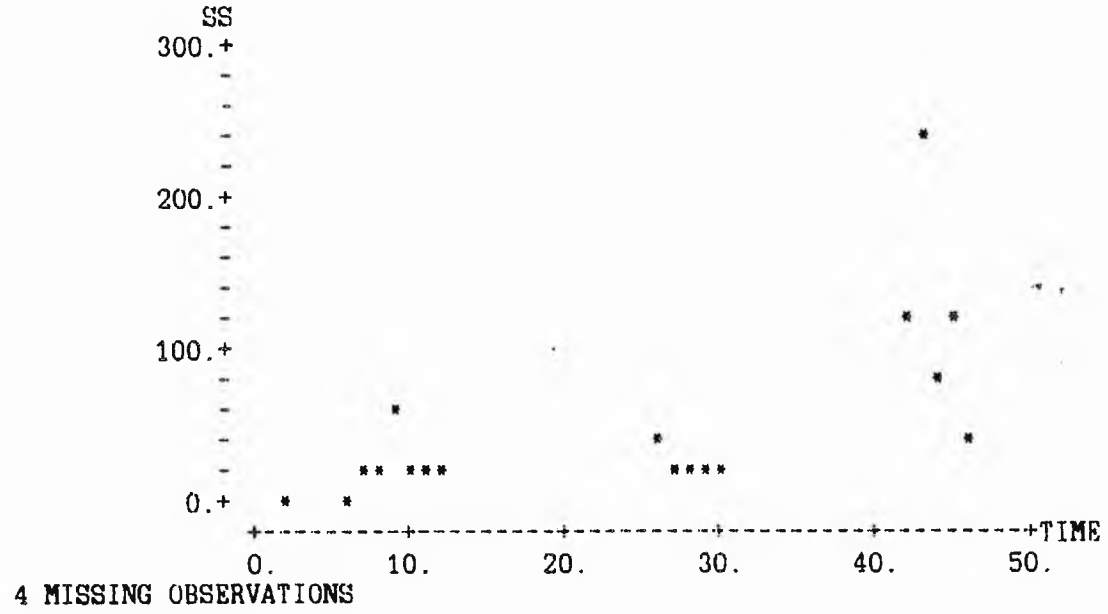


Figure 7.145

Graphs of Gully Pot Liquor Quality for Churnet 2 Gully Pot.



4 MISSING OBSERVATIONS

Figure 7.146

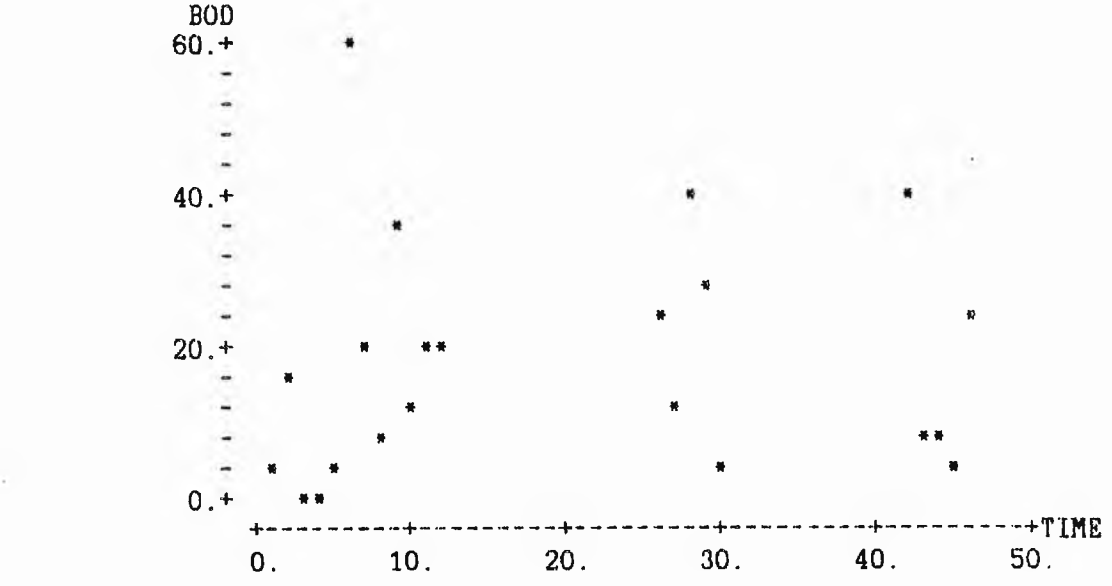


Figure 7.147

Graphs of Gully Pot Liquor Quality for Churnet 2 Gully Pot.

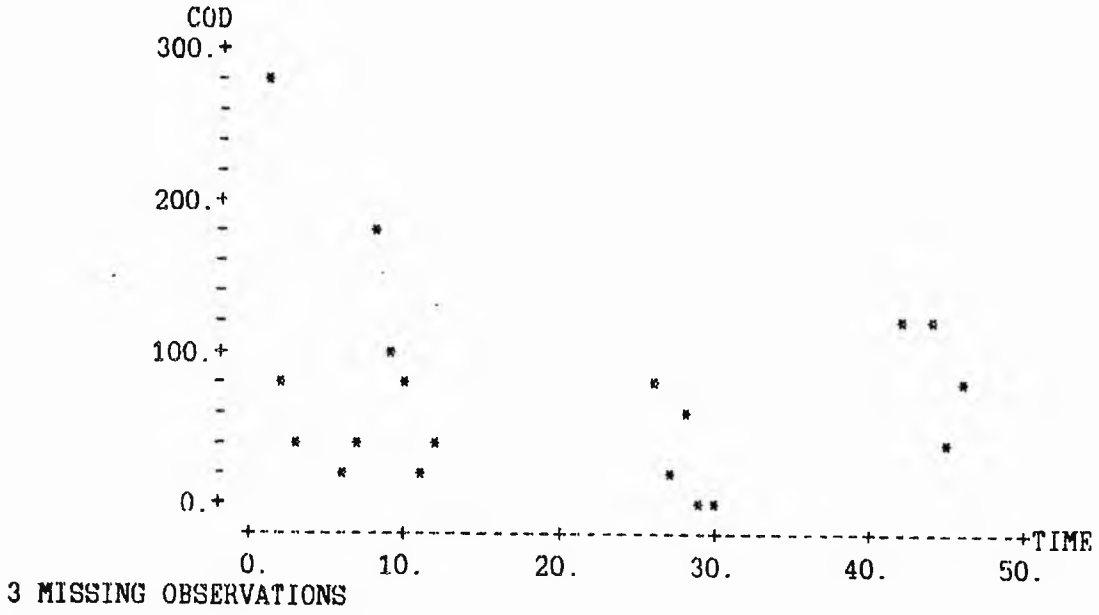


Figure 7.148

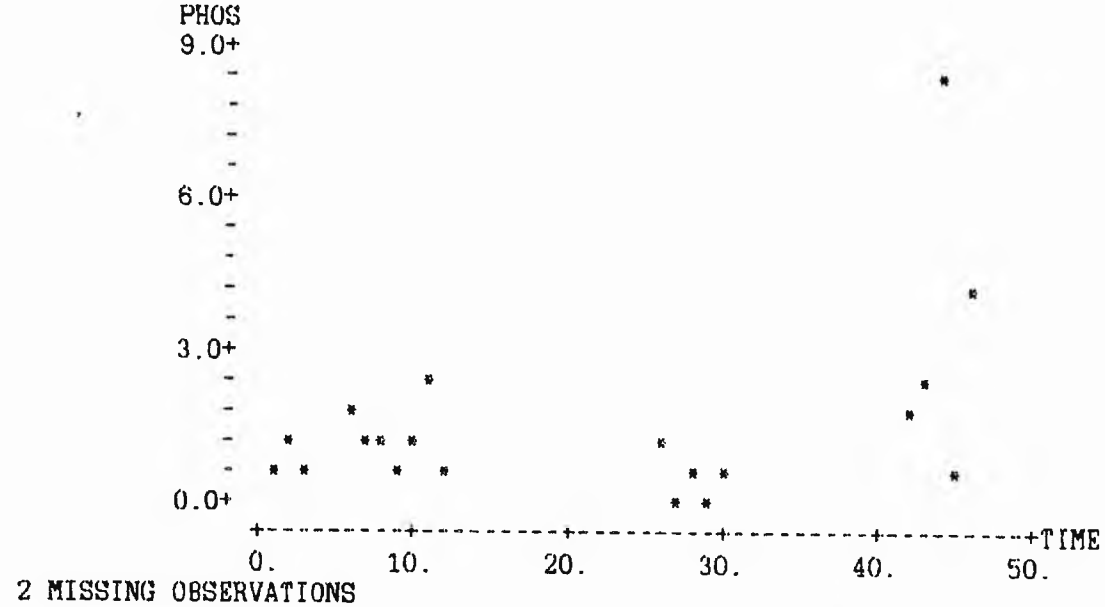
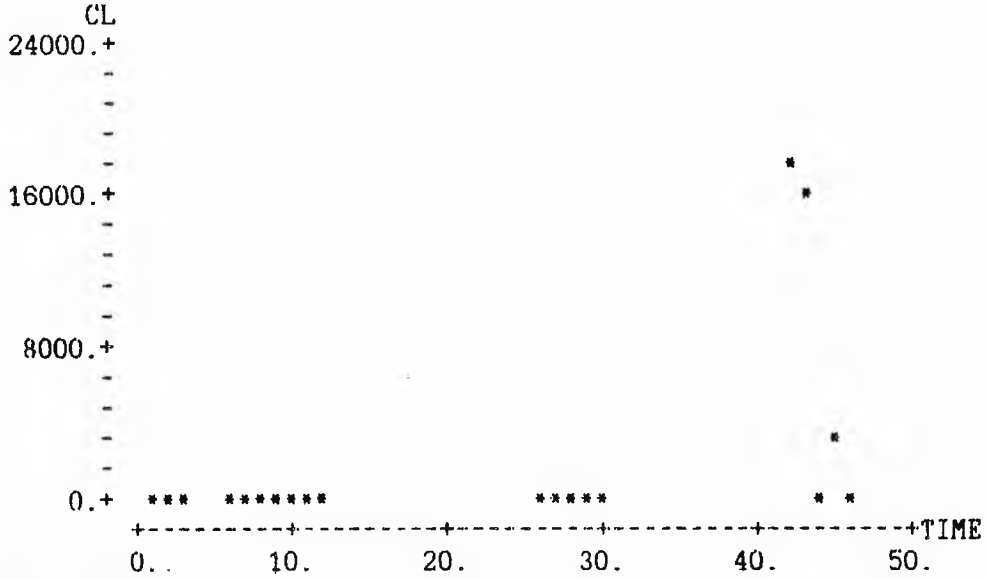


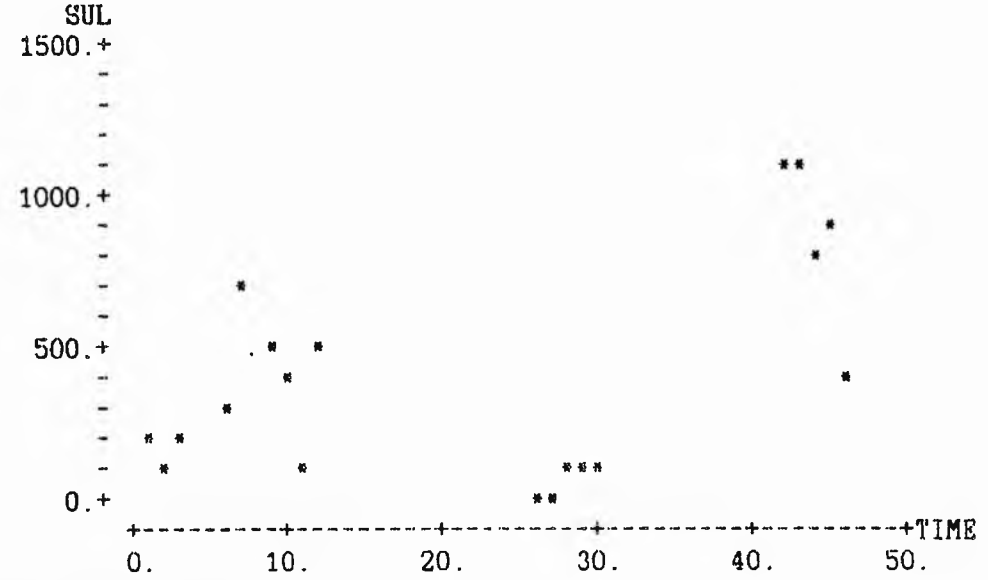
Figure 7.149

Graphs of Gully Pot Liquor Quality for Churnet 2 Gully Pot.



2 MISSING OBSERVATIONS

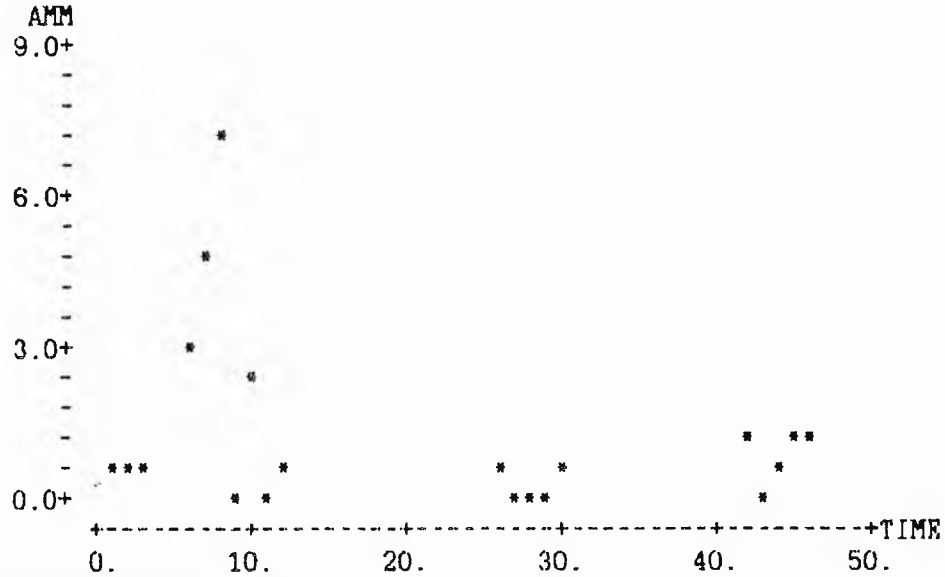
Figure 7.150



3 MISSING OBSERVATIONS

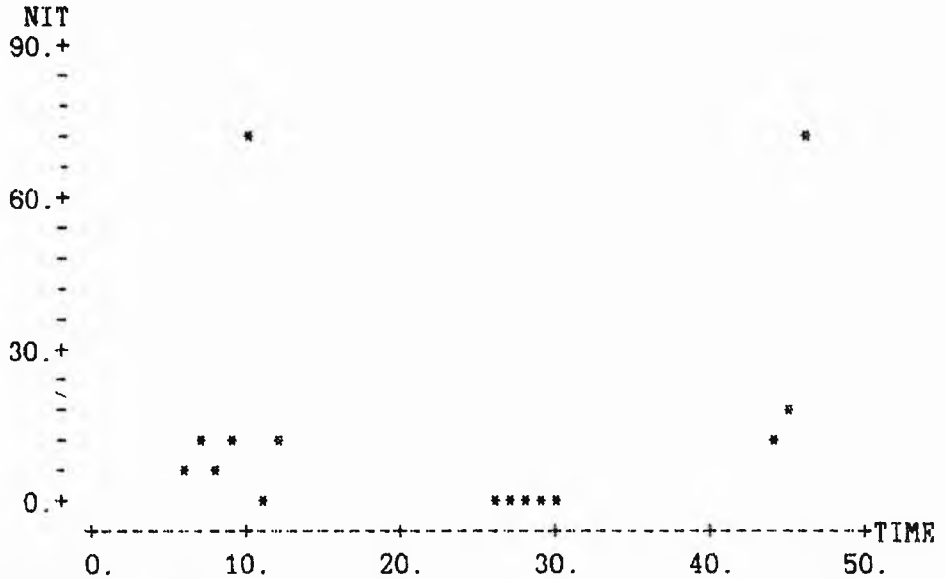
Figure 7.151

Graphs of Gully Pot Liquor Quality for Churnet 2 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.152



7 MISSING OBSERVATIONS

Figure 7.153

Graphs of Gully Pot Liquor Quality for Churnet 2 Gully Pot.

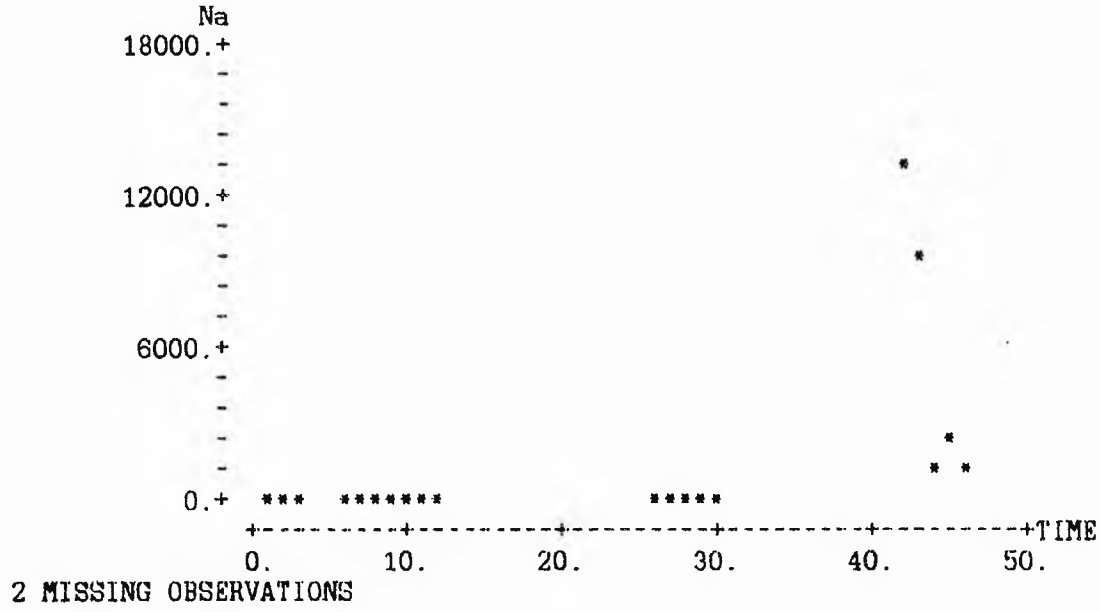


Figure 7.154

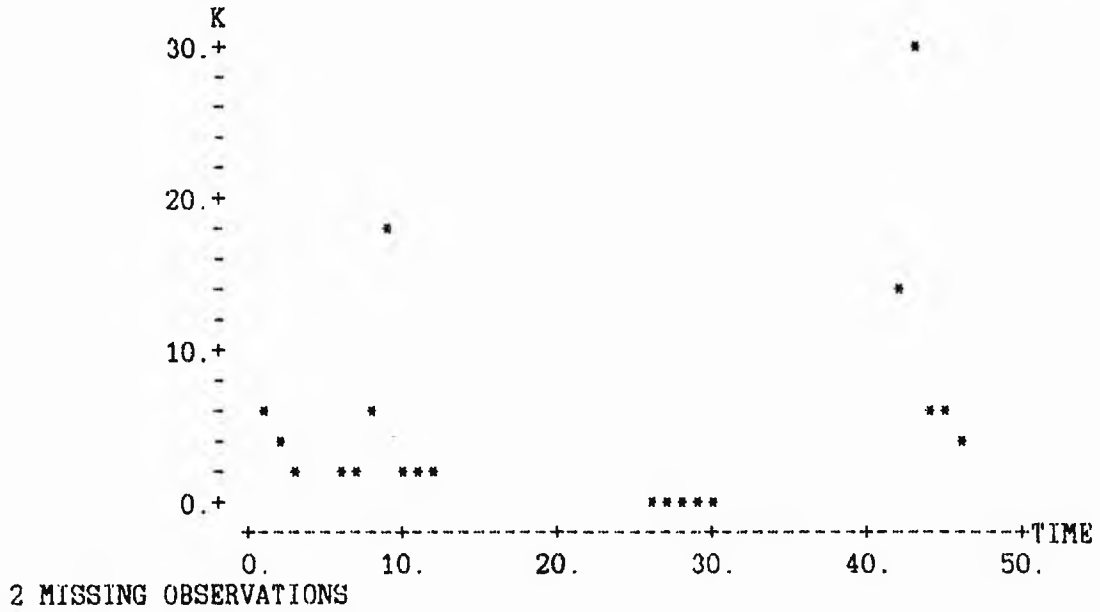
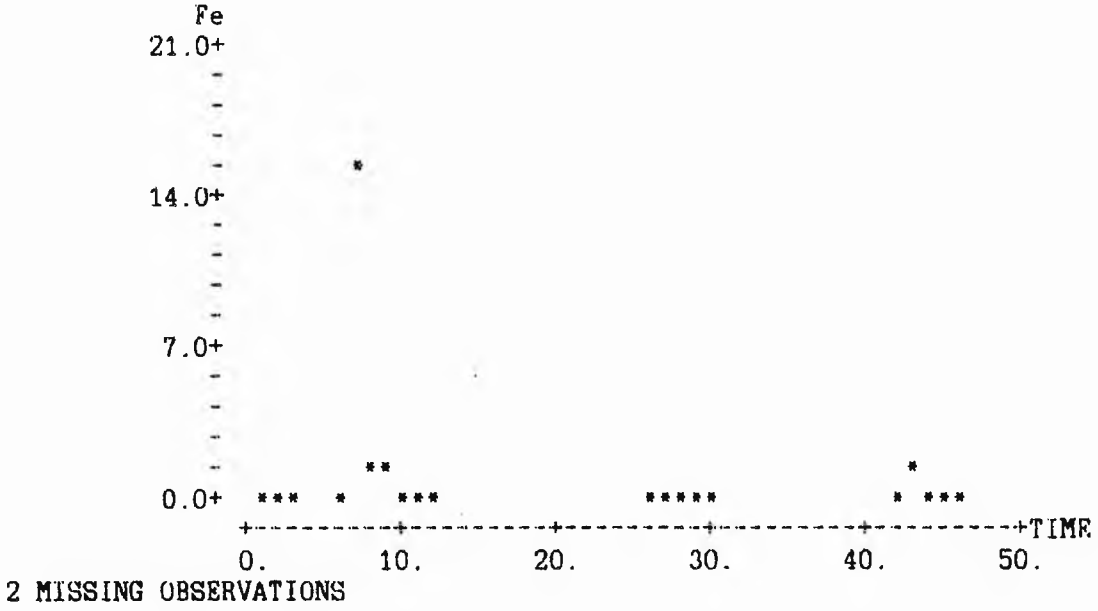


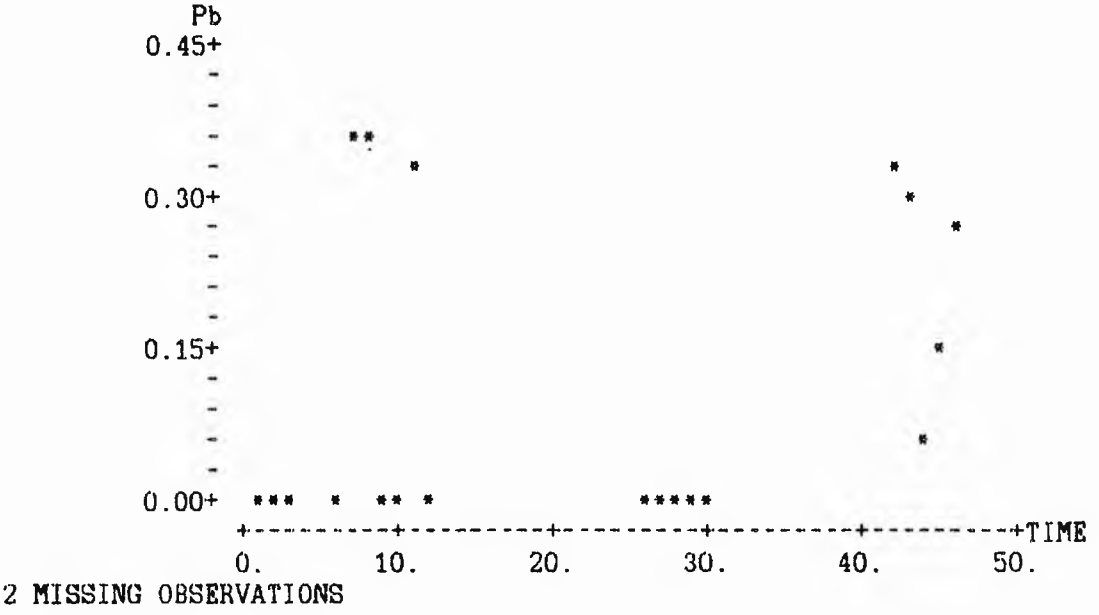
Figure 7.155

Graphs of Gully Pot Liquor Quality for Churnet 2 Gully Pot.



2 MISSING OBSERVATIONS

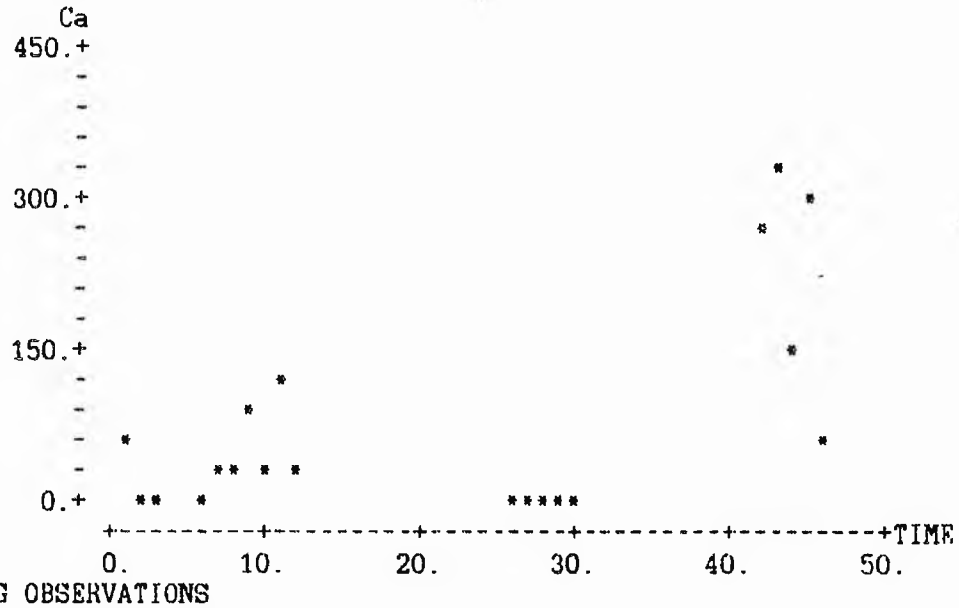
Figure 7.156



2 MISSING OBSERVATIONS

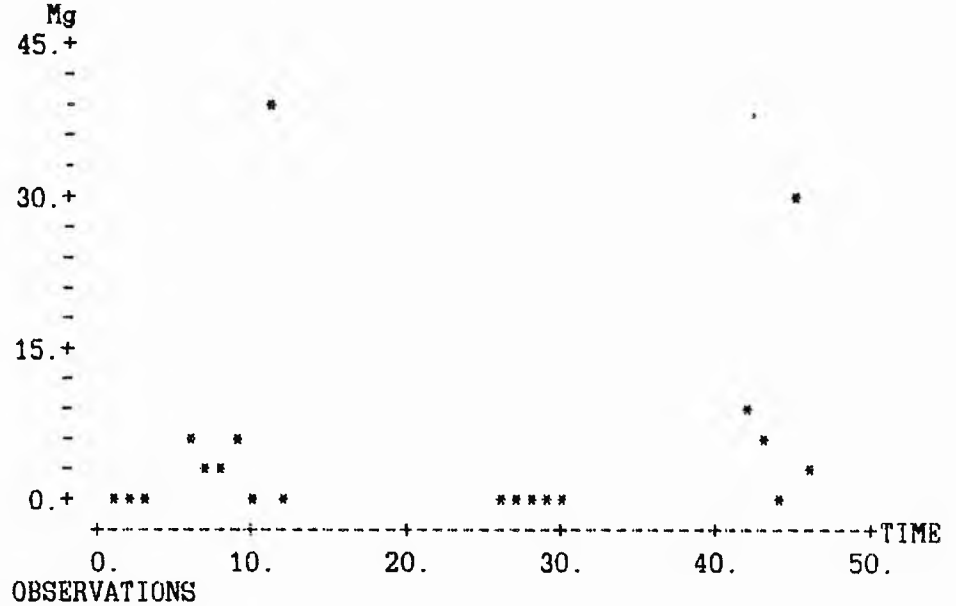
Figure 7.157

Graphs of Gully Pot Liquor Quality for Churnet 2 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.158



2 MISSING OBSERVATIONS

Figure 7.159

Graphs of Gully Pot Liquor Quality for Churnet 2 Gully Pot.

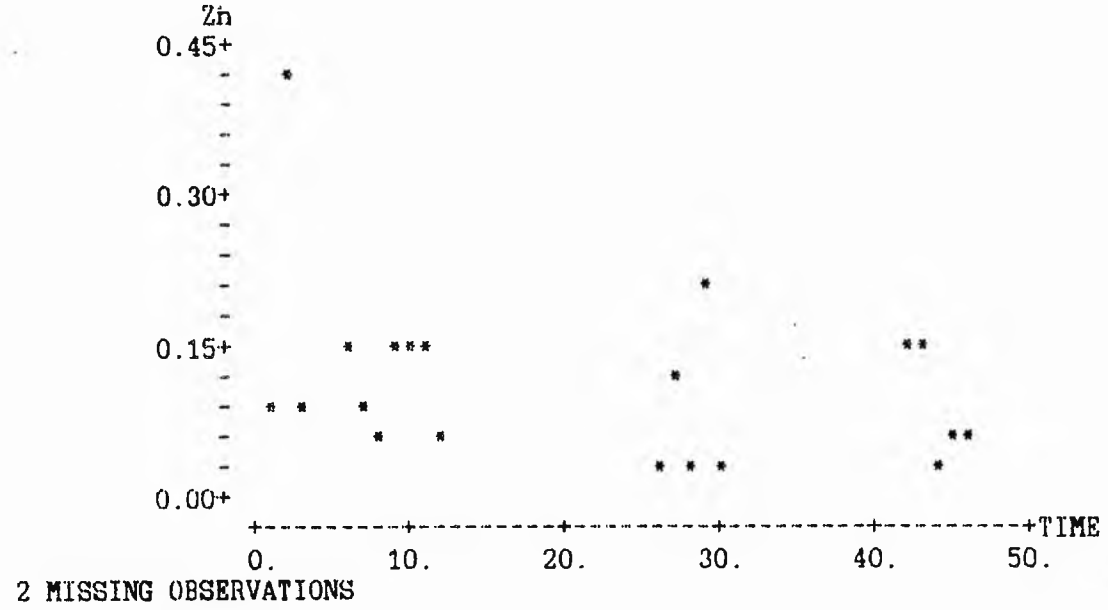


Figure 7.160

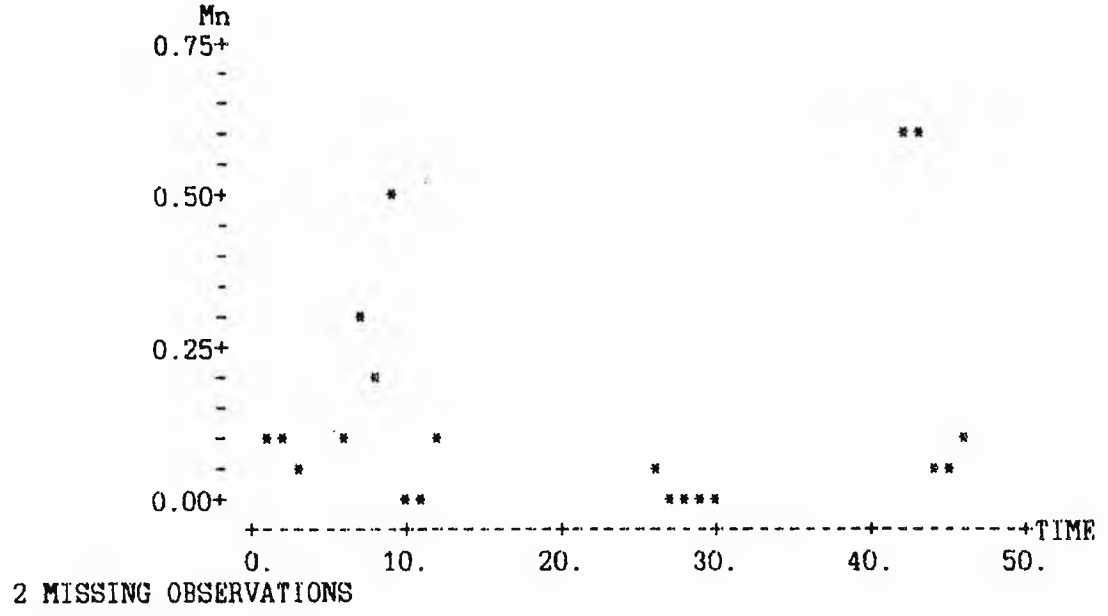
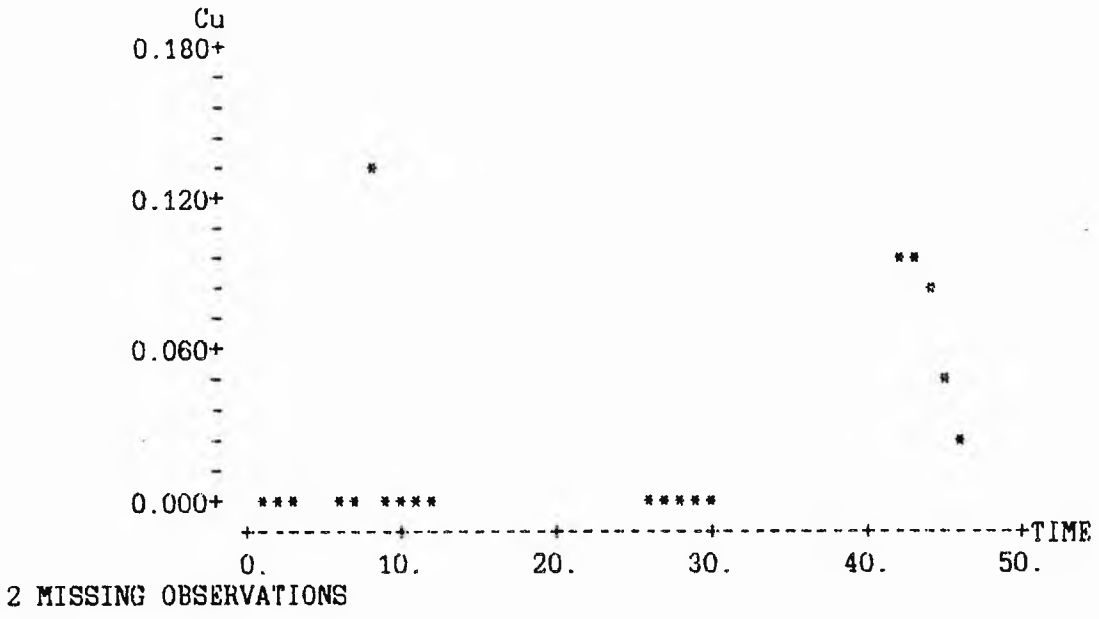


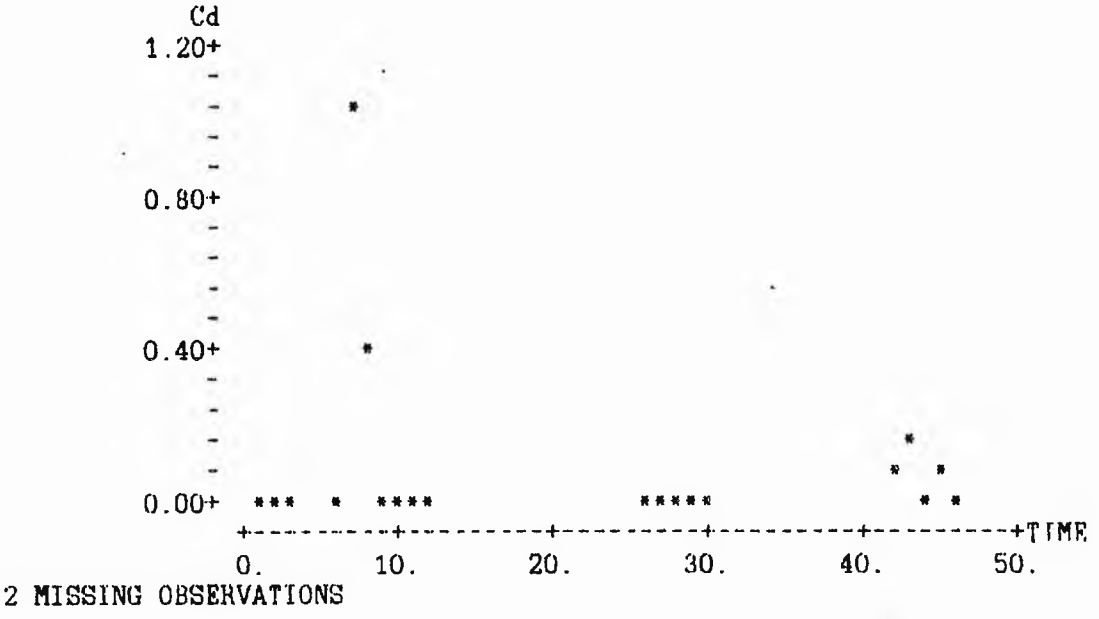
Figure 7.161

Graphs of Gully Pot Liquor Quality for Churnet 2 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.162



2 MISSING OBSERVATIONS

Figure 7.163

Graphs of Gully Pot Liquor Quality for Churnet 2 Gully Pot.

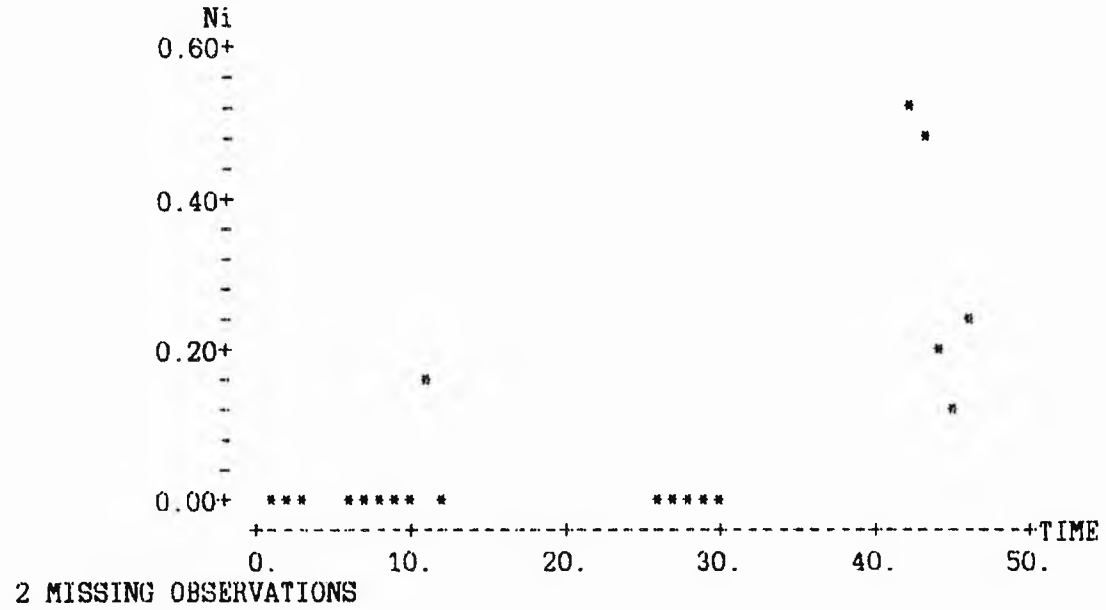


Figure 7.164

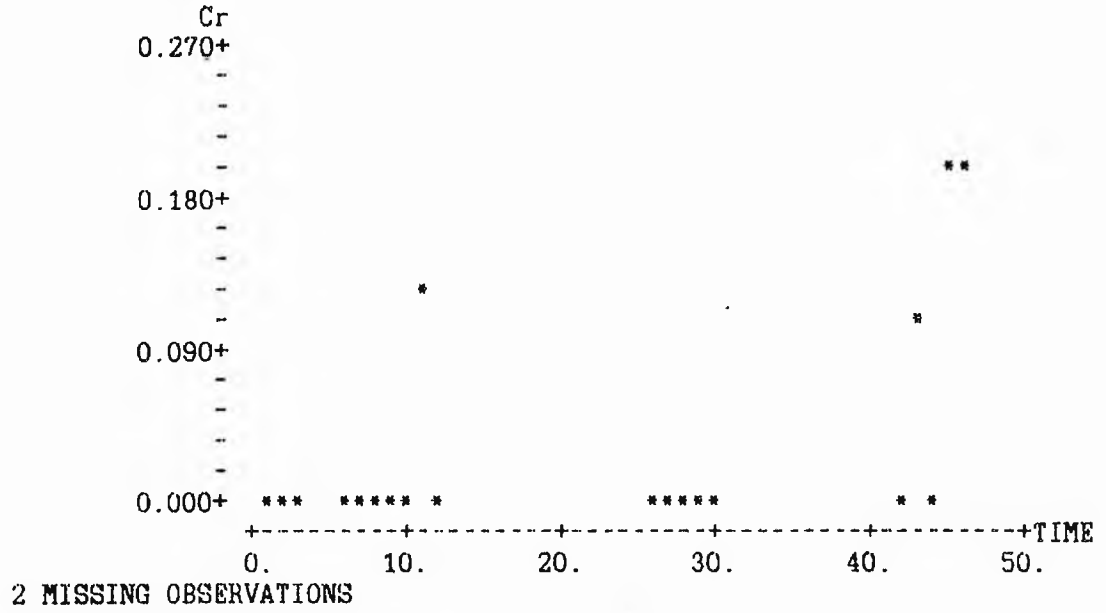


Figure 7.165

7.11 CHURNET 3:

(see Figures 7.166 to 7.191 and Tables 7.19 to 7.21 inclusive).

The pH values were generally below the pH 7.0 neutral point during the summer and autumn periods but once again they were in excess of pH 7.0 for all of the spring period. This increase was not as marked as that experienced in other pot liquors.

The Conductivity, sodium and chloride values again increased dramatically during the spring period owing to the influence of the rock salt. The maxima values reached for the Conductivity, sodium and chloride were 13.4 (x1000) μscm-1, 9000.0 mgl-1 and 2836.0 mgl-1 as Cl^- respectively, which were considerably lower than the concentrations found in some of the other pot liquors. It seems that the significance of rock salt was not as marked in this particular micro-catchment and this was probably attributed to the actions, or rather inactivity, of the local residents whose land area drained by this gully pot.

Further evidence of this point was illustrated by the values obtained for calcium, sulphate and Total Hardness. Enhanced concentrations of these determinands were associated with road salting. The maxima obtained for calcium, sulphate and Total Hardness were 250.0 mgl-1, 1143.0 mgl-1 as SO_4^{2-} and 910.0 mgl-1 as $CaCO_3$ respectively, and these values fall well short of those obtained from some of the other gully pots during the same sampling run.

The values for SS, BOD and COD showed no real seasonal variation and their respective concentrations were probably more influenced by rainstorm events with the input of flow and associated sediments, the turbulent effects of the inflow upon the pot chamber liquor, the

influence of varying mass and particle fractionation composition within the pot etc. and not by the seasonal factors which help to explain the very presence or changes in concentration of some of the water quality determinands in the gully pot liquor. The maximum values obtained were 199.0 mgl-1 for SS, 62 mgl-1 as BOD for BOD and 193 mgl-1 as COD for COD.

One important observation made in the analysis of the liquor quality for the Churnet 3 gully pot, was the very high ammonia and nitrate values in the summer period. Ammonia concentrations of 22.4 and 26.6 mgl-1 as N and nitrate values of 84.0 and 109.2 mgl-1 as N were observed for the samples taken on 840620 and 840627. Such high concentrations were probably due to the input of a highly nitrogenous material such as a garden fertiliser, garden wastes, grass cuttings or perhaps some animal faeces. The ammonia value of 26.6 mgl-1 as N was the highest recorded throughout the whole study period in any gully pot.

Detectable concentrations of copper, cadmium and chromium were observed in the summer period, which was consistent with the findings from Churnet 2 gully pot (which also lies at the downslope end of the sub-catchment). A single value of 1.00 mgl-1 of copper, two values of 1.00 mgl-1 and a 0.55 mgl-1 value of cadmium and a single value of 0.13 mgl-1 of chromium were observed during the summer period. Copper, cadmium, nickel and chromium were not detected at all during the autumn period but were found in relatively high concentrations again during the spring period. The presence of these heavy metals in the spring period was consistent with the findings from other gully pot liquor analysis.

One other interesting observation for the Churnet 3 gully pot liquor was that levels of lead were detected during the summer period. Four

samples taken during the summer period contained detectable concentrations of lead and the maximum value was 0.45 mgl-1. These concentrations were much higher than those found during the spring period and may be due to an increased input of fine sediment into the pot chamber. This may have built up within the micro-catchment during the dry period of weather experienced in the summer and some of the fine material is capable of being windblown into the pot by aeolian processes. A major source of such fine sediment would be the drying out of soil surfaces and the soil particles can be blown on to the road and paved surfaces where they will accumulate. Highway runoff generated by a rainstorm event will then transport the sediments into the pot. Lead is a heavy metal which is chiefly associated with fine particles (<250 μm) and this hypothesis may help to explain the levels of lead found during the summer period. It should be noted, however, that the Churnet 3 micro-catchment did not show any particular characteristic source of fine sediments (ie. it is not immediately adjacent to a bare soil or grassed surface) but its hydrologic and hydraulic characteristics may disguise the source of these sediments which seem to have shown their presence in this particular gully pot during the summer months.

Table 7.19

Table of all the Water Quality Data collected over the Twenty-Two Week Period for the Gully Pot Standing Liquor in the Churnet 3 Gully Pot.

ROW	DATE	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
1	84Ø5Ø9	11.Ø	2.8	6.6	32Ø	22Ø	Ø.62	*	59	15Ø
2	84Ø516	13.Ø	3.5	6.7	9Ø	5Ø	Ø.11	6	23	113
3	84Ø523	14.Ø	2.8	7.Ø	2ØØ	35Ø	Ø.ØØ	*	6	48
4	84Ø53Ø	15.Ø	4.8	6.7	*	*	Ø.ØØ	*	Ø	*
5	84Ø6Ø6	14.5	6.5	6.8	*	*	Ø.14	*	4	*
6	84Ø613	18.Ø	1.7	7.1	19Ø	21Ø	Ø.42	199	62	193
7	84Ø62Ø	2Ø.Ø	Ø.5	6.9	27Ø	37Ø	Ø.51	47	43	138
8	84Ø627	2Ø.Ø	1.7	6.5	17Ø	16Ø	Ø.28	9Ø	18	139
9	84Ø7Ø4	24.Ø	3.7	8.Ø	23Ø	33Ø	Ø.4Ø	112	44	124
1Ø	84Ø711	23.Ø	Ø.7	6.8	26Ø	41Ø	Ø.43	53	25	172
11	84Ø718	21.Ø	2.7	6.3	12Ø	24Ø	Ø.1Ø	13	16	16
12	84Ø725	17.Ø	Ø.8	6.7	21Ø	19Ø	Ø.17	1Ø	32	6Ø
13	841Ø31	12.Ø	6.Ø	6.Ø	3Ø	5Ø	Ø.Ø7	34	15	86
14	8411Ø7	1Ø.Ø	Ø.8	5.8	16Ø	4Ø	Ø.ØØ	46	16	129
15	841114	1Ø.Ø	1.8	6.Ø	4Ø	4Ø	Ø.Ø5	47	42	34
16	841121	8.Ø	5.5	6.3	2Ø	13Ø	Ø.Ø4	49	31	82
17	841128	7.Ø	5.9	6.3	2Ø	16Ø	Ø.Ø3	7Ø	4	38
18	85Ø22Ø	2.5	2.9	7.2	7Ø	21Ø	3.21	8	36	1Ø
19	85Ø227	3.5	1.1	7.5	85	28Ø	3.58	37	6	82
2Ø	85Ø3Ø6	5.Ø	4.1	7.5	19Ø	91Ø	13.39	116	7	59
21	85Ø313	5.5	6.1	7.3	5Ø	53Ø	3.41	56	8	1Ø
22	85Ø32Ø	4.5	6.1	7.1	19Ø	67Ø	5.35	52	11	57

ROW	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
1	2.1	21.3	1Ø	Ø.1	*	32.4Ø	5.4Ø	1.7Ø	Ø.ØØ
2	1.3	31.9	221	Ø.1	*	6.6Ø	3.4Ø	Ø.5Ø	Ø.ØØ
3	Ø.7	7Ø.9	125	Ø.1	*	1.7Ø	1.ØØ	Ø.1Ø	Ø.ØØ
4	*	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*	*
6	4.7	5Ø.Ø	183	8.Ø	53.2	27.ØØ	4.ØØ	Ø.8Ø	Ø.ØØ
7	3.3	67.Ø	413	22.4	84.Ø	25.ØØ	5.ØØ	17.ØØ	Ø.35
8	3.Ø	39.Ø	*	26.6	1Ø9.2	17.5Ø	7.ØØ	2.7Ø	Ø.35
9	3.7	6Ø.Ø	Ø	Ø.1	13.3	22.5Ø	19.ØØ	2.7Ø	Ø.ØØ
1Ø	1.4	43.Ø	327	1.Ø	43.4	6.25	3.ØØ	1.4Ø	Ø.35
11	1.8	25.Ø	442	Ø.2	1.5	8.2Ø	1.25	Ø.5Ø	Ø.45
12	1.Ø	32.Ø	615	Ø.2	6.4	7.1Ø	1.5Ø	1.6Ø	Ø.ØØ
13	1.4	28.4	2Ø2	Ø.1	2.Ø	1.76	Ø.6Ø	Ø.2Ø	Ø.ØØ
14	Ø.4	35.5	Ø	Ø.2	1.5	2.8Ø	1.ØØ	Ø.ØØ	Ø.ØØ
15	Ø.8	17.7	Ø	Ø.2	1.5	1.6Ø	Ø.5Ø	Ø.ØØ	Ø.ØØ
16	Ø.Ø	7.1	86	Ø.1	1.Ø	3.ØØ	Ø.6Ø	Ø.ØØ	Ø.ØØ
17	Ø.6	1Ø.6	125	Ø.4	Ø.6	3.3Ø	Ø.4Ø	Ø.ØØ	Ø.ØØ
18	1.9	1773.Ø	327	1.1	*	9ØØØ.ØØ	2.1Ø	Ø.22	Ø.ØØ
19	1.Ø	2836.Ø	634	Ø.1	*	82ØØ.ØØ	34.ØØ	Ø.62	Ø.ØØ
2Ø	Ø.2	89.Ø	1143	1.2	12.6	85ØØ.ØØ	5.ØØ	Ø.45	Ø.Ø5
21	Ø.Ø	1276.2	798	Ø.9	7.7	58Ø.ØØ	2.6Ø	Ø.1Ø	Ø.Ø8
22	4.4	355.Ø	5Ø9	1.5	9.Ø	4ØØ.ØØ	3.ØØ	Ø.4Ø	Ø.ØØ

ROW	Ca	Mg	Zn	Mn	Cu	Cd	Ni	Cr
1	62.Ø	Ø.ØØ	Ø.1Ø	Ø.49	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
2	16.Ø	Ø.ØØ	Ø.18	Ø.14	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
3	9.6	Ø.ØØ	Ø.Ø6	Ø.Ø4	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
4	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*
6	36.Ø	1Ø5.ØØ	Ø.15	Ø.4Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
7	65.Ø	12.ØØ	Ø.15	Ø.58	Ø.ØØ	1.ØØ	Ø.ØØ	Ø.ØØ
8	45.Ø	5.ØØ	Ø.ØØ	Ø.9Ø	Ø.13	Ø.55	Ø.ØØ	Ø.ØØ
9	1Ø2.5	5.ØØ	Ø.17	Ø.3Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
1Ø	59.Ø	5.ØØ	Ø.14	Ø.65	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
11	19Ø.5	46.ØØ	Ø.16	Ø.13	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.13
12	24.4	3.ØØ	Ø.1Ø	Ø.55	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
13	2Ø.1	Ø.8Ø	Ø.Ø2	Ø.Ø8	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
14	9.4	1.ØØ	Ø.61	Ø.2Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
15	9.5	Ø.8Ø	Ø.Ø4	Ø.Ø5	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
16	1Ø.8	Ø.5Ø	Ø.3Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
17	5.3	Ø.4Ø	Ø.Ø3	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ
18	168.Ø	3.65	Ø.Ø7	Ø.27	Ø.ØØ	Ø.ØØ	Ø.Ø7	Ø.ØØ
19	25Ø.Ø	4.15	Ø.ØØ	Ø.38	Ø.ØØ	Ø.Ø2	Ø.Ø5	Ø.ØØ
2Ø	22Ø.Ø	2.3Ø	Ø.19	Ø.55	Ø.Ø2	Ø.Ø5	Ø.23	Ø.ØØ
21	62.Ø	1.5Ø	Ø.16	Ø.11	Ø.Ø2	Ø.Ø2	Ø.1Ø	Ø.1Ø
22	4Ø.8	Ø.92	Ø.11	Ø.32	Ø.ØØ	Ø.ØØ	Ø.1Ø	Ø.2Ø

Statistical Summary of the Water Quality Data for the Standing Pot Liquor collected in the Churnet 3 Gully Pot.

Table 7.20

	TEMP	DO	PH	ALK	TH	COND	SS	BOD
N	22	22	22	20	20	22	18	22
NMISS	0	0	0	2	2	0	4	0
MEAN	12.66	3.30	6.777	145.8	278	1.48	58.1	23.1
MEDIAN	12.50	2.85	6.750	165.0	215	0.23	48.0	17.0
TMEAN	12.60	3.28	6.765	143.1	256	0.96	52.5	22.3
STDEV	6.57	2.05	0.545	91.3	222	3.05	47.5	18.2
SEMEAN	1.40	0.44	0.116	20.4	50	0.65	11.2	3.9
MAX	24.00	6.50	8.000	320.0	910	13.39	199.0	62.0
MIN	2.50	0.50	5.000	20.0	40	0.03	6.0	0.0
Q3	18.50	5.60	7.125	207.5	365	1.27	75.0	37.5
Q1	6.62	1.55	6.300	55.0	138	0.08	28.8	6.7

	COD	PHOS	CL	SUL	AMM	NIT	Na	K
N	20	20	20	19	20	15	20	20
NMISS	2	2	2	3	2	7	2	2
MEAN	87.0	1.69	343	324	3.23	23.1	1342	5.02
MEDIAN	82.0	1.35	41	221	0.20	7.7	13	2.80
TMEAN	85.4	1.61	224	295	2.11	18.2	991	3.66
STDEV	55.1	1.43	747	310	7.51	34.0	3120	7.96
SEMEAN	12.3	0.32	167	71	1.68	8.8	698	1.78
MAX	193.0	4.70	2836	1143	26.60	109.2	9000	34.00
MIN	10.0	0.00	7	0	0.10	0.6	2	0.40
Q3	135.7	2.78	84	509	1.17	43.4	308	5.00
Q1	40.5	0.63	26	86	0.10	1.5	3	1.00

	Fe	Pb	Ca	Mg	Zn	Mn	Cu	Cd
N	20	20	20	20	20	20	20	20
NMISS	2	2	2	2	2	2	2	2
MEAN	1.55	0.082	70.3	9.9	0.141	0.307	0.0085	0.082
MEDIAN	0.48	0.000	42.9	1.9	0.125	0.285	0.0000	0.000
TMEAN	0.78	0.066	63.9	5.1	0.123	0.291	0.0022	0.036
STDEV	3.73	0.153	75.8	24.6	0.131	0.251	0.0292	0.248
SEMEAN	0.84	0.034	16.9	5.5	0.029	0.056	0.0065	0.056
MAX	17.00	0.450	250.0	105.0	0.610	0.900	0.1300	1.000
MIN	0.00	0.000	5.3	0.0	0.000	0.000	0.0000	0.000
Q3	1.55	0.072	93.1	5.0	0.168	0.535	0.0000	0.015
Q1	0.10	0.000	12.1	0.6	0.063	0.088	0.0000	0.000

	Ni	Cr
N	20	20
NMISS	2	2
MEAN	0.0275	0.0215
MEDIAN	0.0000	0.0000
TMEAN	0.0178	0.0128
STDEV	0.0586	0.0551
SEMEAN	0.0131	0.0123
MAX	0.2300	0.2000
MIN	0.0000	0.0000
Q3	0.0375	0.0000
Q1	0.0000	0.0000

Table of the Correlation Coefficients between all Twenty-Six Water Quality Parameters for the Standing Pot Liquor in the Churnet 3 Gully Pot.

Table 7.21

	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
DO	-0.390								
PH	-0.026	0.035							
ALK	0.522	-0.503	0.322						
TH	-0.192	0.232	0.648	0.349					
COND	-0.519	0.172	0.497	0.056	0.831				
SS	0.211	0.005	0.351	0.315	0.283	0.209			
BOD	0.311	-0.447	0.045	0.411	-0.296	-0.257	0.364		
COD	0.547	-0.456	0.013	0.593	-0.159	-0.271	0.514	0.520	
PHOS	0.422	-0.143	0.322	0.482	0.091	-0.115	0.454	0.502	0.479
CL	-0.543	-0.043	0.446	-0.299	0.122	0.273	-0.226	-0.243	-0.318
SUL	-0.297	0.091	0.462	0.024	0.751	0.791	-0.018	-0.448	-0.342
AMM	0.394	-0.347	-0.006	0.290	-0.006	-0.111	0.268	0.177	0.406
NIT	0.524	-0.495	0.166	0.525	0.024	-0.122	0.349	0.314	0.645
Na	-0.572	-0.050	0.479	-0.153	0.386	0.705	-0.049	-0.217	-0.313
K	-0.035	-0.233	0.581	0.103	0.116	0.161	0.126	-0.046	0.179
Fe	0.397	-0.374	0.124	0.450	0.100	-0.114	0.006	0.315	0.332
Pb	0.595	-0.358	-0.112	0.282	0.112	-0.132	-0.093	-0.054	0.164
Ca	-0.195	-0.138	0.538	0.043	0.451	0.597	-0.025	-0.174	-0.236
Mg	0.347	-0.227	0.003	0.128	-0.062	-0.128	0.609	0.434	0.340
Zn	-0.037	-0.153	-0.202	0.075	-0.060	0.010	0.007	-0.004	0.219
Mn	0.385	-0.545	0.283	0.679	0.301	0.219	0.270	0.230	0.546
Cu	0.182	-0.086	-0.036	0.042	0.020	0.055	0.212	-0.167	0.152
Cd	0.340	-0.346	0.010	0.317	0.062	-0.079	0.042	0.146	0.295
Ni	-0.569	0.335	0.494	-0.033	0.830	0.982	0.161	-0.381	-0.372
Cr	-0.163	0.417	0.089	-0.043	0.425	0.219	-0.156	-0.310	-0.398

	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
CL	-0.130								
SUL	-0.173	0.368							
AMM	0.465	-0.142	0.079						
NIT	0.522	-0.127	0.061	0.946					
Na	-0.189	0.714	0.554	-0.142	-0.097				
K	0.166	0.646	0.169	0.028	0.289	0.443			
Fe	0.371	-0.124	0.052	0.681	0.607	-0.135	0.082		
Pb	0.185	-0.179	0.205	0.570	0.583	-0.187	-0.082	0.470	
Ca	-0.014	0.616	0.593	-0.081	-0.015	0.803	0.593	0.000	0.210
Mg	0.518	-0.111	-0.042	0.180	0.239	-0.119	-0.036	0.028	0.176
Zn	-0.223	-0.150	-0.124	-0.187	-0.258	-0.093	-0.110	-0.035	-0.089
Mn	0.416	-0.017	0.408	0.637	0.795	0.151	0.251	0.413	0.465
Cu	0.135	-0.063	0.735	0.707	0.668	-0.026	0.047	0.048	0.402
Cd	0.329	-0.110	0.114	0.898	0.793	-0.106	0.043	0.907	0.571
Ni	-0.162	0.313	0.809	-0.141	-0.172	0.678	0.090	-0.157	-0.149
Cr	0.260	0.069	0.317	-0.124	-0.241	-0.134	-0.136	-0.131	0.196

	Ca	Mg	Zn	Mn	Cu	Cd	Ni
Mg	0.082						
Zn	-0.090	0.019					
Mn	0.239	0.085	-0.147				
Cu	-0.011	-0.069	-0.233	0.559			
Cd	-0.023	-0.018	-0.108	0.514	0.427		
Ni	0.551	-0.153	0.014	0.138	0.059	-0.111	
Cr	0.112	0.081	-0.013	-0.153	-0.054	-0.128	0.296

Graphs of Gully Pot Liquor Quality for Churnet 3 Gully Pot.

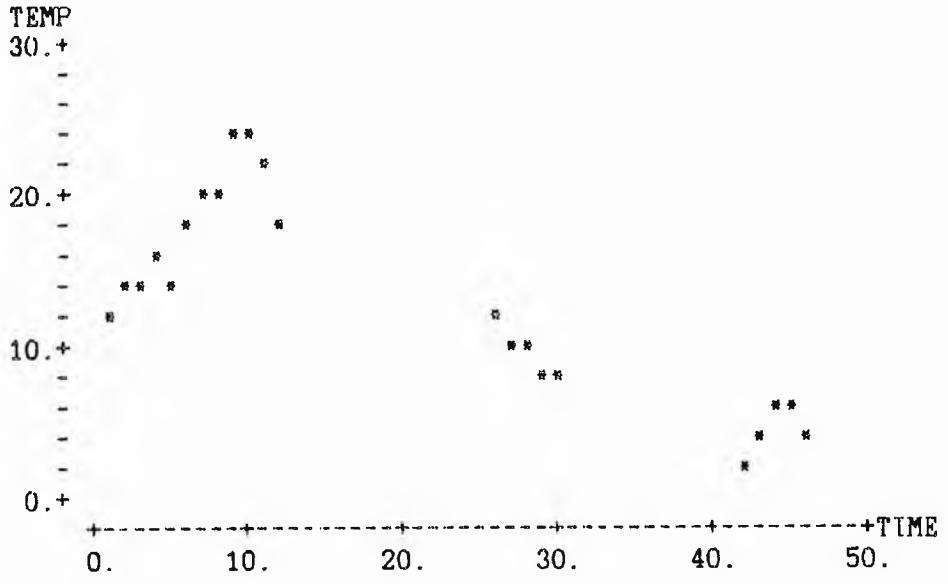


Figure 7.166

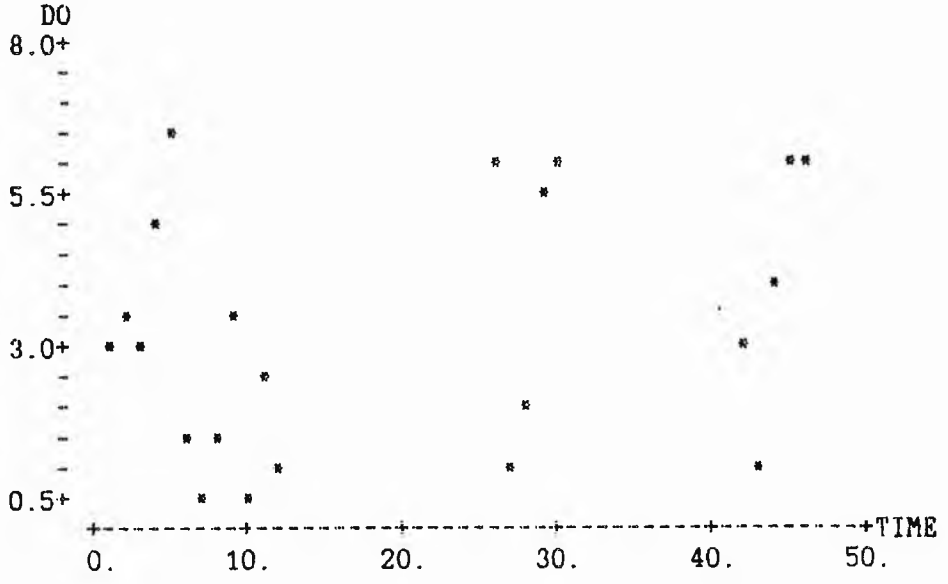


Figure 7.167

Graphs of Gully Pot Liquor Quality for Churnet 3 Gully Pot.

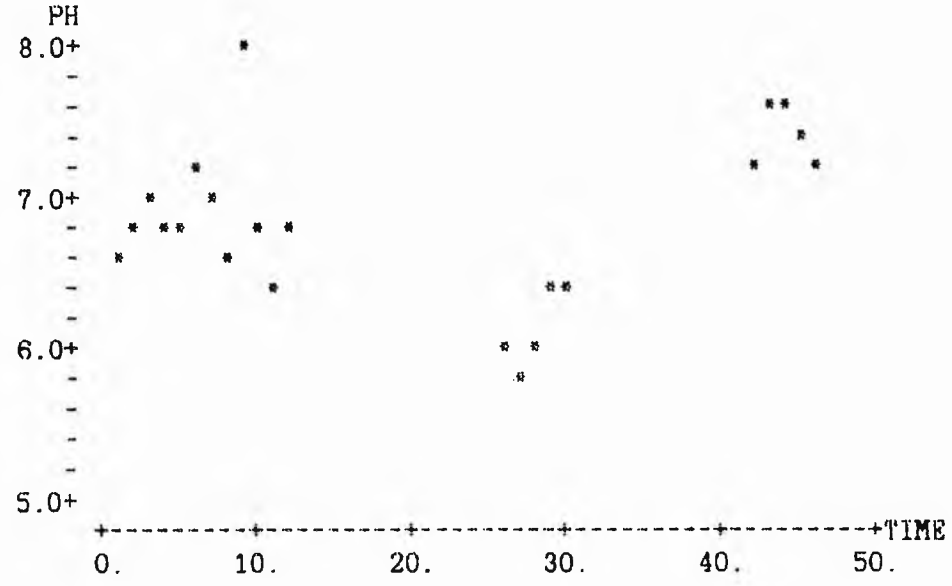
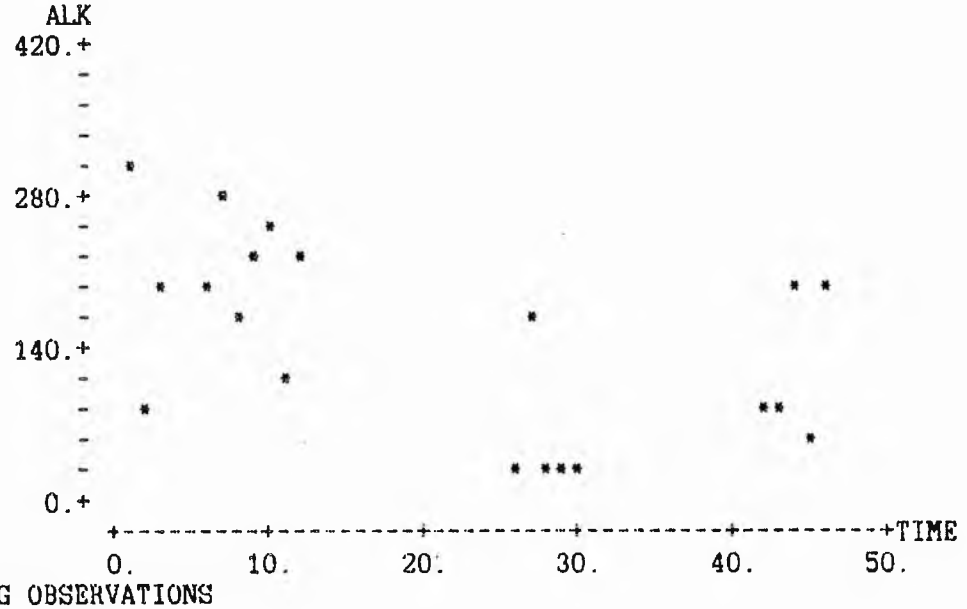


Figure 7.168



2 MISSING OBSERVATIONS

Figure 7.169

Graphs of Gully Pot Liquor Quality for Churnet 3 Gully Pot.

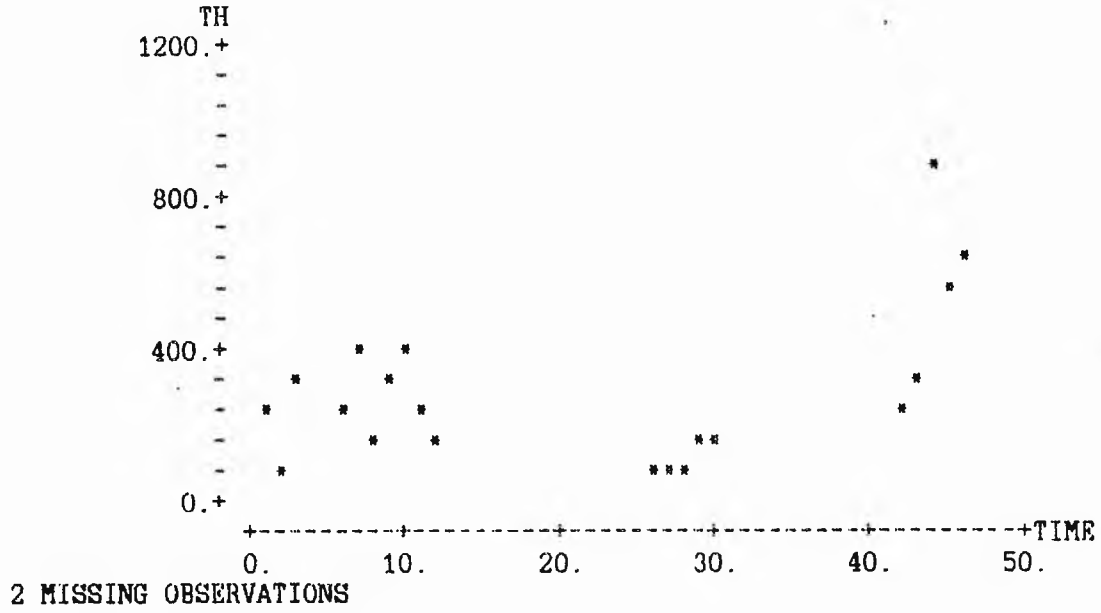


Figure 7.170

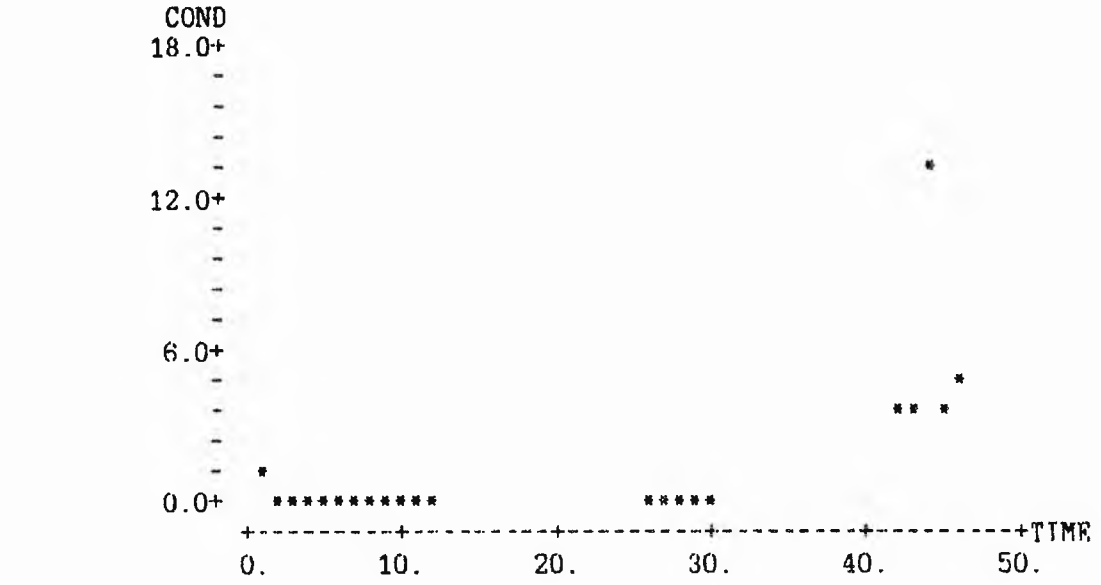


Figure 7.171

Graphs of Gully Pot Liquor Quality for Churnet 3 Gully Pot.

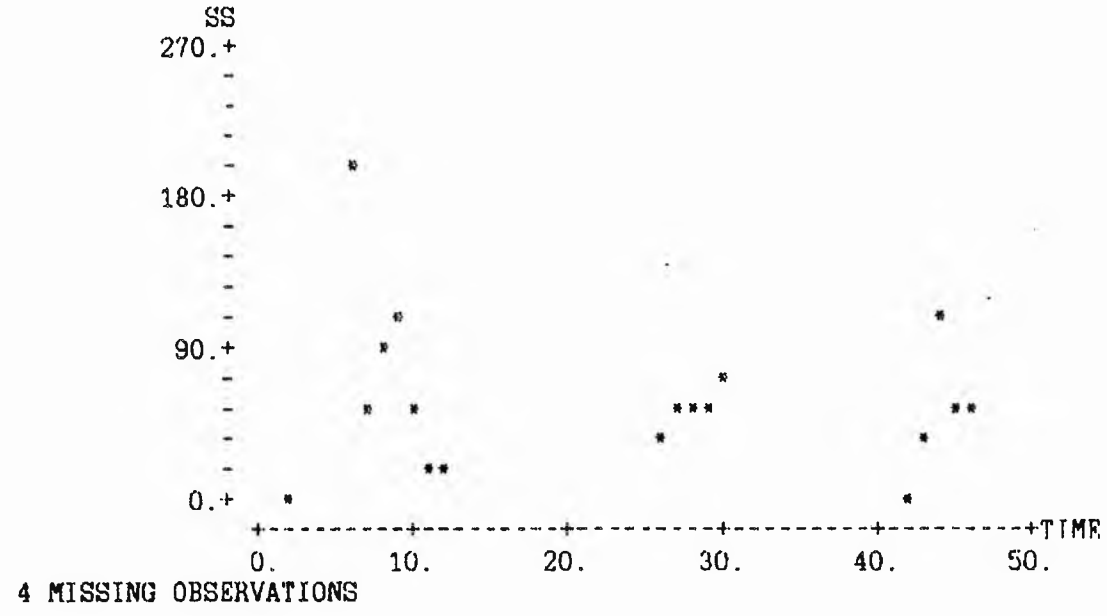


Figure 7.172

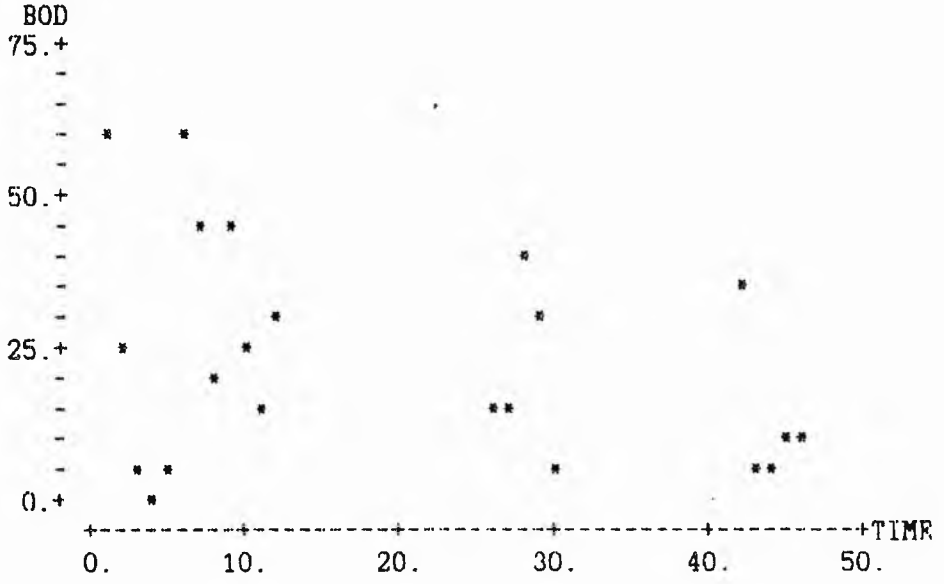
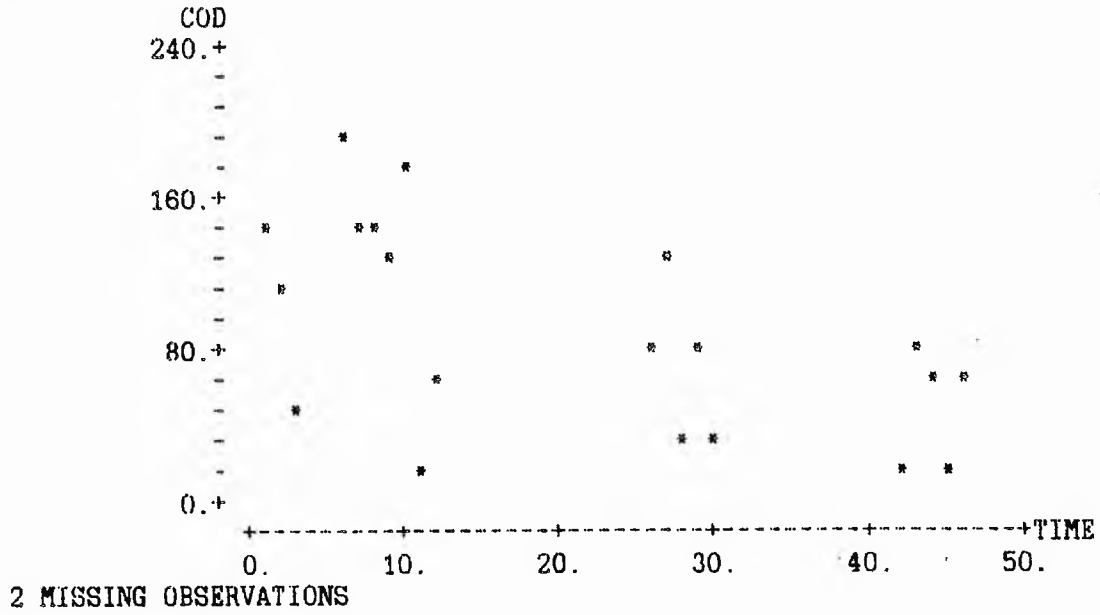


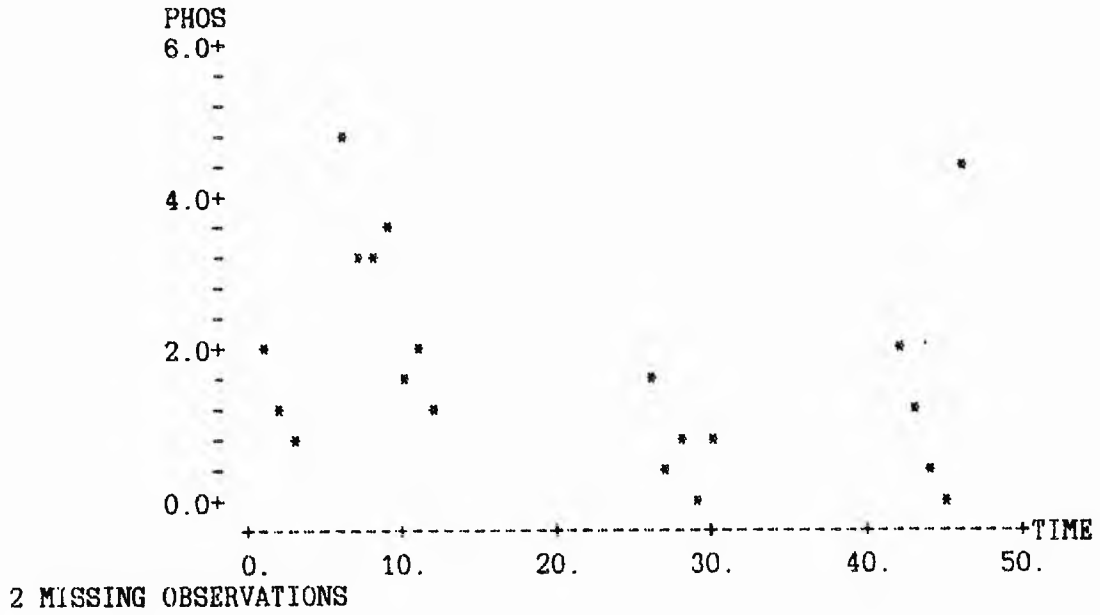
Figure 7.173

Graphs of Gully Pot Liquor Quality for Churnet 3 Gully Pot.



2 MISSING OBSERVATIONS

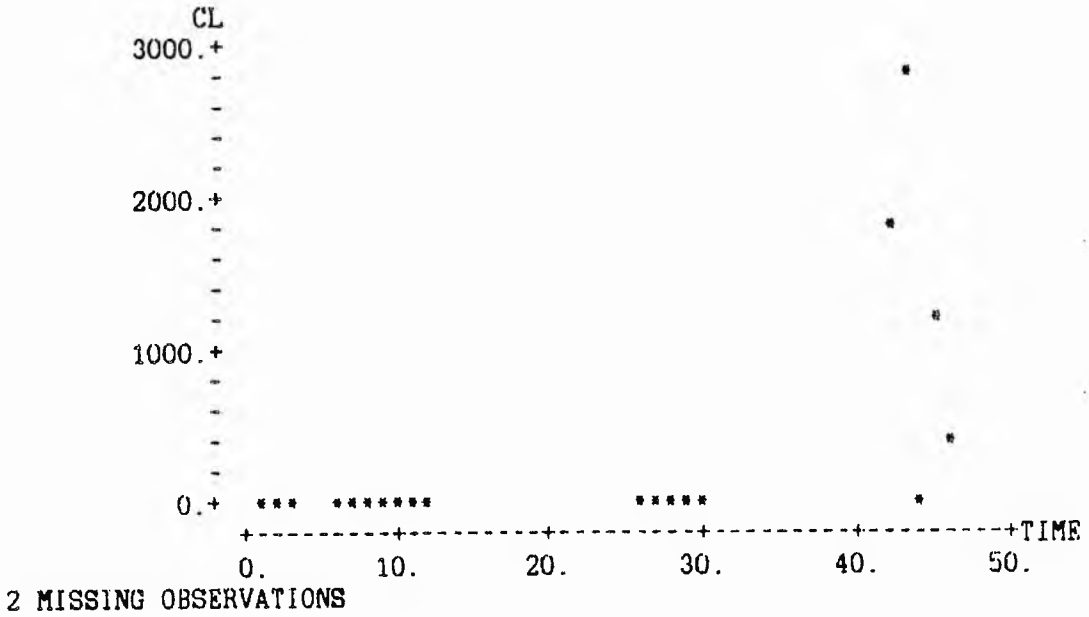
Figure 7.174



2 MISSING OBSERVATIONS

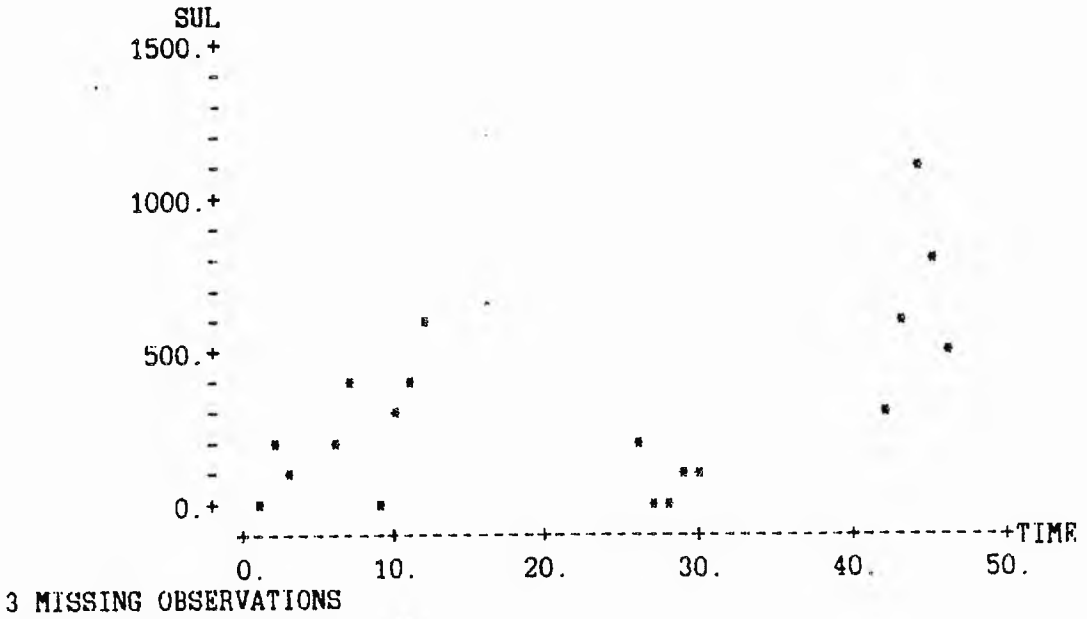
Figure 7.175

Graphs of Gully Pot Liquor Quality for Churnet 3 Gully Pot.



2 MISSING OBSERVATIONS

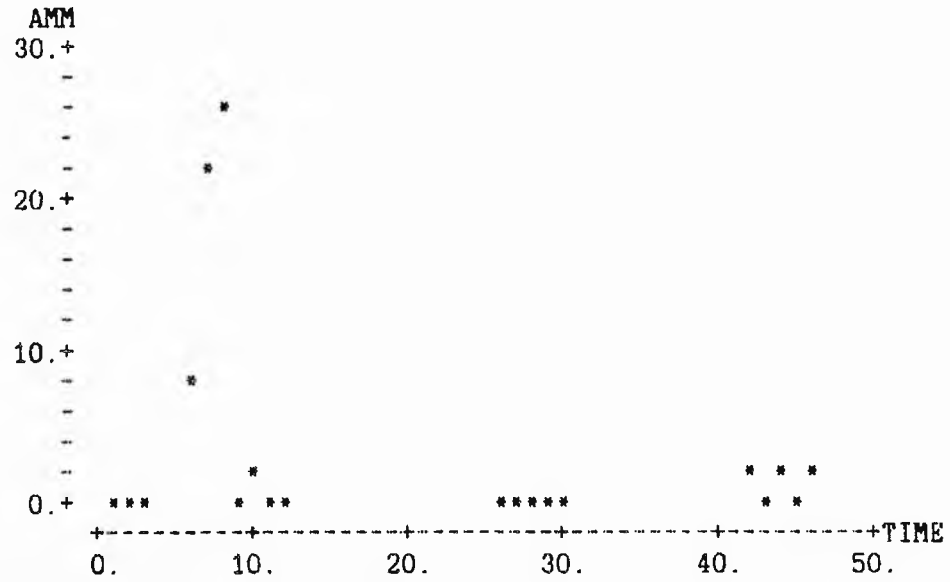
Figure 7.176



3 MISSING OBSERVATIONS

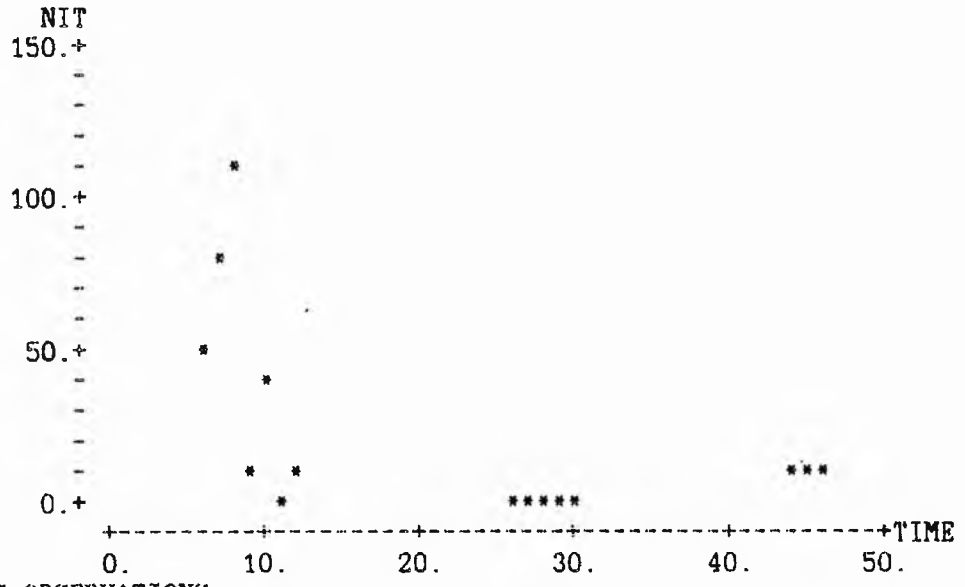
Figure 7.177

Graphs of Gully Pot Liquor Quality for Churnet 3 Gully Pot.



2 MISSING OBSERVATIONS

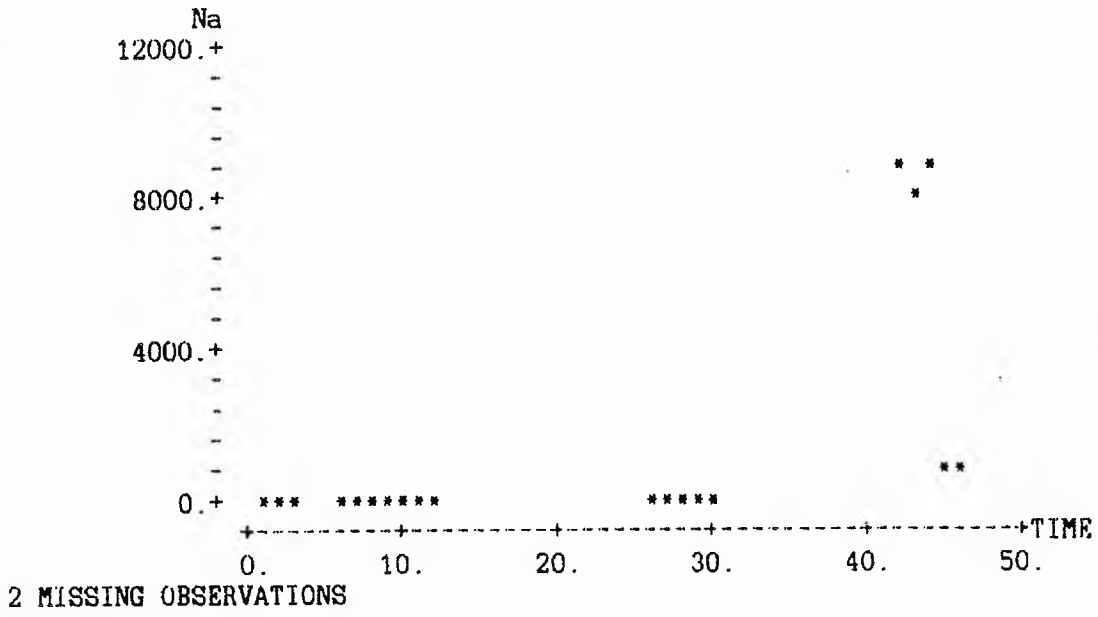
Figure 7.178



7 MISSING OBSERVATIONS

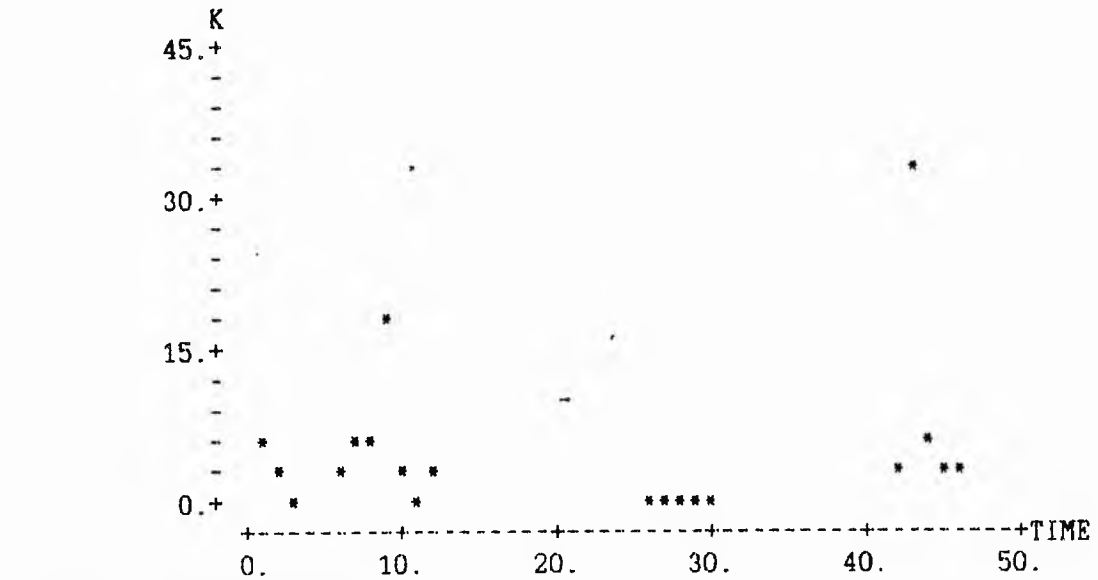
Figure 7.179

Graphs of Gully Pot Liquor Quality for Churnet 3 Gully Pot.



2 MISSING OBSERVATIONS

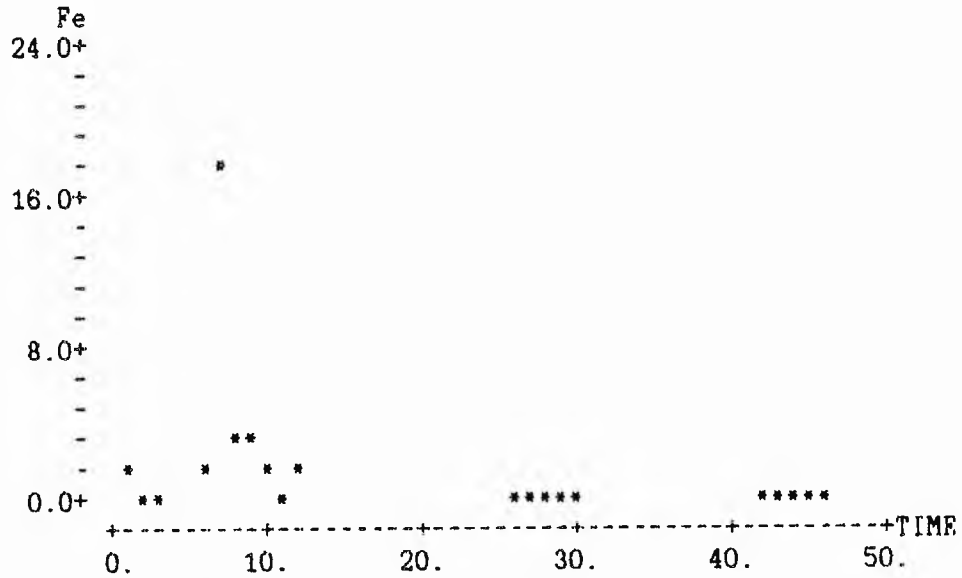
Figure 7.180



2 MISSING OBSERVATIONS

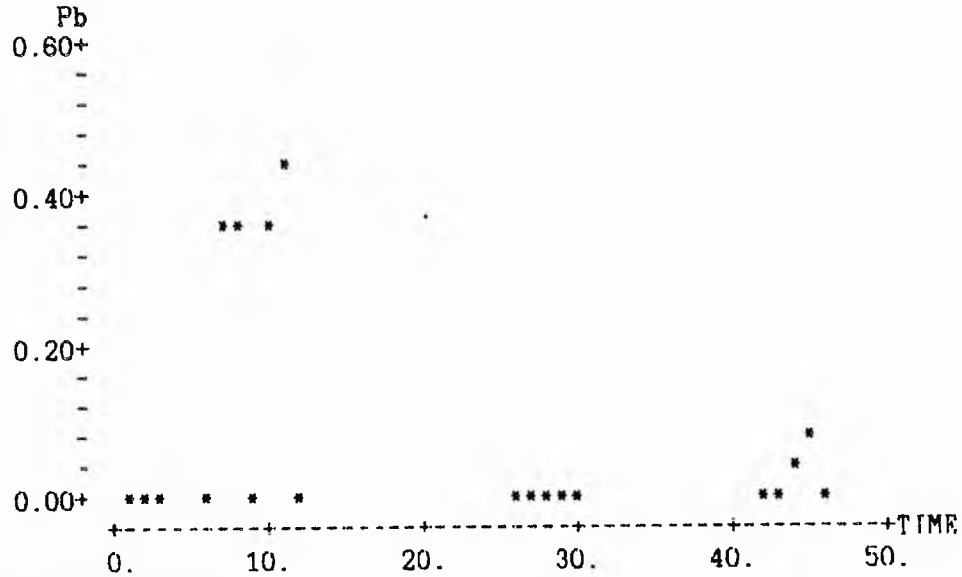
Figure 7.181

Graphs of Gully Pot Liquor Quality for Churnet 3 Gully Pot.



2 MISSING OBSERVATIONS

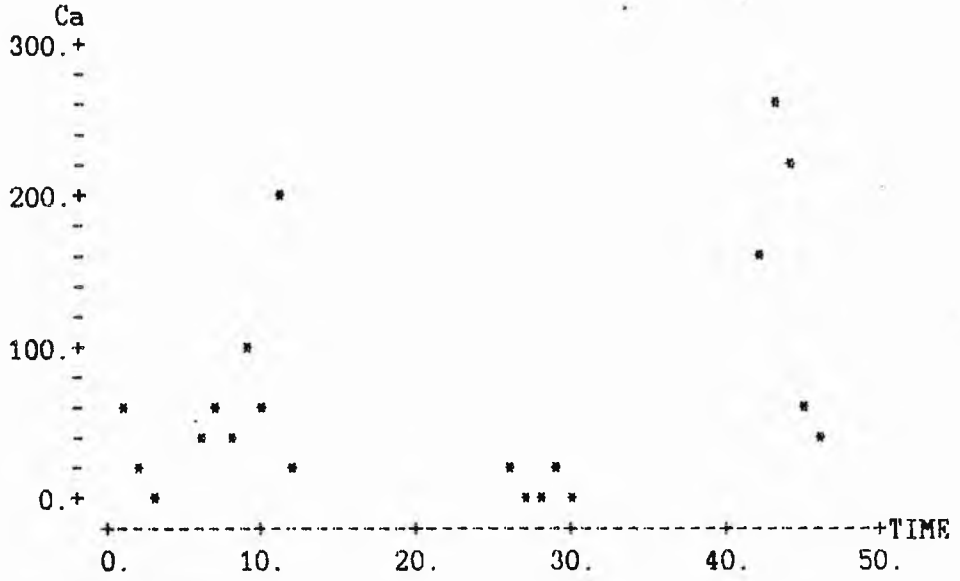
Figure 7.182



2 MISSING OBSERVATIONS

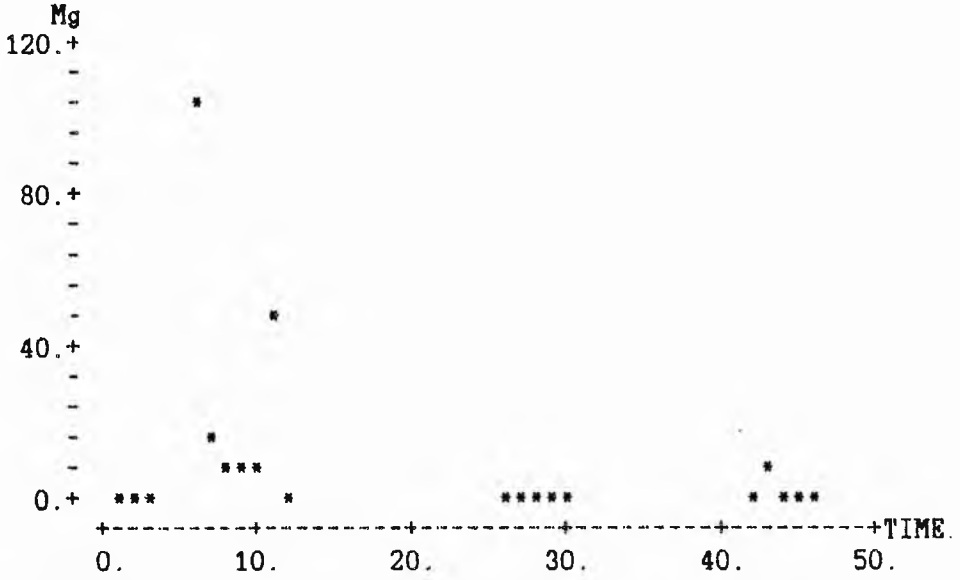
Figure 7.183

Graphs of Gully Pot Liquor Quality for Churnet 3 Gully Pot.



2 MISSING OBSERVATIONS

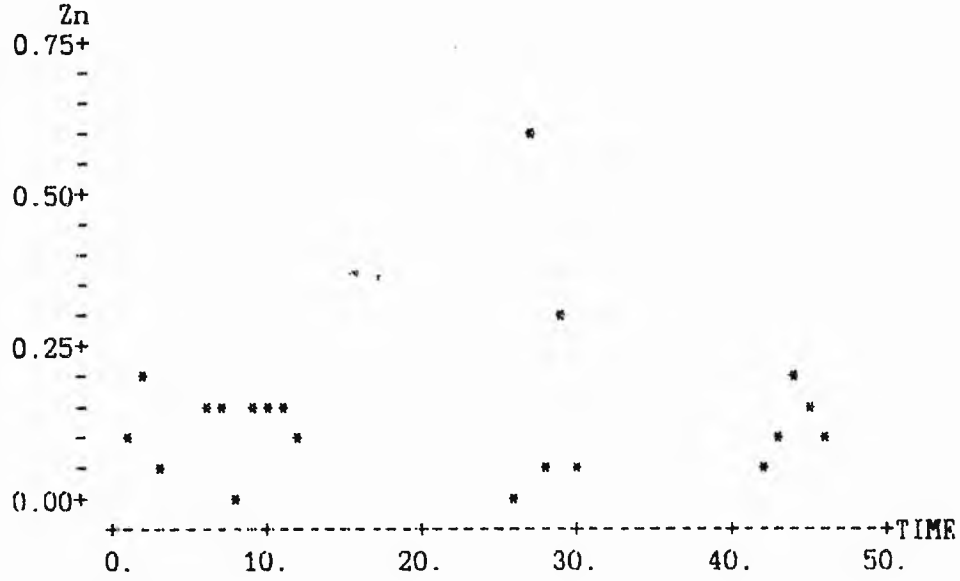
Figure 7.184



2 MISSING OBSERVATIONS

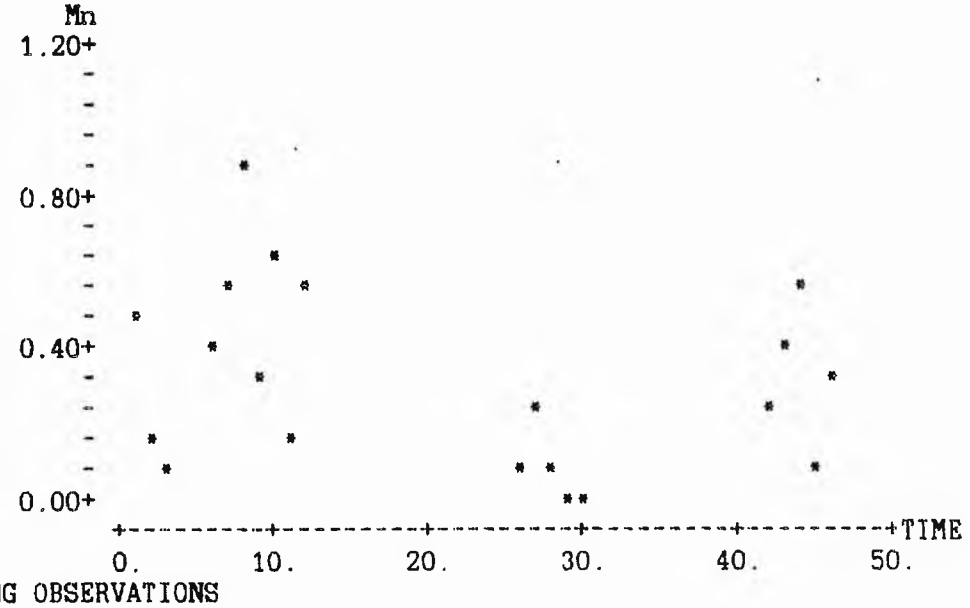
Figure 7.185

Graphs of Gully Pot Liquor Quality for Churnet 3 Gully Pot.



2 MISSING OBSERVATIONS

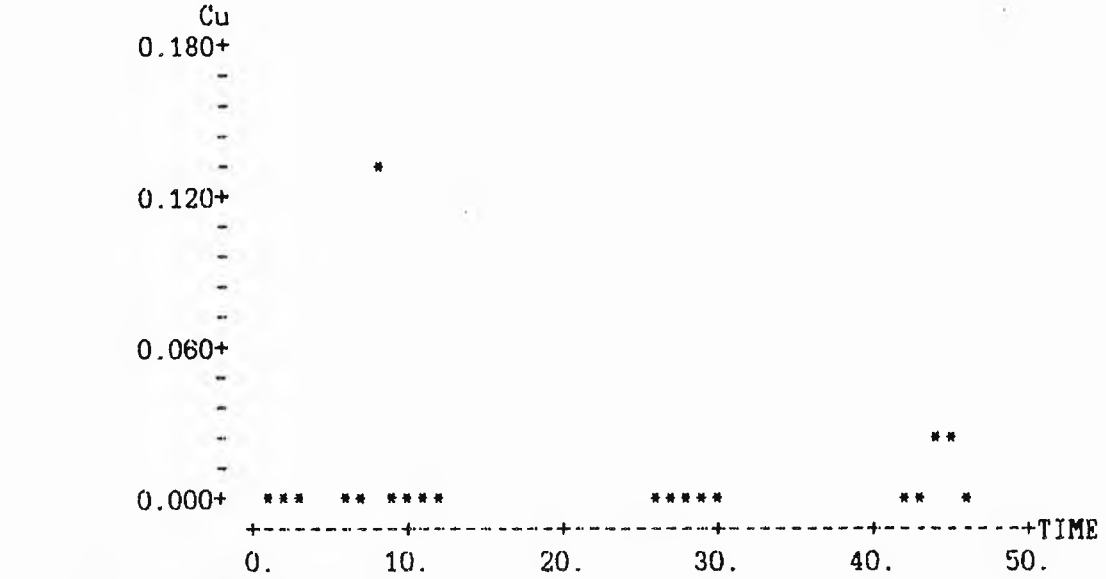
Figure 7.186



2 MISSING OBSERVATIONS

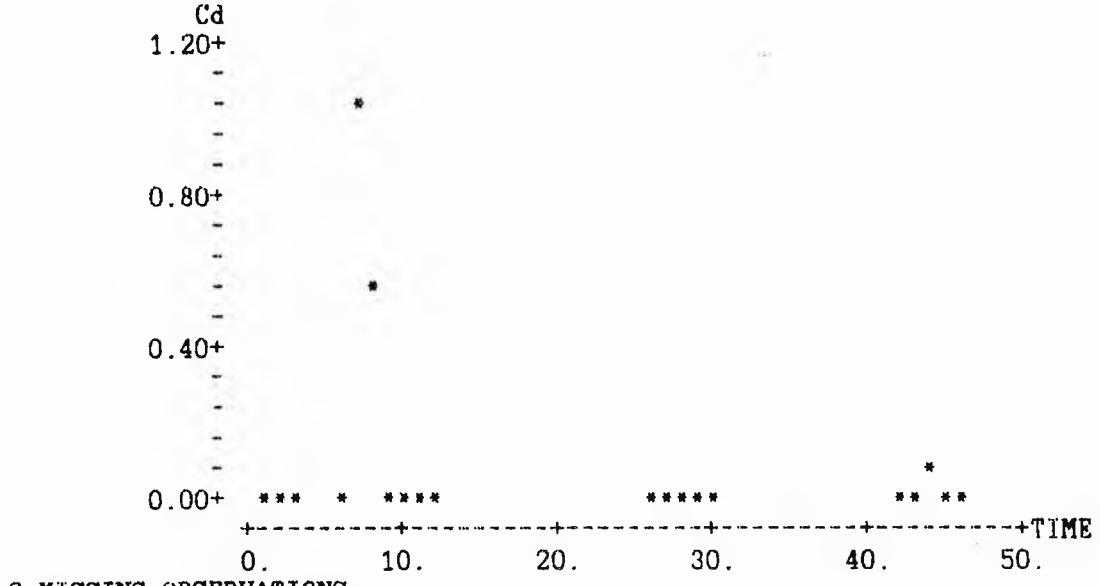
Figure 7.187

Graphs of Gully Pot Liquor Quality for Churnet 3 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.188



2 MISSING OBSERVATIONS

Figure 7.189

Graphs of Gully Pot Liquor Quality for Churnet 3 Gully Pot.

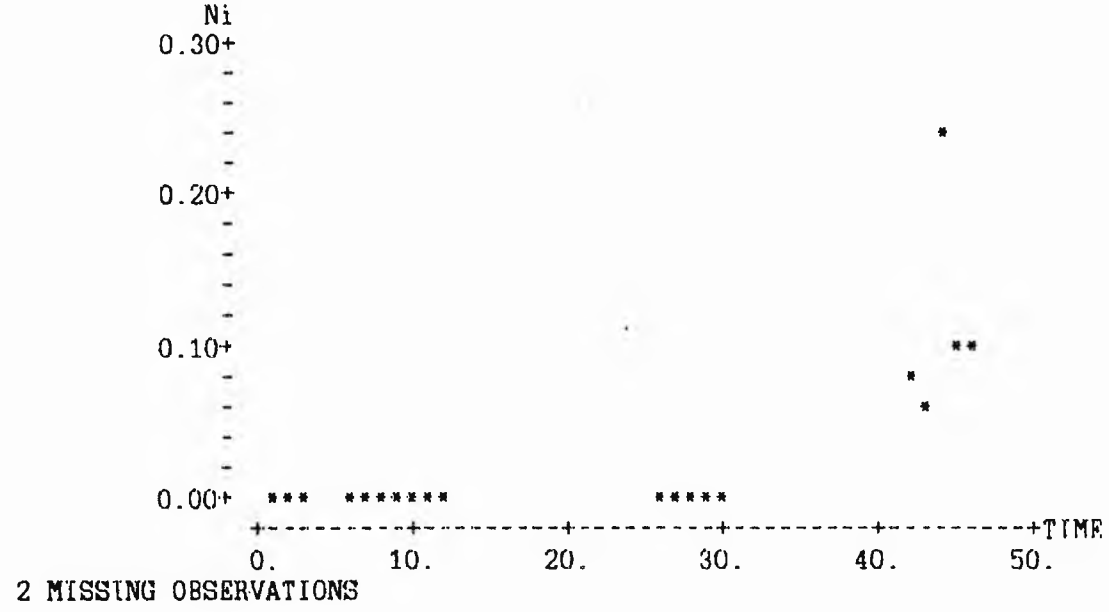


Figure 7.190

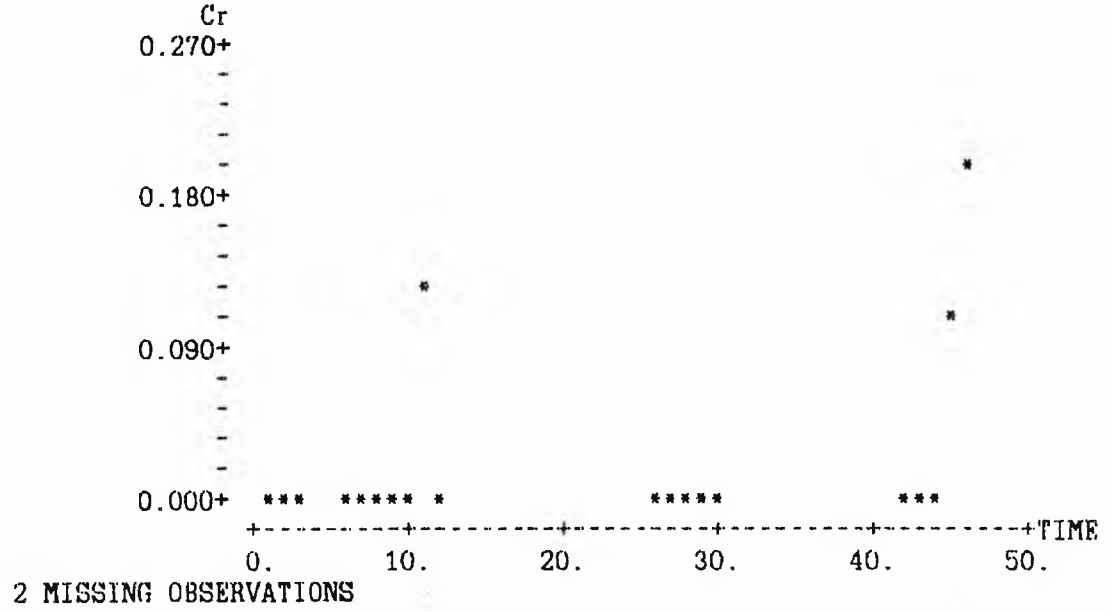


Figure 7.191

7.12 CHURNET 4:

(see Figures 7.192 to 7.217 and Tables 7.22 to 7.24 inclusive).

The pH values for this pot liquor are higher for the summer period than the values found in the other gully pots. The liquor shows marked alkaline conditions during the summer months with two pH values of pH 11.4 being observed on the 840613 and 840620. The field notes made during the collection of these samples describe a scum on the surface of the liquor and it was thought that a cleaning material had found its way into the gully pot. There were no signs of any caustic attack on the perimeter concrete of the pot (a condition observed elsewhere), but these exceptionally high pH values were undoubtedly derived from an anthropogenic source.

The maximum values found for Conductivity, sodium and chloride in the Churnet 4 pot liquor were 6.15 (x1000) μscm^{-1}, 3800.0 mgl^{-1} and 3191.0 mgl^{-1} as Cl^-, respectively. These maxima were not as high as those found in some of the other pots and the increase in the concentrations of these parameters during the winter in comparison to the average values for the rest of the year, were not as marked as that found for some of the other pots under consideration.

The rock salt-associated increases in levels of calcium, sulphate and the Total Hardness were much less evident for this gully pot and the values found during the spring period were only slightly above those for the summer and autumn periods.

High ammonia concentrations were observed during the summer period with values of 16.8 mgl^{-1} as N and 11.2 mgl^{-1} as N occurring on the 840613 and 840620. The levels of ammonia measured during the autumn and spring periods were very low by comparison. A similar trend was

also observed for the nitrate data but a number of missing values appear in the dataset which invalidates some of the conclusions to be drawn. Problems encountered with the ion selective electrode caused some data loss during the autumn period.

Lead was detected during the summer period with a maximum concentration of 0.70 mgl-1 being observed on the 840627 and 840711. This observation was consistent with that found in the Churnet 3 pot liquor. Lead was not found during the autumn period but detectable concentrations were evident in the spring period possibly due to the presence of alkyl-lead compounds in petrol. Previous studies have detected significant quantities of lead in the atmospheric particulates near to vehicles in their start-up mode. This is particularly marked during the increased stress upon the engine in the cold weather due to the increased revving and the slower movement of the vehicle over a snowcover or iced surface.

The four heavy metals - Copper, Cadmium, Nickel and Chromium were all detected again during the spring period, but were otherwise undetected during the rest of the study period. (The notable exception was the presence of copper in concentrations of 0.13 and 0.20 mgl-1 in two samples taken on the 840613 and 840627). In the spring period, the concentrations of the heavy metals detected were generally lower than for other gully pots in the study.

Table 7.22

Table of all the Water Quality Data collected over the Twenty-Two Week Period for the Gully Pot Standing Liquor in the Churnet 4 Gully Pot.

ROW	DATE	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
1	84Ø5Ø9	11.5	2.8	6.3	12Ø	3ØØ	Ø.4Ø	*	58	537
2	84Ø516	13.5	4.3	6.7	8Ø	8Ø	Ø.1Ø	22	9	32
3	84Ø523	14.Ø	2.1	9.8	19Ø	19Ø	Ø.11	*	5	Ø
4	84Ø53Ø	14.5	6.3	9.3	*	*	Ø.Ø9	*	Ø	*
5	84Ø6Ø6	15.Ø	8.3	8.7	*	*	Ø.17	*	7	*
6	84Ø613	17.5	2.6	11.4	2ØØ	26Ø	1.56	2449	59	97
7	84Ø62Ø	19.5	4.2	11.4	3ØØ	39Ø	1.65	2Ø2	38	98
8	84Ø627	19.Ø	1.9	7.1	21Ø	8Ø	Ø.23	184	2	83
9	84Ø7Ø4	24.Ø	3.9	7.9	22Ø	29Ø	Ø.34	227	17	67
1Ø	84Ø711	23.Ø	Ø.7	8.1	19Ø	46Ø	Ø.4Ø	63	31	118
11	84Ø718	2Ø.Ø	2.1	6.8	8Ø	42Ø	Ø.11	17	9	16
12	84Ø725	17.Ø	Ø.3	7.3	21Ø	24Ø	Ø.17	28	17	66
13	841Ø31	12.Ø	6.1	5.9	3Ø	4Ø	Ø.Ø7	27	12	55
14	841Ø7	1Ø.Ø	Ø.4	6.Ø	15Ø	5Ø	Ø.Ø9	75	9	84
15	841114	1Ø.Ø	2.5	6.1	5Ø	4Ø	Ø.Ø5	66	39	51
16	841121	8.Ø	3.9	6.1	3Ø	17Ø	Ø.Ø5	26	25	Ø
17	841128	7.Ø	6.Ø	6.3	3Ø	15Ø	Ø.Ø4	7Ø	4	11Ø
18	85Ø22Ø	2.5	2.2	6.9	7Ø	21Ø	6.15	88	51	71
19	85Ø227	4.Ø	Ø.6	7.Ø	13Ø	25Ø	5.86	46	41	275
2Ø	85Ø3Ø6	5.Ø	4.9	7.9	17Ø	4ØØ	1.45	62	3	74
21	85Ø313	5.5	3.9	7.3	5Ø	51Ø	Ø.42	3Ø	1Ø	5Ø
22	85Ø32Ø	4.5	6.1	7.1	15Ø	53Ø	Ø.5Ø	82	14	149

ROW	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
1	2.6	21.3	211	4.1	*	16.2Ø	1Ø.5Ø	Ø.4Ø	Ø.ØØ
2	1.6	24.8	2Ø2	4.1	*	1.5Ø	1.7Ø	Ø.1Ø	Ø.ØØ
3	1.7	49.6	Ø	4.2	*	1.1Ø	1.3Ø	Ø.3Ø	Ø.ØØ
4	*	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*	*
6	1.6	5Ø.Ø	4Ø4	16.8	11.9	34.ØØ	17.5Ø	Ø.4Ø	Ø.ØØ
7	Ø.6	71.Ø	163	11.2	12.6	22.ØØ	5.ØØ	5.ØØ	Ø.ØØ
8	Ø.3	252.Ø	*	2.4	7.Ø	7.5Ø	6.5Ø	Ø.8Ø	Ø.7Ø
9	Ø.6	35.Ø	163	Ø.2	6.3	22.ØØ	25.ØØ	2.7Ø	Ø.ØØ
1Ø	1.1	35.Ø	375	3.4	47.6	12.5Ø	3.ØØ	Ø.3Ø	Ø.7Ø
11	4.Ø	25.Ø	8Ø7	Ø.2	1.5	4.ØØ	1.1Ø	Ø.3Ø	Ø.54
12	1.5	28.Ø	596	1.4	6.4	7.4Ø	1.2Ø	Ø.5Ø	Ø.ØØ
13	2.1	28.4	Ø	Ø.3	1.5	1.72	Ø.8Ø	Ø.2Ø	Ø.ØØ
14	Ø.7	31.9	58	Ø.3	1.5	3.5Ø	Ø.9Ø	Ø.ØØ	Ø.ØØ
15	Ø.9	17.7	96	Ø.1	2.Ø	1.7Ø	Ø.7Ø	Ø.ØØ	Ø.ØØ
16	Ø.Ø	7.1	135	Ø.1	Ø.8	3.7Ø	Ø.7Ø	Ø.ØØ	Ø.ØØ
17	Ø.3	14.2	96	Ø.4	Ø.5	3.6Ø	Ø.6Ø	Ø.ØØ	Ø.ØØ
18	6.9	3191.Ø	432	Ø.9	*	38ØØ.ØØ	4.2Ø	Ø.52	Ø.11
19	1.9	2836.Ø	471	Ø.Ø	*	25ØØ.ØØ	42.ØØ	1.78	Ø.3Ø
2Ø	1.Ø	53.Ø	1451	Ø.4	4.6	23ØØ.ØØ	1.2Ø	Ø.23	Ø.ØØ
21	Ø.7	81.5	25Ø	Ø.5	6.3	55.ØØ	1.Ø7	Ø.18	Ø.ØØ
22	5.6	1Ø6.Ø	7Ø2	Ø.7	8.1	5Ø.ØØ	13.8Ø	Ø.71	Ø.Ø8

ROW	Ca	Mg	Zn	Mn	Cu	Cd	Ni	Cr
1	44.Ø	Ø.ØØ	Ø.Ø7	Ø.13	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
2	15.Ø	Ø.ØØ	1.18	Ø.16	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
3	15.2	Ø.ØØ	Ø.Ø4	Ø.Ø6	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
4	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*
6	1ØØ.Ø	1.ØØ	Ø.ØØ	Ø.Ø5	Ø.13	Ø.ØØ	Ø.ØØ	Ø.Ø
7	13Ø.Ø	3.ØØ	Ø.1Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
8	37.5	3.ØØ	Ø.ØØ	Ø.ØØ	Ø.2Ø	Ø.ØØ	Ø.ØØ	Ø.Ø
9	7Ø.Ø	5.ØØ	Ø.2Ø	Ø.28	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
1Ø	5Ø.Ø	1.4Ø	Ø.Ø8	Ø.13	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
11	141.Ø	35.ØØ	Ø.Ø6	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
12	2Ø.5	Ø.76	Ø.Ø5	Ø.1Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
13	1Ø.Ø	Ø.7Ø	Ø.Ø2	Ø.Ø3	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
14	9.3	1.2Ø	Ø.19	Ø.1Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
15	9.Ø	Ø.7Ø	Ø.Ø5	Ø.Ø5	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
16	5.7	Ø.4Ø	Ø.22	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
17	4.6	Ø.4Ø	Ø.Ø3	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
18	8Ø.Ø	3.15	Ø.18	Ø.22	Ø.ØØ	Ø.Ø3	Ø.Ø9	Ø.Ø
19	13Ø.Ø	4.6Ø	Ø.22	Ø.34	Ø.ØØ	Ø.Ø2	Ø.13	Ø.Ø
2Ø	29.Ø	1.ØØ	Ø.16	Ø.1Ø	Ø.Ø2	Ø.ØØ	Ø.ØØ	Ø.Ø
21	33.8	1.5Ø	Ø.16	Ø.1Ø	Ø.ØØ	Ø.Ø2	Ø.ØØ	Ø.1
22	18.8	1.28	Ø.16	Ø.22	Ø.ØØ	Ø.Ø1	Ø.1Ø	Ø.1

Statistical Summary of the Water Quality Data for the Standing Pot Liquor collected in the Churnet 4 Gully Pot.

Table 7.23

	TEMP	DO	PH	ALK	TH	COND	SS	BOD
N	22	22	22	20	20	22	18	22
NMISS	0	0	0	2	2	0	4	0
MEAN	12.59	3.46	7.61	133.0	253	0.91	209	20.9
MEDIAN	12.75	3.35	7.10	140.0	245	0.20	65	13.0
TMEAN	12.52	3.38	7.50	129.4	249	0.69	81	20.1
STDEV	6.38	2.19	1.61	78.0	158	1.72	563	18.8
SEMEAN	1.36	0.47	0.34	17.4	35	0.37	133	4.0
MAX	24.00	8.30	11.40	300.0	530	6.15	2449	59.0
MIN	2.50	0.30	5.90	30.0	40	0.04	17	0.0
Q3	17.87	5.18	8.25	197.5	398	0.74	112	38.3
Q1	6.62	2.05	6.30	55.0	98	0.09	28	6.5

	COD	PHOS	CL	SUL	AMM	NIT	Na	K
N	20	20	20	19	20	15	20	20
NMISS	2	2	2	3	2	7	2	2
MEAN	102	1.78	348	348	2.59	7.9	442	6.9
MEDIAN	73	1.30	35	211	0.60	6.3	10	1.5
TMEAN	83	1.60	209	304	1.94	5.4	280	5.3
STDEV	119	1.79	915	354	4.27	11.6	1078	10.6
SEMEAN	27	0.40	205	81	0.96	3.0	241	2.4
MAX	537	6.90	3191	1451	16.80	47.6	3800	42.0
MIN	0	0.00	7	0	0.00	0.5	1	0.6
Q3	107	2.05	79	471	3.93	8.1	46	9.5
Q1	50	0.63	25	96	0.22	1.5	4	0.9

	Fe	Pb	Ca	Mg	Zn	Mn	Cu	Cd
N	20	20	20	20	20	20	20	20
NMISS	2	2	2	2	2	2	2	2
MEAN	0.72	0.122	47.7	3.20	0.162	0.1035	0.0215	0.00400
MEDIAN	0.30	0.000	31.4	1.10	0.090	0.1000	0.0000	0.00000
TMEAN	0.52	0.096	44.9	1.62	0.115	0.0961	0.0128	0.00278
STDEV	1.20	0.239	45.3	7.63	0.250	0.0988	0.0535	0.00883
SEMEAN	0.27	0.053	10.1	1.71	0.056	0.0221	0.0120	0.00197
MAX	5.00	0.700	141.0	35.00	1.100	0.3400	0.2000	0.03000
MIN	0.00	0.000	4.6	0.00	0.000	0.0000	0.0000	0.00000
Q3	0.66	0.103	77.5	3.00	0.188	0.1525	0.0000	0.00000
Q1	0.12	0.000	11.3	0.48	0.050	0.0075	0.0000	0.00000

	Ni	Cr
N	20	20
NMISS	2	2
MEAN	0.0200	0.0100
MEDIAN	0.0000	0.0000
TMEAN	0.0150	0.0056
STDEV	0.0419	0.0308
SEMEAN	0.0094	0.0069
MAX	0.1300	0.1000
MIN	0.0000	0.0000
Q3	0.0000	0.0000
Q1	0.0000	0.0000

Table of the Correlation Coefficients between all Twenty-Six Water Quality Parameters for the Standing Pot Liquor in the Churnet 4 Gully Pot.

Table 7.24

	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
DO	-0.156								
PH	0.426	0.106							
ALK	0.574	-0.310	0.726						
TH	0.039	0.110	0.349	0.287					
COND	-0.437	-0.281	0.065	0.021	0.088				
SS	0.231	-0.063	0.672	0.287	0.013	0.078			
BOD	-0.060	-0.371	0.160	0.088	0.068	0.528	0.541		
COD	-0.148	-0.106	-0.122	0.076	0.164	0.222	0.072	0.533	
PHOS	-0.324	0.038	-0.113	-0.169	0.268	0.482	-0.038	0.272	0.148
CL	-0.463	-0.299	-0.101	-0.130	-0.049	0.959	-0.089	0.415	0.186
SUL	-0.171	0.016	0.066	0.185	0.550	0.223	0.002	-0.126	0.011
AMM	0.391	-0.044	0.838	0.521	0.104	0.035	0.826	0.495	0.086
NIT	0.477	-0.349	0.382	0.417	0.432	0.221	0.105	0.355	0.455
Na	-0.553	-0.135	-0.066	-0.098	0.062	0.894	-0.107	0.283	0.106
K	-0.021	-0.170	0.168	0.272	0.153	0.542	0.266	0.390	0.448
Fe	0.353	0.059	0.553	0.646	0.262	0.259	0.011	0.221	0.100
Pb	0.395	-0.425	-0.056	0.166	0.182	0.071	-0.124	-0.094	0.008
Ca	0.285	-0.277	0.476	0.363	0.400	0.548	0.295	0.448	0.170
Mg	0.294	-0.160	-0.064	-0.084	0.277	-0.002	-0.093	-0.137	-0.158
Zn	-0.008	0.140	-0.135	-0.167	-0.174	0.018	-0.113	-0.122	-0.125
Mn	-0.242	-0.167	-0.117	0.101	0.218	0.574	-0.120	0.243	0.346
Cu	0.173	-0.241	0.247	0.310	-0.193	0.177	0.504	0.087	0.074
Cd	-0.608	-0.093	-0.123	-0.263	0.248	0.786	-0.133	0.278	0.100
Ni	-0.632	0.032	-0.089	-0.023	0.280	0.762	-0.135	0.167	0.236
Cr	-0.378	0.352	-0.057	-0.145	0.579	-0.101	-0.099	-0.193	-0.006

	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
CL	0.525								
SUL	0.305	0.109							
AMM	-0.102	-0.164	-0.103						
NIT	-0.021	0.051	0.047	0.302					
Na	0.489	0.869	0.451	-0.200	-0.074				
K	0.091	0.489	0.069	0.110	0.106	0.297			
Fe	-0.110	0.121	-0.079	0.351	0.123	0.034	0.407		
Pb	0.071	0.139	0.265	-0.101	0.543	0.023	0.094	-0.032	
Ca	0.258	0.424	0.248	0.390	0.205	0.310	0.523	0.594	0.345
Mg	0.301	0.025	0.323	-0.143	-0.134	-0.013	0.004	0.045	0.463
Zn	0.012	0.040	-0.046	0.013	-0.086	0.038	0.009	-0.066	-0.183
Mn	0.382	0.592	0.166	-0.243	0.231	0.509	0.721	0.169	-0.037
Cu	-0.179	0.145	0.180	0.359	0.028	0.056	0.368	0.040	0.460
Cd	0.572	0.830	0.114	-0.227	-0.033	0.720	0.320	0.021	0.009
Ni	0.555	0.729	0.540	-0.250	-0.047	0.791	0.537	0.083	0.044
Cr	0.260	-0.095	0.127	-0.159	-0.025	-0.124	0.016	-0.079	-0.117

	Ca	Mg	Zn	Mn	Cu	Cd	Ni
Mg	0.595						
Zn	-0.117	-0.117					
Mn	0.205	-0.137	0.305				
Cu	0.239	-0.034	-0.152	-0.088			
Cd	0.270	-0.021	0.038	0.563	-0.013		
Ni	0.256	-0.032	0.043	0.668	0.080	0.668	
Cr	-0.162	-0.081	-0.003	0.196	-0.137	0.426	0.245

Graphs of Gully Pot Liquor Quality for Churnet 4 Gully Pot.

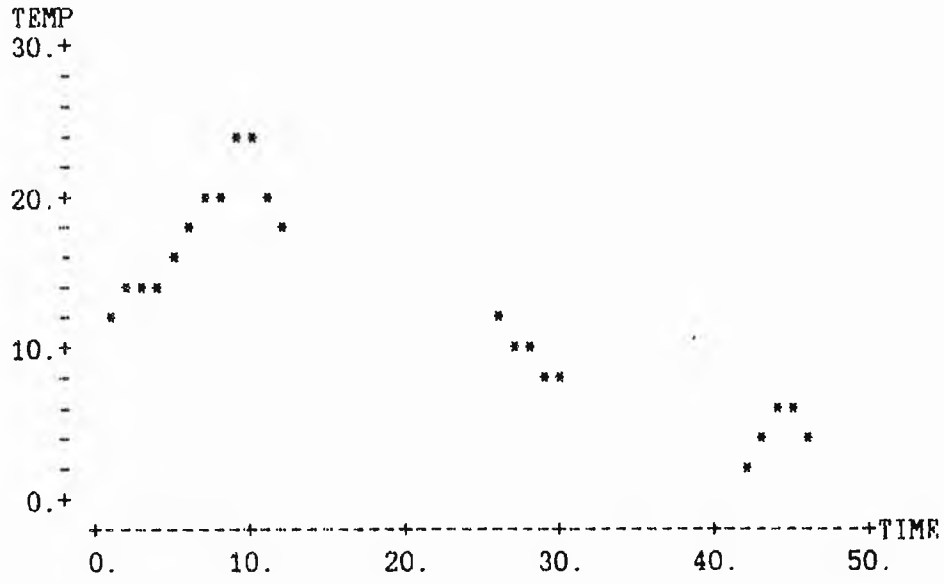


Figure 7.192

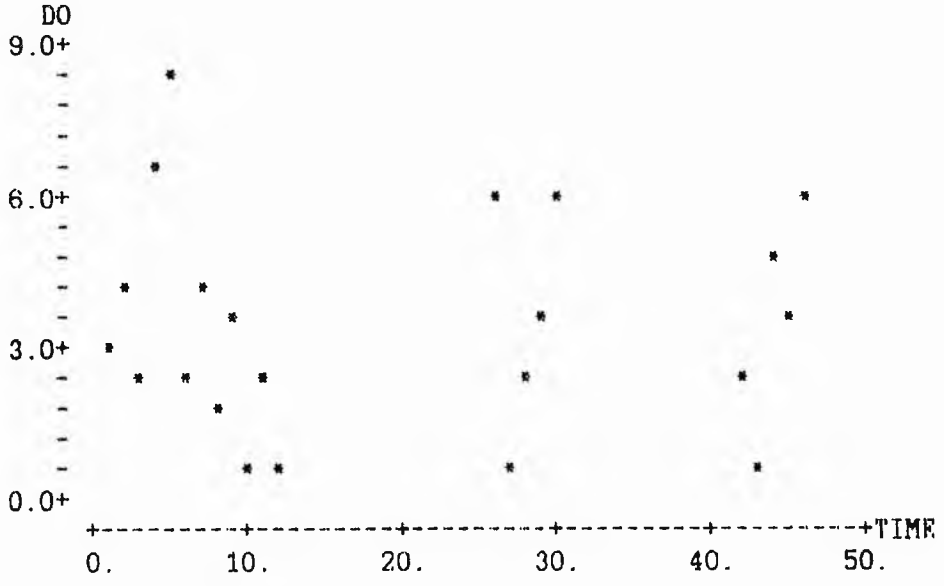


Figure 7.193

Graphs of Gully Pot Liquor Quality for Churnet 4 Gully Pot.

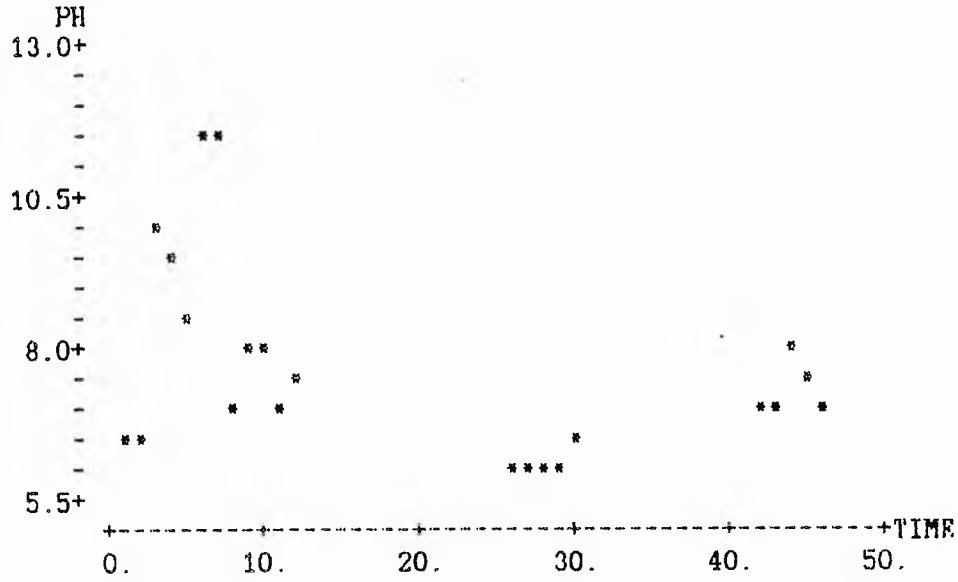
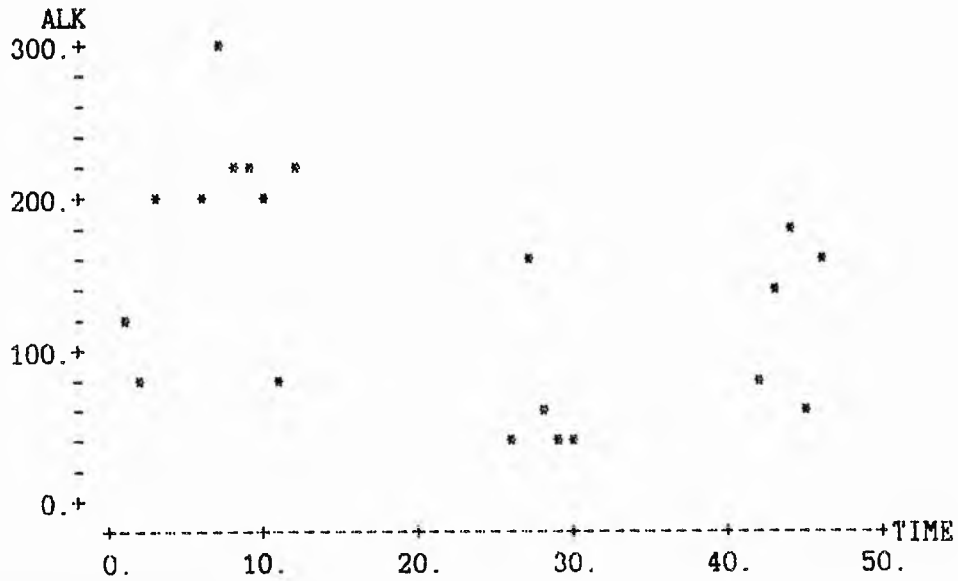


Figure 7.194



2 MISSING OBSERVATIONS

Figure 7.195

Graphs of Gully Pot Liquor Quality for Churnet 4 Gully Pot.

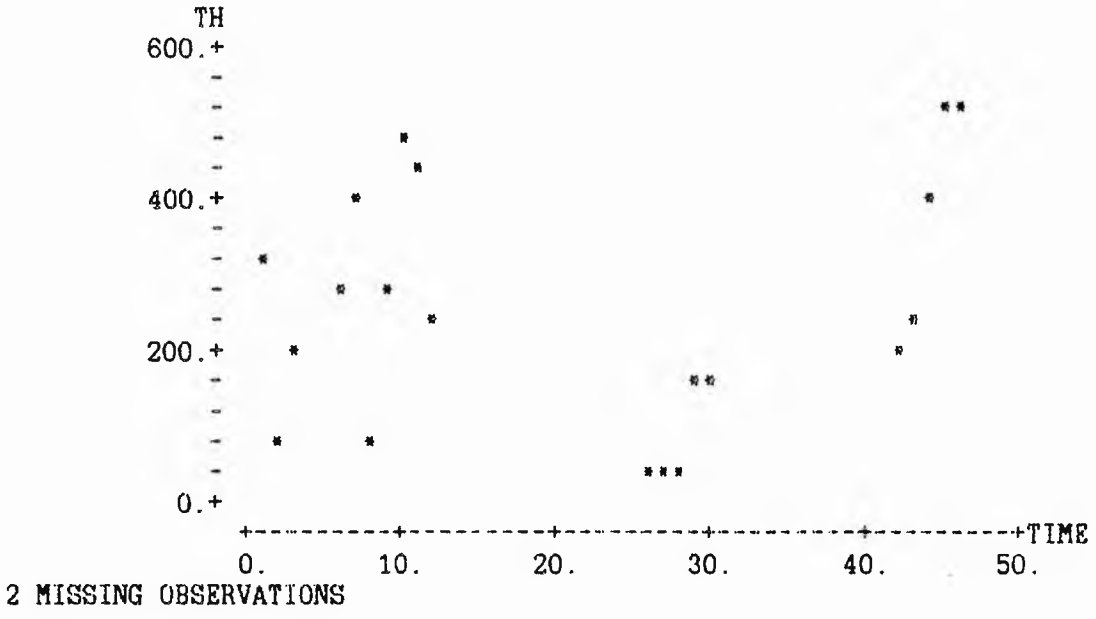


Figure 7.196

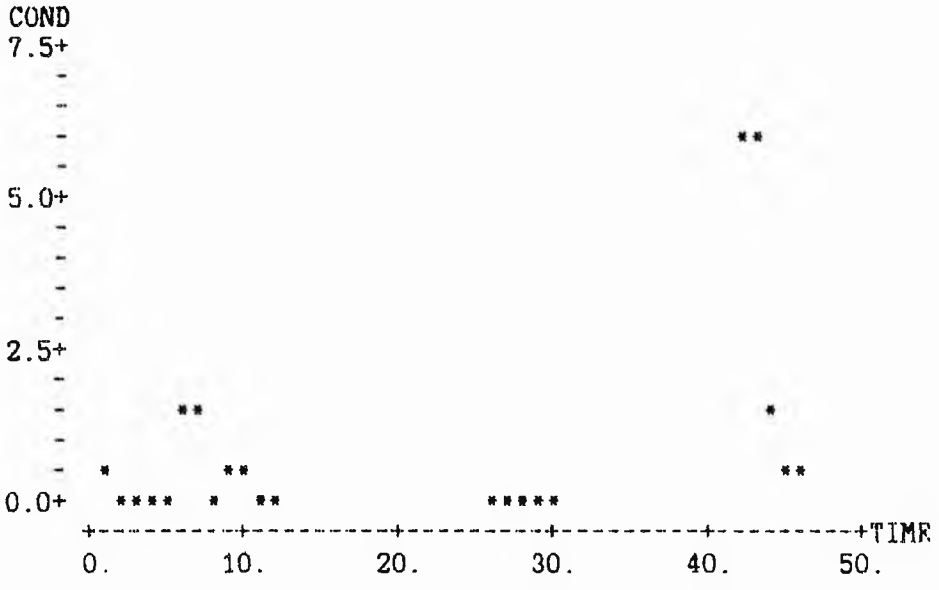
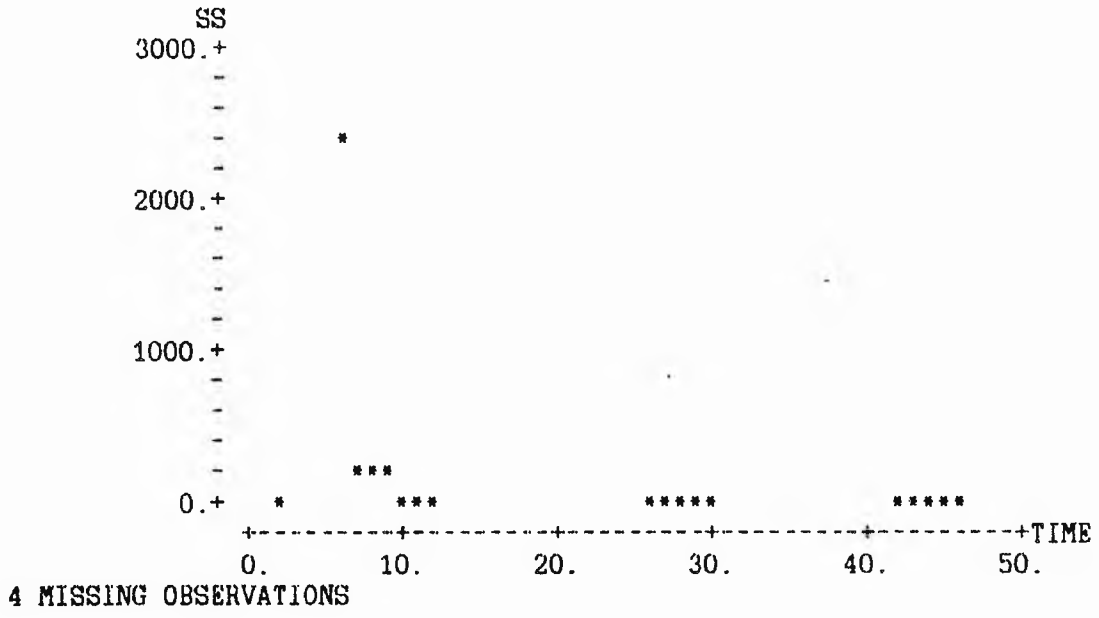


Figure 7.197

Graphs of Gully Pot Liquor Quality for Churnet 4 Gully Pot.



4 MISSING OBSERVATIONS

Figure 7.198

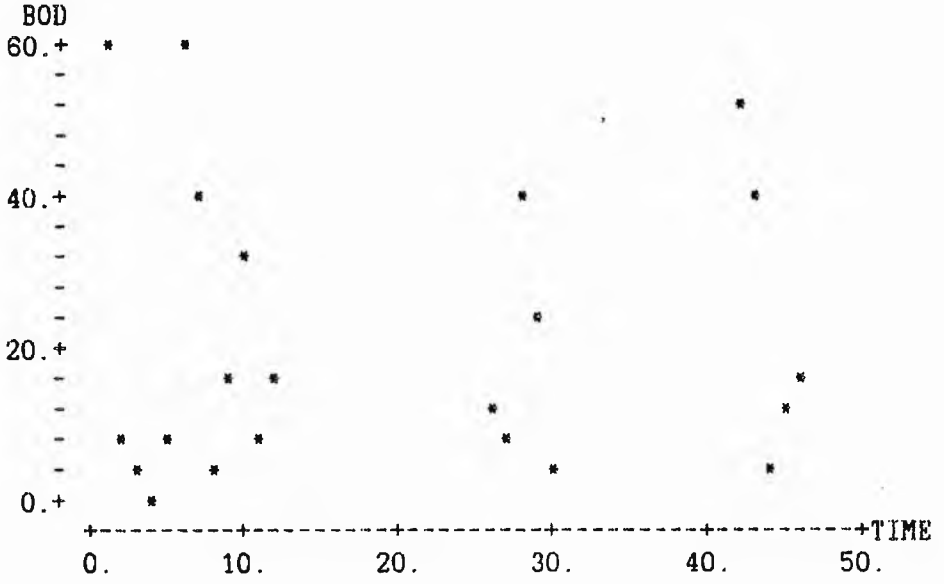
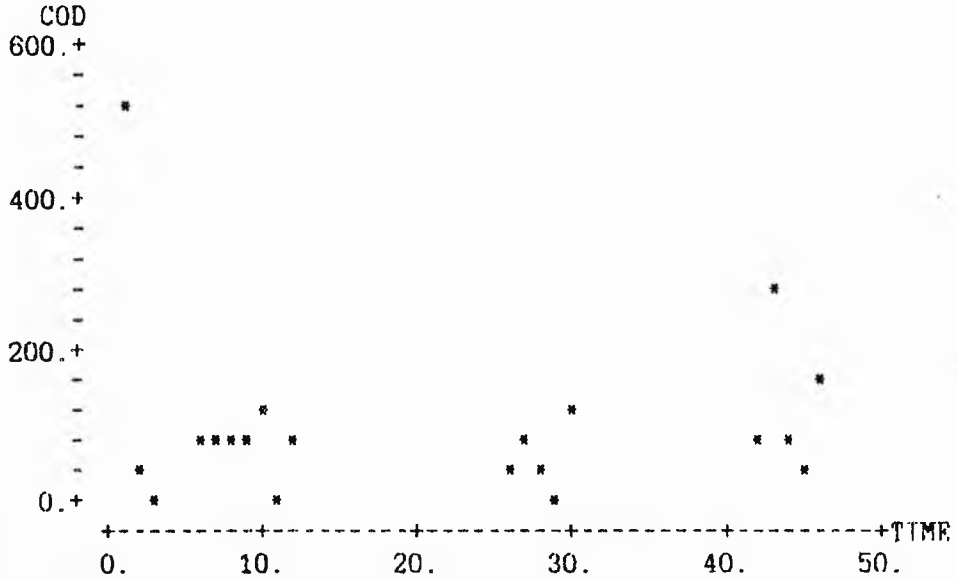


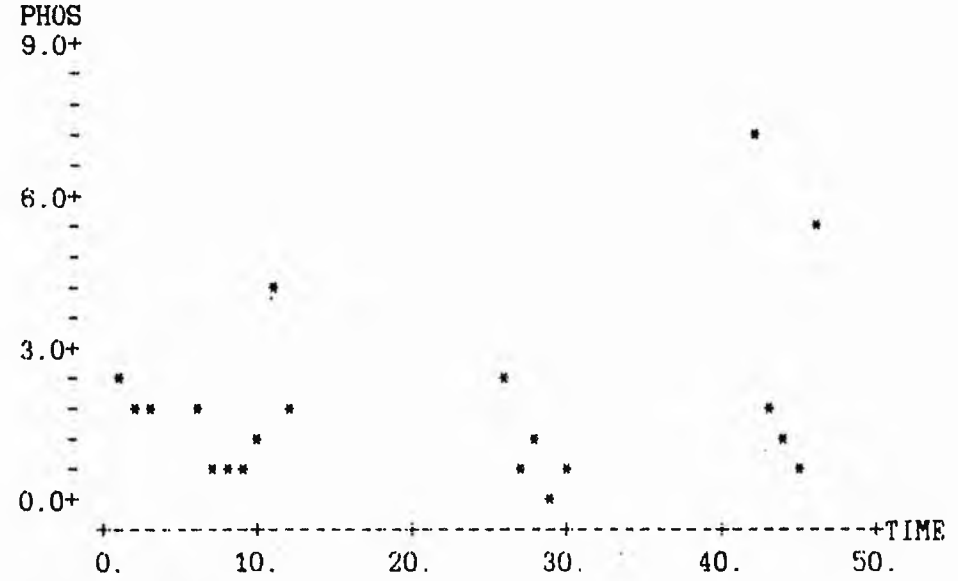
Figure 7.199

Graphs of Gully Pot Liquor Quality for Churnet 4 Gully Pot.



2 MISSING OBSERVATIONS

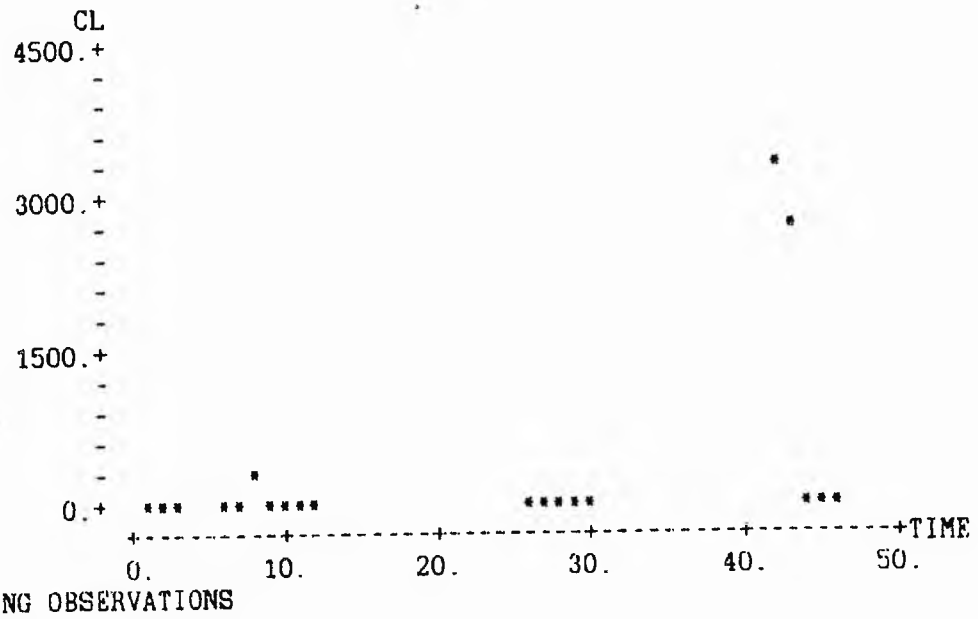
Figure 7.200



2 MISSING OBSERVATIONS

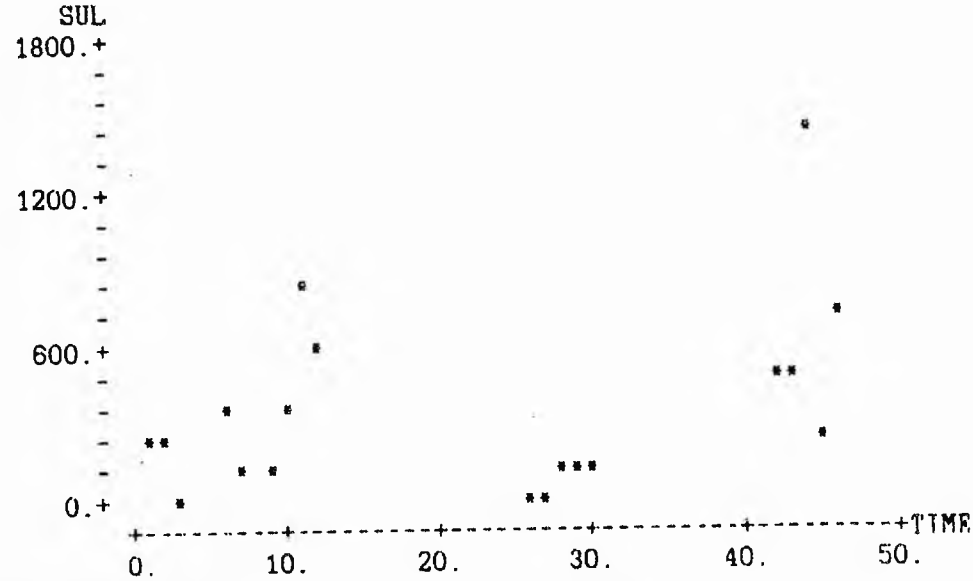
Figure 7.201

Graphs of Gully Pot Liquor Quality for Churnet 4 Gully Pot.



2 MISSING OBSERVATIONS

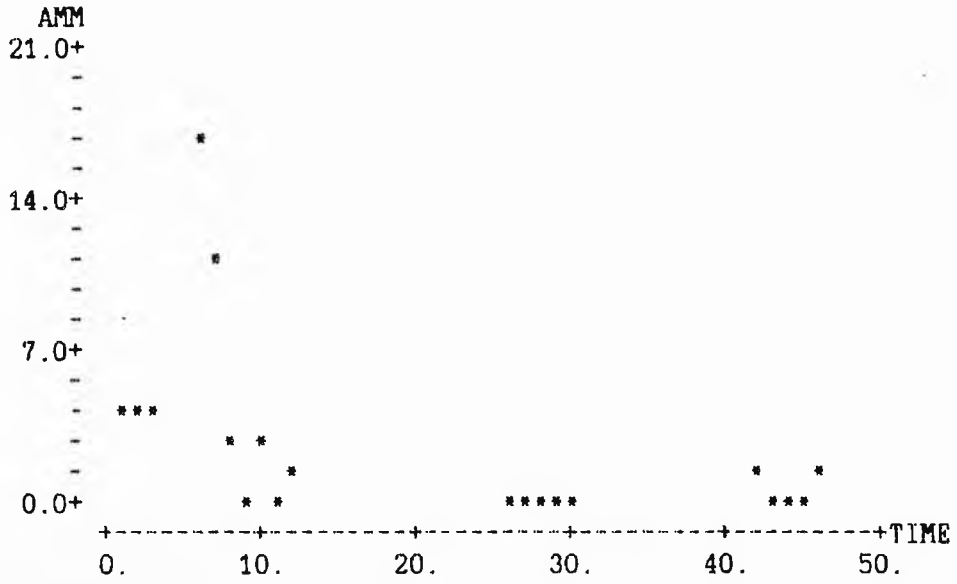
Figure 7.202



3 MISSING OBSERVATIONS

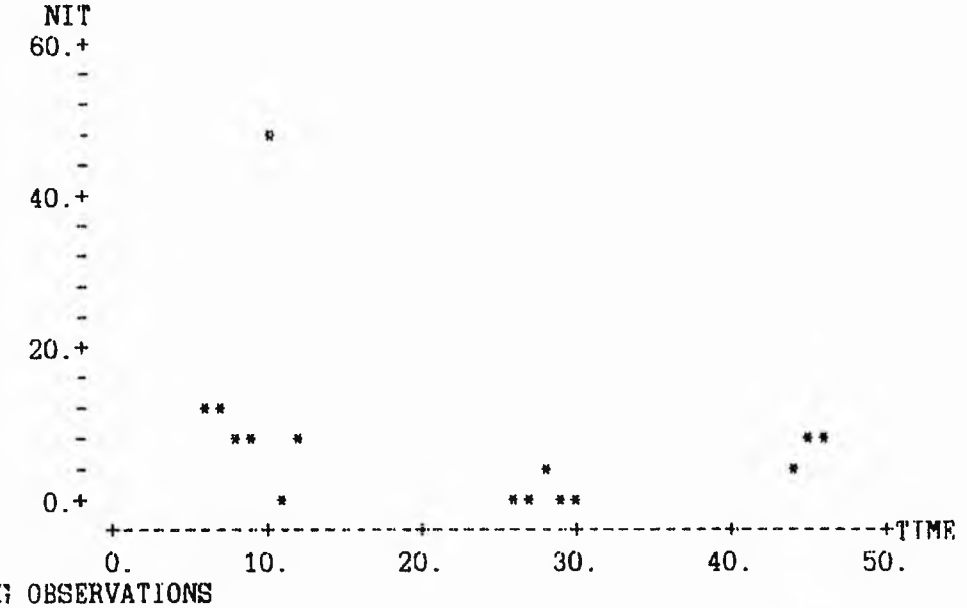
Figure 7.203

Graphs of Gully Pot Liquor Quality for Churnet 4 Gully Pot.



2 MISSING OBSERVATIONS

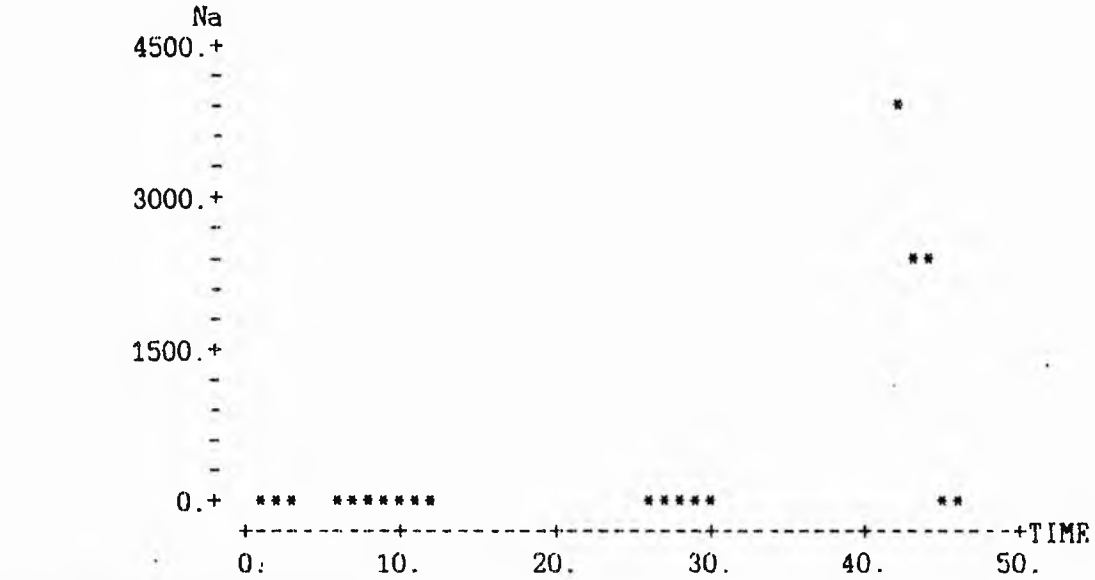
Figure 7.204



7 MISSING OBSERVATIONS

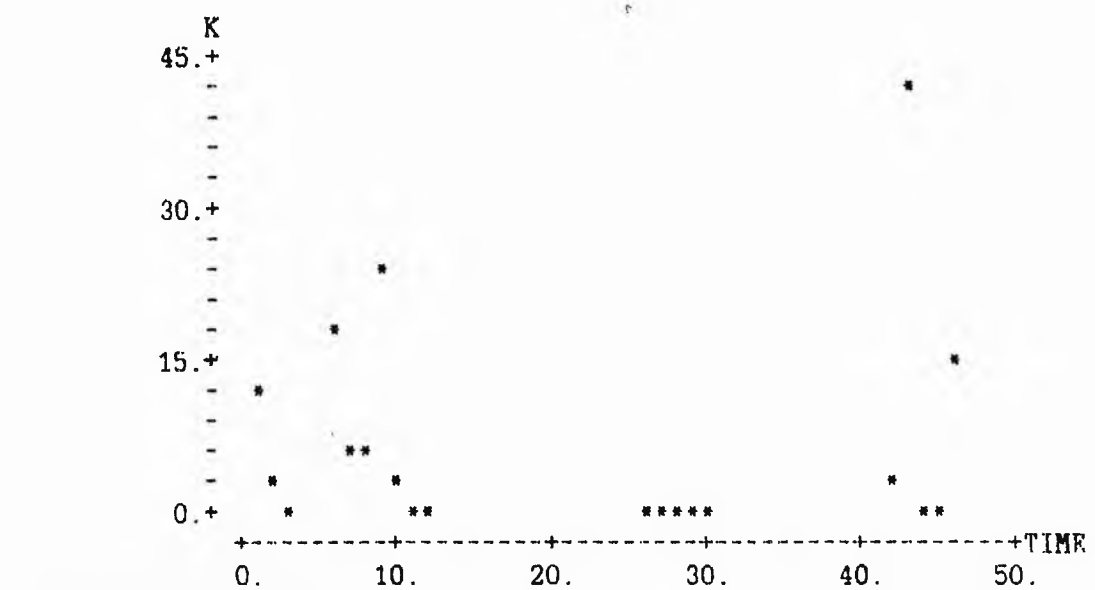
Figure 7.205

Graphs of Gully Pot Liquor Quality for Churnet 4 Gully Pot.



2 MISSING OBSERVATIONS

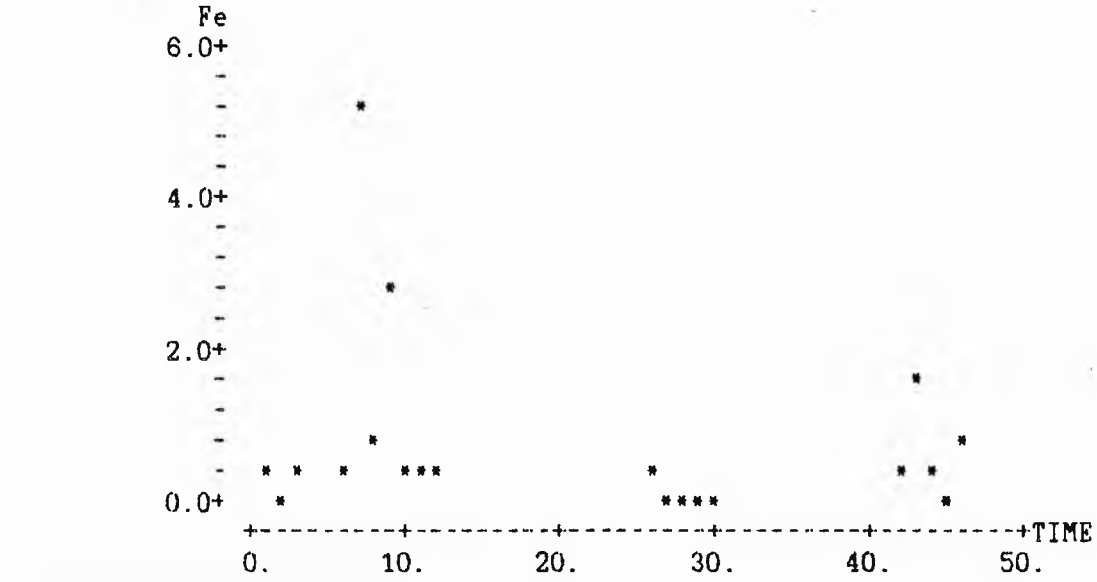
Figure 7.206



2 MISSING OBSERVATIONS

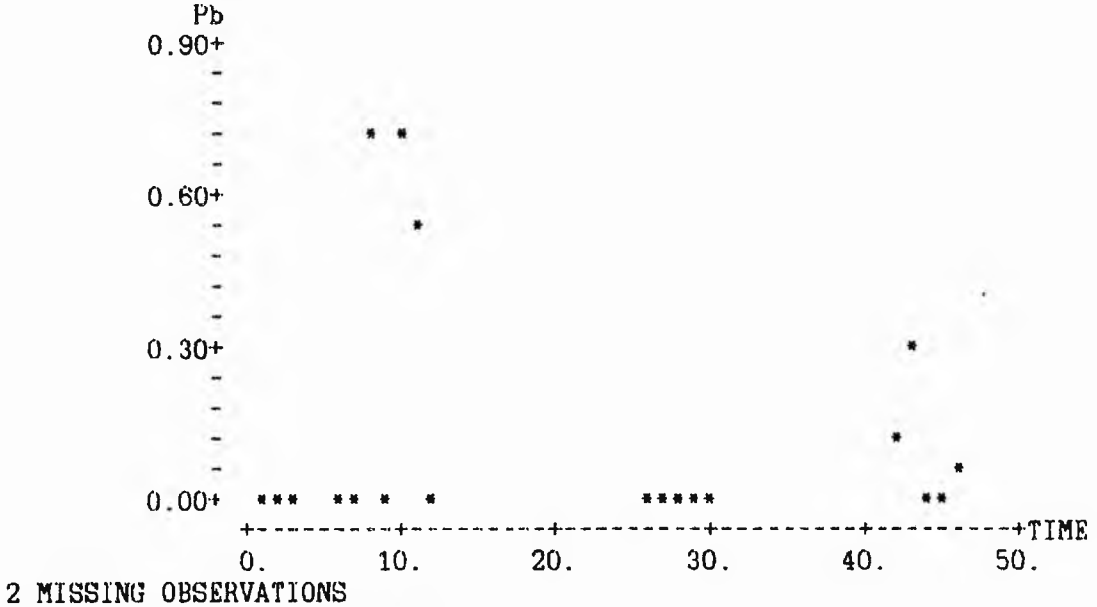
Figure 7.207

Graphs of Gully Pot Liquor Quality for Churnet 4 Gully Pot.



2 MISSING OBSERVATIONS

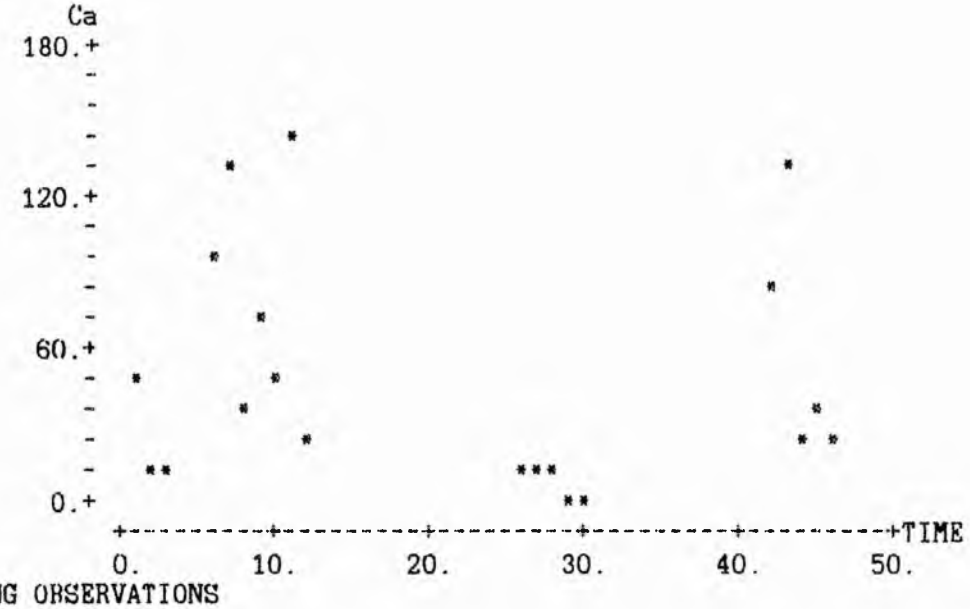
Figure 7.208



2 MISSING OBSERVATIONS

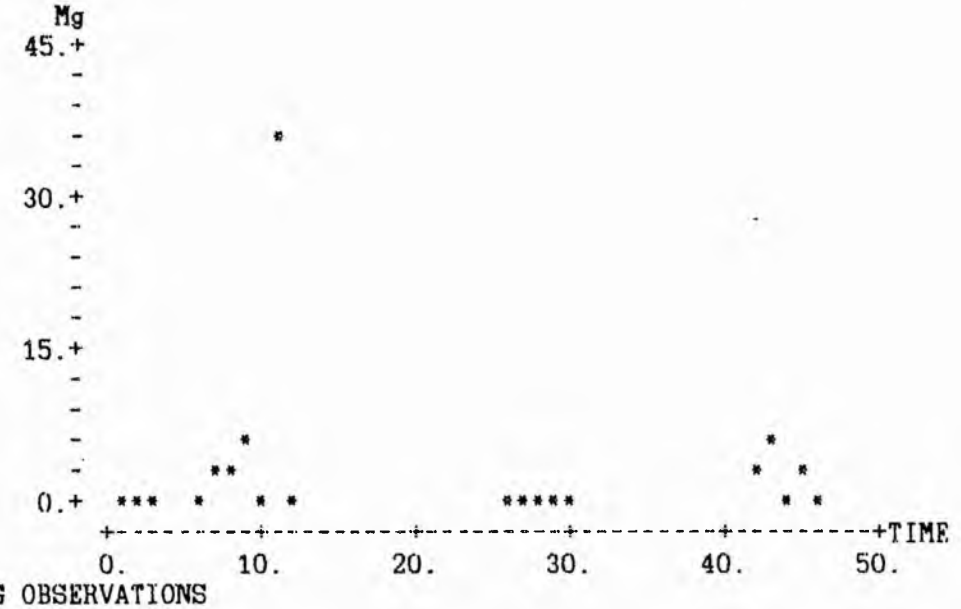
Figure 7.209

Graphs of Gully Pot Liquor Quality for Churnet 4 Gully Pot.



2 MISSING OBSERVATIONS

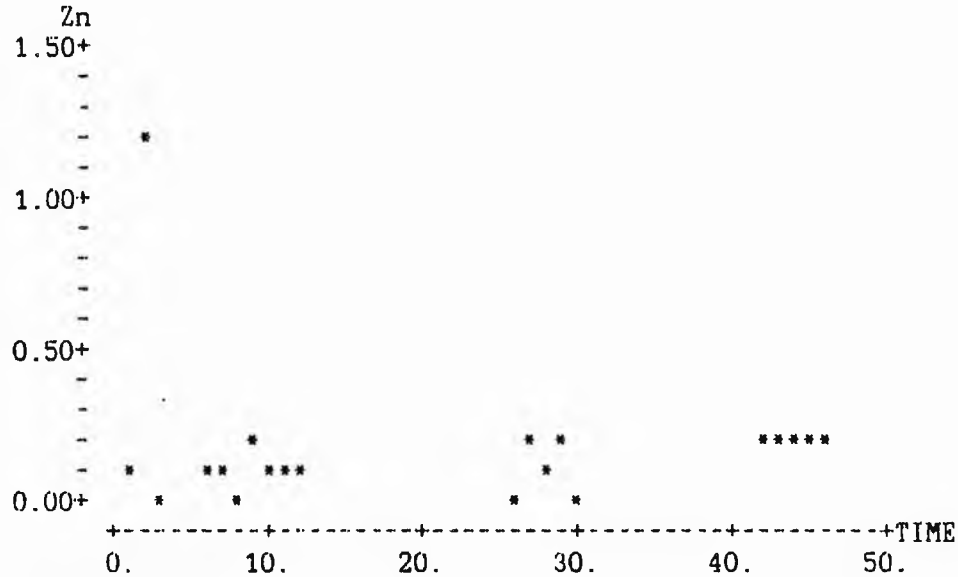
Figure 7.210



2 MISSING OBSERVATIONS

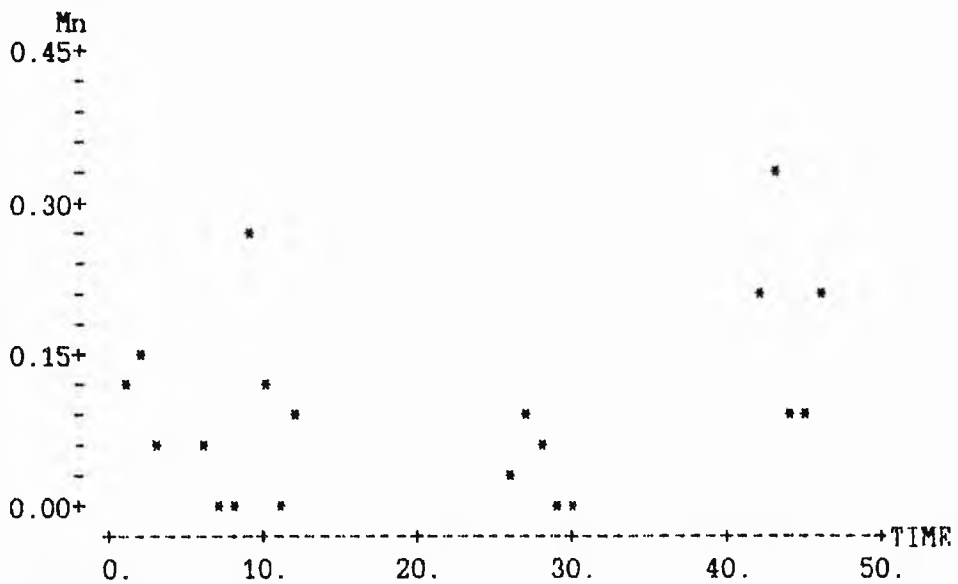
Figure 7.211

Graphs of Gully Pot Liquor Quality for Churnet 4 Gully Pot.



2 MISSING OBSERVATIONS

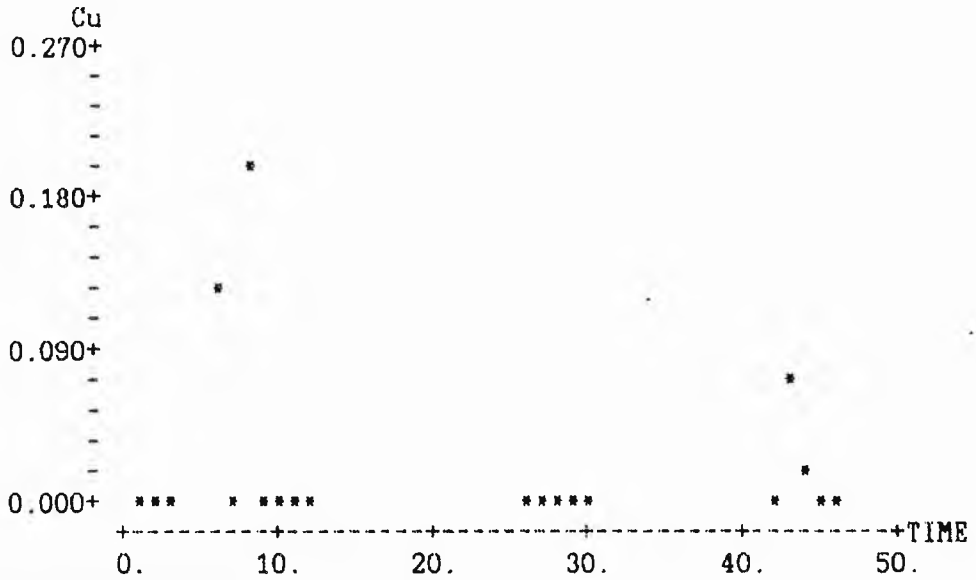
Figure 7.212



2 MISSING OBSERVATIONS

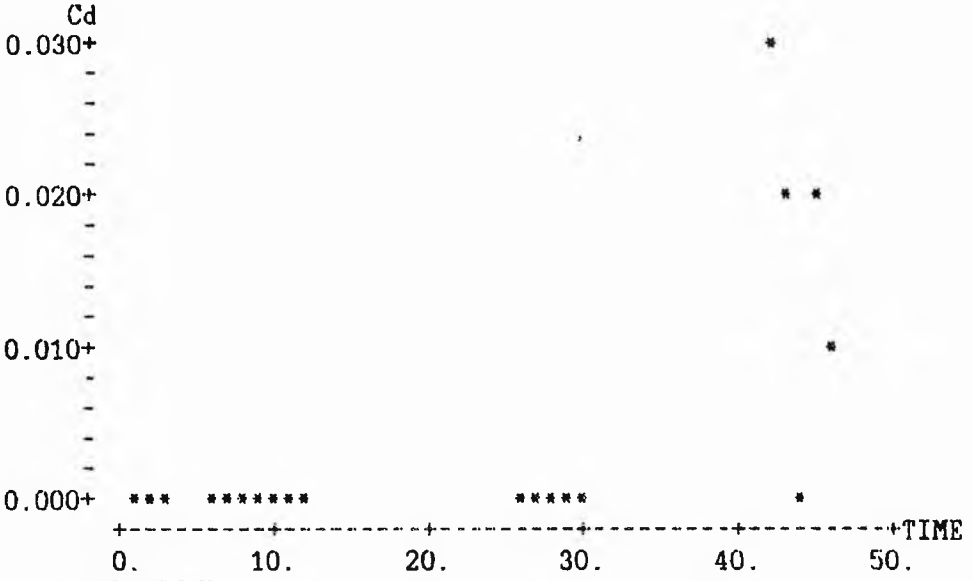
Figure 7.213

Graphs of Gully Pot Liquor Quality for Churnet 4 Gully Pot.



2 MISSING OBSERVATIONS

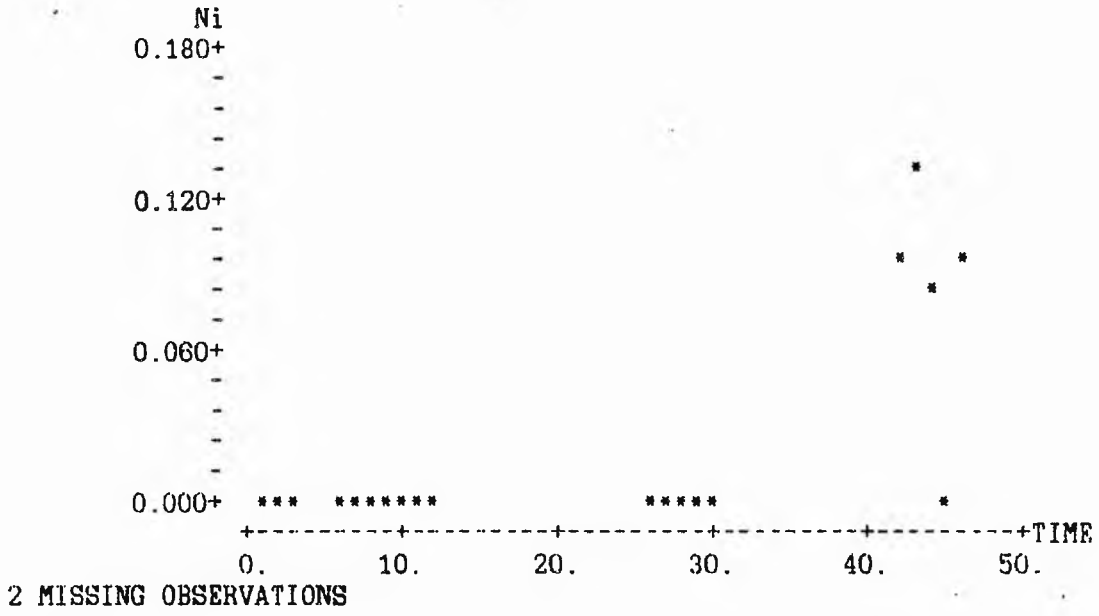
Figure 7.214



2 MISSING OBSERVATIONS

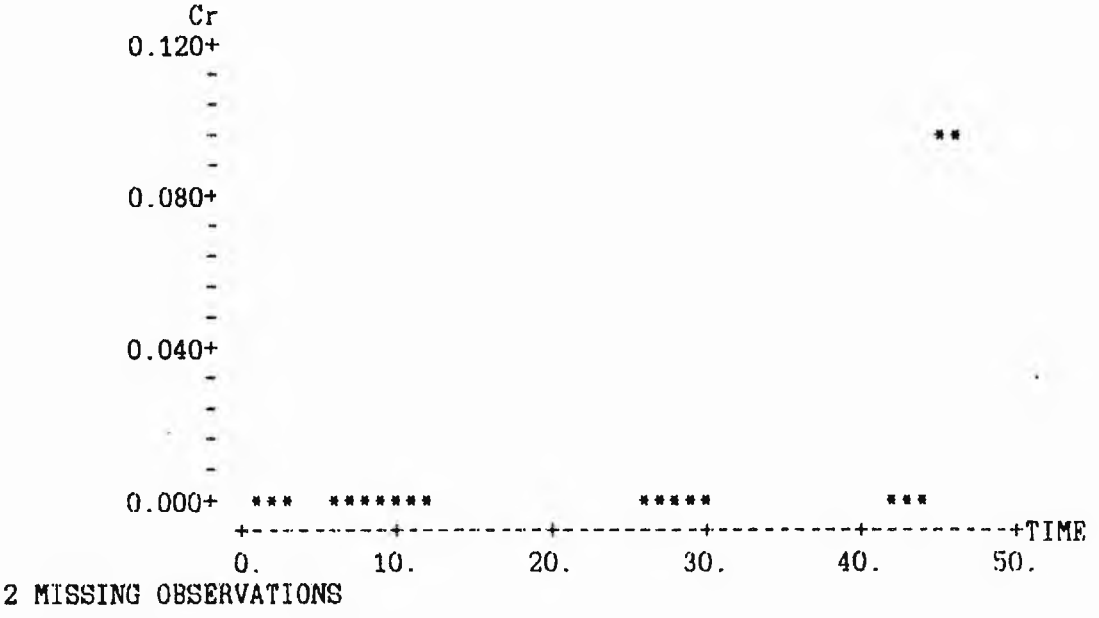
Figure 7.215

Graphs of Gully Pot Liquor Quality for Churnet 4 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.216



2 MISSING OBSERVATIONS

Figure 7.217

7.13 TWYFORD 1:

(see Figures 7.218 to 7.243 and Tables 7.25 to 7.27 inclusive).

The pH values for Twyford 1 gully pot liquor varied slightly during the summer period but they were seen to decrease during the autumn period to a range of pH 5.5-6.3, which is a fairly acidic pot liquor. The values increased in the spring period to give a maximum value of pH 8.1 on the 850306.

The presence and influence of road salting with rock salt was again illustrated with the enhanced concentrations of Conductivity, sodium and chloride found in the spring period. These levels were not as high as some others found in some of the other pot liquors but a considerable increase could be seen over those concentrations found in the summer and autumn periods. The maxima obtained for the Twyford 1 pot were 6.98 (x1000) μscm-1 for Conductivity, a sodium maximum of 1750.0 mgl-1 and 3900.0 mgl-1 as Cl^- for chloride.

The concentrations of calcium, sulphate and the Total Hardness showed increases during the spring, an effect associated again with the road salting. This trend was not as marked as for other gully pots but it was certainly apparent. The maximum values reached for calcium, sulphate and Total Hardness all occurred during the spring period and were 288.0 mgl-1, 1345.0 mgl-1 as SO_4^{2-} and 720.0 mgl-1 as $CaCO_3$, respectively.

A high ammonia value of 19.6 mgl-1 as N was observed on the 840613 with high nitrate values prevailing for most of the summer period. The introduction of nitrogenous compounds from lawn conditioners, fertilisers etc. from increased summertime gardening, into the drainage system was responsible for this rise.

The SS values were particularly high in the summer period for the Twyford 1 pot liquor, giving a maximum value of 562 mgl-1 on the 840613. Some of the SS levels can be explained by increased gardening activity and vegetal growth during the summer with associated flowers and grass cutting. There were no seasonal or general temporal trends observed for the BOD and COD data, since the values attained seemed to fluctuate greatly over the twenty-two week study period.

The concentrations of the heavy metals - copper, cadmium and nickel were very low and chromium was not detected at all in this pot liquor. Copper and nickel were detected during the spring period with maximum values of 0.01 and 0.13 mgl-1, respectively. Two samples taken during the summer period had detectable levels of cadmium with values of 0.05 and 0.03 mgl-1, but no cadmium was found during the autumn period although it reappeared in detectable concentrations in the spring period. The presence of these heavy metals in the spring period seemed to be a consistent feature in all the pot liquors under analysis.

Table 7.25

Table of all the Water Quality Data collected over the Twenty-Two Week Period for the Gully Pot Standing Liquor in the Twyford 1 Gully Pot.

ROW	DATE	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
1	840505	11.5	2.7	7.6	310	190	0.42	*	17	10
2	840516	14.0	2.8	6.6	100	50	0.10	7	10	54
3	840523	14.0	3.2	6.2	180	220	0.07	*	6	26
4	840530	15.0	4.1	6.5	*	*	0.08	*	0	*
5	840606	14.0	7.1	6.8	*	*	0.09	*	6	*
6	840613	16.5	0.9	7.2	120	160	0.51	562	60	51
7	840620	19.0	2.3	7.4	240	370	0.68	445	31	74
8	840627	19.0	2.3	6.3	90	80	0.14	507	5	36
9	840704	24.0	4.3	7.6	150	320	0.20	440	11	46
10	840711	24.0	1.0	6.8	160	300	0.21	20	5	113
11	840718	20.0	2.1	6.6	80	310	0.10	22	0	54
12	840725	17.5	1.0	6.5	180	150	0.11	10	4	11
13	841031	12.0	6.0	5.9	20	40	0.00	0	5	0
14	841107	10.0	1.0	5.5	100	50	0.00	37	0	20
15	841114	10.0	4.8	5.7	40	40	0.04	15	56	6
16	841121	8.0	4.0	6.3	30	110	0.04	23	16	0
17	841128	8.0	6.4	6.3	20	180	0.06	40	3	22
18	850220	2.5	5.6	7.6	45	255	6.60	310	7	15
19	850227	4.0	3.3	7.6	60	290	6.98	35	4	102
20	850306	5.0	4.0	8.1	160	720	6.00	50	5	34
21	850313	6.0	1.9	7.8	60	570	3.86	50	10	0
22	850320	5.0	4.5	7.6	140	470	4.00	22	19	72

ROW	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
1	0.9	17.7	106	0.6	*	18.60	6.2	0.50	0.00
2	1.6	24.8	0	0.6	*	6.60	3.4	0.20	0.00
3	1.3	248.2	86	0.7	*	1.10	1.1	0.20	0.00
4	*	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*	*
6	5.3	71.0	135	19.6	105.0	44.00	5.2	0.70	0.00
7	1.9	92.0	327	1.8	56.0	47.50	5.5	10.50	0.00
8	2.1	21.0	*	1.5	109.2	2.50	1.5	1.80	0.00
9	1.4	28.0	509	0.1	12.0	17.50	27.0	2.70	0.00
10	1.3	25.0	298	0.7	37.8	7.00	1.5	0.30	0.35
11	1.7	28.0	548	0.1	1.0	8.50	1.6	0.30	0.34
12	1.9	25.0	432	0.3	6.4	3.70	1.1	0.00	0.00
13	1.2	28.4	0	0.3	2.9	1.85	0.6	0.10	0.00
14	0.3	31.9	0	0.1	1.5	2.70	0.7	0.00	0.00
15	0.5	17.7	96	0.1	0.3	1.40	0.7	0.00	0.00
16	0.0	7.1	106	0.1	0.8	3.50	0.7	0.00	0.00
17	0.2	17.7	163	0.5	0.5	3.60	0.6	0.00	0.00
18	1.3	3545.0	197	0.4	*	1500.00	5.5	0.00	0.00
19	1.6	3900.0	836	0.6	*	1750.00	21.0	0.48	0.09
20	0.1	50.0	1345	0.7	5.3	1740.00	7.8	0.28	0.00
21	0.3	1488.9	759	0.9	8.4	610.00	3.0	0.10	0.00
22	3.9	340.0	605	0.6	42.0	520.00	8.7	0.33	0.28

ROW	Ca	Mg	Zn	Mn	Cu	Cd	Ni	Cr
1	47.0	0.00	0.17	0.06	0.00	0.05	0.00	0
2	14.0	0.00	0.00	0.00	0.00	0.00	0.00	0
3	10.5	0.00	0.09	0.13	0.00	0.00	0.00	0
4	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*
6	48.0	70.00	0.20	0.55	0.00	0.00	0.00	0
7	75.0	7.50	0.30	0.45	0.00	0.00	0.00	0
8	17.5	2.00	0.05	0.00	0.00	0.00	0.00	0
9	65.0	3.00	0.25	0.15	0.00	0.00	0.00	0
10	100.0	2.50	0.35	0.00	0.00	0.03	0.00	0
11	190.5	47.50	0.06	0.13	0.00	0.00	0.00	0
12	16.3	0.82	0.08	0.18	0.00	0.00	0.00	0
13	15.5	0.90	0.04	0.07	0.00	0.00	0.00	0
14	8.2	0.80	0.05	0.05	0.00	0.00	0.00	0
15	8.0	0.60	0.03	0.00	0.00	0.00	0.00	0
16	5.7	0.50	0.02	0.00	0.00	0.00	0.00	0
17	5.3	0.60	0.04	0.10	0.00	0.00	0.00	0
18	168.0	3.95	0.07	0.08	0.00	0.03	0.13	0
19	80.0	3.52	0.08	0.13	0.00	0.03	0.07	0
20	120.0	2.50	0.08	0.10	0.01	0.01	0.08	0
21	288.0	18.20	0.11	0.10	0.00	0.03	0.10	0
22	47.0	2.00	0.07	0.10	0.00	0.00	0.00	0

Statistical Summary of the Water Quality Data for the Standing Pot Liquor collected in the Twyford 1 Gully Pot.

Table 7.26

	TEMP	DO	PH	ALK	TH	COND	SS	BOD
N	22	22	22	2Ø	2Ø	22	18	22
NMISS	Ø	Ø	Ø	2	2	Ø	4	Ø
MEAN	12.68	3.42	6.841	114.2	244	1.39	144	12.7
MEDIAN	13.ØØ	3.25	6.7ØØ	1ØØ.Ø	2Ø5	Ø.13	36	6.Ø
TMEAN	12.62	3.37	6.845	1Ø8.6	229	1.18	127	11.Ø
STDEV	6.32	1.83	Ø.739	76.8	184	2.38	2Ø3	16.4
SEMEAN	1.35	Ø.39	Ø.157	17.2	41	Ø.51	48	3.5
MAX	24.ØØ	7.1Ø	8.1ØØ	31Ø.Ø	72Ø	6.98	562	6Ø.Ø
MIN	2.5Ø	Ø.9Ø	5.5ØØ	2Ø.Ø	4Ø	Ø.Ø4	Ø	Ø.Ø
Q3	17.87	4.57	7.6ØØ	16Ø.Ø	318	1.48	342	16.3
Q1	7.5Ø	2.Ø5	6.3ØØ	48.8	88	Ø.Ø8	19	4.Ø

	COD	PHOS	CL	SUL	AMM	NIT	Na	K
N	2Ø	2Ø	2Ø	19	2Ø	15	2Ø	2Ø
NMISS	2	2	2	3	2	7	2	2
MEAN	37.3	1.44	5ØØ	345	1.52	25.9	315	5.17
MEDIAN	3Ø.Ø	1.3Ø	28	197	Ø.6Ø	6.4	8	2.3Ø
TMEAN	35.2	1.31	339	3Ø6	Ø.59	21.5	252	4.21
STDEV	33.3	1.28	1151	354	4.28	37.3	6Ø7	7.ØØ
SEMEAN	7.4	Ø.29	257	81	Ø.96	9.6	136	1.56
MAX	113.Ø	5.3Ø	39ØØ	1345	19.6Ø	1Ø9.2	175Ø	27.ØØ
MIN	Ø.Ø	Ø.ØØ	7	Ø	Ø.1Ø	Ø.3	1	Ø.6Ø
Q3	54.Ø	1.85	2Ø9	548	Ø.7Ø	42.Ø	4Ø2	6.Ø2
Q1	1Ø.3	Ø.35	22	96	Ø.15	1.Ø	3	Ø.8Ø

	Fe	Pb	Ca	Mg	Zn	Mn	Cu	Cd
N	2Ø	2Ø	2Ø	2Ø	2Ø	2Ø	2Ø	2Ø
NMISS	2	2	2	2	2	2	2	2
MEAN	Ø.92	Ø.Ø57	66.5	8.3	Ø.111Ø	Ø.123	Ø.ØØØ5Ø	Ø.ØØ9Ø
MEDIAN	Ø.24	Ø.ØØØ	47.Ø	2.Ø	Ø.ØØØØ	Ø.1ØØ	Ø.ØØØØØ	Ø.ØØØØ
TMEAN	Ø.44	Ø.Ø44	57.6	5.4	Ø.1Ø28	Ø.1Ø6	Ø.ØØØØØ	Ø.ØØ72
STDEV	2.35	Ø.118	75.3	18.1	Ø.Ø935	Ø.14Ø	Ø.ØØ224	Ø.Ø155
SEMEAN	Ø.53	Ø.Ø26	16.8	4.Ø	Ø.Ø2Ø9	Ø.Ø31	Ø.ØØØ5Ø	Ø.ØØ35
MAX	1Ø.5Ø	Ø.35Ø	288.Ø	7Ø.Ø	Ø.35ØØ	Ø.55Ø	Ø.Ø1ØØØ	Ø.Ø5ØØ
MIN	Ø.ØØ	Ø.ØØØ	5.3	Ø.Ø	Ø.ØØ2ØØ	Ø.ØØØ	Ø.ØØØØØ	Ø.ØØØØ
Q3	Ø.5Ø	Ø.Ø6Ø	95.Ø	3.8	Ø.155Ø	Ø.13Ø	Ø.ØØØØØ	Ø.Ø25Ø
Q1	Ø.ØØ	Ø.ØØØ	11.4	Ø.6	Ø.Ø5ØØ	Ø.Ø52	Ø.ØØØØØ	Ø.ØØØØ

	Ni	Cr
N	2Ø	2Ø
NMISS	2	2
MEAN	Ø.Ø19Ø	Ø
MEDIAN	Ø.ØØØØ	Ø
TMEAN	Ø.Ø139	Ø
STDEV	Ø.Ø4Ø4	Ø
SEMEAN	Ø.ØØ9Ø	Ø
MAX	Ø.13ØØ	Ø
MIN	Ø.ØØØØ	Ø
Q3	Ø.ØØØØ	Ø
Q1	Ø.ØØØØ	Ø

Table of the Correlation Coefficients between all Twenty-Six Water Quality Parameters for the Standing Pot Liquor in the Twyford 1 Gully Pot.

Table 7.27

	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
DO	-0.394								
PH	-0.218	-0.024							
ALK	0.374	-0.448	0.379						
TH	-0.225	-0.012	0.794	0.253					
COND	-0.694	0.141	0.683	-0.138	0.628				
SS	0.389	-0.162	0.279	0.329	-0.025	-0.076			
BOD	0.038	-0.112	0.036	0.073	-0.148	-0.122	0.389		
COD	0.321	-0.381	0.324	0.233	0.265	0.281	0.126	-0.024	
PHOS	0.268	-0.294	0.216	0.199	-0.028	-0.005	0.587	0.461	0.426
CL	-0.546	0.198	0.416	-0.297	0.195	0.888	0.006	-0.174	0.179
SUL	-0.228	-0.041	0.691	0.094	0.883	0.678	-0.086	-0.238	0.288
AMM	0.157	-0.341	0.136	0.057	-0.077	-0.085	0.561	0.649	0.131
NIT	0.357	-0.398	0.196	0.326	-0.083	-0.066	0.797	0.392	0.444
Na	-0.654	0.247	0.625	-0.146	0.586	0.971	-0.089	-0.281	0.186
K	0.029	0.148	0.598	0.168	0.348	0.415	0.297	-0.027	0.407
Fe	0.373	-0.135	0.238	0.428	0.169	-0.115	0.546	0.235	0.313
Pb	0.214	-0.238	0.138	0.014	0.329	0.083	-0.321	-0.195	0.598
Ca	-0.147	-0.151	0.592	-0.069	0.679	0.528	-0.008	-0.172	0.079
Mg	0.235	-0.395	0.151	-0.066	0.086	-0.073	0.378	0.437	0.144
Zn	0.612	-0.415	0.407	0.681	0.265	-0.148	0.441	0.285	0.574
Mn	0.245	-0.315	0.318	0.314	0.146	-0.038	0.594	0.521	0.249
Cu	-0.267	0.118	0.378	0.148	0.618	0.429	-0.116	-0.122	-0.023
Cd	-0.272	-0.095	0.528	0.277	0.282	0.465	-0.132	-0.158	0.184
Ni	-0.619	0.192	0.576	-0.247	0.535	0.867	-0.021	-0.282	-0.093

	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
CL	-0.021								
SUL	-0.049	0.271							
AMM	0.726	-0.085	-0.123						
NIT	0.735	-0.078	-0.098	0.658					
Na	-0.182	0.766	0.697	-0.098	-0.139				
K	0.159	0.391	0.453	-0.005	0.035	0.415			
Fe	0.153	-0.115	0.034	0.048	0.337	-0.135	0.198		
Pb	0.226	0.005	0.264	-0.128	-0.018	-0.001	-0.016	-0.133	
Ca	-0.094	0.436	0.553	-0.044	-0.121	0.452	0.123	0.018	0.398
Mg	0.682	-0.052	0.051	0.793	0.481	-0.096	-0.043	0.006	0.243
Zn	0.278	-0.138	0.046	0.263	0.355	-0.163	0.315	0.561	0.247
Mn	0.649	-0.039	0.031	0.749	0.483	-0.054	0.168	0.559	-0.154
Cu	-0.246	-0.092	0.684	-0.045	-0.153	0.552	0.088	-0.064	-0.113
Cd	-0.287	0.538	0.193	-0.125	-0.068	0.434	0.188	-0.162	0.153
Ni	-0.232	0.789	0.528	-0.182	-0.284	0.854	0.213	-0.158	-0.081

	Ca	Mg	Zn	Mn	Cu	Cd
Mg	0.347					
Zn	0.178	0.168				
Mn	0.054	0.652	0.448			
Cu	0.167	-0.076	-0.078	-0.039		
Cd	0.488	-0.119	0.276	-0.214	0.015	
Ni	0.782	-0.028	-0.148	-0.086	0.356	0.536

Graphs of Gully Pot Liquor Quality for Twyford 1 Gully Pot.

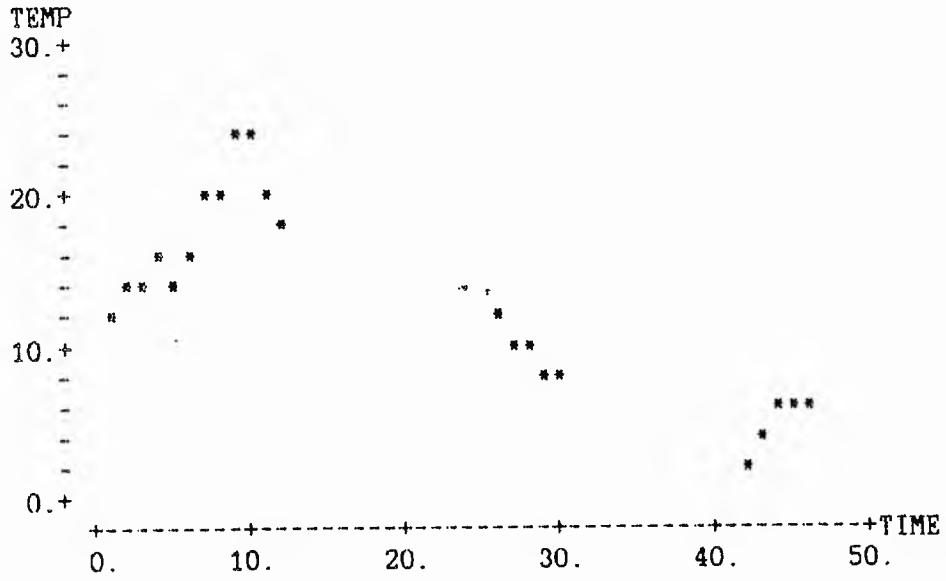


Figure 7.218

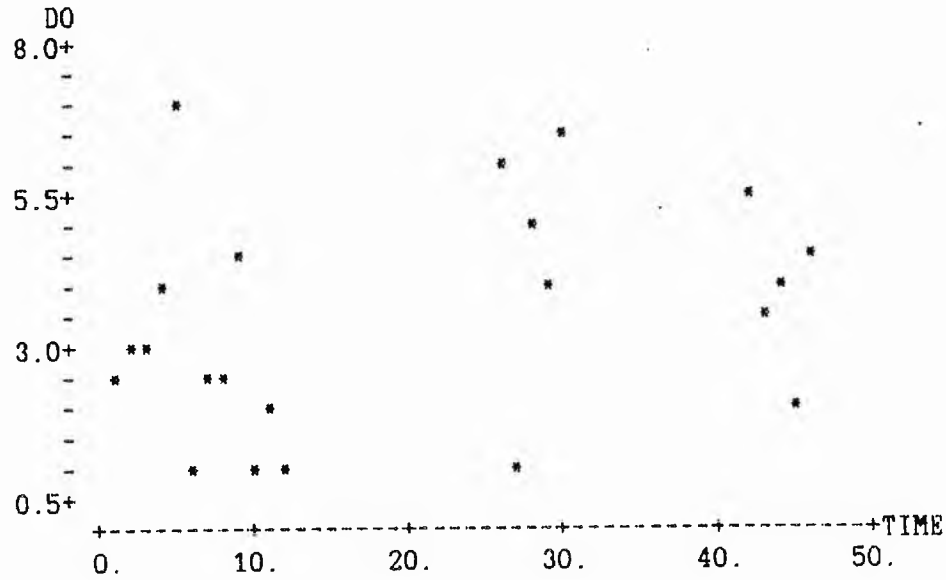


Figure 7.219

Graphs of Gully Pot Liquor Quality for Twyford 1 Gully Pot.

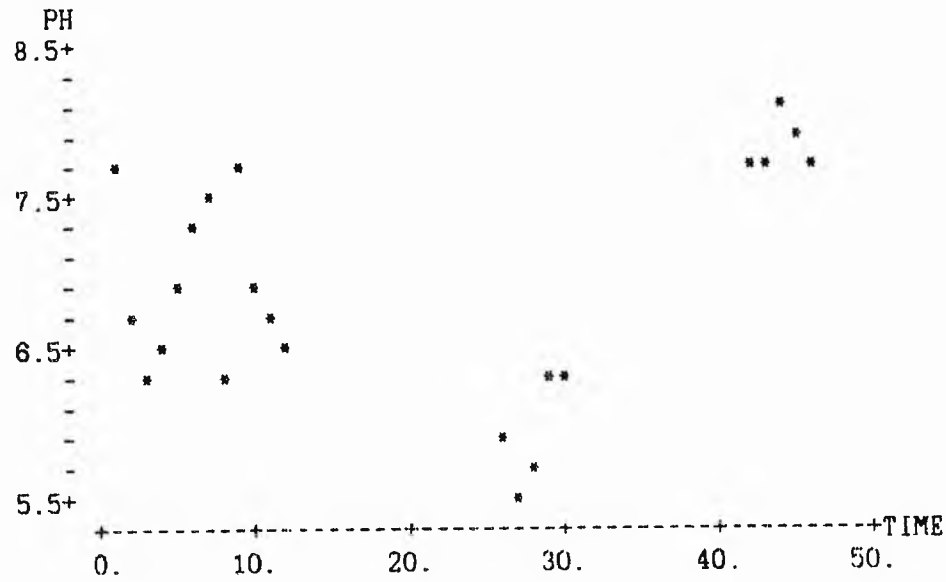
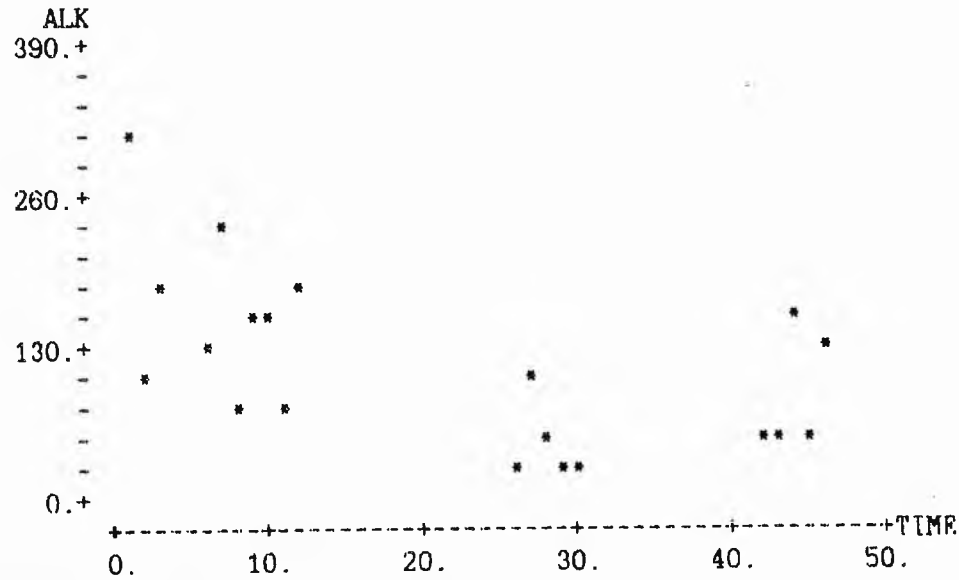


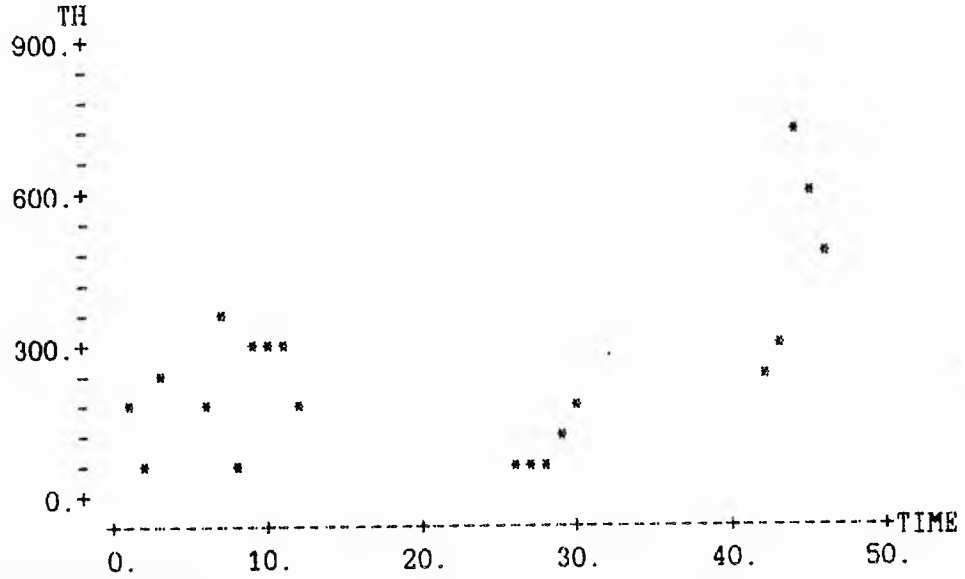
Figure 7.220



2 MISSING OBSERVATIONS

Figure 7.221

Graphs of Gully Pot Liquor Quality for Twyford 1 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.222

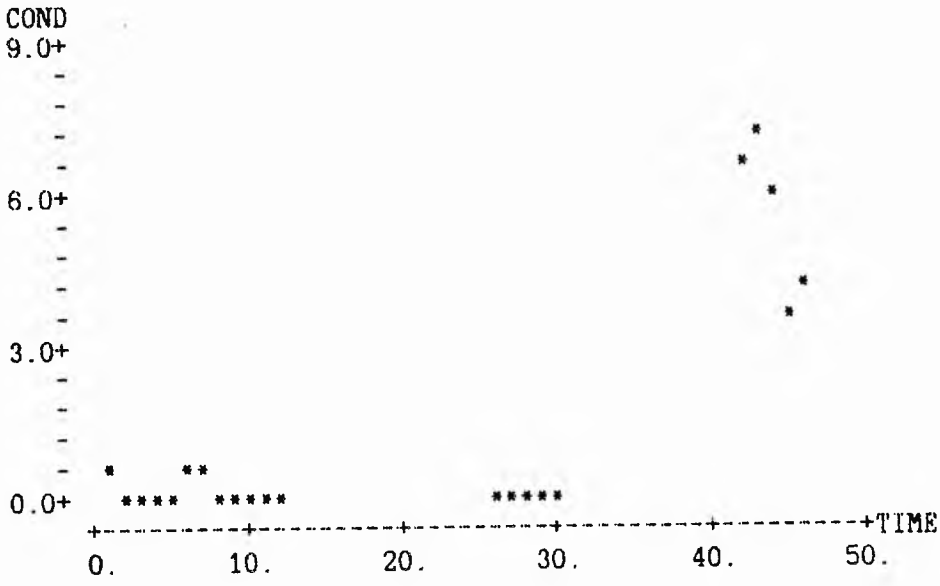
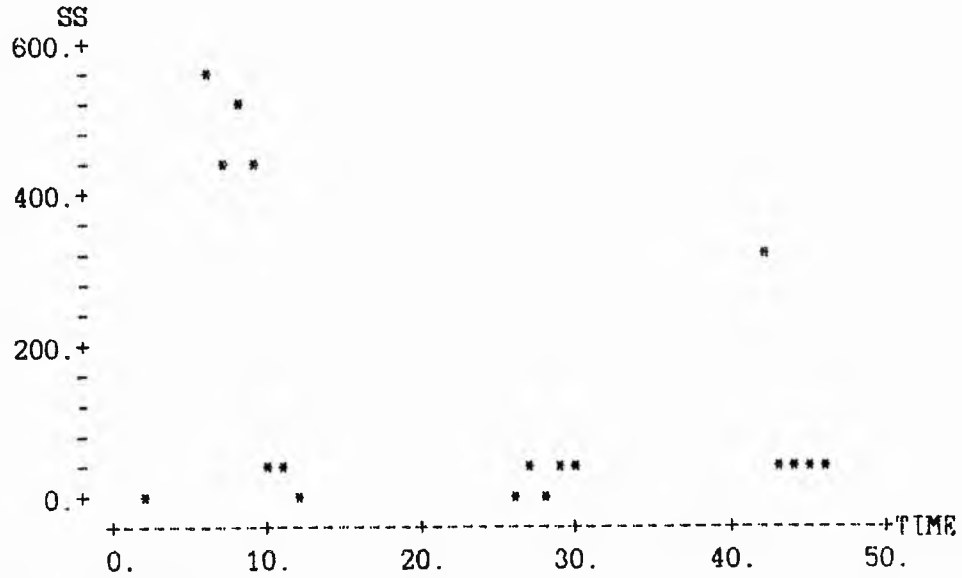


Figure 7.223

Graphs of Gully Pot Liquor Quality for Twyford 1 Gully Pot.



4 MISSING OBSERVATIONS

Figure 7.224

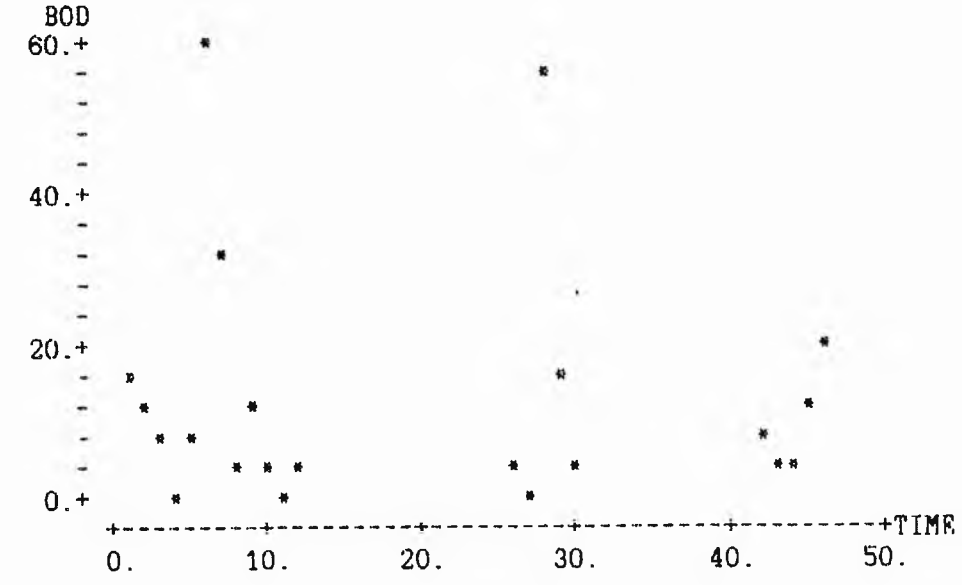
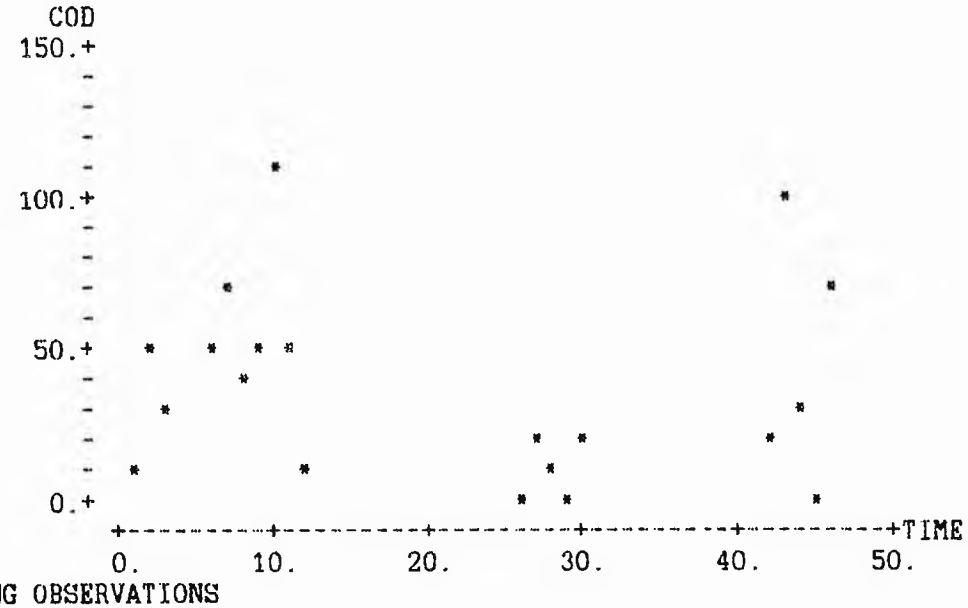


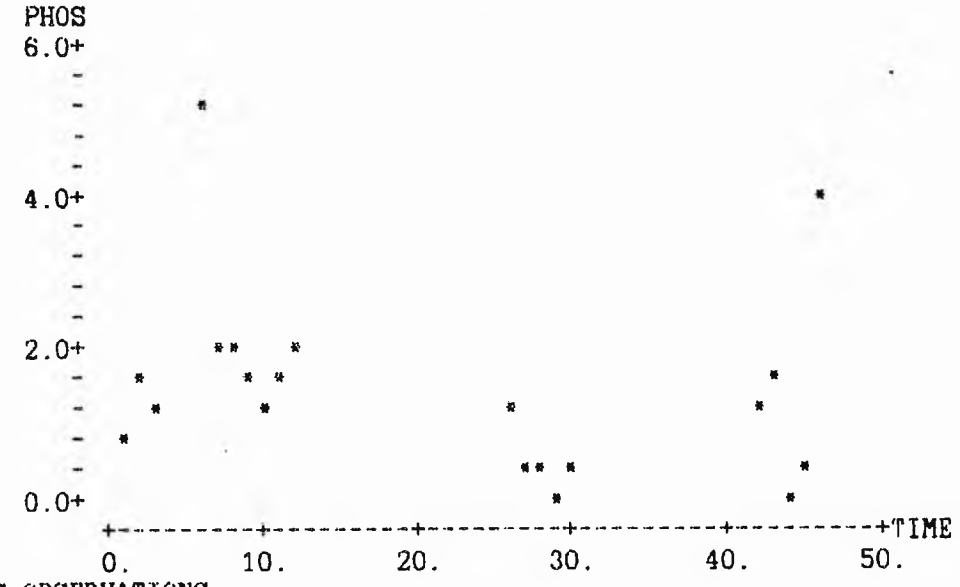
Figure 7.225

Graphs of Gully Pot Liquor Quality for Twyford 1 Gully Pot.



2 MISSING OBSERVATIONS

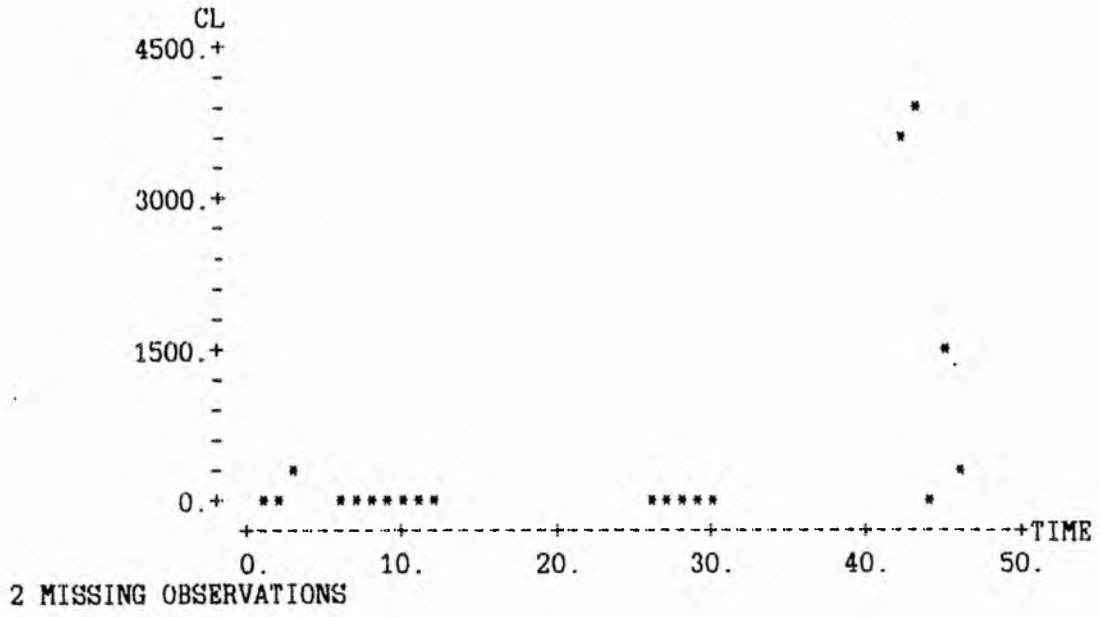
Figure 7.226



2 MISSING OBSERVATIONS

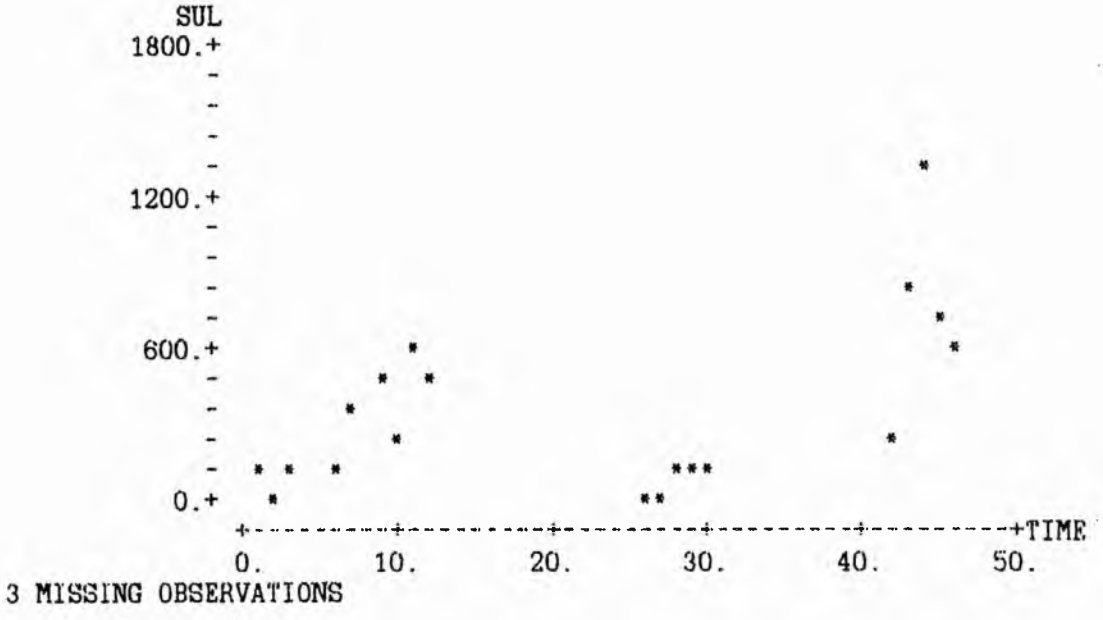
Figure 7.227

Graphs of Gully Pot Liquor Quality for Twyford 1 Gully Pot.



2 MISSING OBSERVATIONS

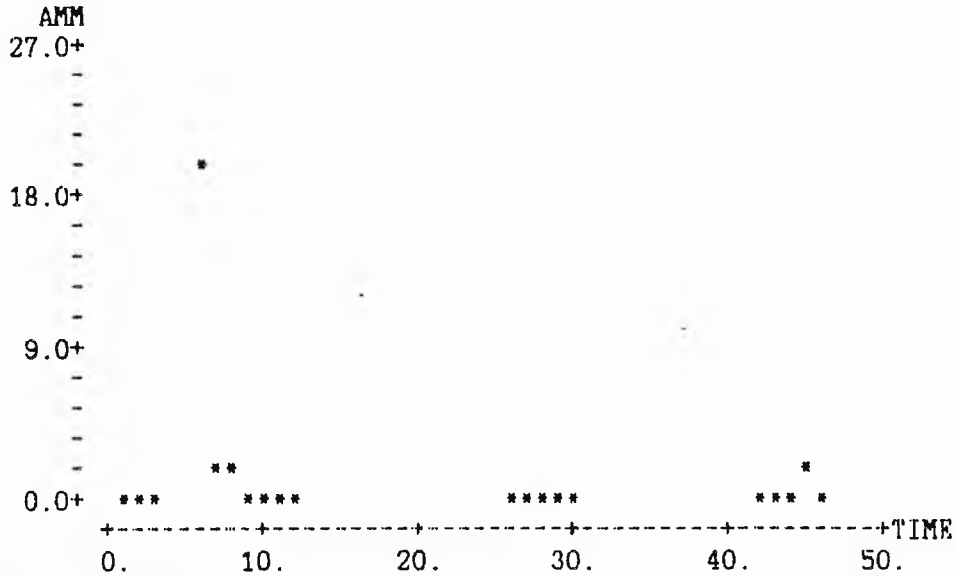
Figure 7.228



3 MISSING OBSERVATIONS

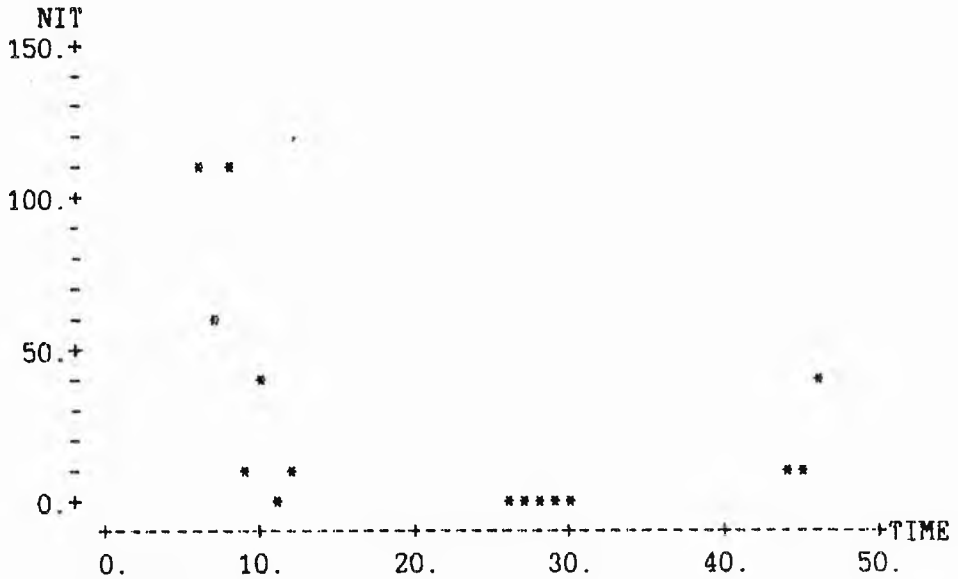
Figure 7.229

Graphs of Gully Pot Liquor Quality for Twyford 1 Gully Pot.



2 MISSING OBSERVATIONS

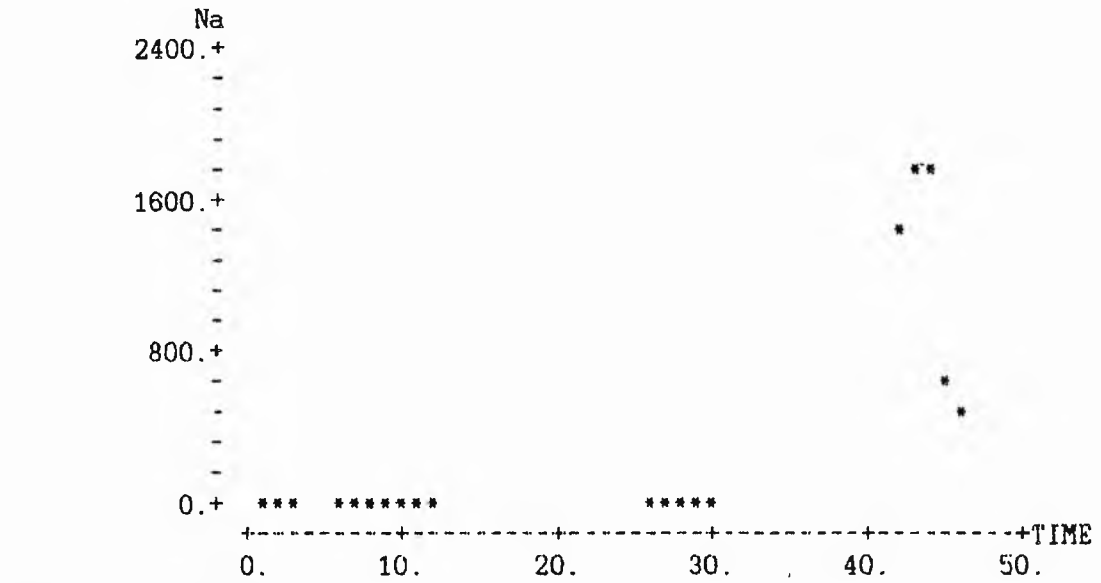
Figure 7.230



7 MISSING OBSERVATIONS

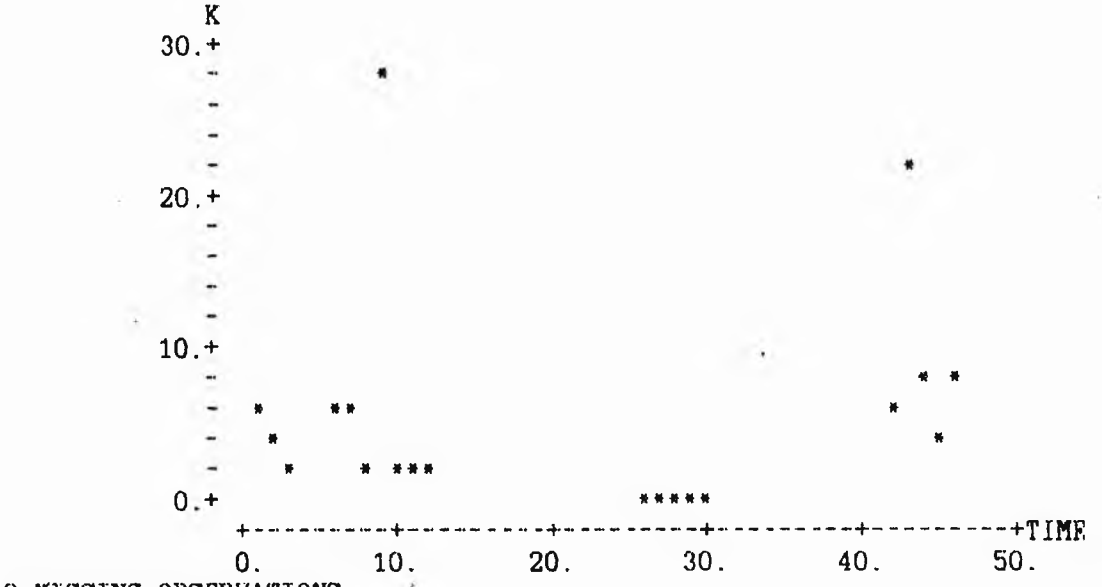
Figure 7.231

Graphs of Gully Pot Liquor Quality for Twyford 1 Gully Pot.



2 MISSING OBSERVATIONS

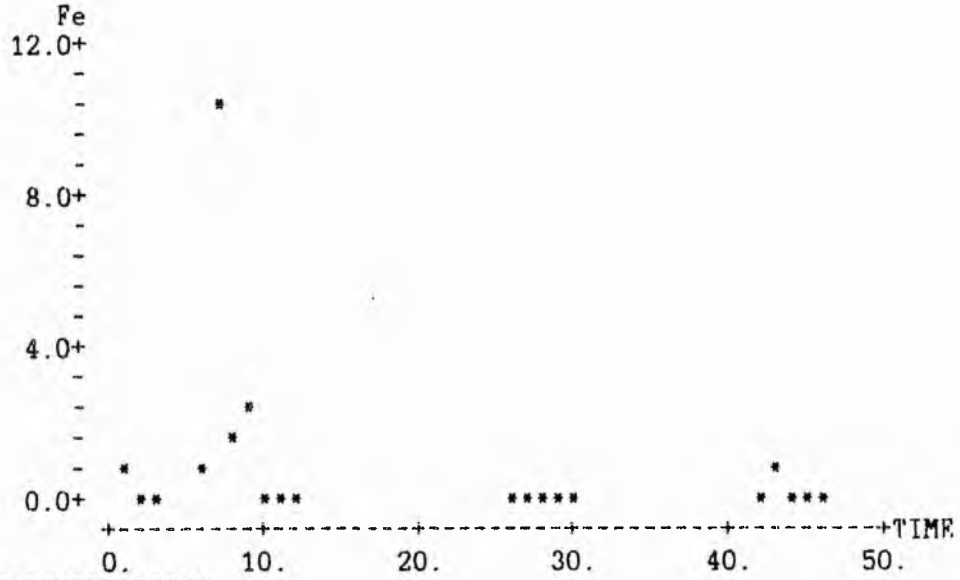
Figure 7.232



2 MISSING OBSERVATIONS

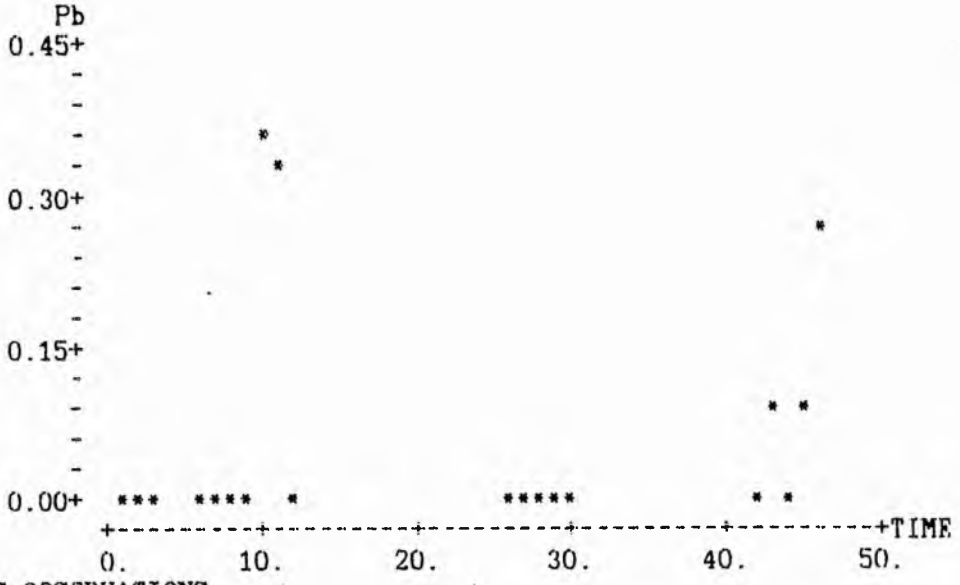
Figure 7.233

Graphs of Gully Pot Liquor Quality for Twyford 1 Gully Pot.



2 MISSING OBSERVATIONS

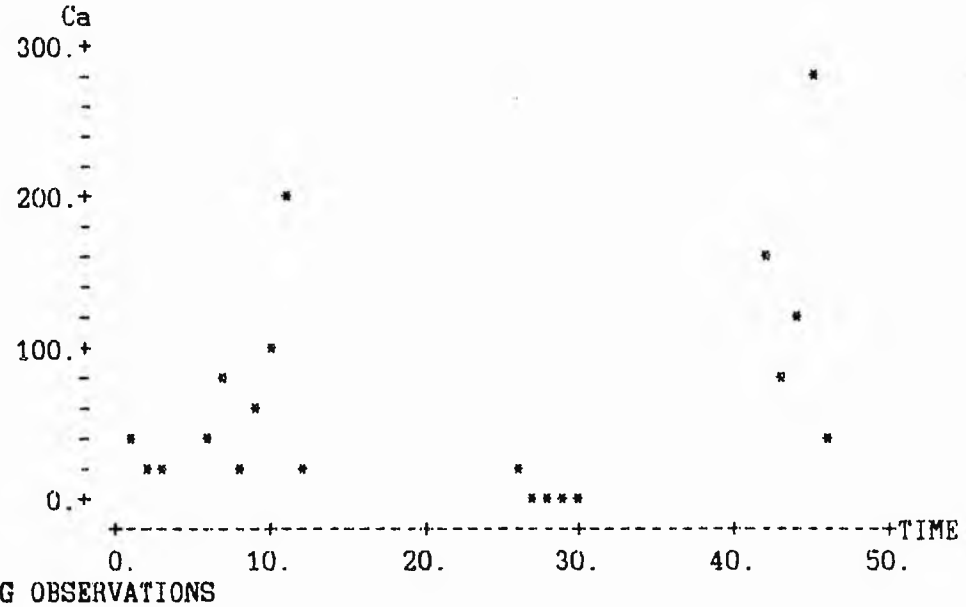
Figure 7.234



2 MISSING OBSERVATIONS

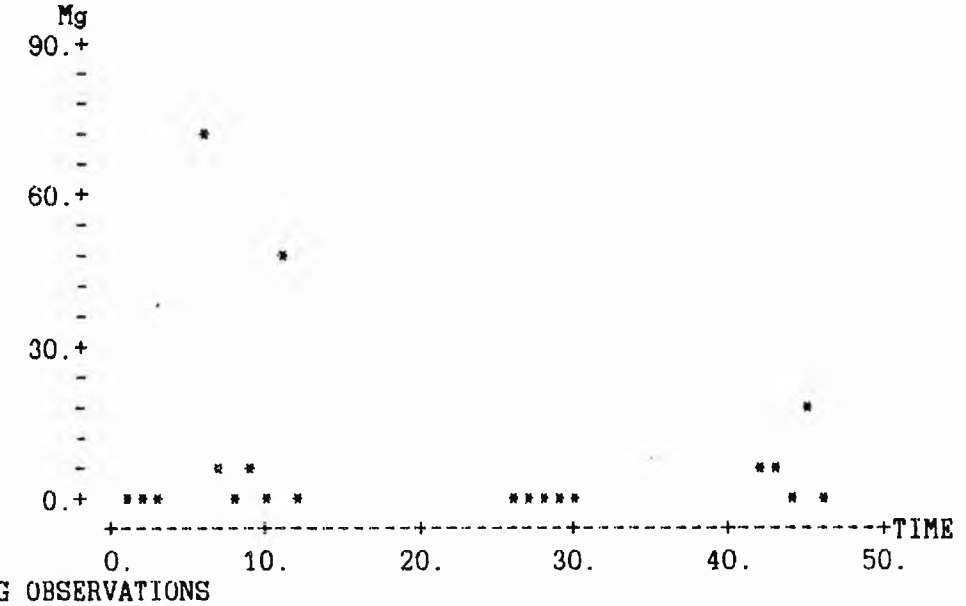
Figure 7.235

Graphs of Gully Pot Liquor Quality for Twyford 1 Gully Pot.



2 MISSING OBSERVATIONS

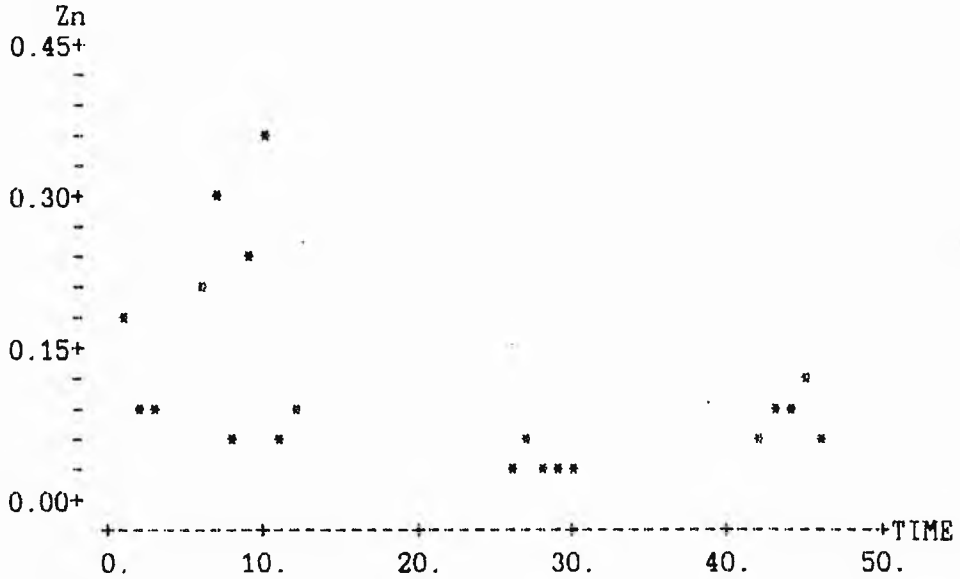
Figure 7.236



2 MISSING OBSERVATIONS

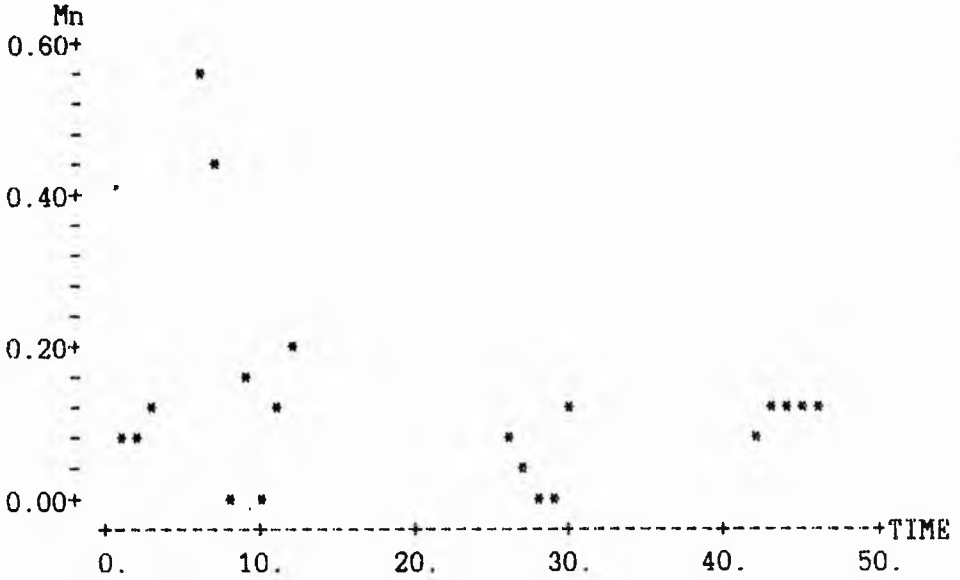
Figure 7.237

Graphs of Gully Pot Liquor Quality for Twyford 1 Gully Pot.



2 MISSING OBSERVATIONS

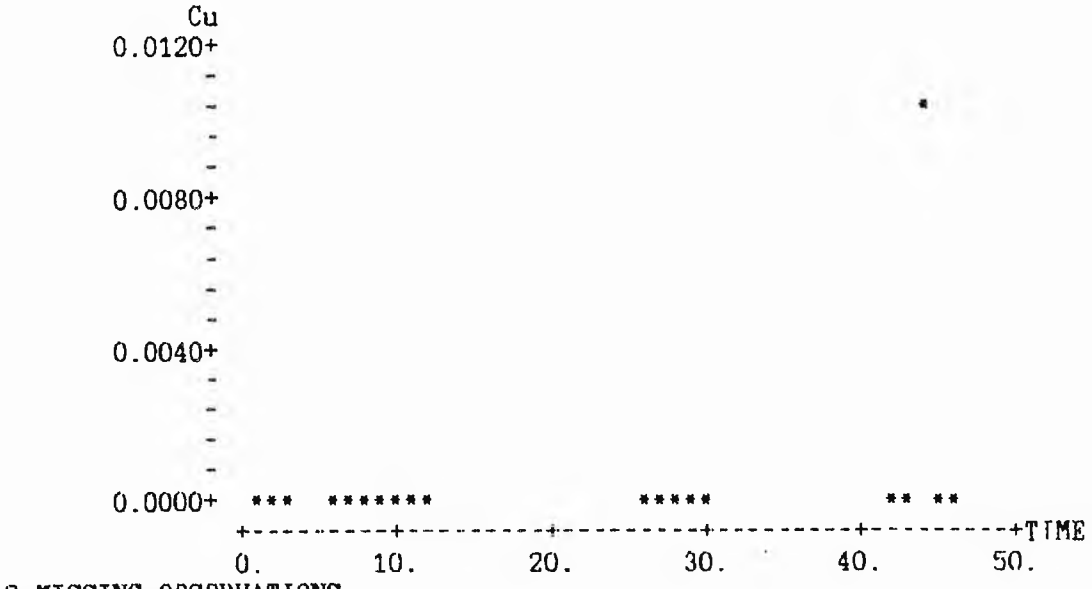
Figure 7.238



2 MISSING OBSERVATIONS

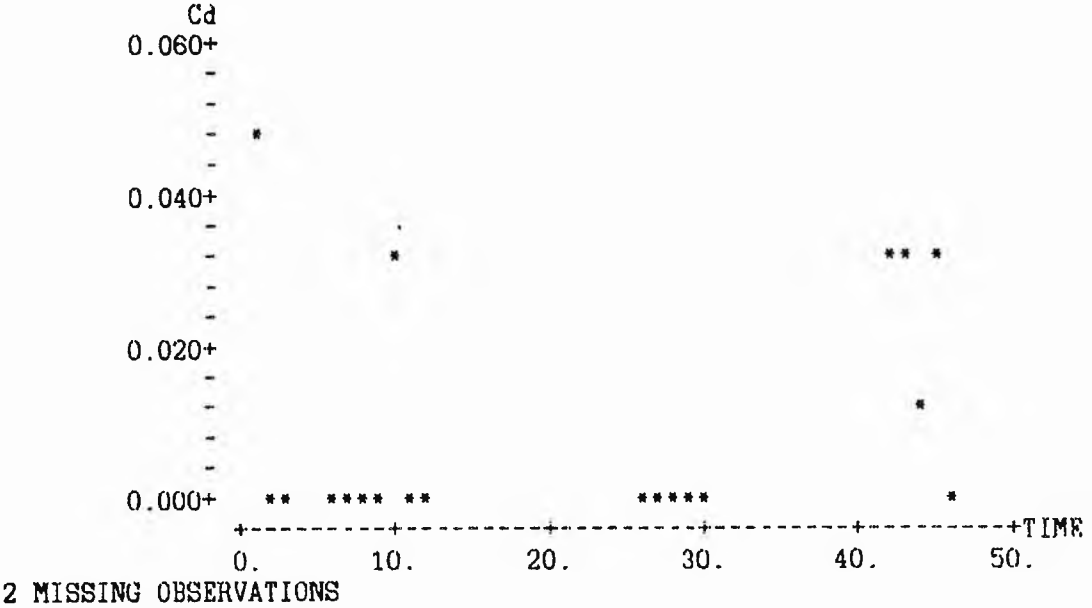
Figure 7.239

Graphs of Gully Pot Liquor Quality for Twyford 1 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.240



2 MISSING OBSERVATIONS

Figure 7.241

Graphs of Gully Pot Liquor Quality for Twyford 1 Gully Pot.

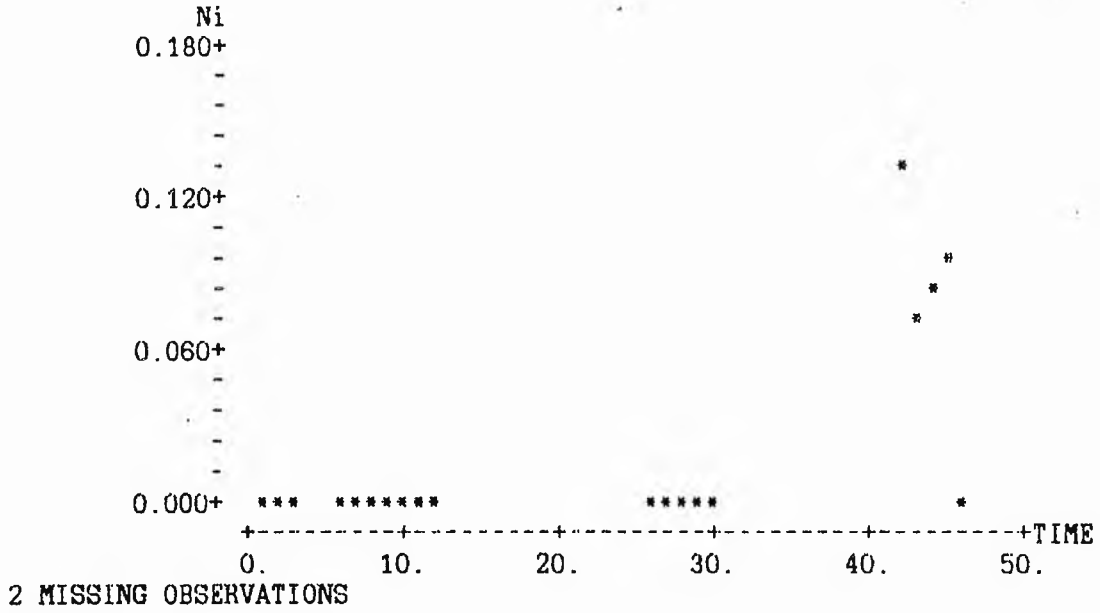


Figure 7.242

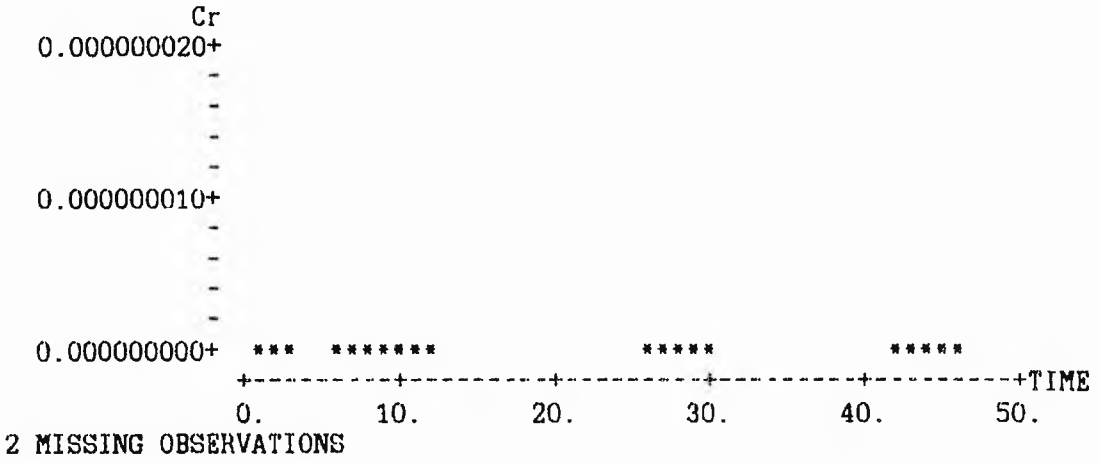


Figure 7.243

7.14 TWYFORD 2:

(see Figures 7.244 to 7.269 and Tables 7.28 to 7.30 inclusive).

The pH values were quite variable throughout the whole year but decreased slightly in the autumn period before rising to much higher levels in the spring period. The maximum pH value for the Twyford 2 gully pot liquor was pH 9.9 and was obtained on the 850313, showing that the pot liquor was highly alkaline at the end of the spring period. This observation was in contrast to the slightly acidic liquors found in other pots at the end of the period of snowcover, where the influence of the acidic precipitation and the low pH values of snow meltwater were more marked.

The SS values were again fairly variable throughout the study period but they increased to much higher than average levels in the spring period to a maximum of 361 mgl-1 on the 850227.

The BOD and COD values were consistent throughout the whole twenty-two week period and no seasonal trends could be detected.

The action of road salting again influenced the concentrations found for Conductivity, sodium and chloride, whose maxima were 47.6 (x1000) µscm-1, 12000.0 mgl-1 and 20916.0 mgl-1 as Cl^-, respectively. The values found during the spring period showed marked rises from the levels observed during the summer and autumn periods and the chloride values were some of the highest found in any of the pot liquors under study.

Increases in the concentrations of calcium, sulphate and the Total Hardness were observed during the spring period and this tend was found in nearly all the twelve datasets. The maximum values reached for calcium and Total Hardness were 420.0 mgl-1 and 961.0 mgl-1 as

$CaCO_3$, respectively. The correlation coefficient between the values for calcium and sulphate was r = +0.823, which was a statistical verification that most of the increased hardness in the pot liquors, was due to increased calcium (ie. as Calcium Hardness) which was entering the drainage system predominantly in the form of calcium sulphate, but as other calcium salts as well.

The heavy metals - copper, nickel and chromium were all undetected during the summer and autumn periods but they were detected in the spring period with maxima of 0.12, 0.87 and 0.20 mgl-1, respectively. Three samples taken during the summer period, showed detectable levels of cadmium with the maximum concentration of 1.00 mgl-1, but cadmium was not found during the autumn period. All five samples taken in the spring showed cadmium being detected within the range of 0.09 to 0.16 mgl-1.

Table 7.28

Table of all the Water Quality Data collected over the Twenty-Two Week Period for the Gully Pot Standing Liquor in the Twyford 2 Gully Pot.

ROW	DATE	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
1	840509	11.5	2.5	8.2	170	230	0.51	*	10	16
2	840516	14.0	7.9	6.8	70	70	0.09	0	5	64
3	840523	13.0	3.3	6.4	190	280	0.05	*	2	11
4	840530	14.0	4.9	6.5	*	*	0.06	*	6	*
5	840606	15.0	7.2	6.8	*	*	0.09	*	8	*
6	840613	16.5	1.4	6.6	40	90	0.09	14	36	5
7	840620	19.5	3.2	7.9	80	230	0.12	9	6	30
8	840627	21.0	2.3	8.9	140	230	0.28	39	30	46
9	840704	24.5	4.3	7.7	310	250	0.29	80	35	144
10	840711	22.5	1.2	8.1	210	510	0.53	15	17	75
11	840718	20.0	3.6	6.8	100	260	0.10	21	11	43
12	840725	17.5	3.3	7.6	200	190	0.16	9	33	49
13	841031	12.0	7.4	5.7	20	40	0.07	4	19	70
14	841107	10.0	5.2	5.9	110	40	0.09	46	3	30
15	841114	10.0	6.7	6.2	40	50	0.04	17	41	0
16	841121	8.0	6.2	5.9	40	110	0.04	9	20	0
17	841128	8.0	6.2	6.4	20	100	0.06	45	2	0
18	850220	3.0	4.0	7.7	40	840	47.60	86	8	*
19	850227	4.0	1.6	8.4	50	820	46.60	361	0	76
20	850306	5.0	2.6	8.5	130	1010	41.70	316	1	93
21	850313	5.5	2.9	9.9	90	1060	39.80	332	6	80
22	850320	4.5	5.8	9.3	210	830	40.30	288	23	*

ROW	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
1	0.2	17.7	192	0.2	*	8.8	4.20	0.10	0.00
2	1.3	28.4	48	0.3	*	7.8	2.50	0.20	0.00
3	0.7	70.9	48	0.3	*	0.7	0.60	0.20	0.00
4	*	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*	*
6	1.0	11.0	144	26.6	6.6	6.0	1.00	0.60	0.00
7	0.3	25.0	202	5.6	4.3	2.5	0.55	3.00	0.00
8	0.4	43.0	*	3.8	2.9	22.5	6.50	2.00	0.15
9	0.6	195.0	240	0.1	9.8	6.5	16.00	2.00	0.00
10	1.5	57.0	509	10.6	47.6	17.5	6.50	0.30	0.00
11	2.3	25.0	826	1.1	2.9	8.4	1.20	0.30	0.34
12	1.1	64.0	577	7.0	10.5	13.5	2.20	0.00	0.00
13	1.5	28.4	77	0.2	4.2	1.5	0.60	0.10	0.00
14	0.3	24.8	106	0.2	2.7	3.0	0.70	0.00	0.00
15	0.6	21.3	96	0.1	2.2	1.4	0.40	0.00	0.00
16	0.0	7.1	48	0.1	1.1	5.7	0.60	0.00	0.00
17	0.3	17.7	58	0.4	0.7	5.3	0.50	0.00	0.00
18	1.4	20916.0	682	1.5	*	12000.0	6.50	0.45	0.32
19	1.8	20916.0	769	4.3	*	1660.0	34.00	0.75	0.34
20	0.6	219.0	961	0.9	29.4	1850.0	8.20	0.45	0.28
21	0.9	20207.0	894	1.5	53.2	9500.0	7.80	0.65	0.32
22	3.1	301.0	865	1.5	217.0	7200.0	13.80	0.50	0.28

ROW	Ca	Mg	Zn	Mn	Cu	Cd	Ni	Cr
1	58.0	0.00	0.06	0.03	0.00	0.03	0.00	0.0
2	17.0	0.00	0.24	0.13	0.00	0.00	0.00	0.0
3	7.0	0.00	0.08	0.12	0.00	0.00	0.00	0.0
4	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*
6	16.0	8.50	0.26	0.15	0.00	0.00	0.00	0.0
7	20.0	0.68	0.10	0.00	0.00	1.00	0.00	0.0
8	37.5	3.00	0.08	0.40	0.00	0.00	0.00	0.0
9	80.0	2.00	0.22	0.00	0.00	0.00	0.00	0.0
10	130.0	2.00	0.14	0.25	0.00	0.01	0.00	0.0
11	190.5	50.00	0.16	0.13	0.00	0.00	0.00	0.0
12	28.5	0.96	0.10	0.10	0.00	0.00	0.00	0.0
13	10.5	0.80	0.02	0.10	0.00	0.00	0.00	0.0
14	8.4	1.20	0.08	0.20	0.00	0.00	0.00	0.0
15	5.8	0.60	0.03	0.03	0.00	0.00	0.00	0.0
16	5.7	0.50	0.06	0.00	0.00	0.00	0.00	0.0
17	4.6	0.70	0.03	0.10	0.00	0.00	0.00	0.0
18	52.0	4.50	0.12	0.42	0.09	0.11	0.65	0.1
19	315.0	5.00	0.09	0.37	0.09	0.16	0.62	0.1
20	220.0	3.50	0.08	0.26	0.09	0.13	0.70	0.0
21	420.0	13.80	0.07	0.11	0.12	0.16	0.87	0.1
22	173.0	3.45	0.06	0.11	0.09	0.09	0.10	0.2

Statistical Summary of the Water Quality Data for the Standing Pot Liquor collected in the Twyford 2 Gully Pot.

Table 7.29

	TEMP	DO	PH	ALK	TH	COND	SS	BOD
N	22	22	22	2Ø	2Ø	22	18	22
NMISS	Ø	Ø	Ø	2	2	Ø	4	Ø
MEAN	12.68	4.26	7.37	113.Ø	362	9.9	94	14.6
MEDIAN	12.5Ø	3.8Ø	7.2Ø	95.Ø	23Ø	Ø.1	3Ø	9.Ø
TMEAN	12.58	4.23	7.33	1Ø7.2	341	8.6	83	14.Ø
STDEV	6.39	2.Ø5	1.18	8Ø.Ø	347	18.5	13Ø	13.Ø
SEMEAN	1.36	Ø.44	Ø.25	17.9	78	4.Ø	31	2.8
MAX	24.5Ø	7.9Ø	9.9Ø	31Ø.Ø	1Ø6Ø	47.6	361	41.Ø
MIN	3.ØØ	1.2Ø	5.7Ø	2Ø.Ø	4Ø	Ø.Ø	Ø	Ø.Ø
Q3	18.ØØ	6.2Ø	8.25	185.Ø	743	1Ø.3	136	24.8
Q1	7.37	2.57	6.4Ø	4Ø.Ø	92	Ø.1	9	4.5

	COD	PHOS	CL	SUL	AMM	NIT	Na	K
N	18	2Ø	2Ø	19	2Ø	15	2Ø	2Ø
NMISS	4	2	2	3	2	7	2	2
MEAN	46.2	Ø.995	316Ø	386	3.31	26.3	1616	5.72
MEDIAN	44.5	Ø.8ØØ	36	2Ø2	1.ØØ	4.3	8	2.35
TMEAN	43.Ø	Ø.933	2348	373	2.2Ø	13.6	1129	4.44
STDEV	39.3	Ø.78Ø	7553	346	6.17	55.4	3554	8.Ø7
SEMEAN	9.3	Ø.174	1689	79	1.38	14.3	795	1.8Ø
MAX	144.Ø	3.1ØØ	2Ø916	961	26.6Ø	217.Ø	12ØØØ	34.ØØ
MIN	Ø.Ø	Ø.ØØØ	7	48	Ø.1Ø	Ø.7	1	Ø.4Ø
Q3	75.2	1.475	213	769	4.18	29.4	1251	7.48
Q1	9.5	Ø.325	22	77	Ø.2Ø	2.7	4	Ø.6Ø

	Fe	Pb	Ca	Mg	Zn	Mn	Cu	Cd
N	2Ø	2Ø	2Ø	2Ø	2Ø	2Ø	2Ø	2Ø
NMISS	2	2	2	2	2	2	2	2
MEAN	Ø.58Ø	Ø.1Ø1	9Ø	5.1	Ø.1Ø4Ø	Ø.15Ø	Ø.Ø24Ø	Ø.ØØ9
MEDIAN	Ø.3ØØ	Ø.ØØØ	33	1.6	Ø.ØØØØ	Ø.115	Ø.ØØØØ	Ø.ØØØ
TMEAN	Ø.478	Ø.Ø94	77	2.8	Ø.1ØØØ	Ø.144	Ø.ØØØØ	Ø.Ø43
STDEV	Ø.813	Ø.147	117	11.1	Ø.Ø682	Ø.129	Ø.Ø431	Ø.222
SEMEAN	Ø.182	Ø.Ø33	26	2.5	Ø.Ø153	Ø.Ø29	Ø.ØØ96	Ø.Ø5Ø
MAX	3.ØØØ	Ø.34Ø	42Ø	5Ø.Ø	Ø.26ØØ	Ø.42Ø	Ø.12ØØ	1.ØØØ
MIN	Ø.ØØØ	Ø.ØØØ	5	Ø.Ø	Ø.ØØØØ	Ø.ØØØ	Ø.ØØØØ	Ø.ØØØ
Q3	Ø.638	Ø.28Ø	163	4.3	Ø.135Ø	Ø.238	Ø.Ø675	Ø.1Ø5
Q1	Ø.Ø25	Ø.ØØØ	9	Ø.6	Ø.Ø6ØØ	Ø.Ø47	Ø.ØØØØ	Ø.ØØØ

	Ni	Cr
N	2Ø	2Ø
NMISS	2	2
MEAN	Ø.147	Ø.Ø25Ø
MEDIAN	Ø.ØØØ	Ø.ØØØØ
TMEAN	Ø.115	Ø.Ø167
STDEV	Ø.293	Ø.Ø55Ø
SEMEAN	Ø.Ø66	Ø.Ø123
MAX	Ø.87Ø	Ø.2ØØØ
MIN	Ø.ØØØ	Ø.ØØØØ
Q3	Ø.Ø75	Ø.ØØØØ
Q1	Ø.ØØØ	Ø.ØØØØ

Table of the Correlation Coefficients between all Twenty-Six Water Quality Parameters for the Standing Pot Liquor in the Twyford 2 Gully Pot.

Table 7.30

	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
DO	-0.193								
PH	-0.115	-0.543							
ALK	0.468	-0.318	0.402						
TH	-0.517	-0.418	0.772	0.135					
COND	-0.719	-0.258	0.638	-0.088	0.927				
SS	-0.614	-0.306	0.703	0.113	0.872	0.877			
BOD	0.412	-0.005	-0.039	0.239	-0.358	-0.309	-0.387		
COD	0.228	-0.165	0.497	0.523	0.513	0.438	0.456	-0.018	
PHOS	-0.121	0.021	0.267	0.109	0.392	0.425	0.326	0.022	0.348
CL	-0.548	-0.264	0.434	-0.281	0.679	0.765	0.591	-0.344	0.300
SUL	-0.298	-0.452	0.766	0.196	0.866	0.781	0.746	-0.182	0.585
AMM	0.313	-0.536	0.022	-0.073	-0.090	-0.126	-0.172	0.378	-0.155
NIT	-0.383	0.061	0.568	0.384	0.611	0.682	0.629	-0.003	0.583
Na	-0.587	-0.049	0.527	-0.086	0.754	0.803	0.538	-0.193	0.302
K	-0.239	-0.348	0.543	0.222	0.586	0.634	0.726	-0.128	0.576
Fe	0.458	-0.328	0.409	0.239	0.072	-0.013	0.019	0.111	0.332
Pb	-0.465	-0.283	0.592	-0.092	0.815	0.835	0.746	-0.316	0.358
Ca	-0.327	-0.411	0.705	0.089	0.822	0.713	0.853	-0.315	0.511
Mg	0.171	-0.184	0.045	-0.079	0.128	0.046	0.038	-0.076	0.055
Zn	0.500	-0.221	-0.017	0.216	-0.119	-0.168	-0.229	0.194	0.315
Mn	-0.228	-0.418	0.318	-0.134	0.464	0.517	0.318	-0.244	0.226
Cu	-0.704	-0.218	0.669	-0.072	0.944	0.979	0.906	-0.345	0.422
Cd	0.089	-0.281	0.288	-0.115	0.149	0.118	0.078	-0.253	-0.004
Ni	-0.633	-0.307	0.564	-0.191	0.880	0.894	0.806	-0.426	0.425
Cr	-0.586	-0.014	0.581	0.042	0.708	0.797	0.699	-0.121	0.294

	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
CL	0.213								
SUL	0.584	0.512							
AMM	0.003	-0.063	-0.021						
NIT	0.719	0.147	0.545	-0.064					
Na	0.374	0.741	0.597	-0.131	0.712				
K	0.381	0.564	0.514	-0.042	0.606	0.255			
Fe	-0.162	0.021	0.050	0.124	-0.065	-0.026	0.228		
Pb	0.555	0.666	0.888	-0.157	0.475	0.676	0.537	0.043	
Ca	0.408	0.638	0.823	-0.067	0.426	0.498	0.624	0.047	0.781
Mg	0.439	0.182	0.468	0.036	-0.049	0.082	-0.034	-0.046	0.539
Zn	0.159	-0.066	-0.033	0.531	-0.131	-0.111	0.066	0.232	-0.074
Mn	0.244	0.507	0.509	0.132	0.033	0.358	0.411	0.016	0.549
Cu	0.394	0.763	0.792	-0.133	0.635	0.828	0.578	-0.018	0.828
Cd	-0.141	0.186	0.073	0.057	-0.009	0.076	0.025	0.733	0.056
Ni	0.141	0.833	0.709	-0.117	0.208	0.726	0.499	-0.004	0.762
Cr	0.653	0.593	0.612	-0.097	0.939	0.794	0.561	-0.006	0.673

	Ca	Mg	Zn	Mn	Cu	Cd	Ni
Mg	0.409						
Zn	-0.047	0.239					
Mn	0.264	0.048	0.042				
Cu	0.787	0.078	-0.179	0.429			
Cd	0.069	-0.008	-0.069	-0.118	0.114		
Ni	0.767	0.096	-0.129	0.485	0.918	0.121	
Cr	0.557	0.042	-0.168	0.272	0.799	0.072	0.524

Graphs of Gully Pot Liquor Quality for Twyford 2 Gully Pot.

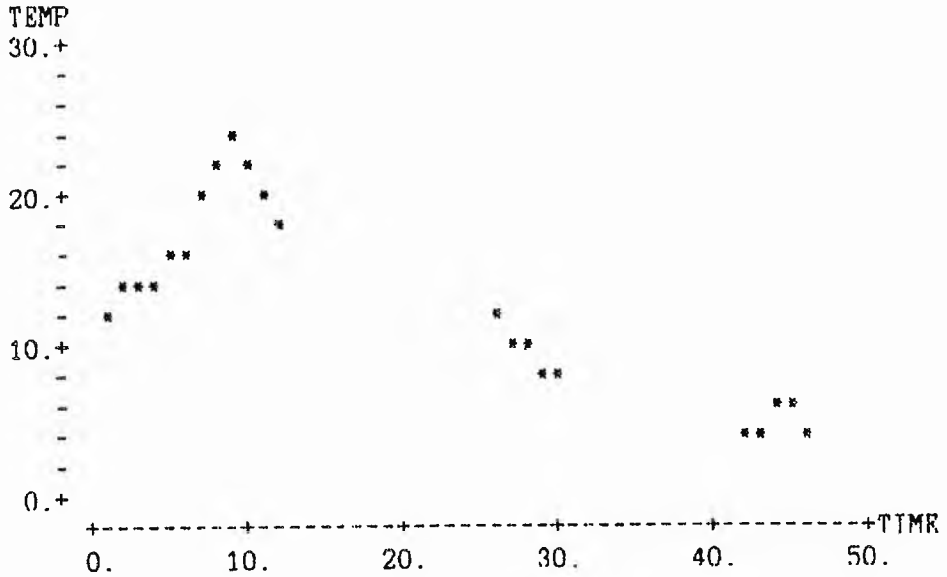


Figure 7.244

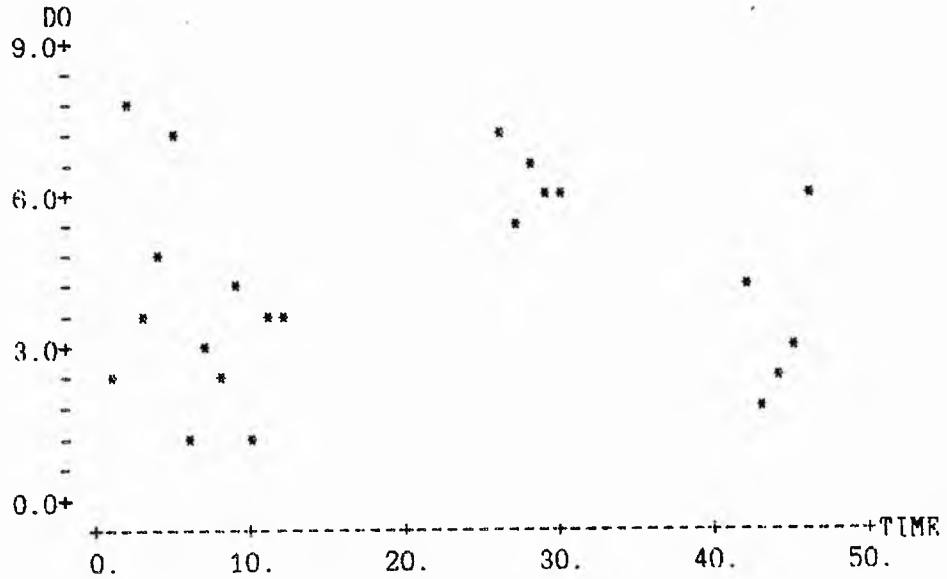


Figure 7.245

Graphs of Gully Pot Liquor Quality for Twyford 2 Gully Pot.

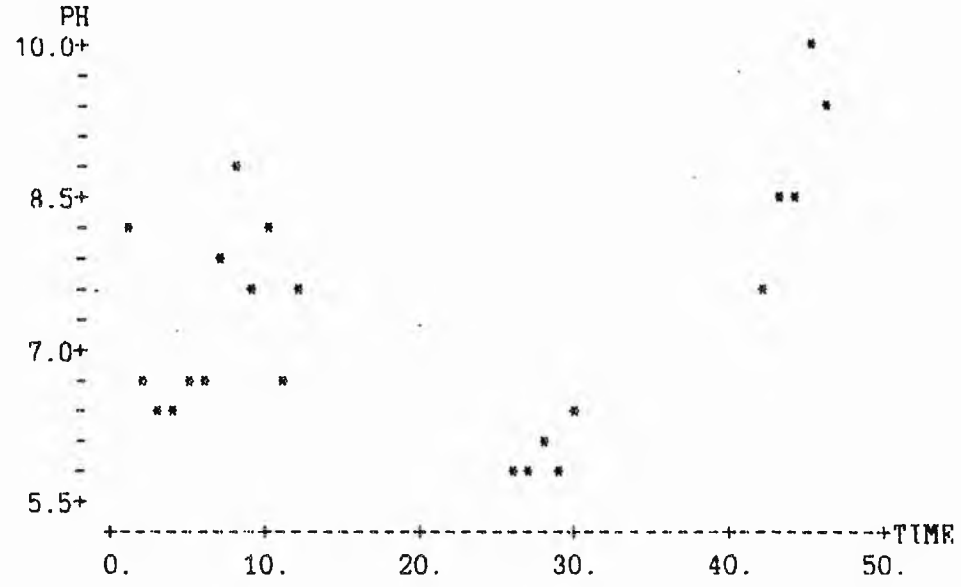
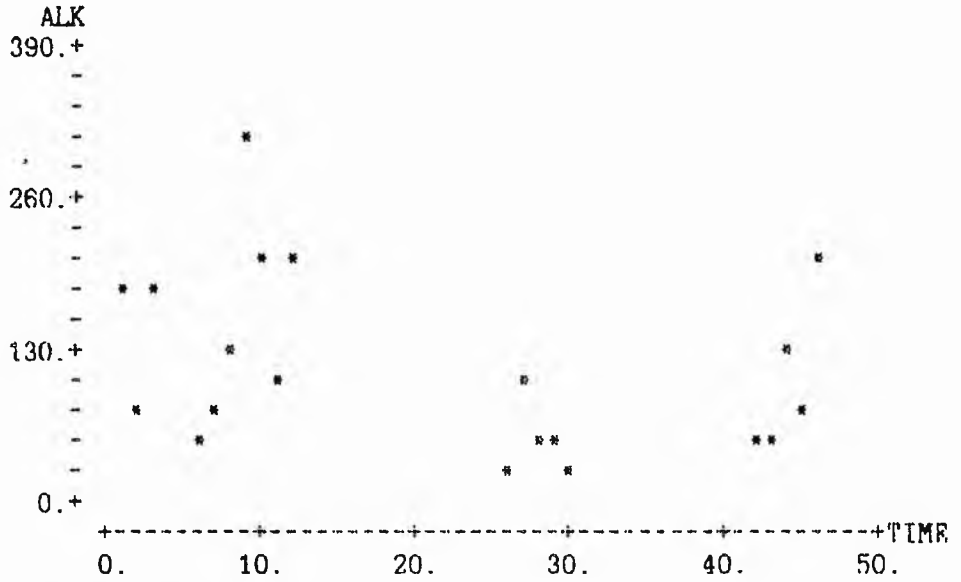


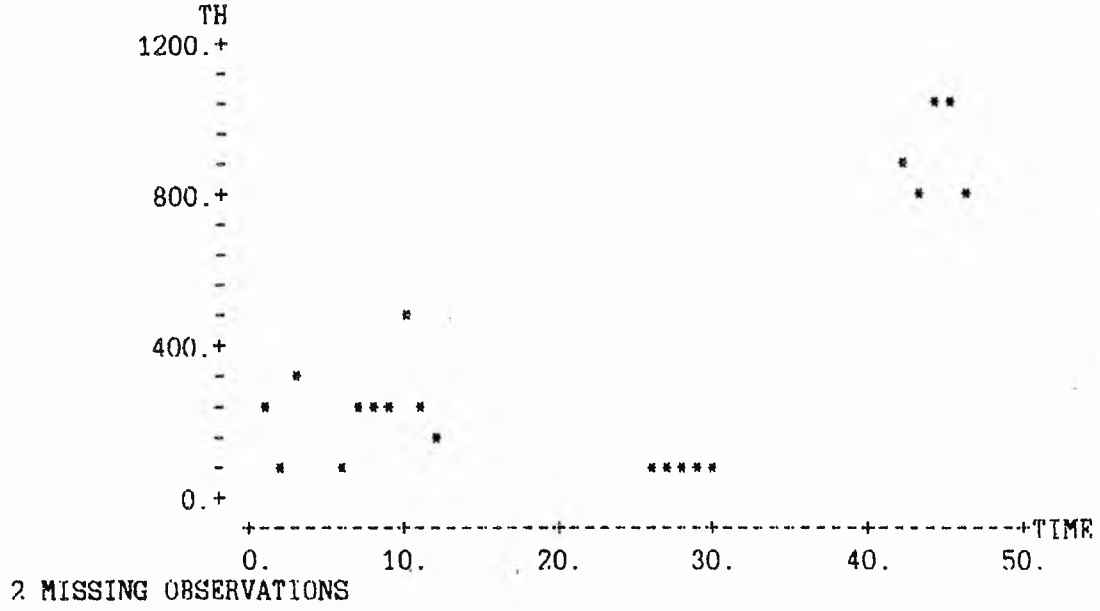
Figure 7.246



2 MISSING OBSERVATIONS

Figure 7.247

Graphs of Gully Pot Liquor Quality for Twyford 2 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.248

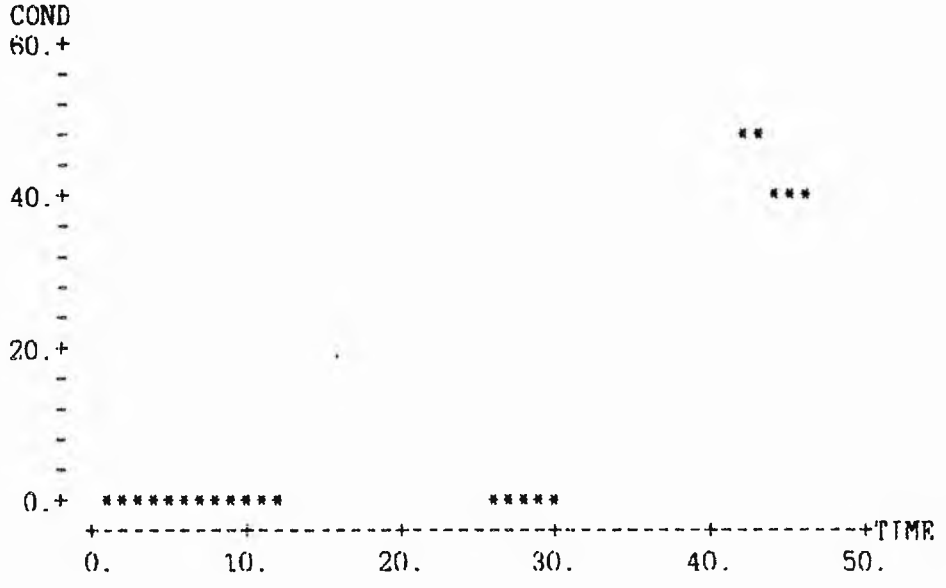


Figure 7.249

Graphs of Gully Pot Liquor Quality for Twyford 2 Gully Pot.

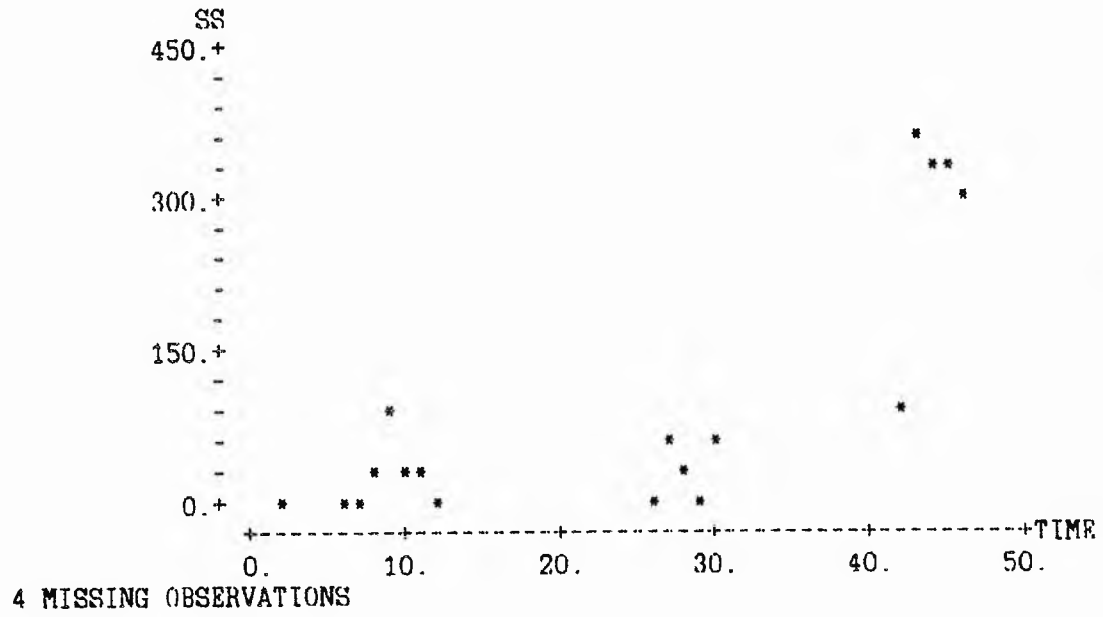


Figure 7.250

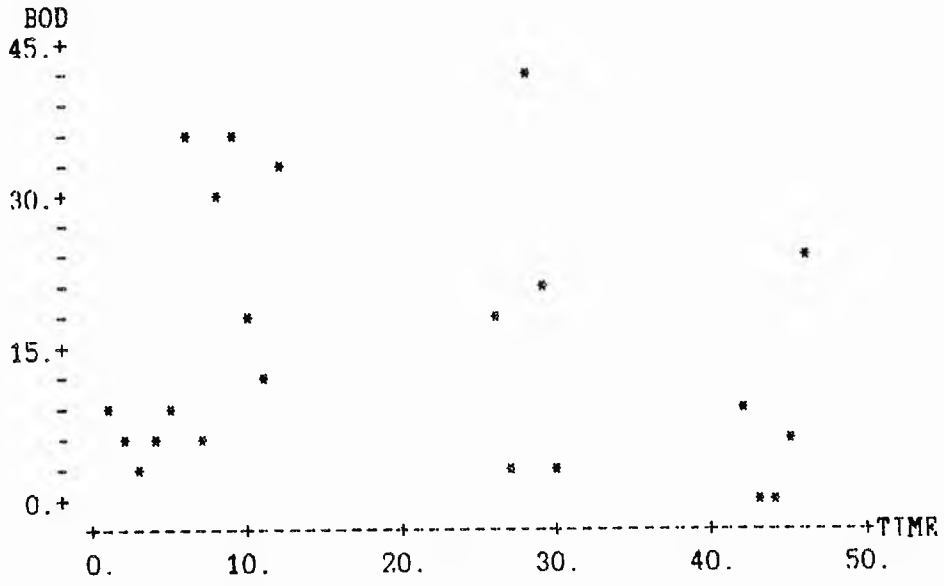
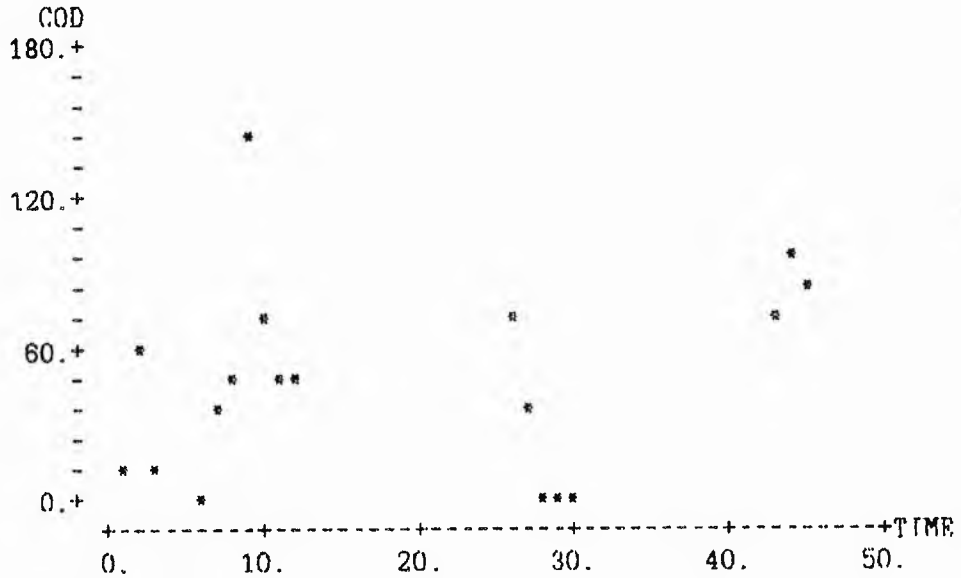


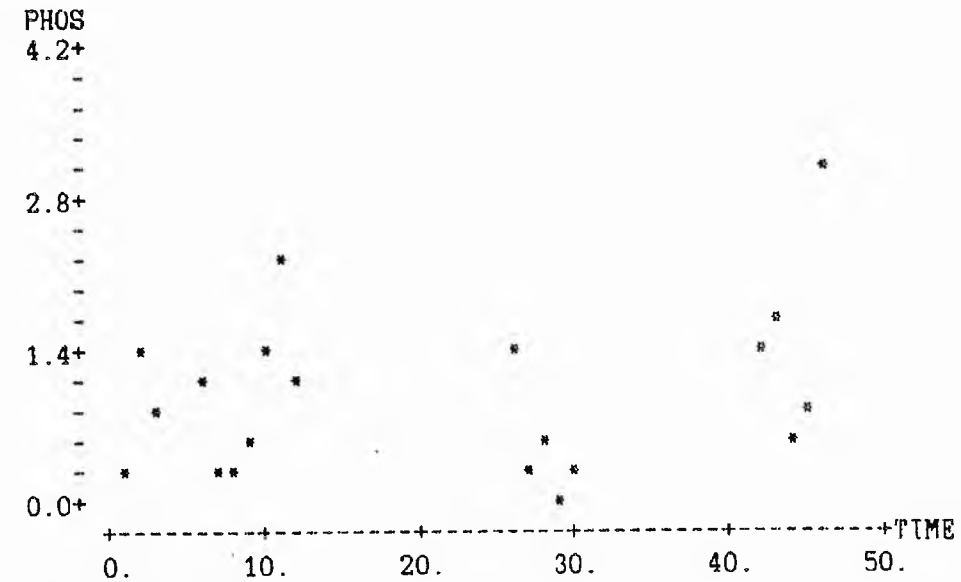
Figure 7.251

Graphs of Gully Pot Liquor Quality for Twyford 2 Gully Pot.



4 MISSING OBSERVATIONS

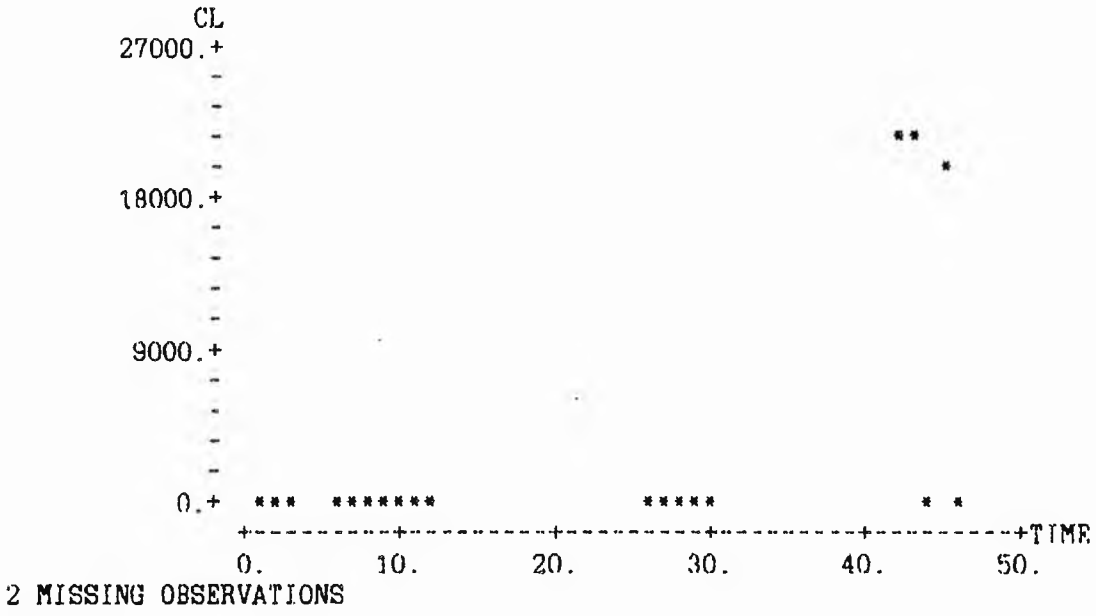
Figure 7.252



2 MISSING OBSERVATIONS

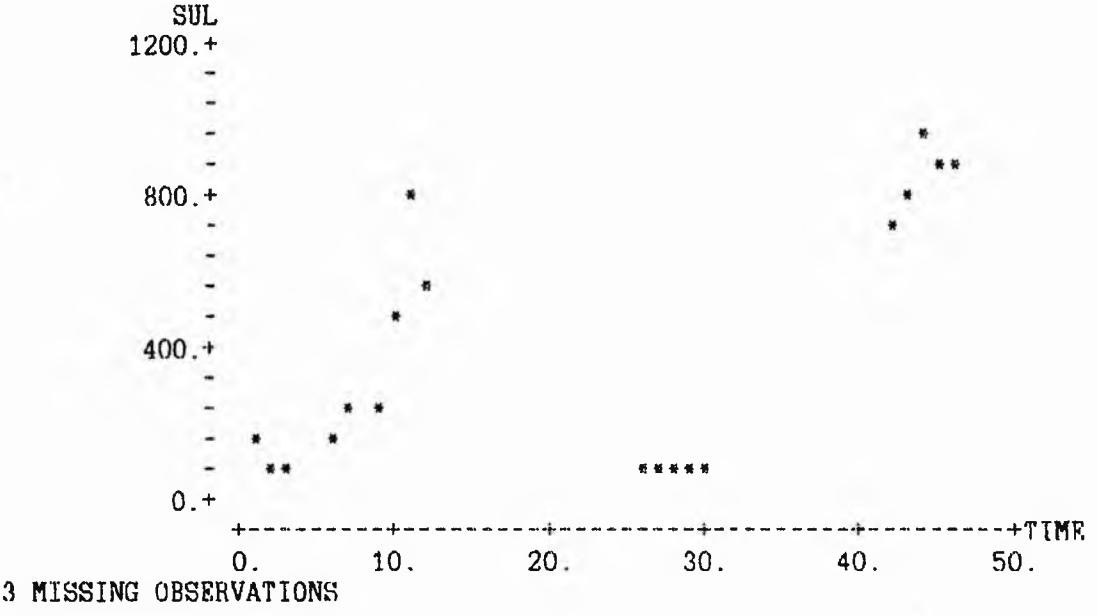
Figure 7.253

Graphs of Gully Pot Liquor Quality for Twyford 2 Gully Pot.



2 MISSING OBSERVATIONS

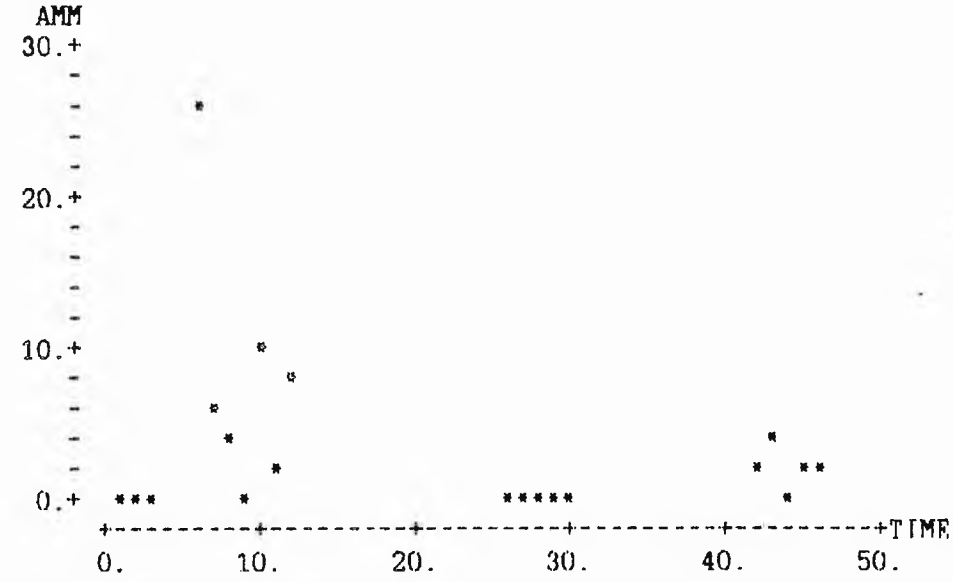
Figure 7.254



3 MISSING OBSERVATIONS

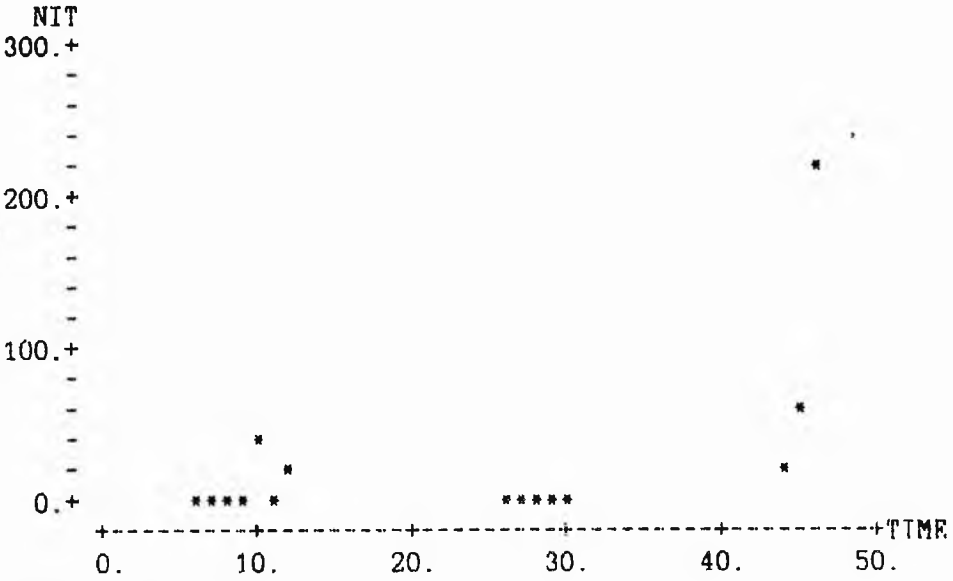
Figure 7.255

Graphs of Gully Pot Liquor Quality for Twyford 2 Gully Pot.



2 MISSING OBSERVATIONS

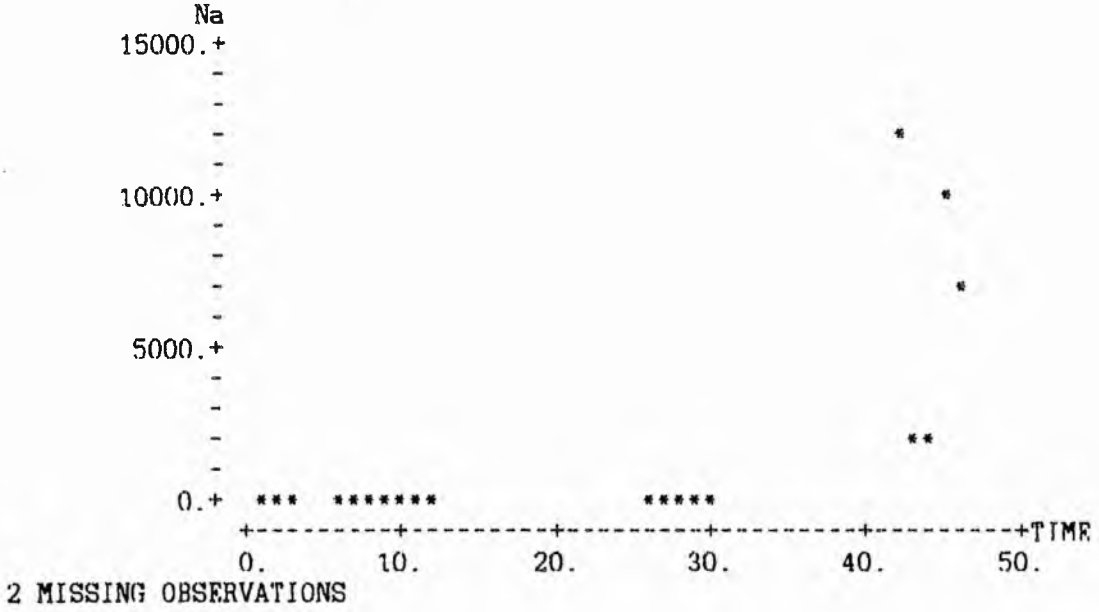
Figure 7.256



7 MISSING OBSERVATIONS

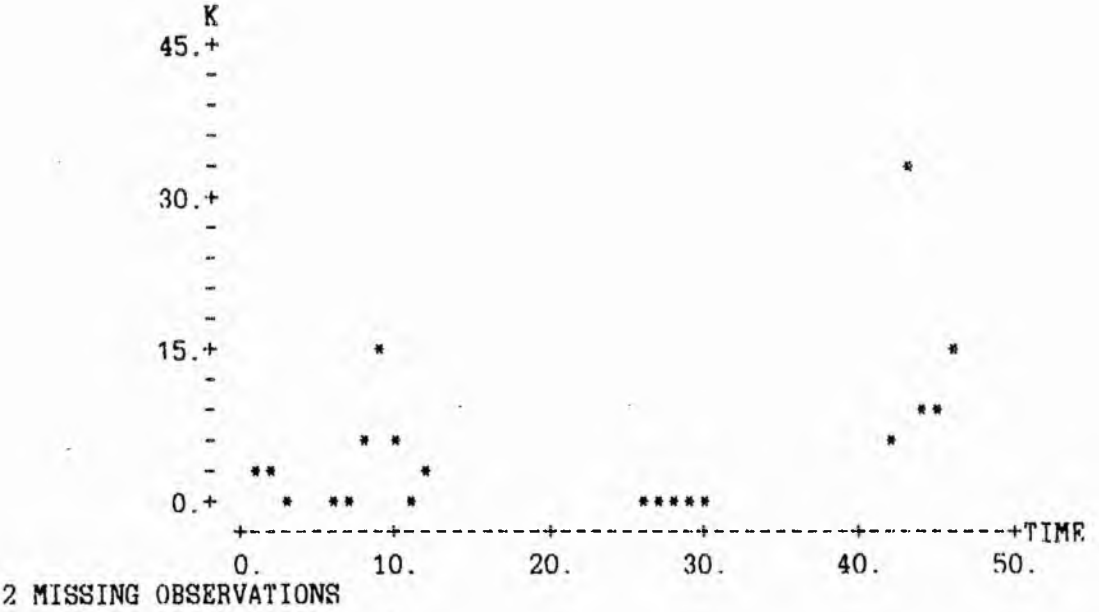
Figure 7.257

Graphs of Gully Pot Liquor Quality for Twyford 2 Gully Pot.



2 MISSING OBSERVATIONS

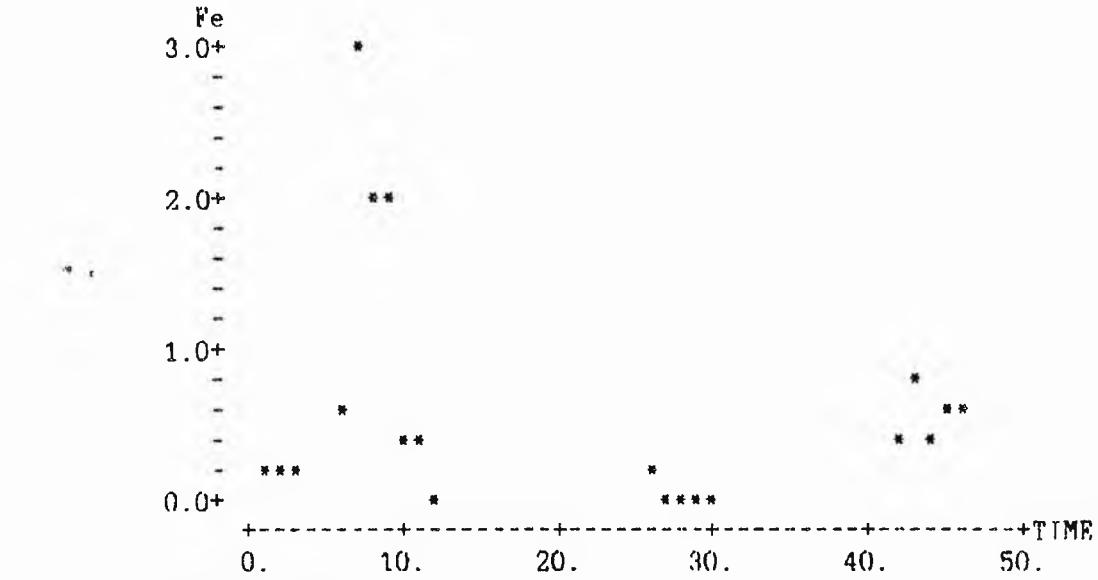
Figure 7.258



2 MISSING OBSERVATIONS

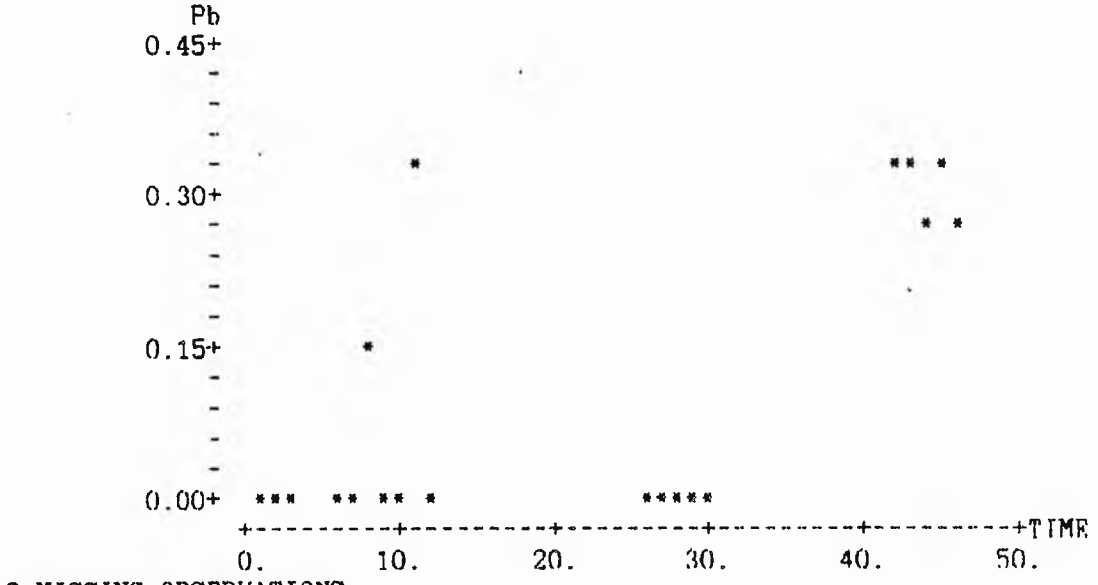
Figure 7.259

Graphs of Gully Pot Liquor Quality for Twyford 2 Gully Pot.



2 MISSING OBSERVATIONS

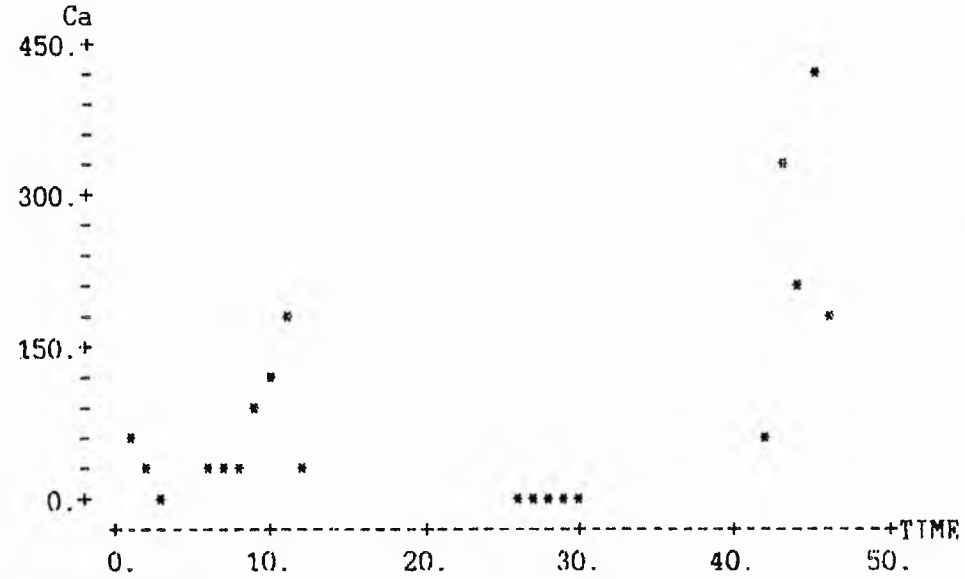
Figure 7.260



2 MISSING OBSERVATIONS

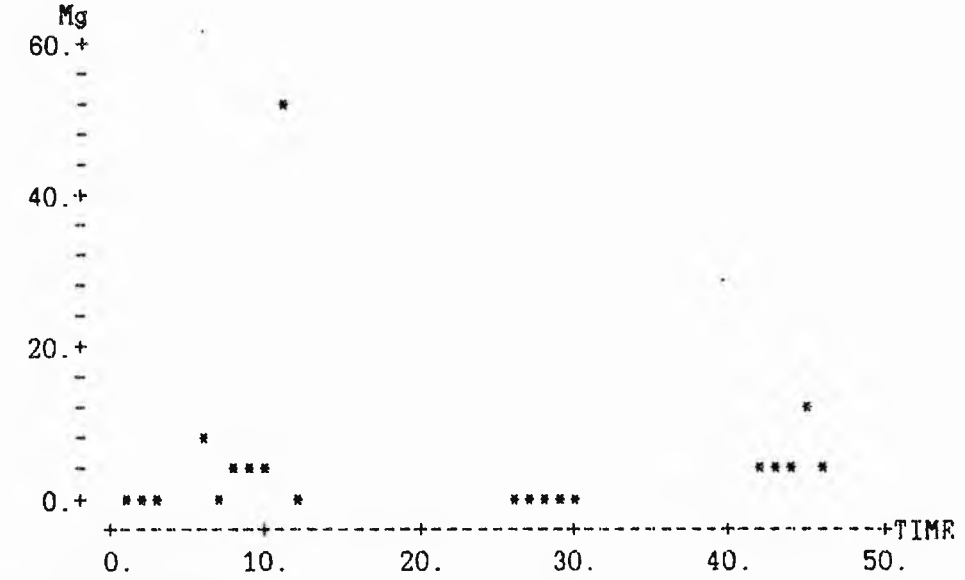
Figure 7.261

Graphs of Gully Pot Liquor Quality for Twyford 2 Gully Pot.



2 MISSING OBSERVATIONS

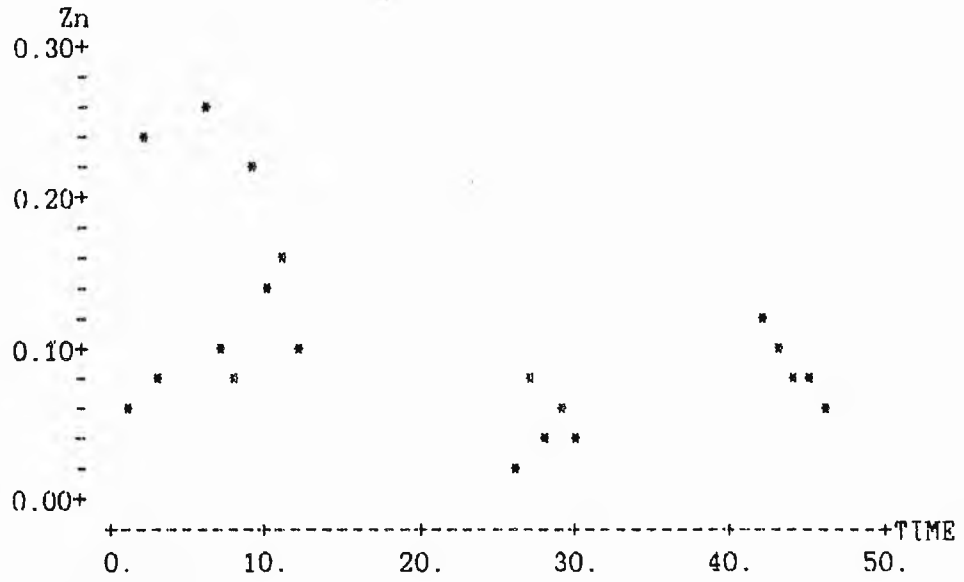
Figure 7.262



2 MISSING OBSERVATIONS

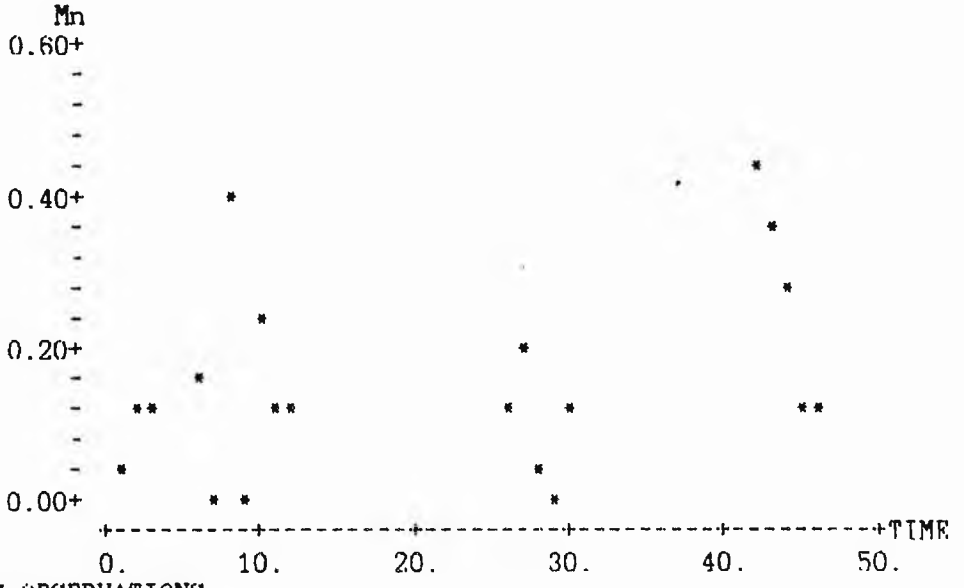
Figure 7.263

Graphs of Gully Pot Liquor Quality for Twyford 2 Gully Pot.



2 MISSING OBSERVATIONS

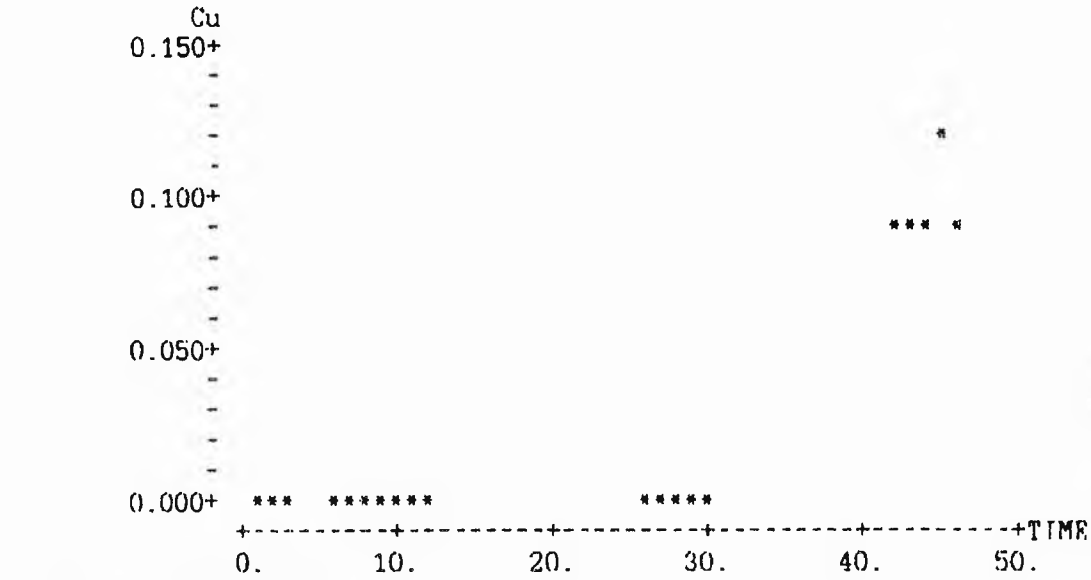
Figure 7.264



2 MISSING OBSERVATIONS

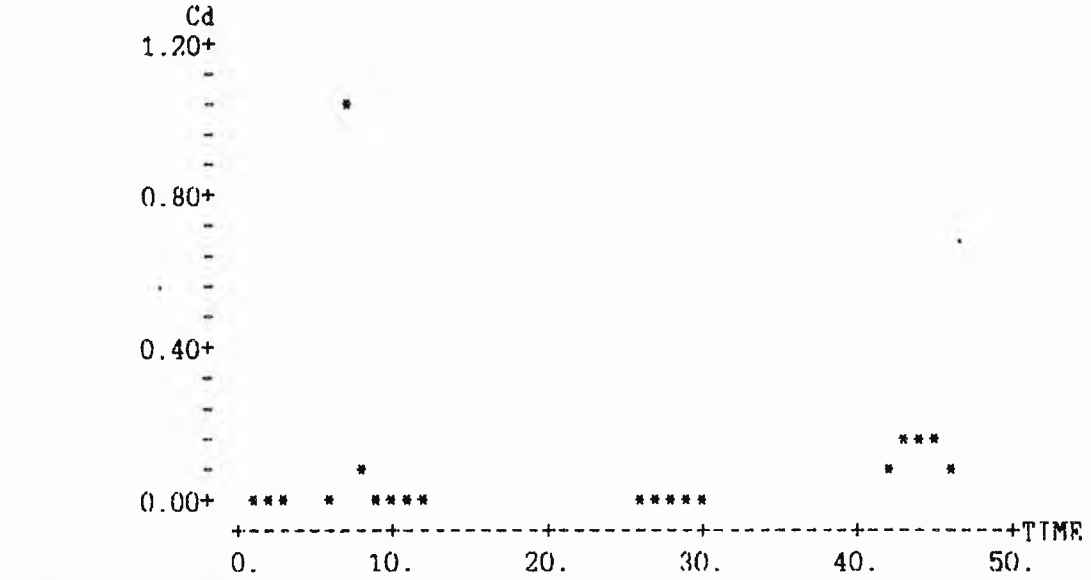
Figure 7.265

Graphs of Gully Pot Liquor Quality for Twyford 2 Gully Pot.



2 MISSING OBSERVATIONS

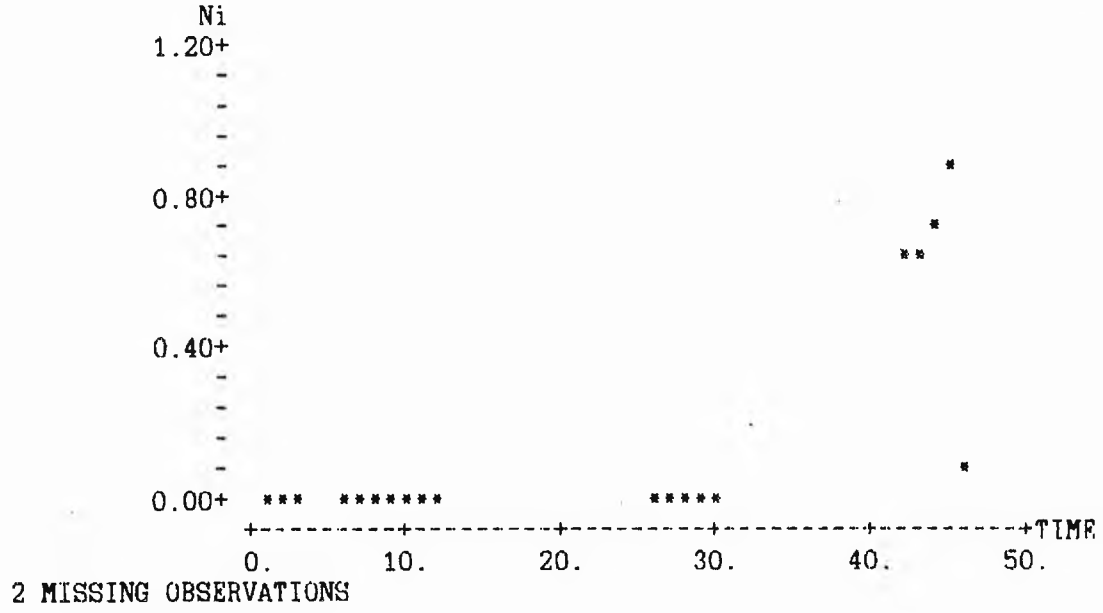
Figure 7.266



2 MISSING OBSERVATIONS

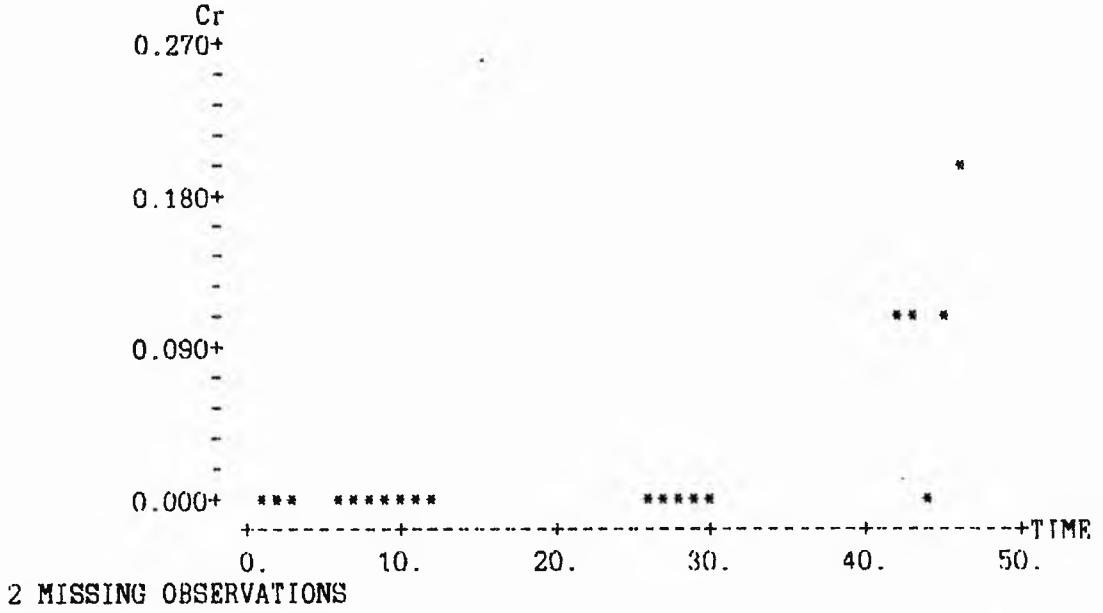
Figure 7.267

Graphs of Gully Pot Liquor Quality for Twyford 2 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.268



2 MISSING OBSERVATIONS

Figure 7.269

7.15 TWYFORD 3:

(see Figures 7.270 to 7.295 and Tables 7.31 to 7.33 inclusive).

The pH values were seen to vary considerably during the summer period within a range of pH 6.4-8.0. Acidic liquor conditions were obtained in the autumn period with all values falling below the neutral pH 7.0 point. The pH values in the spring rose to a maximum value of pH 9.3, which was recorded on the 850313.

The SS values were particularly high in the middle part of the summer period and a maximum SS value of 1256 mgl-1 was recorded on the 840620. The Twyford 3 gully pot was adjacent to a grassed area (see Figure 7.9) and the elevated SS values may be attributed to grass cuttings, soil and associated vegetal debris from this grassed area. A thin film of engine oil was observed on the surface of the pot liquor and this undoubtedly accounted for the high COD value of 356 mgl-1 as COD, which was measured on the first sample taken during the summer period (840509). Some droplets of oil may have been in suspension within the pot liquor or were drawn down into the sample bottle, at the time of sampling. This accounts for the presence of the oil in a sample taken at a depth equal to half the depth of the standing pot liquor and so surface phenomenon may be accounted for in the dataset. Once again, the COD and BOD measurements showed no seasonal trends and a great deal of variation in their respective values can be seen throughout the whole study period.

The Conductivity, sodium and chloride concentrations were again much higher for the spring period, illustrating the influence of road salting and the subsequent snowmelt on the gully liquor system with maxima of 5.50 (x1000) µscm-1, 1900.0 mgl-1 and 3545.0 mgl-1 as Cl^-,

respectively. The sodium and chloride levels were not as high as those found in some of the other gully pots but were noticeably higher than the concentrations found in the summer and autumn periods. This may signify a lesser degree of road salting than experienced elsewhere. The associated increases in the calcium, sulphate and the Total Hardness concentrations were not as evident for the Twyford 3 gully pot liquor.

An Ammonia value of 18.2 mgl-1 as N was measured in the pot liquor in the middle of the summer period (840620). The ammonia levels then fell and reached very low values during the autumn and spring periods. High nitrate concentrations were recorded during the summer period with values up to 43.4 mgl-1 as N. Such levels may be attributed to the influence of the grassed area adjacent to the gully pot with the input of soil and grass into the pot during the summer months. This source of nitrogen has influenced both the ammonia and the nitrate values for this pot.

The heavy metals - nickel and chromium were only detected in the spring with maxima of 0.25 and 0.10 mgl-1, respectively. Copper and cadmium were each detected on one occasion during the summer period with values of 0.05 and 0.08 mgl-1, respectively. The four heavy metals were not detected at all during the autumn period but copper and cadmium were found in the spring period with maxima of 0.02 and 0.03 mgl-1, respectively. All four metals were therefore found during the spring period which substantiates the conclusion that these metals do appear in the spring period after a period of heavy snowfall.

Table 7.31

Table of all the Water Quality Data collected over the Twenty-Two Week Period for the Gully Pot Standing Liquor in the Twyford 3 Gully Pot.

ROW	DATE	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
1	840509	11.5	2.5	8.0	260	230	0.57	*	12	356
2	840516	13.0	3.4	7.3	150	70	0.46	1	7	70
3	840523	12.5	3.3	7.2	170	280	0.09	*	9	21
4	840530	14.0	3.3	6.6	*	*	0.08	*	2	*
5	840606	14.5	3.3	7.2	*	*	0.10	*	5	*
6	840613	16.0	1.4	6.6	180	330	0.38	623	51	71
7	840620	19.0	0.2	7.1	390	370	0.55	1256	42	59
8	840627	18.5	0.7	6.4	140	90	0.25	873	33	62
9	840704	24.5	4.8	7.5	200	420	0.27	612	5	129
10	840711	23.0	1.0	7.2	230	390	0.33	10	14	43
11	840718	20.0	1.0	7.1	180	430	0.31	18	21	145
12	840725	17.5	0.6	7.3	210	300	0.35	13	36	132
13	841031	12.0	1.4	6.5	50	60	0.11	0	7	40
14	841107	10.0	0.6	6.4	80	60	0.11	40	5	45
15	841114	10.0	4.1	6.8	60	60	0.09	25	37	11
16	841121	8.0	6.7	6.2	30	120	0.05	30	25	0
17	841128	8.0	5.9	6.3	30	170	0.10	105	3	27
18	850220	2.5	2.6	7.6	65	170	5.11	11	39	5
19	850227	3.5	1.3	8.1	80	180	5.50	55	6	66
20	850306	5.0	2.7	8.7	150	300	5.17	52	3	29
21	850313	5.5	1.5	9.3	100	400	4.60	70	13	0
22	850320	4.5	4.5	8.5	370	560	5.05	27	15	57

ROW	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb	Ca
1	0.4	42.5	163	0.3	*	10.4	5.4	0.20	0.00	75.0
2	0.8	49.6	125	0.3	*	18.8	3.6	0.30	0.00	61.0
3	0.5	67.4	125	0.3	*	1.8	1.3	0.20	0.00	12.2
4	*	*	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*	*	*
6	2.6	28.0	279	10.4	7.7	18.0	2.5	4.10	0.00	48.0
7	1.4	35.0	221	18.2	4.3	0.2	5.0	16.00	0.00	65.0
8	1.1	32.0	*	14.0	3.6	13.0	7.5	2.00	0.15	17.5
9	0.9	43.0	154	0.1	19.6	21.0	15.0	2.40	0.00	102.5
10	1.2	106.0	644	1.5	43.4	22.5	3.0	0.30	0.00	117.5
11	1.9	35.0	596	0.2	1.4	11.0	8.0	0.35	0.45	190.5
12	1.4	53.0	375	2.4	7.6	5.0	4.5	0.00	0.00	41.5
13	2.7	24.8	77	0.4	6.7	2.6	1.9	0.20	0.00	15.0
14	0.3	17.7	0	0.2	1.7	2.0	1.4	0.00	0.00	10.0
15	1.1	17.7	38	0.1	2.7	1.8	1.3	0.00	0.00	12.5
16	0.0	7.1	135	0.2	1.7	5.0	1.4	0.00	0.00	9.2
17	0.6	14.2	144	0.5	0.9	4.5	1.4	0.00	0.00	11.4
18	3.3	3545.0	288	0.8	*	1900.0	4.5	0.12	0.11	26.0
19	2.4	2836.0	1115	2.9	*	1560.0	25.0	0.87	0.10	95.0
20	0.1	149.0	1096	0.7	5.2	1550.0	7.4	0.18	0.00	109.0
21	0.1	1790.2	240	0.8	7.7	880.0	6.6	0.10	0.15	120.0
22	1.8	238.0	432	1.7	75.6	860.0	7.5	0.33	0.15	64.3

ROW	Mg	Zn	Mn	Cu	Cd	Ni	Cr
1	0.00	0.06	0.06	0.00	0.00	0.00	0.0
2	0.00	0.23	0.16	0.00	0.00	0.00	0.0
3	0.00	0.11	0.11	0.00	0.00	0.00	0.0
4	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*
6	40.00	0.22	2.50	0.05	0.00	0.00	0.0
7	14.00	0.20	2.50	0.00	0.00	0.00	0.0
8	2.00	0.07	0.00	0.00	0.00	0.00	0.0
9	2.00	0.20	0.15	0.00	0.00	0.00	0.0
10	5.00	0.00	0.00	0.00	0.00	0.00	0.0
11	47.50	0.16	0.50	0.00	0.00	0.00	0.0
12	3.60	0.13	0.70	0.00	0.00	0.00	0.0
13	1.00	0.04	0.12	0.00	0.00	0.00	0.0
14	0.80	0.03	0.00	0.00	0.00	0.00	0.0
15	0.90	0.05	0.05	0.00	0.00	0.00	0.0
16	0.70	0.09	0.02	0.00	0.00	0.00	0.0
17	1.10	0.04	0.10	0.00	0.00	0.00	0.0
18	2.72	0.05	0.20	0.00	0.00	0.09	0.0
19	2.68	0.05	0.23	0.00	0.03	0.05	0.0
20	2.30	0.05	0.15	0.01	0.01	0.08	0.0
21	2.58	0.07	0.11	0.02	0.03	0.25	0.0
22	2.72	0.04	0.16	0.02	0.01	0.00	0.1

Statistical Summary of the Water Quality Data for the Standing Pot Liquor collected in the Twyford 3 Gully Pot.

Table 7.32

	TEMP	DO	PH	ALK	TH	COND	SS	BOD
N	22	22	22	20	20	22	18	22
NMISS	0	0	0	2	2	0	4	0
MEAN	12.41	2.58	7.268	156	250	1.35	212	17.7
MEDIAN	12.25	2.55	7.200	150	255	0.32	35	12.5
TMEAN	12.30	2.50	7.220	150	243	1.20	160	16.8
STDEV	6.31	1.81	0.829	102	150	2.09	369	15.2
SEMEAN	1.35	0.39	0.177	23	34	0.44	87	3.2
MAX	24.50	6.70	9.300	390	560	5.50	1256	51.0
MIN	2.50	0.20	6.200	30	60	0.05	0	2.0
Q3	17.75	3.50	7.700	207	385	1.58	232	33.8
Q1	7.37	1.00	6.575	69	98	0.10	13	5.0

	COD	PHOS	CL	SUL	AMM	NIT	Na	K
N	20	20	20	19	20	15	20	20
NMISS	2	2	2	3	2	7	2	2
MEAN	68.4	1.230	457	329	2.80	12.7	344	5.71
MEDIAN	51.0	1.100	43	221	0.60	5.2	12	4.50
TMEAN	56.2	1.183	310	302	2.09	8.7	277	4.88
STDEV	79.7	0.957	1020	323	5.13	20.5	632	5.66
SEMEAN	17.8	0.214	228	74	1.15	5.3	141	1.27
MAX	356.0	3.300	3545	1115	18.20	75.6	1900	25.00
MIN	0.0	0.000	7	0	0.10	0.9	0	1.30
Q3	70.7	1.875	138	432	2.23	7.7	651	7.48
Q1	22.5	0.425	26	125	0.22	1.7	3	1.53

	Fe	Pb	Ca	Mg	Zn	Mn	Cu	Cd
N	20	20	20	20	20	20	20	20
NMISS	2	2	2	2	2	2	2	2
MEAN	1.38	0.056	600.2	6.6	0.0985	0.391	0.0050	0.0080
MEDIAN	0.20	0.000	54.5	2.2	0.0700	0.135	0.0000	0.0000
TMEAN	0.64	0.037	55.7	4.7	0.0950	0.296	0.0028	0.0044
STDEV	3.60	0.110	49.8	13.1	0.0671	0.741	0.0124	0.0194
SEMEAN	0.80	0.025	11.1	2.9	0.0150	0.166	0.0028	0.0043
MAX	16.00	0.450	1900.5	47.5	0.2300	2.500	0.0500	0.0800
MIN	0.00	0.000	9.2	0.0	0.0300	0.000	0.0000	0.0000
Q3	0.73	0.107	100.6	3.4	0.1525	0.223	0.0000	0.0075
Q1	0.02	0.000	13.1	0.8	0.0500	0.052	0.0000	0.0000

	Ni	Cr
N	20	20
NMISS	2	2
MEAN	0.0235	0.0050
MEDIAN	0.0000	0.0000
TMEAN	0.0122	0.0000
STDEV	0.0600	0.0224
SEMEAN	0.0134	0.0050
MAX	0.2500	0.1000
MIN	0.0000	0.0000
Q3	0.0000	0.0000
Q1	0.0000	0.0000

Table of the Correlation Coefficients between all Twenty-Six Water Quality Parameters for the Standing Pot Liquor in the Twyford 3 Gully Pot.

Table 7.33

	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
DO	-0.286								
PH	-0.384	-0.187							
ALK	0.397	-0.263	0.328						
TH	0.247	-0.073	0.546	0.788					
COND	-0.699	-0.052	0.789	0.026	0.292				
SS	0.496	-0.265	-0.285	0.489	0.167	-0.263			
BOD	0.168	-0.282	-0.287	0.194	0.037	-0.073	0.455		
COD	0.321	-0.166	0.134	0.428	0.171	-0.222	0.289	-0.067	
PHOS	-0.015	-0.326	-0.094	0.035	0.047	0.225	0.042	0.426	-0.055
CL	-0.559	-0.128	0.437	-0.289	-0.048	0.736	-0.218	0.063	-0.227
SUL	-0.172	-0.265	0.507	0.119	0.337	0.623	-0.161	-0.172	-0.018
AMM	0.344	-0.458	-0.214	0.443	0.092	-0.138	0.982	0.611	-0.031
NIT	-0.044	0.149	0.414	0.681	0.619	0.446	-0.163	-0.178	0.055
Na	-0.695	-0.027	0.652	-0.135	0.123	0.952	-0.279	-0.092	-0.262
K	-0.062	-0.132	0.458	0.096	0.247	0.515	0.181	-0.245	0.193
Fe	0.351	-0.316	-0.184	0.562	0.235	-0.137	0.851	0.448	0.004
Pb	0.024	-0.232	0.282	0.066	0.353	0.245	-0.185	0.078	0.086
Ca	0.262	-0.283	0.565	0.352	0.655	0.295	-0.058	-0.288	0.318
Mg	0.378	-0.332	-0.158	0.214	0.392	-0.168	0.224	0.435	0.159
Zn	0.622	-0.181	-0.133	0.398	0.276	-0.376	0.491	0.322	0.188
Mn	0.384	-0.366	-0.141	0.462	0.297	-0.148	0.664	0.658	0.042
Cu	-0.111	-0.077	0.211	0.178	0.391	0.231	0.153	0.343	-0.099
Cd	-0.046	-0.273	0.118	-0.085	-0.122	0.248	0.318	0.058	-0.187
Ni	-0.474	-0.135	0.692	-0.228	0.181	0.655	-0.188	-0.098	-0.287
Cr	-0.275	0.248	0.328	0.492	0.487	0.392	-0.125	-0.064	-0.034

	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
CL	0.461								
SUL	0.171	0.337							
AMM	0.289	-0.189	0.028						
NIT	0.224	0.056	0.245	-0.128					
Na	0.385	0.819	0.625	-0.155	0.283				
K	0.225	0.474	0.648	0.046	0.252	0.482			
Fe	0.129	-0.122	-0.071	0.824	-0.111	-0.164	0.043		
Pb	0.271	0.238	0.385	-0.015	0.064	0.189	0.295	-0.124	
Ca	0.011	0.188	0.596	-0.098	0.198	0.286	0.487	0.037	0.591
Mg	0.387	-0.138	0.178	0.294	-0.147	-0.167	0.011	0.263	0.573
Zn	0.079	-0.283	-0.147	0.368	-0.143	-0.388	0.027	0.494	0.081
Mn	0.343	-0.119	-0.021	0.732	-0.147	-0.168	-0.067	0.798	-0.088
Cu	0.285	-0.089	0.074	0.247	0.289	0.113	-0.068	0.092	0.017
Cd	-0.042	0.192	0.529	0.427	-0.052	0.186	0.376	-0.028	0.299
Ni	-0.117	0.687	0.209	-0.144	-0.096	0.598	0.188	-0.135	0.289
Cr	0.148	-0.058	0.077	-0.058	0.858	0.192	0.074	-0.069	0.282

	Ca	Mg	Zn	Mn	Cu	Cd	Ni
Mg	0.488						
Zn	0.271	0.511					
Mn	0.054	0.618	0.624				
Cu	0.099	0.478	0.245	0.534			
Cd	-0.082	-0.142	-0.229	-0.181	0.022		
Ni	0.389	-0.126	-0.233	-0.136	0.245	0.274	
Cr	0.028	-0.069	-0.285	-0.073	0.286	0.024	-0.092

Graphs of Gully Pot Liquor Quality for Twyford 3 Gully Pot.

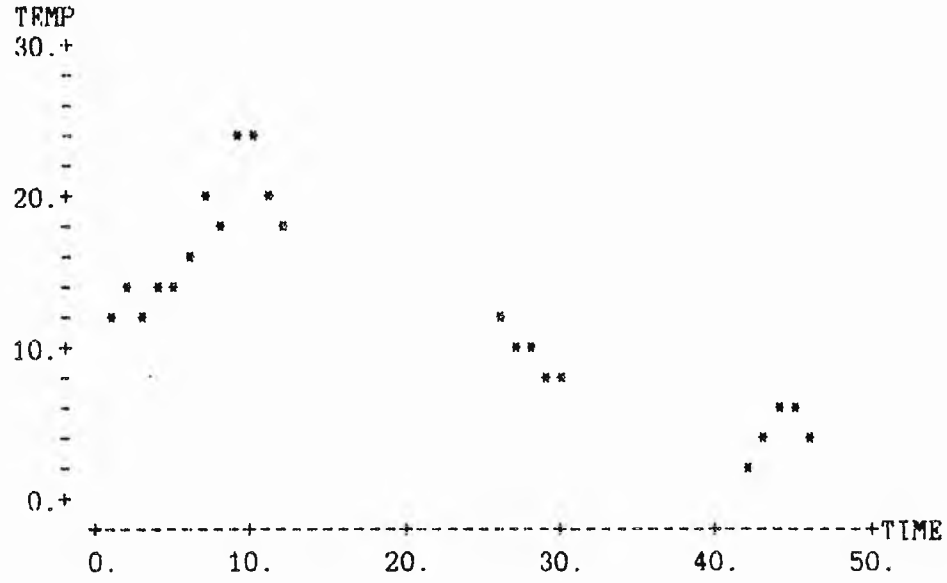


Figure 7.270

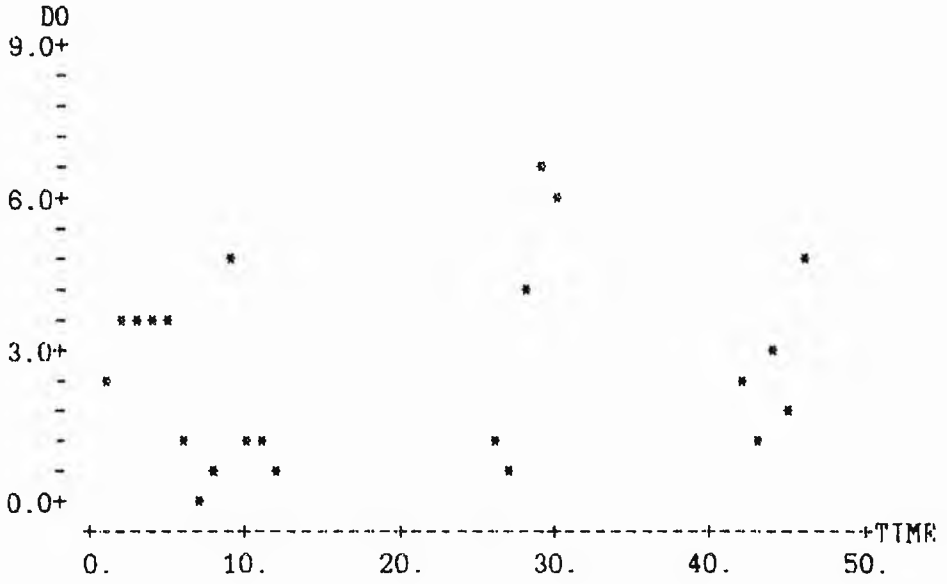


Figure 7.271

Graphs of Gully Pot Liquor Quality for Twyford 3 Gully Pot.

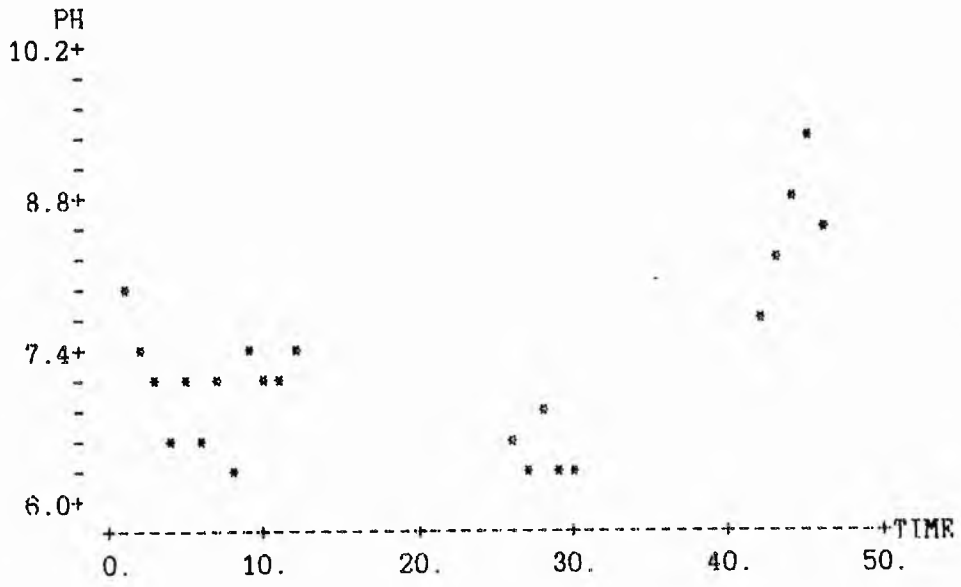
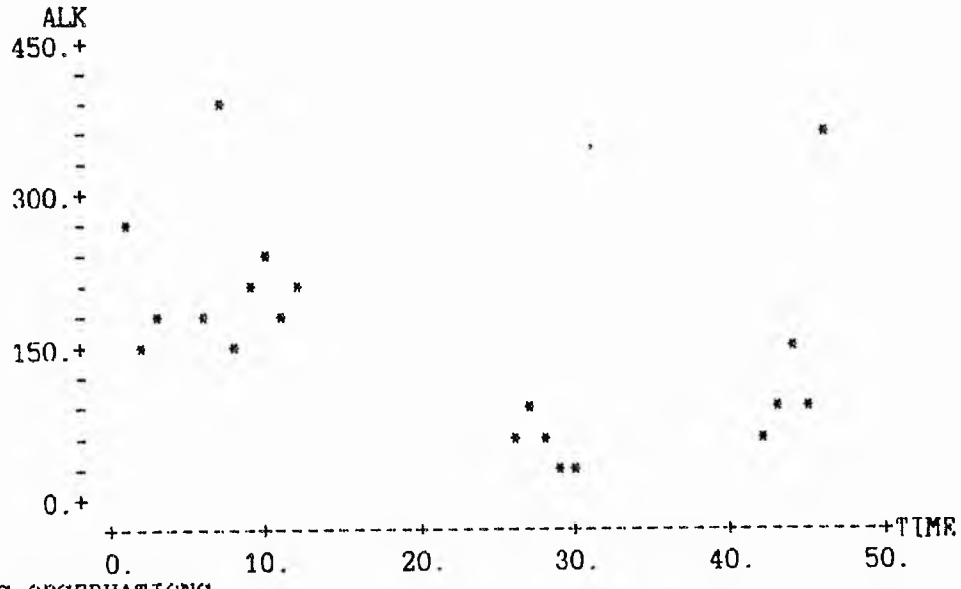


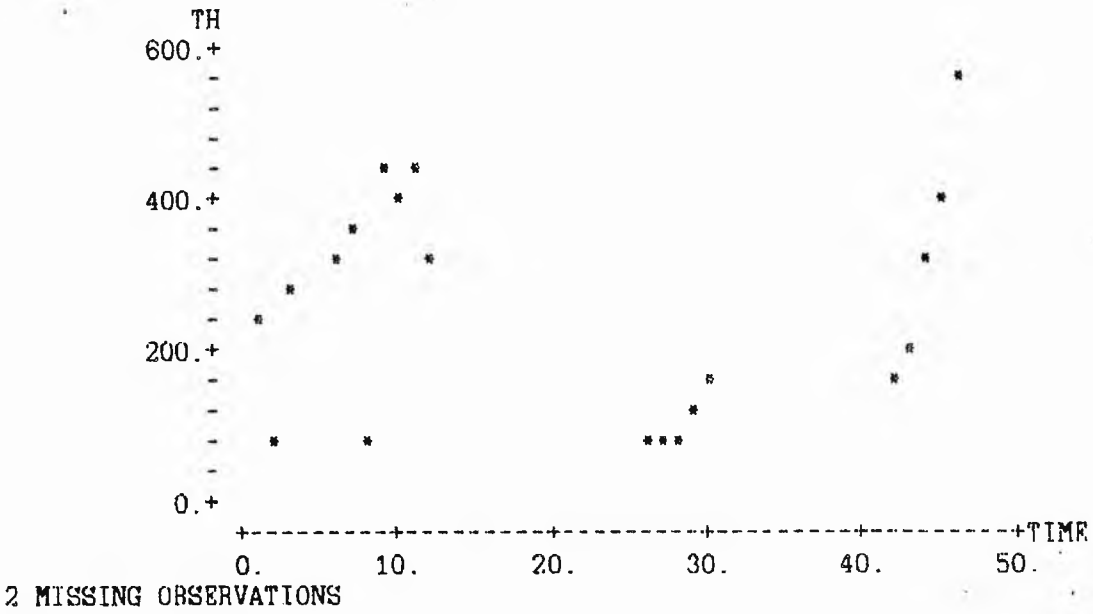
Figure 7.272



2 MISSING OBSERVATIONS

Figure 7.273

Graphs of Gully Pot Liquor Quality for Twyford 3 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.274

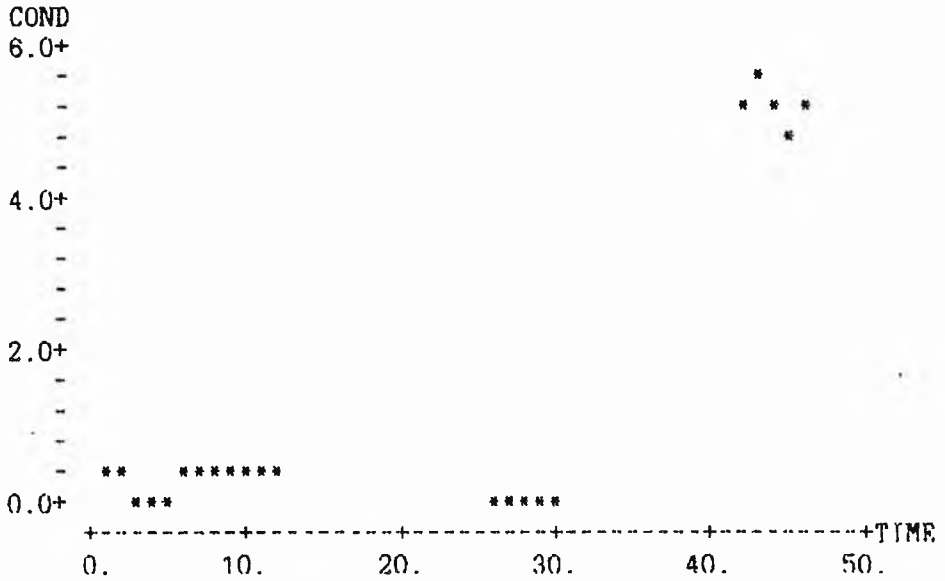
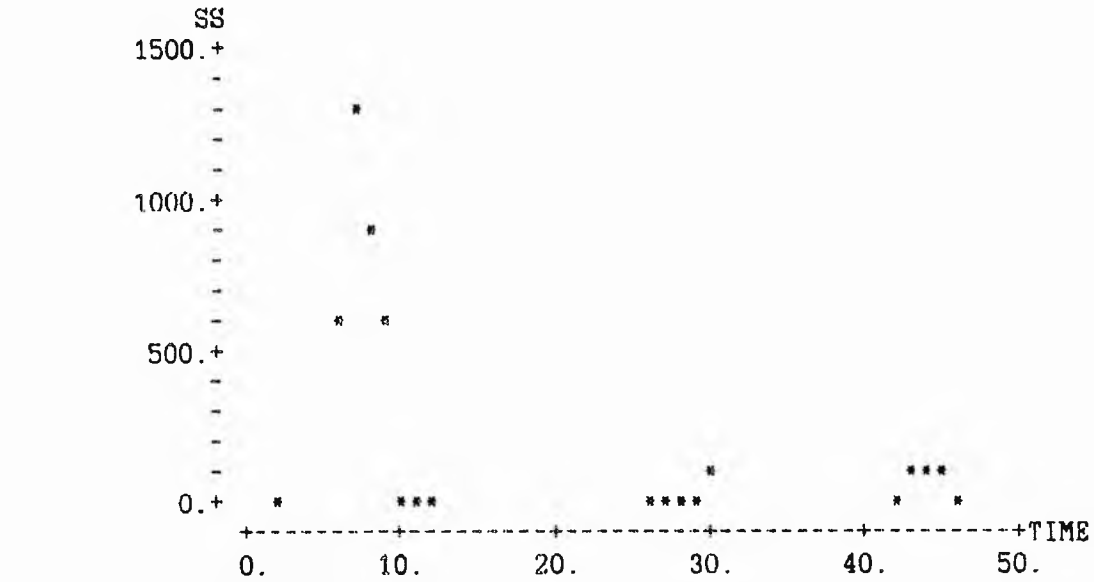


Figure 7.275

Graphs of Gully Pot Liquor Quality for Twyford 3 Gully Pot.



4 MISSING OBSERVATIONS

Figure 7.276

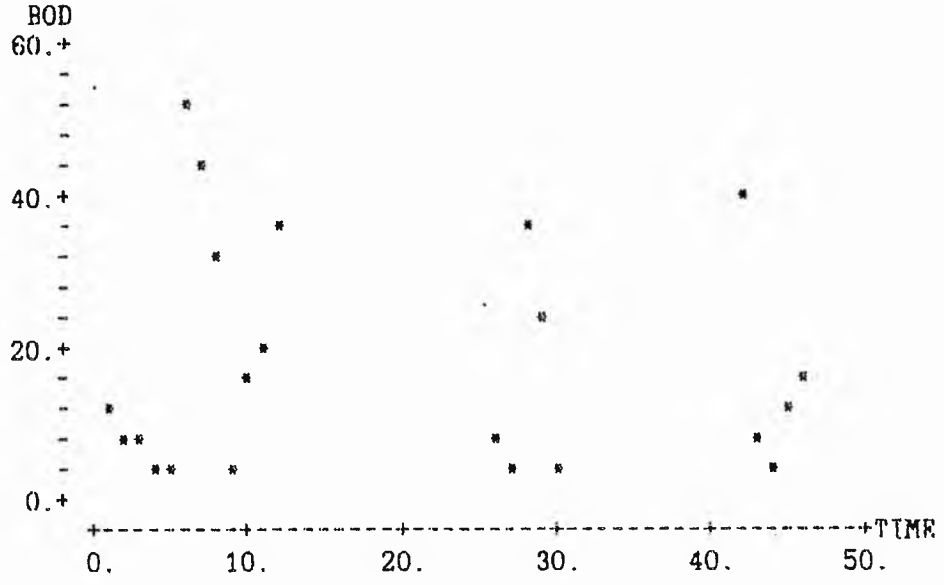
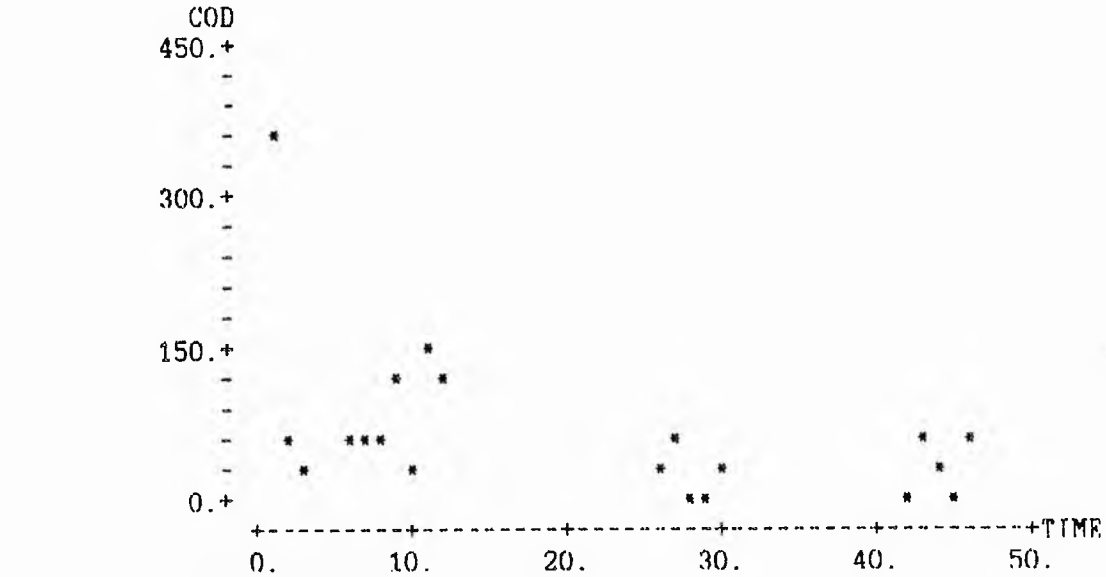


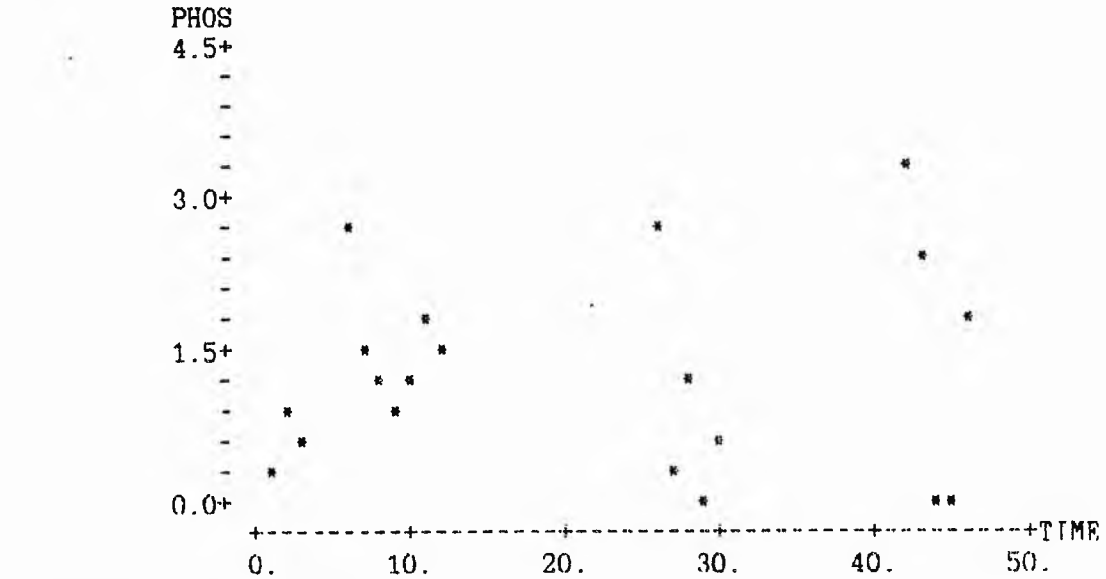
Figure 7.277

Graphs of Gully Pot Liquor Quality for Twyford 3 Gully Pot.



2 MISSING OBSERVATIONS

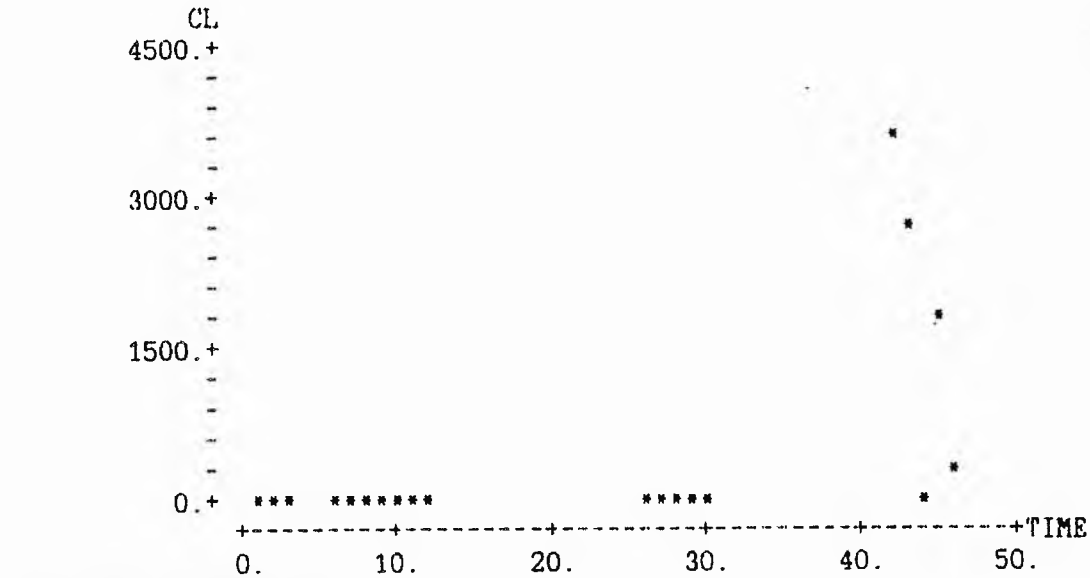
Figure 7.278



2 MISSING OBSERVATIONS

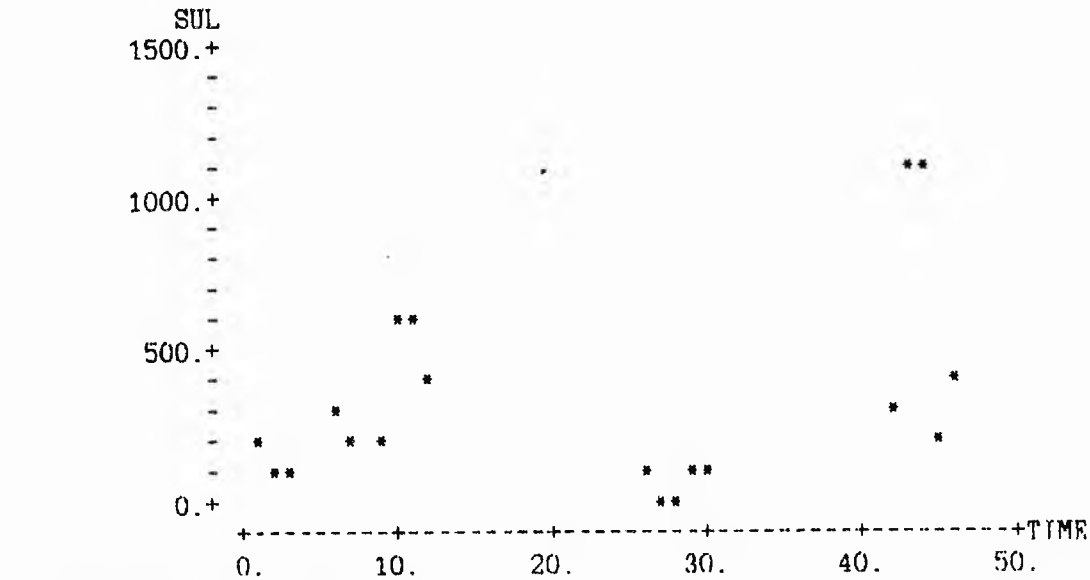
Figure 7.279

Graphs of Gully Pot Liquor Quality for Twyford 3 Gully Pot.



2 MISSING OBSERVATIONS

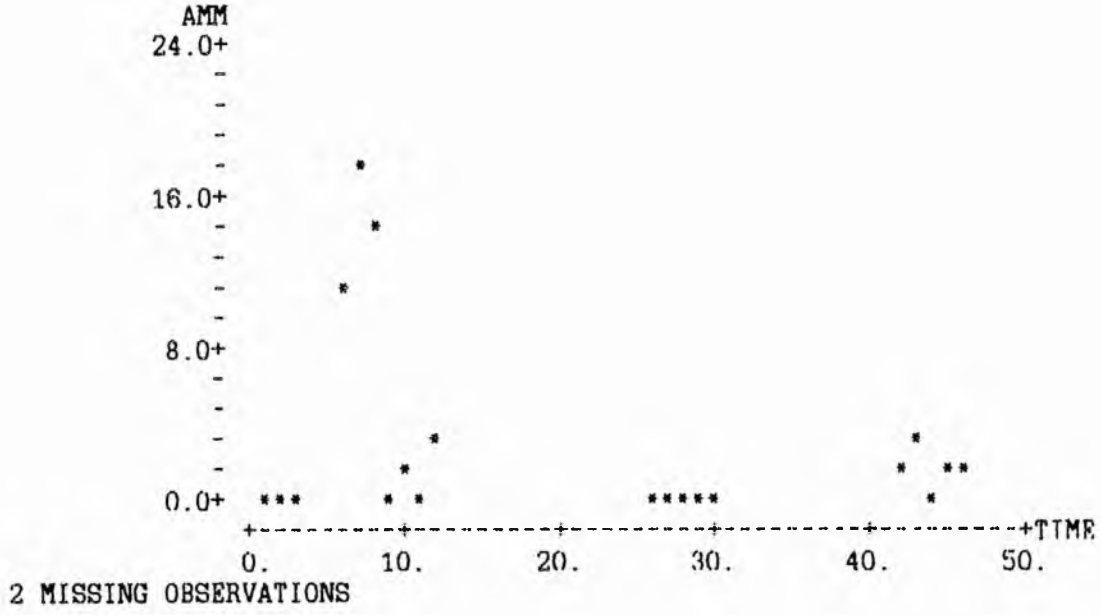
Figure 7.280



3 MISSING OBSERVATIONS

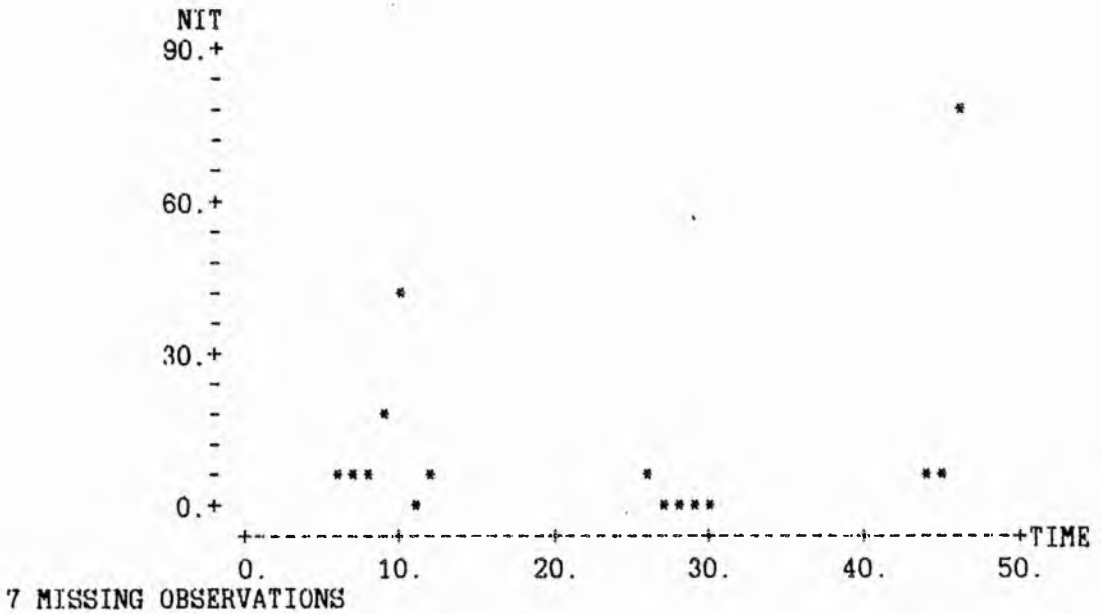
Figure 7.281

Graphs of Gully Pot Liquor Quality for Twyford 3 Gully Pot.



2 MISSING OBSERVATIONS

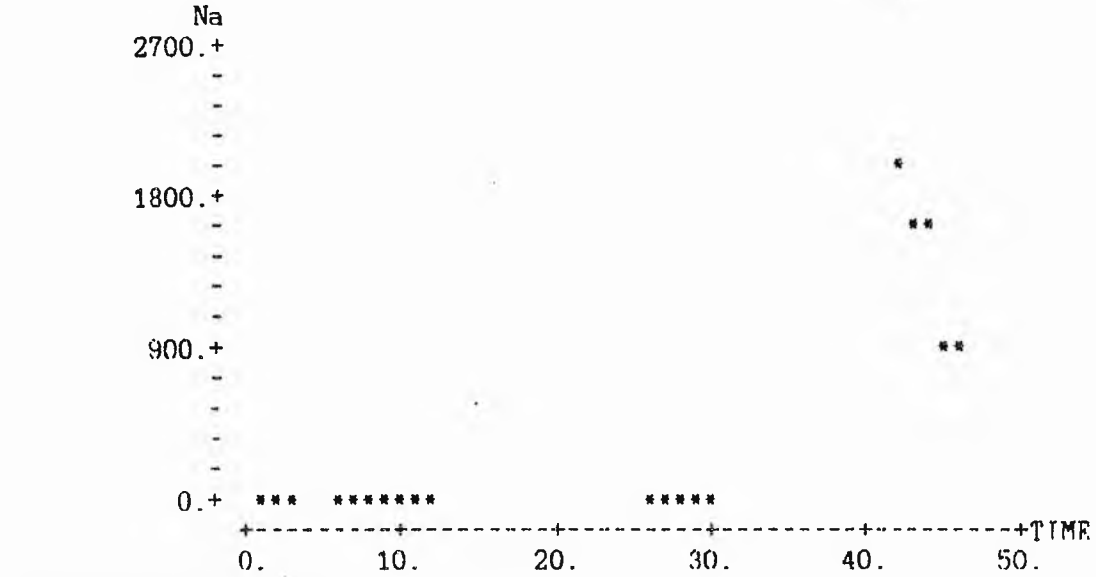
Figure 7.282



7 MISSING OBSERVATIONS

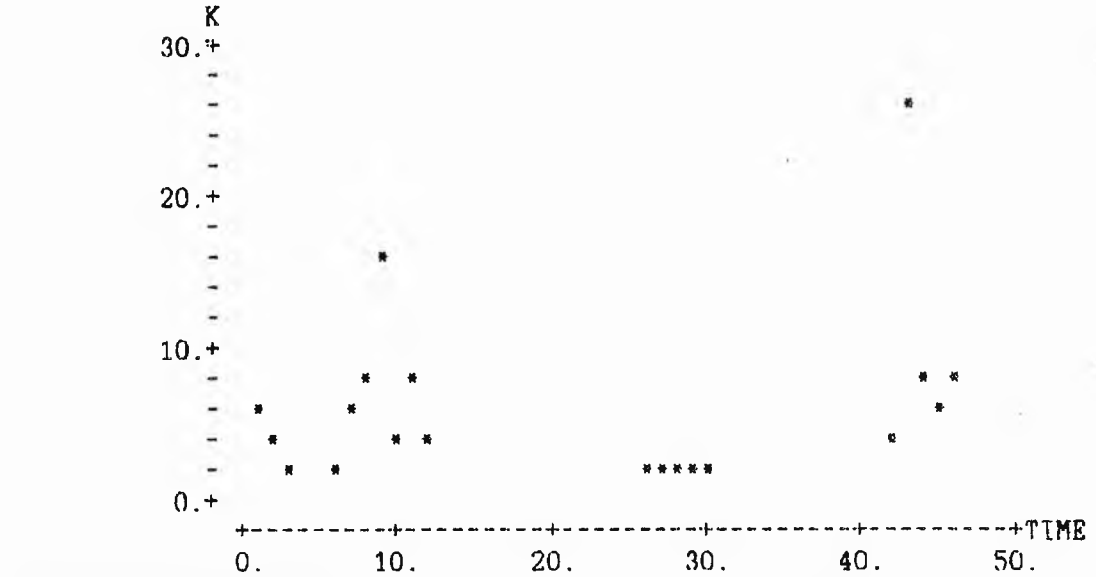
Figure 7.283

Graphs of Gully Pot Liquor Quality for Twyford 3 Gully Pot.



2 MISSING OBSERVATIONS

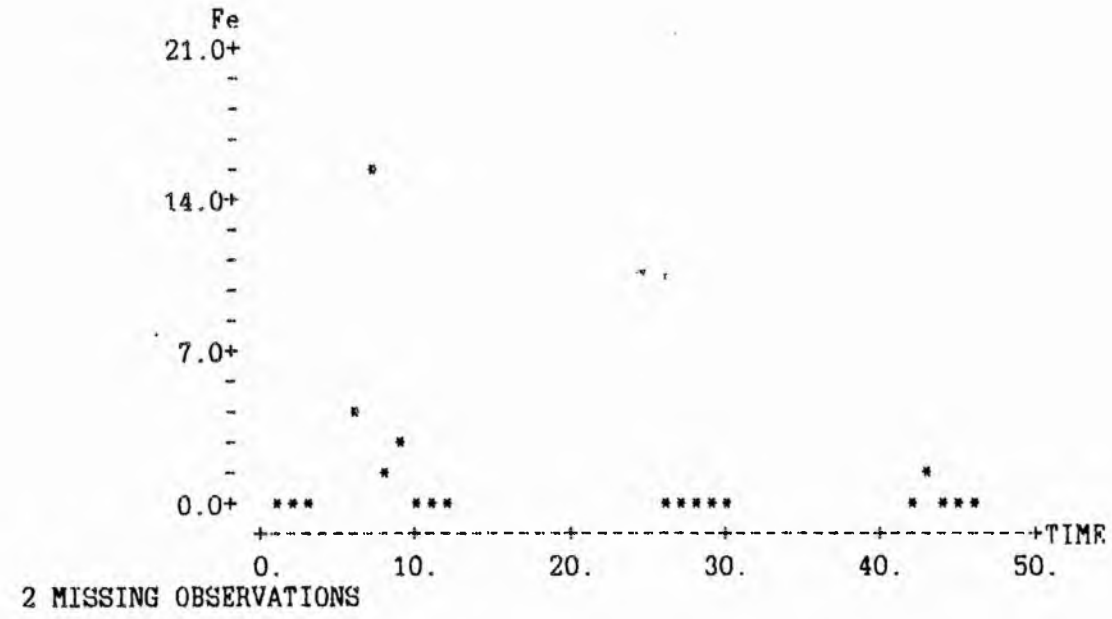
Figure 7.284



2 MISSING OBSERVATIONS

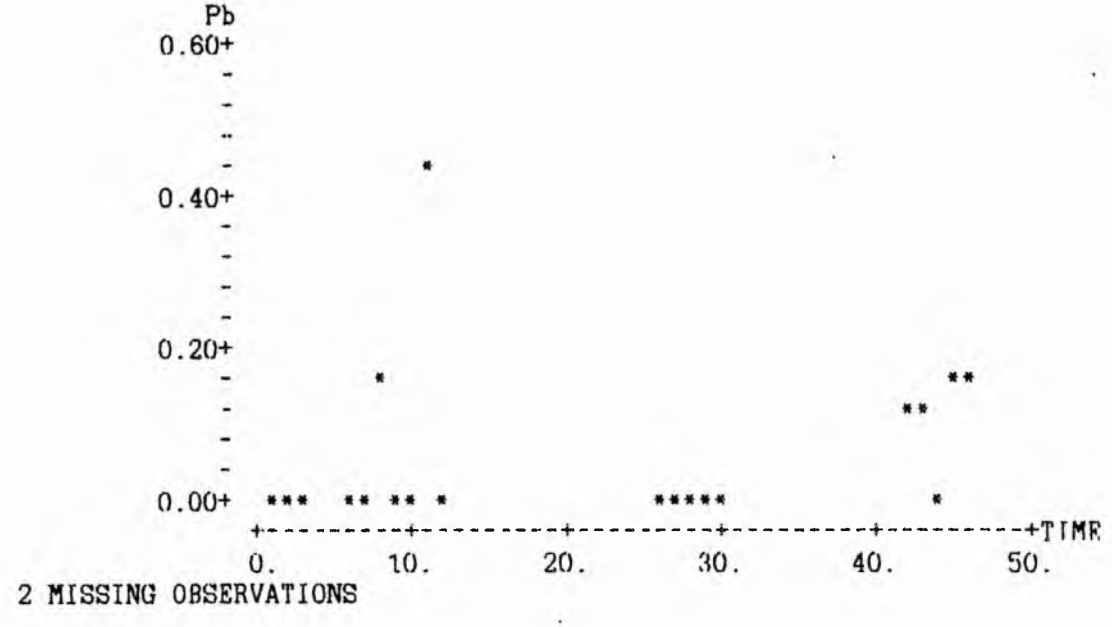
Figure 7.285

Graphs of Gully Pot Liquor Quality for Twyford 3 Gully Pot.



2 MISSING OBSERVATIONS

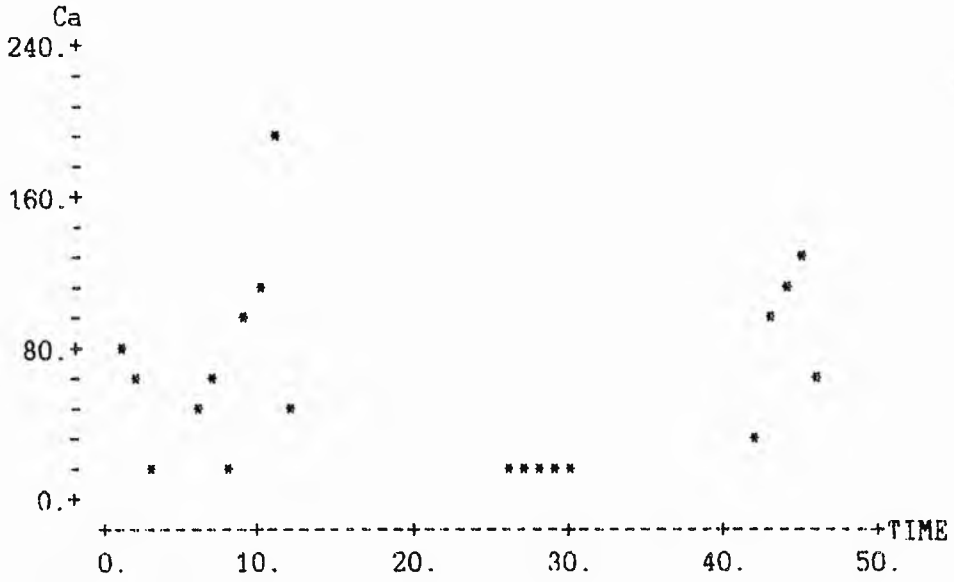
Figure 7.286



2 MISSING OBSERVATIONS

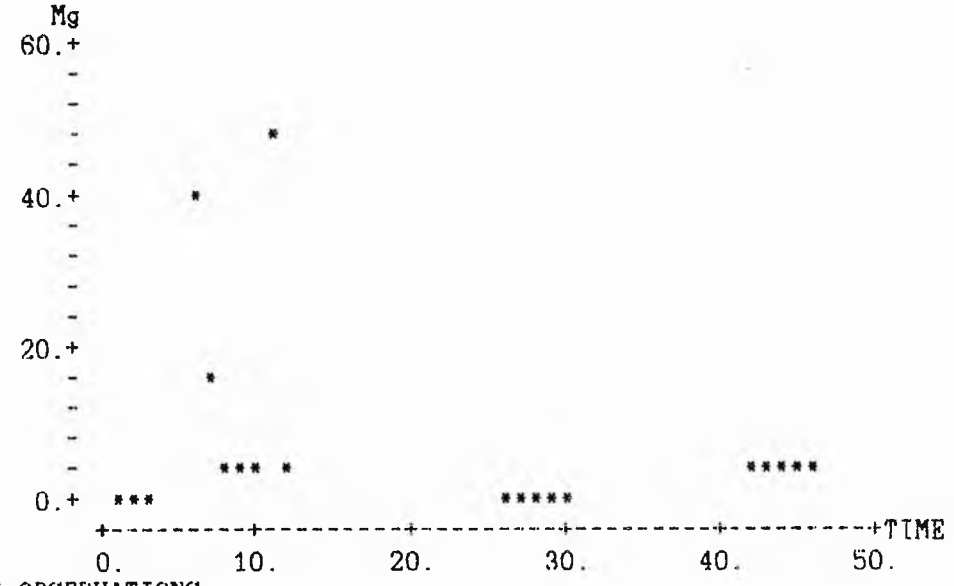
Figure 7.287

Graphs of Gully Pot Liquor Quality for Twyford 3 Gully Pot.



2 MISSING OBSERVATIONS

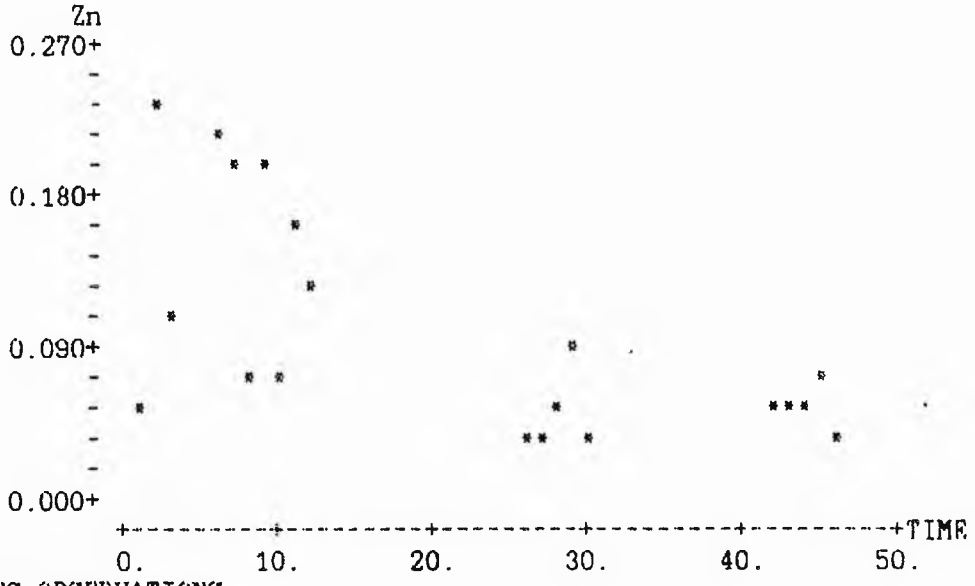
Figure 7.288



2 MISSING OBSERVATIONS

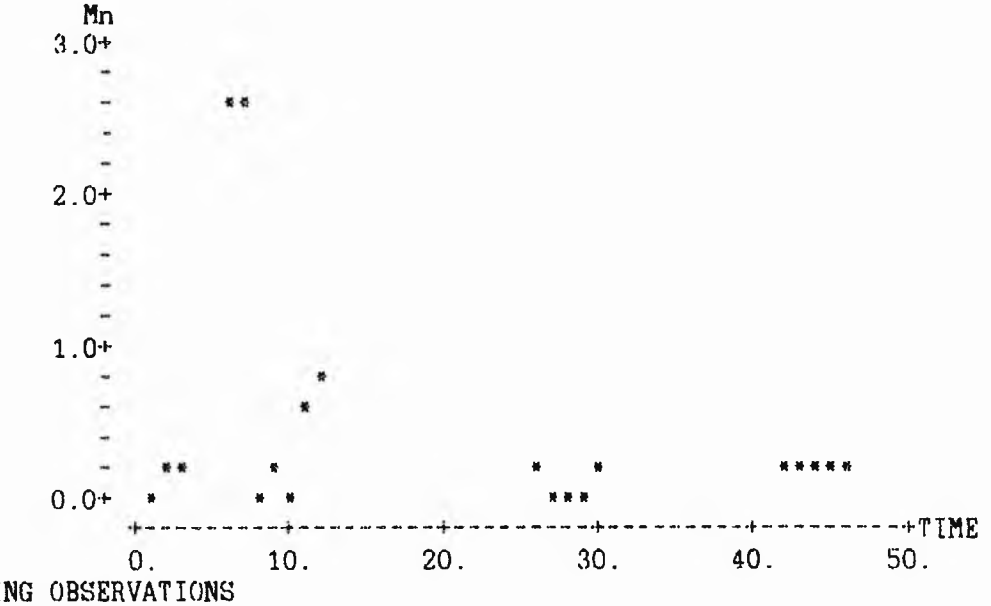
Figure 7.289

Graphs of Gully Pot Liquor Quality for Twyford 3 Gully Pot.



2 MISSING OBSERVATIONS

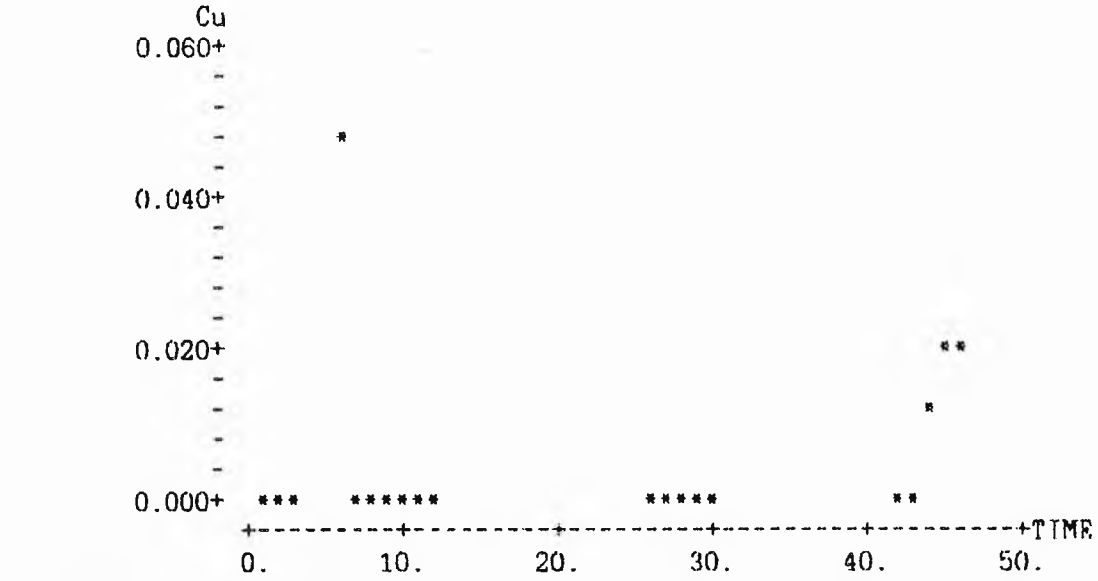
Figure 7.290



2 MISSING OBSERVATIONS

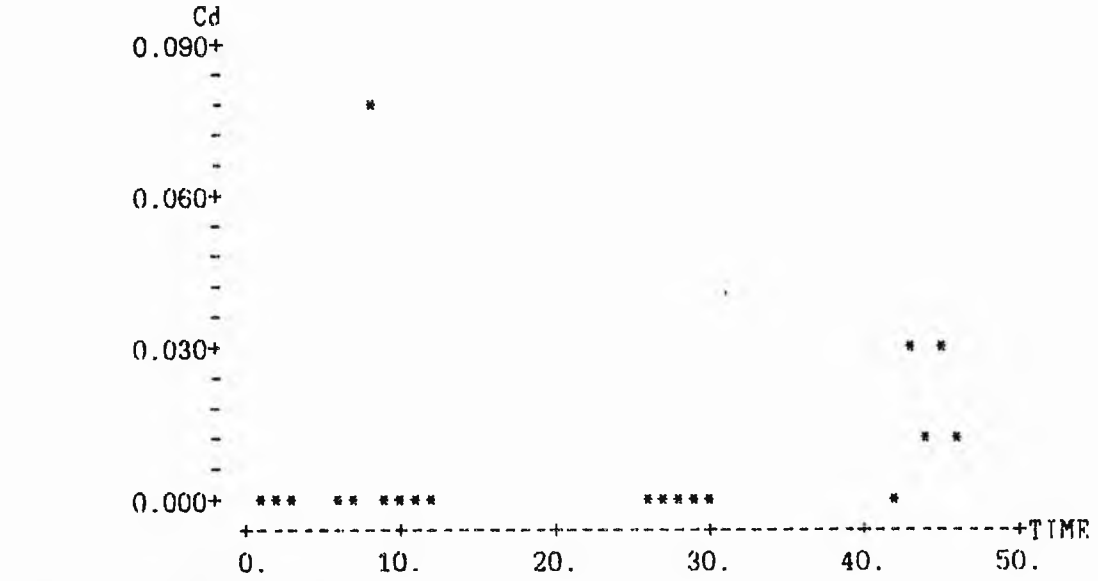
Figure 7.291

Graphs of Gully Pot Liquor Quality for Twyford 3 Gully Pot.



2 MISSING OBSERVATIONS

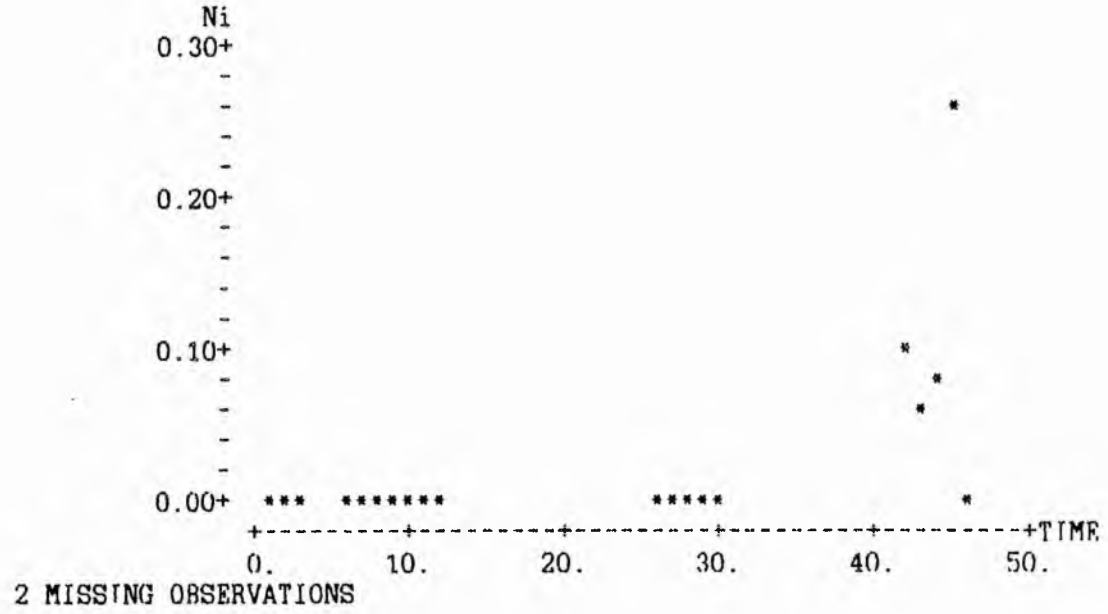
Figure 7.292



2 MISSING OBSERVATIONS

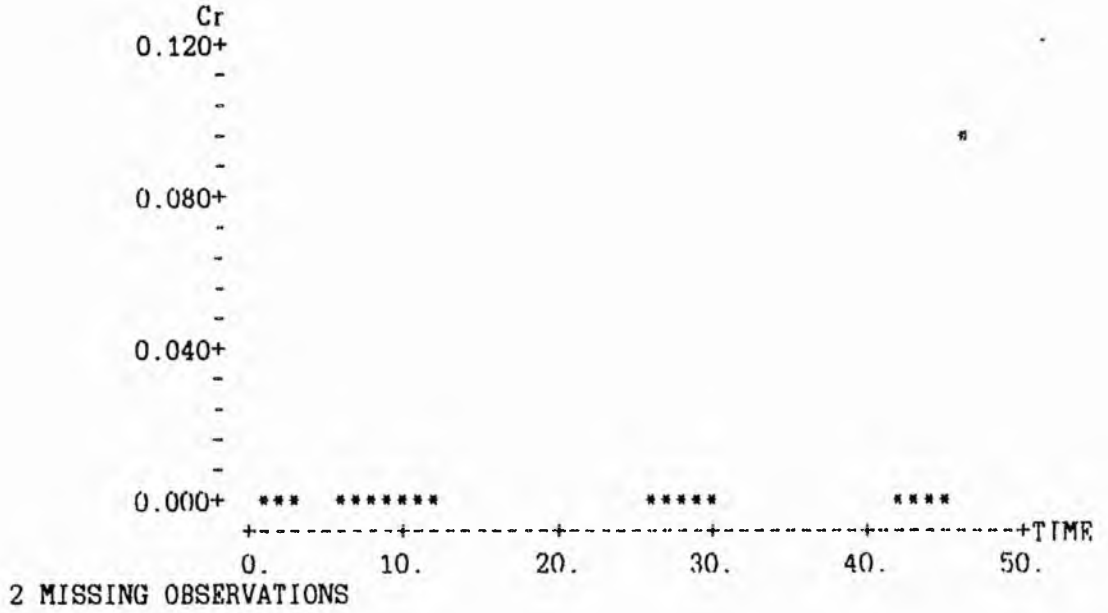
Figure 7.293

Graphs of Gully Pot Liquor Quality for Twyford 3 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.294



2 MISSING OBSERVATIONS

Figure 7.295

7.16 TWYFORD 4:

(see Figures 7.296 to 7.321 and Tables 7.34 to 7.36 inclusive).

The pH values varied considerably throughout the whole of the study period with a range of pH 6.2-8.1 and the maximum value was reached on the 850313 in the spring period. The pH seemed to fluctuate greatly even within each seasonal period although the values for the spring period tended to be at the upper end of the pH range for the pot liquor, as quoted above.

The Conductivity, sodium and chloride levels rose dramatically in the spring period as a consequence of the road salting adopted by the residents, but it was interesting to note that the enhanced concentrations were only evident for three out of the five samples taken in the spring period. The last two samples taken (850313 and 850320) show concentrations of these parameters, not dissimilar for those found during the summer period. The influence of road salting in this micro-catchment therefore seemed short-lived. The maximum values obtained were 17.75 (x1000) μscm-1 for Conductivity, 4500.0 mgl-1 for sodium and 7799.0 mgl-1 as Cl for chloride.

Slight increases in the concentrations of calcium and sulphate were observed but again, this effect was not as marked as in previous cases, as described above. The values for the Total Hardness also increased during the spring period to a maximum value of 720.0 mgl-1 as $CaCO_3$. The relationships between these three determinands were evident but were not as striking as those obtained for some of the other gully pot liquors under analysis.

The SS values showed a considerable degree of variation with the maximum value of 136 mgl-1 on the 850227 in the spring period. The

BOD and COD values fluctuated throughout the whole of the study period and again, no obvious seasonal variations could be detected.

The Ammonia and Nitrate concentrations were generally quite low for this particular gully pot liquor but the maxima reached were 7.4 mgl-1 as N for the ammonia concentration and 69.3 mgl-1 as N for the nitrate value.

Nickel and chromium were only detected during the spring period with maxima of 0.25 and 0.10 mgl-1, respectively. Copper and cadmium were found only once during the summer period with values of 0.05 mgl-1 on the 840613 and 0.03 mgl-1 on the 840711, respectively. Copper and cadmium were not detected during the autumn period but the maximum value for cadmium was found during the spring period when a value of 0.07 mgl-1 was measured on the 840227.

Table 7.34

Table of all the Water Quality Data collected over the Twenty-Two Week Period for the Gully Pot Standing Liquor in the Twyford 4 Gully Pot.

ROW	DATE	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
1	84Ø5Ø9	11.5	2.5	7.1	21Ø	2ØØ	Ø.81	*	53	16Ø
2	84Ø516	13.Ø	6.5	6.7	9Ø	5Ø	Ø.32	Ø	14	86
3	84Ø523	13.Ø	2.7	6.9	21Ø	24Ø	Ø.11	*	9	37
4	84Ø53Ø	14.5	5.6	6.6	*	*	Ø.1Ø	*	Ø	*
5	84Ø6Ø6	15.Ø	7.6	7.Ø	*	*	Ø.12	*	7	*
6	84Ø613	16.Ø	1.6	7.6	17Ø	18Ø	Ø.99	7	55	2Ø
7	84Ø62Ø	19.Ø	1.Ø	7.7	22Ø	34Ø	1.18	6	16	216
8	84Ø627	19.Ø	1.1	6.2	16Ø	12Ø	Ø.21	29	7	237
9	84Ø7Ø4	24.Ø	3.1	7.2	27Ø	28Ø	Ø.33	54	22	114
1Ø	84Ø711	23.Ø	2.5	7.4	28Ø	37Ø	Ø.42	11	4	1Ø7
11	84Ø718	19.5	2.1	6.7	11Ø	32Ø	Ø.17	62	11	38
12	84Ø725	17.Ø	Ø.8	7.Ø	19Ø	22Ø	Ø.33	33	2Ø	66
13	841Ø31	12.Ø	5.Ø	6.2	4Ø	5Ø	Ø.1Ø	28	16	7Ø
14	8411Ø7	1Ø.Ø	1.1	6.2	5Ø	6Ø	Ø.1Ø	38	11	2Ø
15	841114	1Ø.Ø	3.9	6.4	4Ø	4Ø	Ø.Ø6	24	45	Ø
16	841121	8.Ø	5.5	6.4	3Ø	11Ø	Ø.Ø5	19	31	Ø
17	841128	8.Ø	7.1	6.5	3Ø	8Ø	Ø.Ø5	55	1	Ø
18	85Ø22Ø	3.Ø	3.2	7.Ø	1ØØ	6ØØ	17.75	8	59	1Ø
19	85Ø227	4.Ø	Ø.6	7.3	1ØØ	53Ø	14.9Ø	136	21	128
2Ø	85Ø3Ø6	5.5	3.2	7.8	18Ø	41Ø	2.19	41	2	59
21	85Ø313	5.5	4.8	8.1	6Ø	27Ø	Ø.66	43	8	65
22	85Ø32Ø	5.Ø	5.9	7.6	14Ø	72Ø	2.16	1Ø	32	93

ROW	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb	Ca
1	4.Ø	56.7	2Ø2	Ø.5	*	9Ø.Ø	5.8Ø	Ø.5Ø	Ø.ØØ	72.Ø
2	1.6	6Ø.3	2Ø2	Ø.5	*	25.6	2.4Ø	Ø.2Ø	Ø.ØØ	3Ø.Ø
3	Ø.5	131.2	Ø	Ø.6	*	4.8	1.2Ø	Ø.2Ø	Ø.ØØ	12.6
4	*	*	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*	*	*
6	3.5	163.Ø	365	7.4	4.2	125.Ø	3.2Ø	Ø.2Ø	Ø.ØØ	61.Ø
7	Ø.6	277.Ø	365	4.2	2.5	15Ø.Ø	5.ØØ	3.ØØ	Ø.2Ø	8Ø.Ø
8	1.Ø	35.Ø	*	3.4	5.3	17.5	7.5Ø	2.ØØ	Ø.15	Ø.Ø
9	Ø.9	124.Ø	413	Ø.3	18.2	21.Ø	12.ØØ	2.ØØ	Ø.ØØ	7Ø.Ø
1Ø	1.6	316.Ø	Ø	1.8	35.Ø	5.8	7.5Ø	Ø.6Ø	Ø.35	141.5
11	2.9	35.Ø	7Ø2	Ø.6	1.4	16.5	1.85	Ø.3Ø	Ø.54	2ØØ.Ø
12	1.1	85.Ø	365	1.4	1Ø.5	6.8	1.7Ø	Ø.ØØ	Ø.ØØ	28.5
13	1.4	31.9	Ø	Ø.5	3.2	3.Ø	Ø.9Ø	Ø.4Ø	Ø.ØØ	1Ø.Ø
14	Ø.7	1Ø.6	29	Ø.2	1.5	2.Ø	1.1Ø	Ø.ØØ	Ø.ØØ	11.1
15	1.3	17.7	48	Ø.1	2.Ø	1.9	Ø.6Ø	Ø.ØØ	Ø.ØØ	9.5
16	Ø.4	5.3	96	Ø.1	Ø.9	3.8	Ø.7Ø	Ø.ØØ	Ø.ØØ	7.Ø
17	Ø.4	17.7	58	Ø.6	Ø.7	3.6	Ø.8Ø	Ø.ØØ	Ø.ØØ	5.3
18	4.6	7799.Ø	346	3.2	*	45ØØ.Ø	7.8Ø	Ø.35	Ø.15	158.Ø
19	1.6	6736.Ø	1162	9.1	*	181Ø.Ø	21.ØØ	Ø.92	Ø.23	146.Ø
2Ø	Ø.4	39.Ø	673	Ø.4	25.6	15ØØ.Ø	4.5Ø	Ø.16	Ø.ØØ	76.Ø
21	Ø.4	173.7	625	Ø.4	6.3	118.Ø	2.2Ø	Ø.1Ø	Ø.ØØ	29.6
22	4.2	319.Ø	8Ø7	9.Ø	69.3	28Ø.Ø	3.28	Ø.33	Ø.Ø8	6Ø.5

ROW	Mg	Zn	Mn	Cu	Cd	Ni	Cr
1	Ø.ØØ	Ø.19	Ø.44	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
2	Ø.ØØ	Ø.25	Ø.13	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
3	Ø.ØØ	Ø.Ø7	Ø.1Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
4	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*
6	12Ø.ØØ	Ø.19	Ø.4Ø	Ø.Ø5	Ø.ØØ	Ø.ØØ	Ø.Ø
7	12.ØØ	Ø.2Ø	Ø.3Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
8	2.ØØ	Ø.Ø7	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
9	3.ØØ	Ø.2Ø	Ø.15	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
1Ø	6.25	Ø.2Ø	Ø.65	Ø.ØØ	Ø.Ø3	Ø.ØØ	Ø.Ø
11	65.ØØ	Ø.16	Ø.13	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
12	2.6Ø	Ø.13	Ø.38	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
13	1.ØØ	Ø.Ø4	Ø.12	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
14	1.1Ø	Ø.Ø6	Ø.1Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
15	Ø.8Ø	Ø.Ø5	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
16	Ø.6Ø	Ø.17	Ø.Ø2	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
17	Ø.6Ø	Ø.Ø6	Ø.1Ø	Ø.ØØ	Ø.ØØ	Ø.ØØ	Ø.Ø
18	8.8Ø	Ø.11	1.ØØ	Ø.ØØ	Ø.Ø3	Ø.22	Ø.Ø
19	6.5Ø	Ø.Ø9	Ø.74	Ø.ØØ	Ø.Ø7	Ø.22	Ø.1
2Ø	6.ØØ	Ø.15	Ø.1Ø	Ø.Ø3	Ø.ØØ	Ø.11	Ø.Ø
21	2.1Ø	Ø.11	Ø.1Ø	Ø.Ø2	Ø.ØØ	Ø.25	Ø.Ø
22	6.1Ø	Ø.14	Ø.18	Ø.Ø2	Ø.Ø3	Ø.ØØ	Ø.Ø

Statistical Summary of the Water Quality Data for the Standing Pot Liquor collected in the Twyford 4 Gully Pot.

Table 7.35

	TEMP	DO	PH	ALK	TH	COND	SS	BOD
N	22	22	22	2Ø	2Ø	22	18	22
NMISS	Ø	Ø	Ø	2	2	Ø	4	Ø
MEAN	12.52	3.52	6.982	134.Ø	26Ø	1.96	33.6	2Ø.2
MEDIAN	12.5Ø	3.15	7.ØØØ	125.Ø	23Ø	Ø.32	28.5	15.Ø
TMEAN	12.42	3.46	6.965	131.7	246	1.27	29.3	19.2
STDEV	6.13	2.17	Ø.56Ø	8Ø.4	193	4.71	31.6	18.1
SEMEAN	1.31	Ø.46	Ø.119	18.Ø	43	1.ØØ	7.5	3.9
MAX	24.ØØ	7.6Ø	8.1ØØ	28Ø.Ø	72Ø	17.75	136.Ø	59.Ø
MIN	3.ØØ	Ø.6Ø	6.2ØØ	3Ø.Ø	4Ø	Ø.Ø5	Ø.Ø	Ø.Ø
Q3	17.5Ø	5.53	7.45Ø	2Ø5.Ø	363	1.Ø4	45.7	31.3
Q1	7.37	1.47	6.475	52.5	88	Ø.1Ø	9.5	7.Ø

	COD	PHOS	CL	SUL	AMM	NIT	Na	K
N	2Ø	2Ø	2Ø	19	2Ø	15	2Ø	2Ø
NMISS	2	2	2	3	2	7	2	2
MEAN	76.3	1.66	822	34Ø	2.22	12.4	434	4.55
MEDIAN	65.5	1.2Ø	73	346	Ø.6Ø	4.2	19	2.8Ø
TMEAN	71.6	1.56	479	312	1.95	9.Ø	232	3.86
STDEV	68.6	1.39	2213	327	2.97	18.7	1Ø8Ø	4.95
SEMEAN	15.4	Ø.31	495	75	Ø.66	4.8	241	1.11
MAX	237.Ø	4.6Ø	7799	1162	9.1Ø	69.3	45ØØ	21.ØØ
MIN	Ø.Ø	Ø.4Ø	5	Ø	Ø.1Ø	Ø.7	2	Ø.6Ø
Q3	112.2	2.58	251	625	3.35	18.2	144	7.Ø7
Q1	2Ø.Ø	Ø.52	33	48	Ø.4Ø	1.5	4	1.13

	Fe	Pb	Ca	Mg	Zn	Mn	Cu	Cd
N	2Ø	2Ø	2Ø	2Ø	2Ø	2Ø	2Ø	2Ø
NMISS	2	2	2	2	2	2	2	2
MEAN	Ø.563	Ø.Ø85	6Ø.4	12.2	Ø.132Ø	Ø.257	Ø.ØØ6Ø	Ø.ØØ8Ø
MEDIAN	Ø.25Ø	Ø.ØØØ	45.3	2.3	Ø.135Ø	Ø.13Ø	Ø.ØØØØ	Ø.ØØØØ
TMEAN	Ø.459	Ø.Ø64	56.Ø	6.9	Ø.13Ø6	Ø.23Ø	Ø.ØØ39	Ø.ØØ5Ø
STDEV	Ø.819	Ø.148	59.Ø	29.1	Ø.Ø62Ø	Ø.271	Ø.Ø135	Ø.Ø182
SEMEAN	Ø.183	Ø.Ø33	13.2	6.5	Ø.Ø139	Ø.Ø6Ø	Ø.ØØ3Ø	Ø.ØØ41
MAX	3.ØØØ	Ø.54Ø	2ØØ.Ø	12Ø.Ø	Ø.25ØØ	1.ØØØ	Ø.Ø5ØØ	Ø.Ø7ØØ
MIN	Ø.ØØØ	Ø.ØØØ	Ø.Ø	Ø.Ø	Ø.ØØ4ØØ	Ø.ØØØ	Ø.ØØØØ	Ø.ØØØØ
Q3	Ø.575	Ø.15Ø	79.Ø	6.4	Ø.19ØØ	Ø.395	Ø.ØØØØ	Ø.ØØØØ
Q1	Ø.Ø25	Ø.ØØØ	1Ø.3	Ø.6	Ø.Ø7ØØ	Ø.1ØØ	Ø.ØØØØ	Ø.ØØØØ

	Ni	Cr
N	2Ø	2Ø
NMISS	2	2
MEAN	Ø.Ø4ØØ	Ø.ØØ5Ø
MEDIAN	Ø.ØØØØ	Ø.ØØØØ
TMEAN	Ø.Ø3Ø6	Ø.ØØØØ
STDEV	Ø.Ø857	Ø.Ø224
SEMEAN	Ø.Ø192	Ø.ØØ5Ø
MAX	Ø.25ØØ	Ø.1ØØØ
MIN	Ø.ØØØØ	Ø.ØØØØ
Q3	Ø.ØØØØ	Ø.ØØØØ
Q1	Ø.ØØØØ	Ø.ØØØØ

Table of the Correlation Coefficients between all Twenty-Six Water Quality Parameters for the Standing Pot Liquor in the Twyford 4 Gully Pot.

Table 7.36

	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
DO	-0.277								
PH	-0.093	-0.139							
ALK	0.631	-0.484	0.483						
TH	-0.279	-0.143	0.626	0.334					
COND	-0.511	-0.233	0.183	-0.101	0.624				
SS	-0.195	-0.269	0.000	-0.138	0.158	0.352			
BOD	-0.245	-0.184	0.083	-0.034	0.167	0.400	-0.285		
COD	0.405	-0.401	0.204	0.535	0.159	-0.033	0.052	-0.178	
PHOS	-0.148	-0.036	0.156	0.109	0.494	0.424	-0.230	0.728	-0.018
CL	-0.461	-0.211	0.113	-0.119	0.571	0.993	0.374	0.367	-0.042
SUL	-0.286	-0.235	0.586	0.072	0.699	0.472	0.584	-0.001	0.299
AMM	-0.188	-0.253	0.396	0.138	0.623	0.480	0.176	0.300	0.282
NIT	-0.137	0.227	0.459	0.414	0.863	0.690	-0.307	0.020	0.174
Na	-0.517	-0.107	0.184	-0.077	0.597	0.919	0.112	0.382	-0.145
K	0.014	-0.424	0.283	0.349	0.502	0.647	0.620	0.075	0.476
Fe	0.511	-0.404	0.169	0.508	0.152	0.033	0.021	-0.121	0.815
Pb	0.339	-0.355	0.070	0.208	0.400	0.227	0.232	-0.183	0.236
Ca	0.097	-0.343	0.374	0.316	0.663	0.556	0.284	0.152	0.087
Mg	0.247	-0.272	0.225	0.103	0.032	-0.035	-0.086	0.328	-0.197
Zn	0.399	0.007	0.462	0.526	0.173	-0.128	-0.345	0.147	0.261
Mn	-0.127	-0.354	0.327	0.281	0.583	0.795	0.119	0.434	0.076
Cu	-0.183	0.009	0.588	0.008	0.201	-0.068	-0.182	0.212	-0.183
Cd	-0.342	-0.178	0.253	0.042	0.692	0.769	0.490	0.131	0.128
Ni	-0.606	-0.055	0.453	-0.217	0.489	0.735	0.418	0.079	-0.071
Cr	-0.305	-0.307	0.121	-0.100	0.330	0.611	0.800	-0.011	0.177

	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
CL	0.392								
SUL	0.242	0.422							
AMM	0.468	0.450	0.621						
NIT	0.519	0.658	0.455	0.550					
Na	0.424	0.890	0.333	0.271	0.321				
K	0.138	0.653	0.588	0.514	0.317	0.431			
Fe	-0.136	0.037	0.183	0.239	-0.030	-0.041	0.474		
Pb	0.250	0.248	0.348	0.220	0.081	0.138	0.300	0.263	
Ca	0.513	0.546	0.535	0.312	0.258	0.511	0.515	0.142	0.804
Mg	0.406	-0.047	0.197	0.369	-0.151	-0.043	-0.068	-0.078	0.276
Zn	0.235	-0.154	0.135	0.063	0.297	-0.096	0.127	0.246	0.178
Mn	0.555	0.800	0.255	0.444	0.308	0.715	0.583	0.058	0.337
Cu	0.225	-0.140	0.323	0.399	0.250	0.026	-0.111	-0.210	-0.227
Cd	0.330	0.773	0.560	0.683	0.861	0.537	0.757	0.045	0.389
Ni	0.081	0.718	0.563	0.223	-0.005	0.703	0.464	-0.096	0.065
Cr	-0.009	0.629	0.608	0.546	0.000	0.300	0.782	0.103	0.231

	Ca	Mg	Zn	Mn	Cu	Cd	Ni
Mg	0.336						
Zn	0.357	0.277					
Mn	0.674	0.124	0.184				
Cu	-0.000	0.653	0.198	-0.032			
Cd	0.556	-0.086	-0.061	0.700	-0.077		
Ni	0.357	-0.111	-0.174	0.484	0.159	0.526	
Cr	0.342	-0.046	-0.159	0.420	-0.104	0.800	0.495

Graphs of Gully Pot Liquor Quality for Twyford 4 Gully Pot.

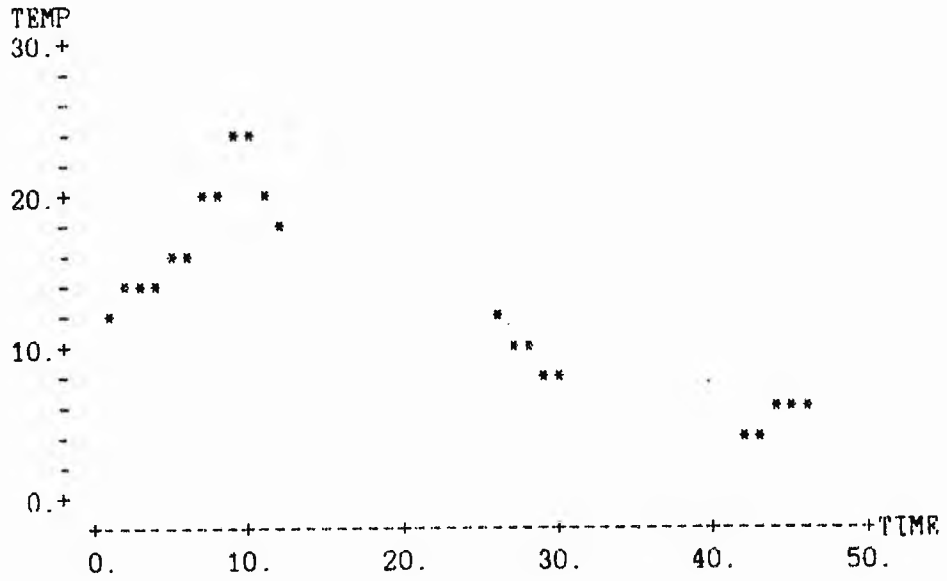


Figure 7.296

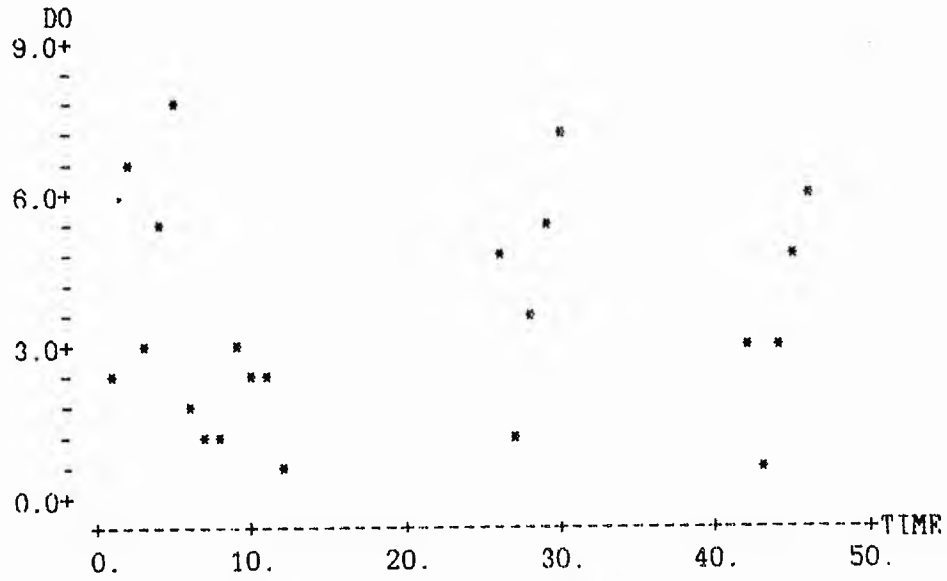


Figure 7.297

Graphs of Gully Pot Liquor Quality for Twyford 4 Gully Pot.

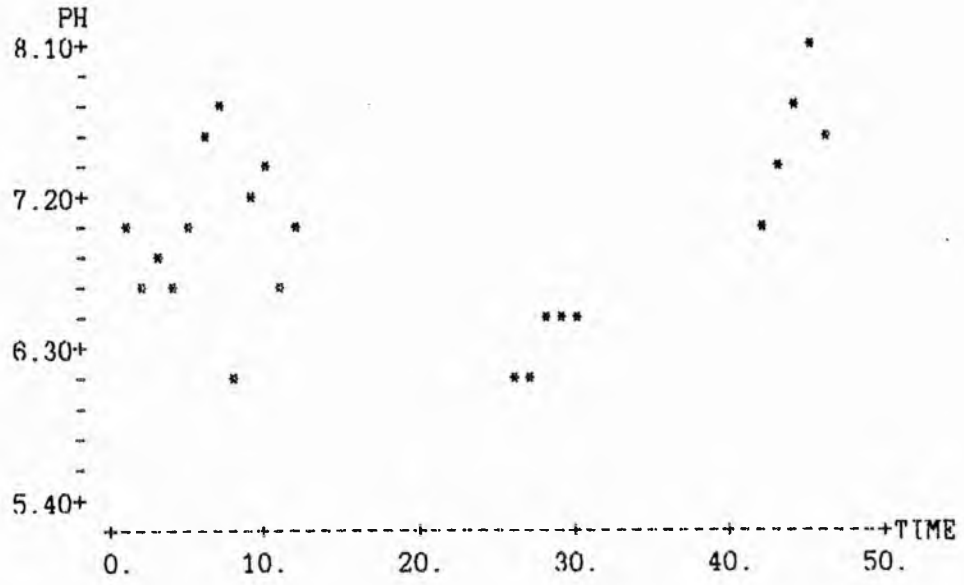
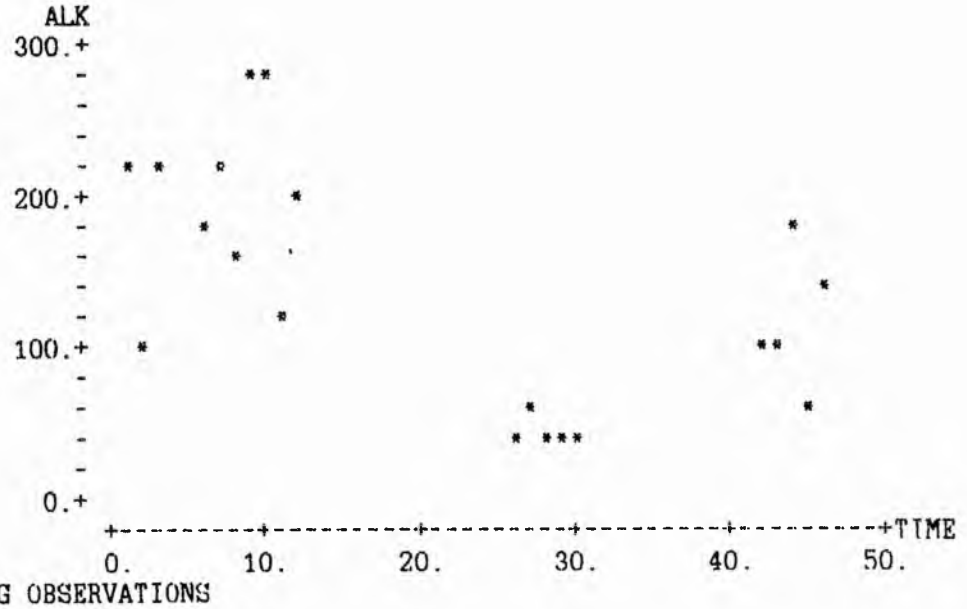


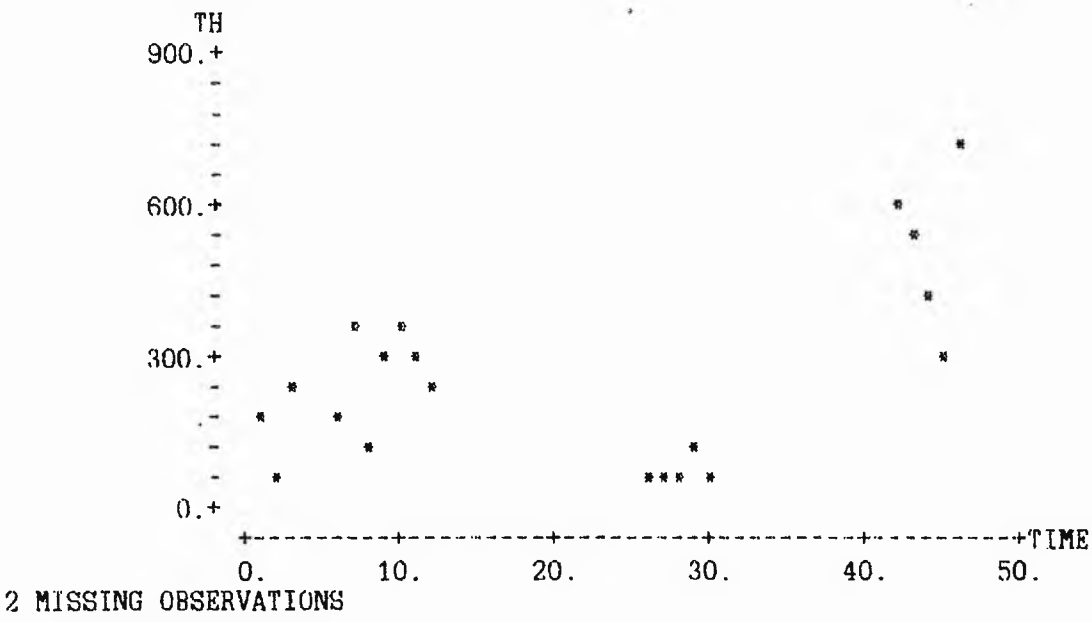
Figure 7.298



2 MISSING OBSERVATIONS

Figure 7.299

Graphs of Gully Pot Liquor Quality for Twyford 4 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.300

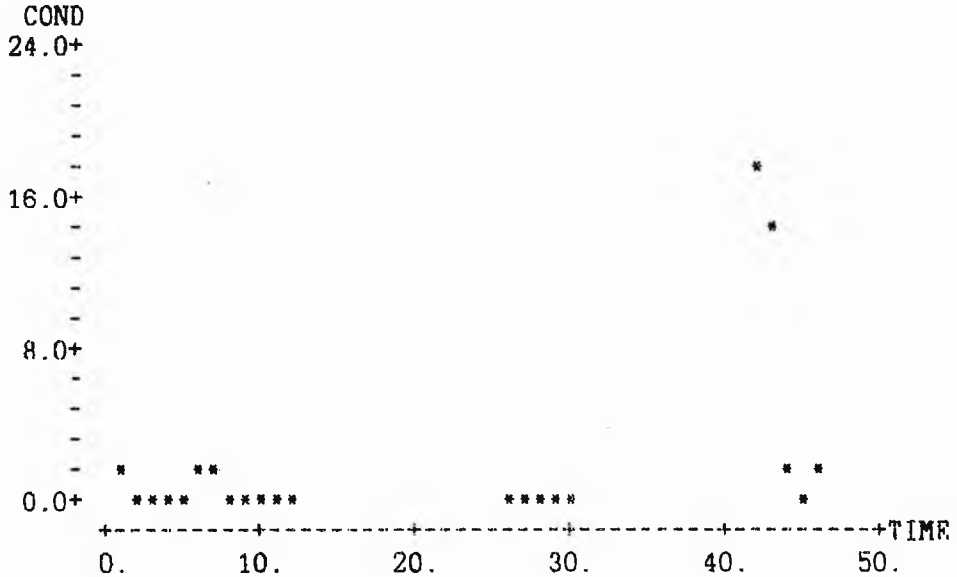
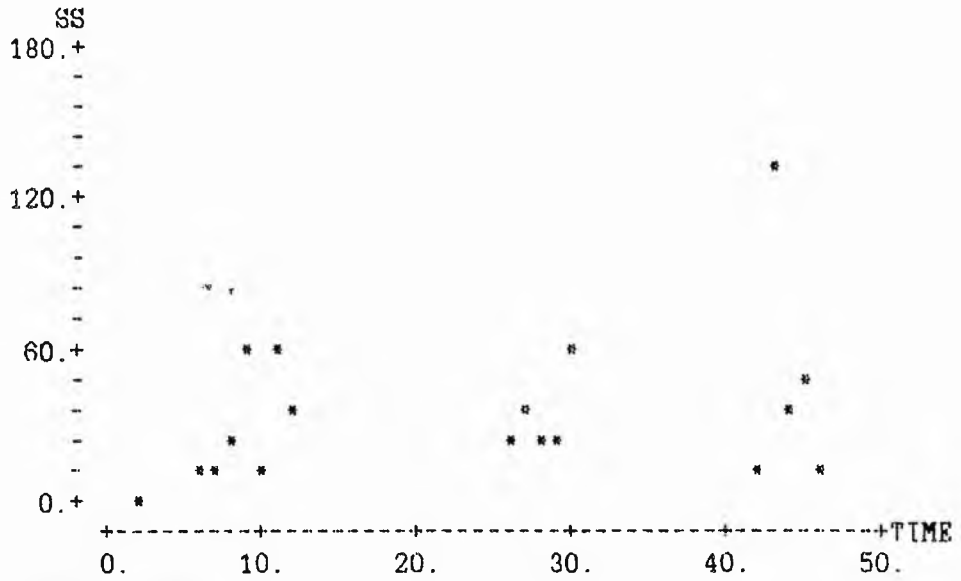


Figure 7.301

Graphs of Gully Pot Liquor Quality for Twyford 4 Gully Pot.



4 MISSING OBSERVATIONS

Figure 7.302

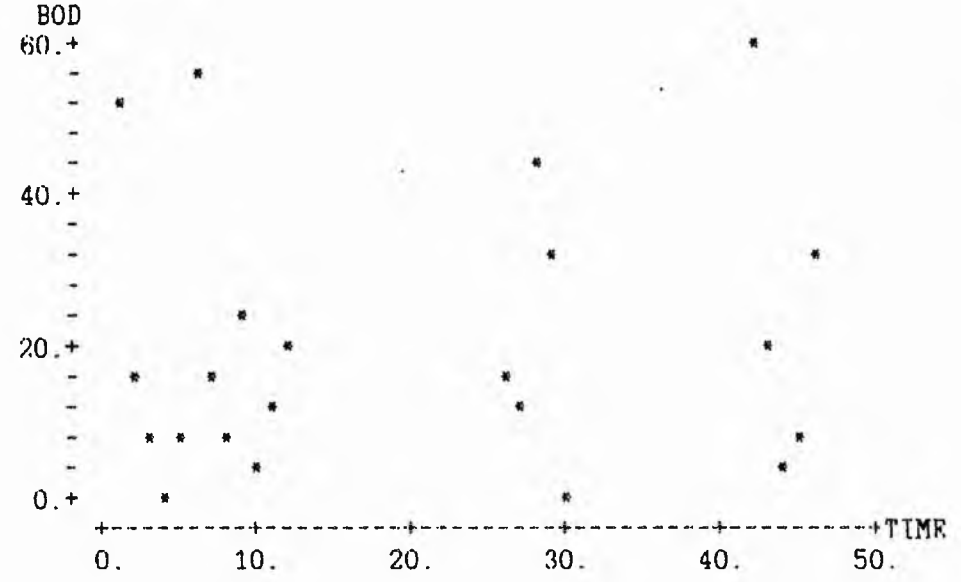
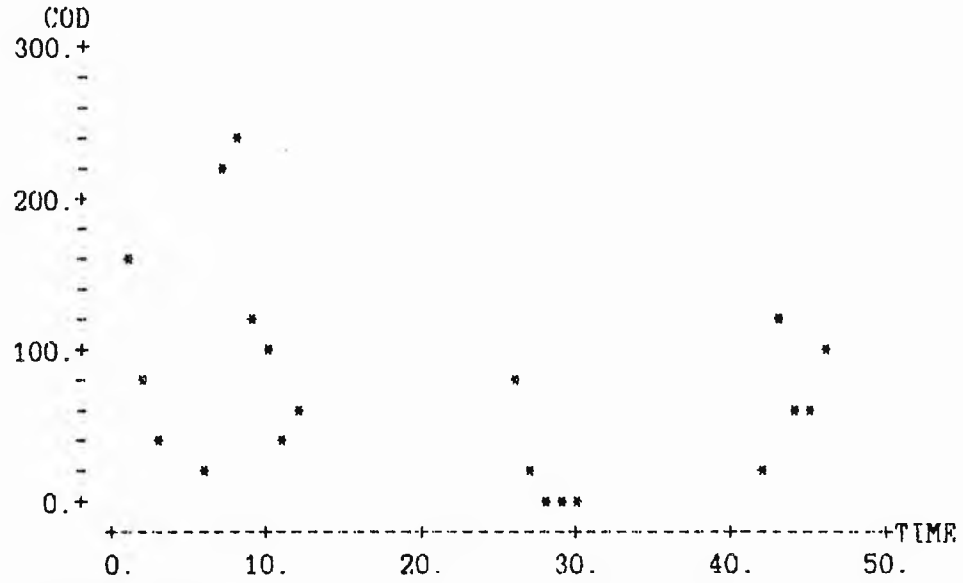


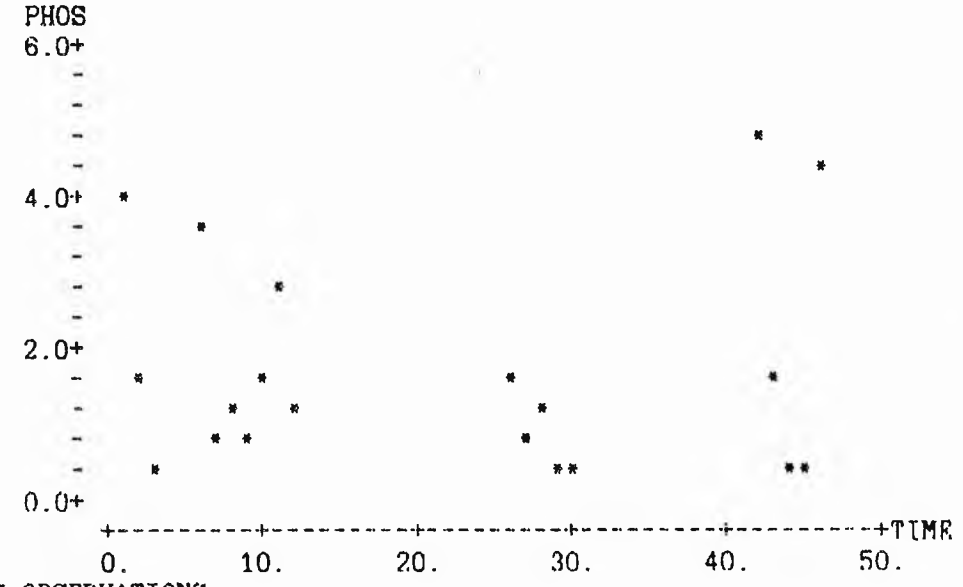
Figure 7.303

Graphs of Gully Pot Liquor Quality for Twyford 4 Gully Pot.



2 MISSING OBSERVATIONS

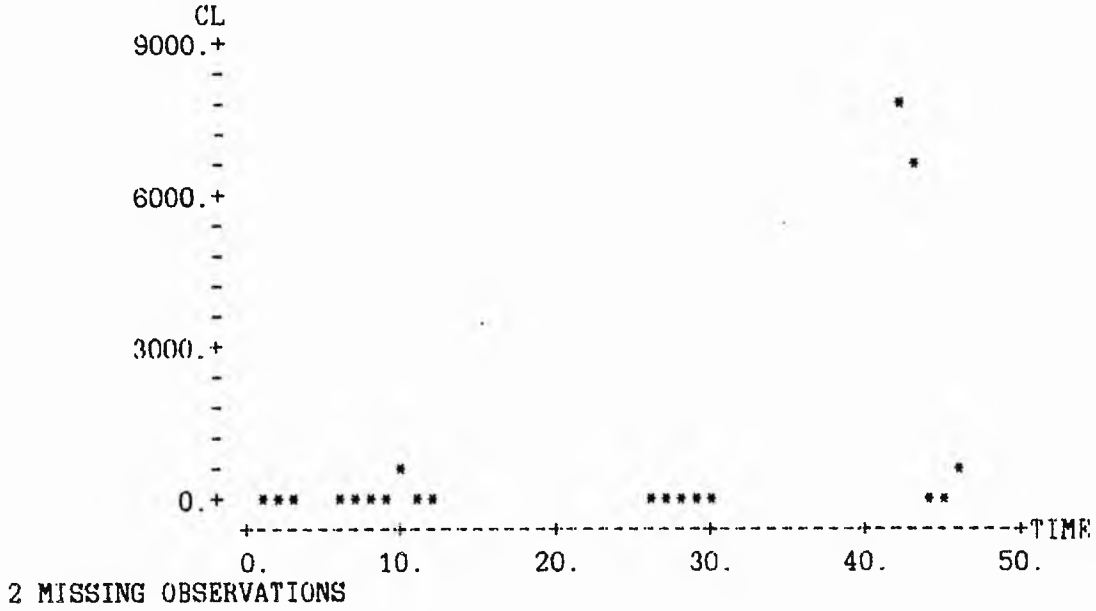
Figure 7.304



2 MISSING OBSERVATIONS

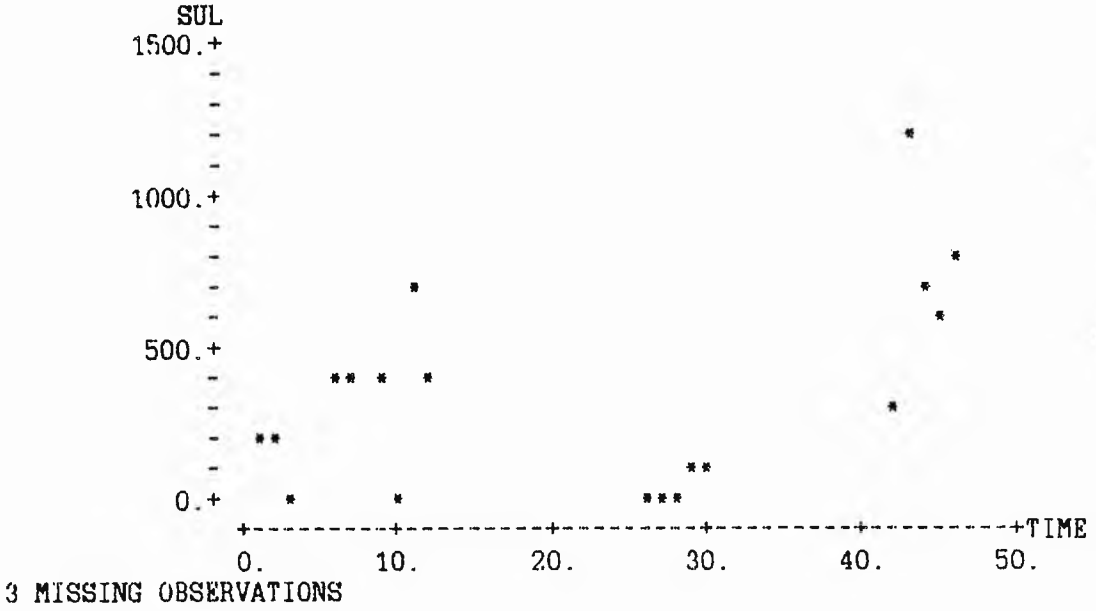
Figure 7.305

Graphs of Gully Pot Liquor Quality for Twyford 4 Gully Pot.



2 MISSING OBSERVATIONS

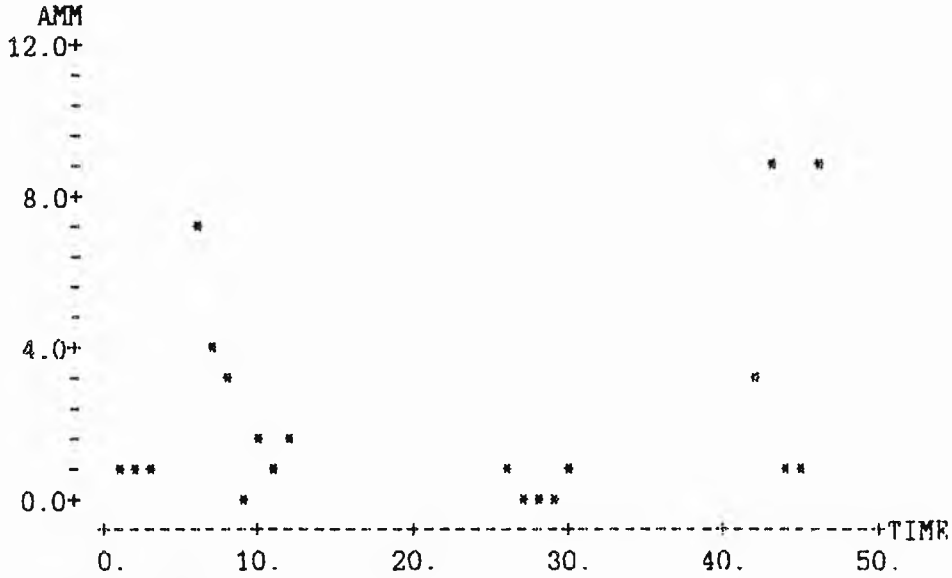
Figure 7.306



3 MISSING OBSERVATIONS

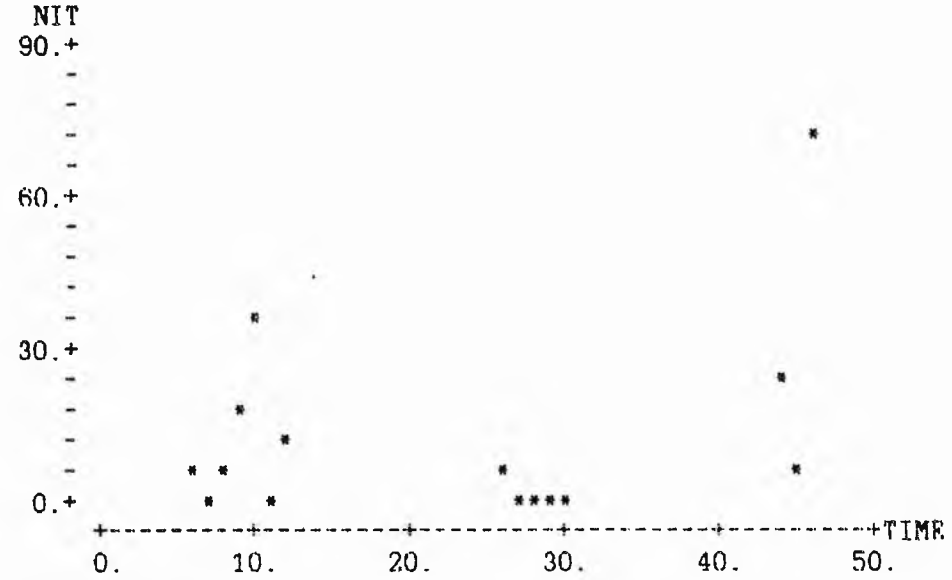
Figure 7.307

Graphs of Gully Pot Liquor Quality for Twyford 4 Gully Pot.



2 MISSING OBSERVATIONS

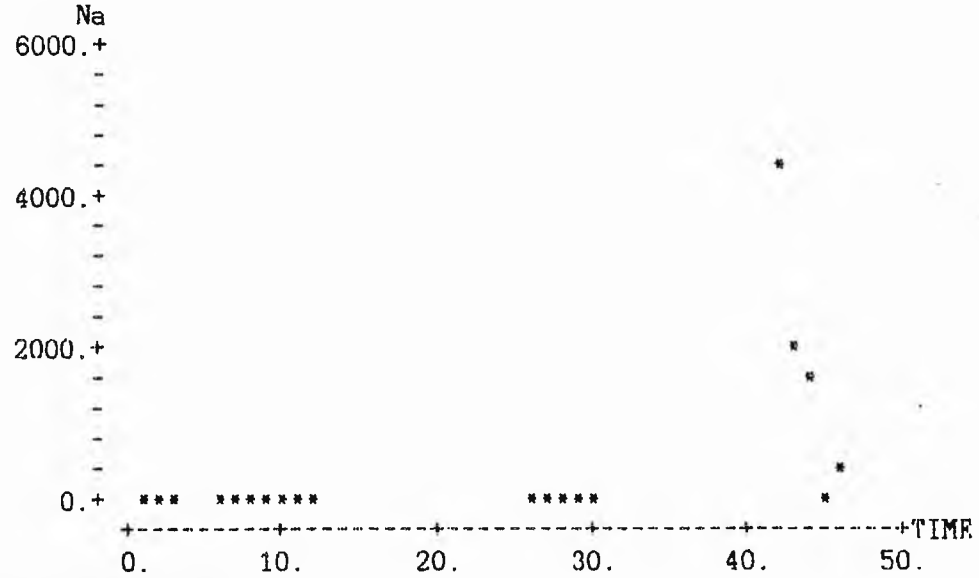
Figure 7.308



7 MISSING OBSERVATIONS

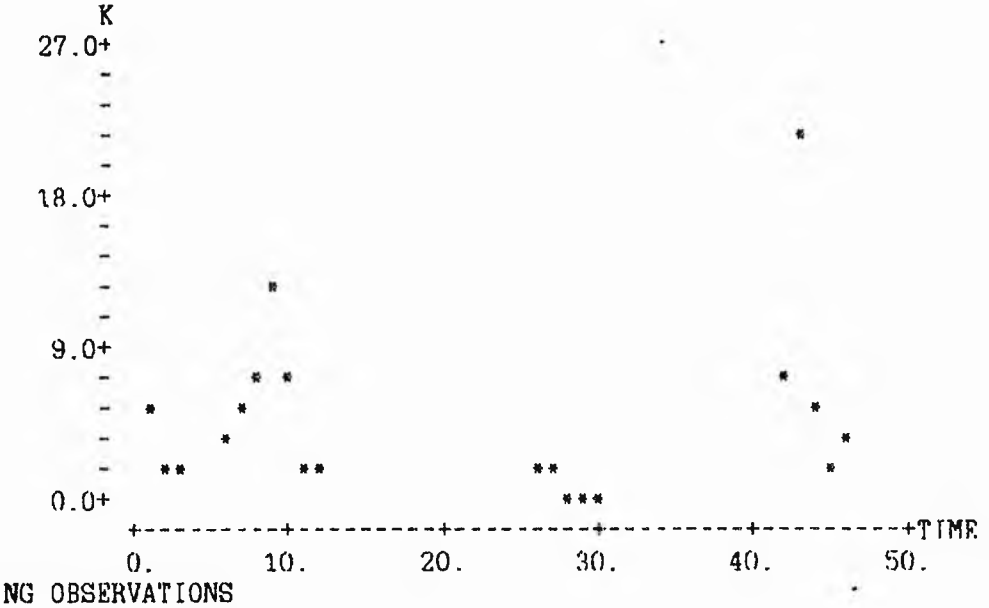
Figure 7.309

Graphs of Gully Pot Liquor Quality for Twyford 4 Gully Pot.



2 MISSING OBSERVATIONS

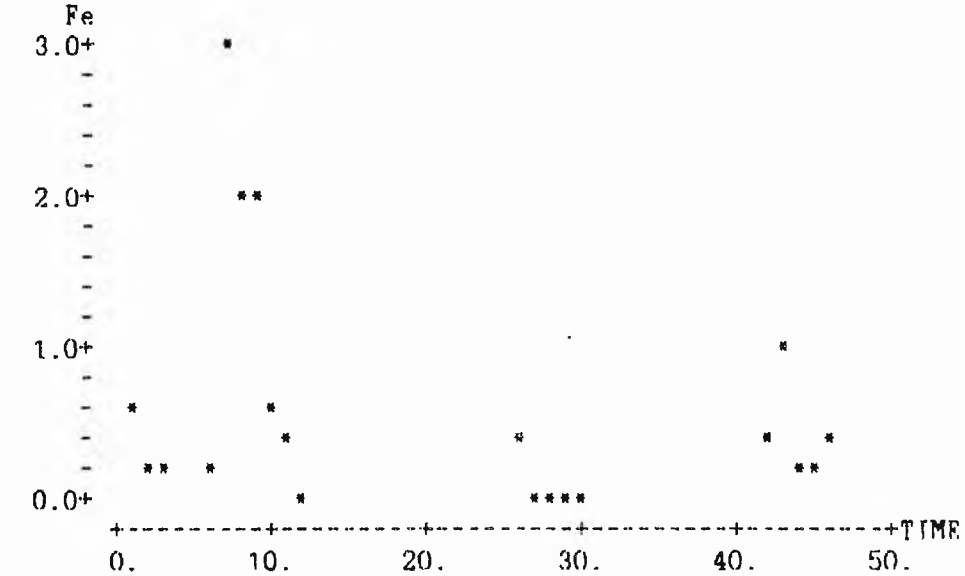
Figure 7.310



2 MISSING OBSERVATIONS

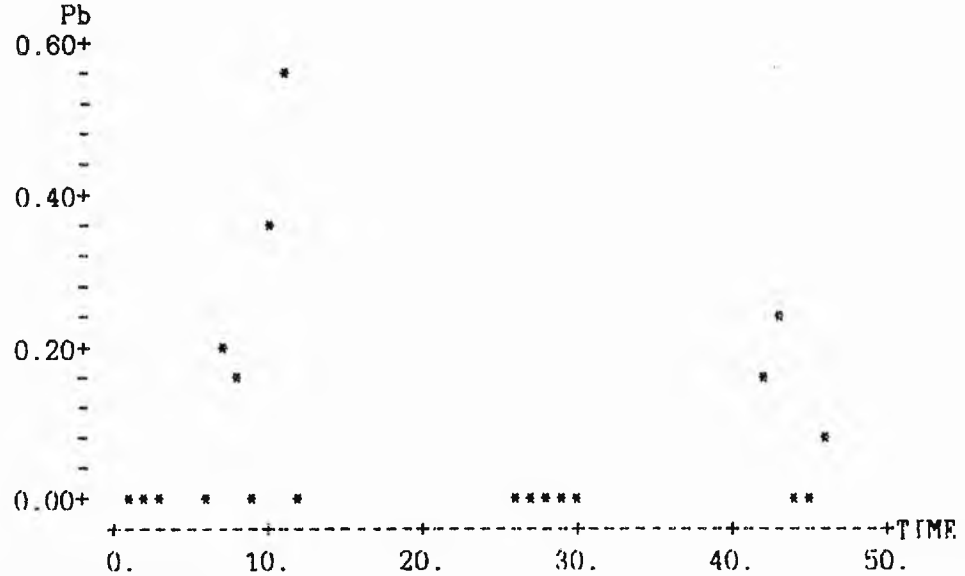
Figure 7.311

Graphs of Gully Pot Liquor Quality for Twyford 4 Gully Pot.



2 MISSING OBSERVATIONS

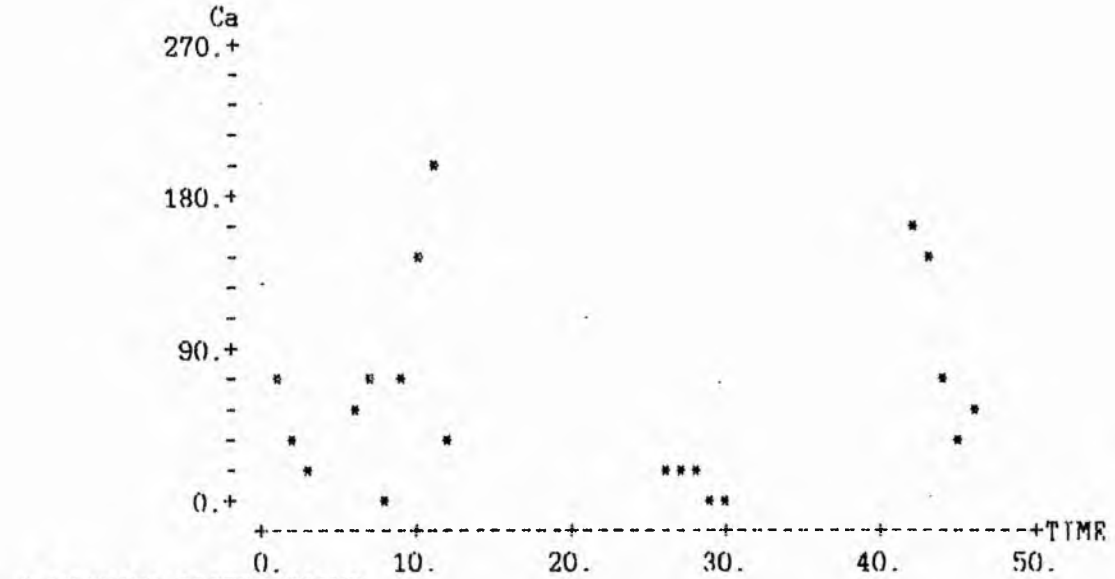
Figure 7.312



2 MISSING OBSERVATIONS

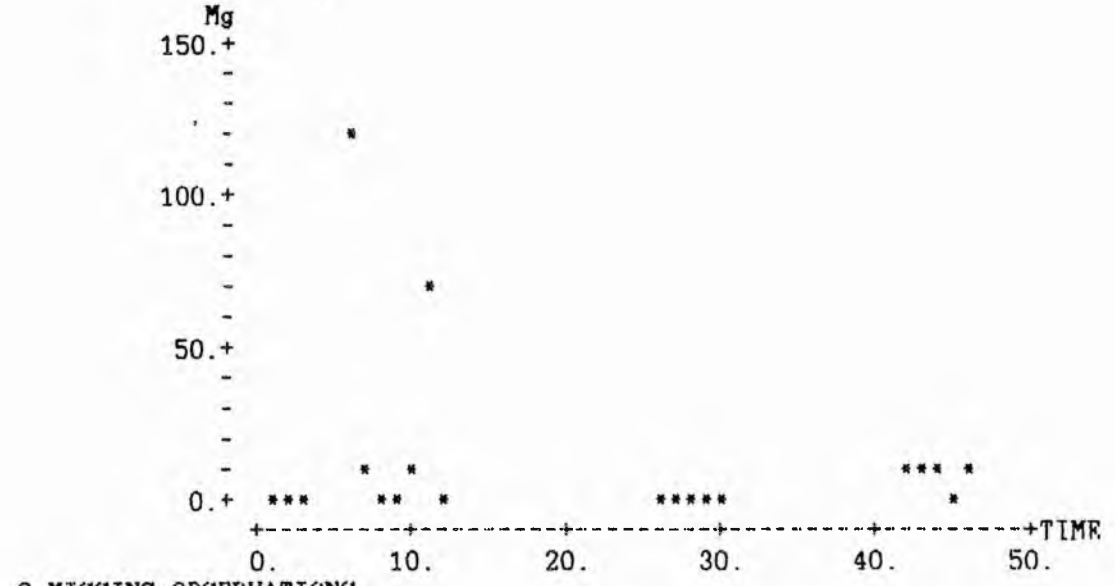
Figure 7.313

Graphs of Gully Pot Liquor Quality for Twyford 4 Gully Pot.



2 MISSING OBSERVATIONS

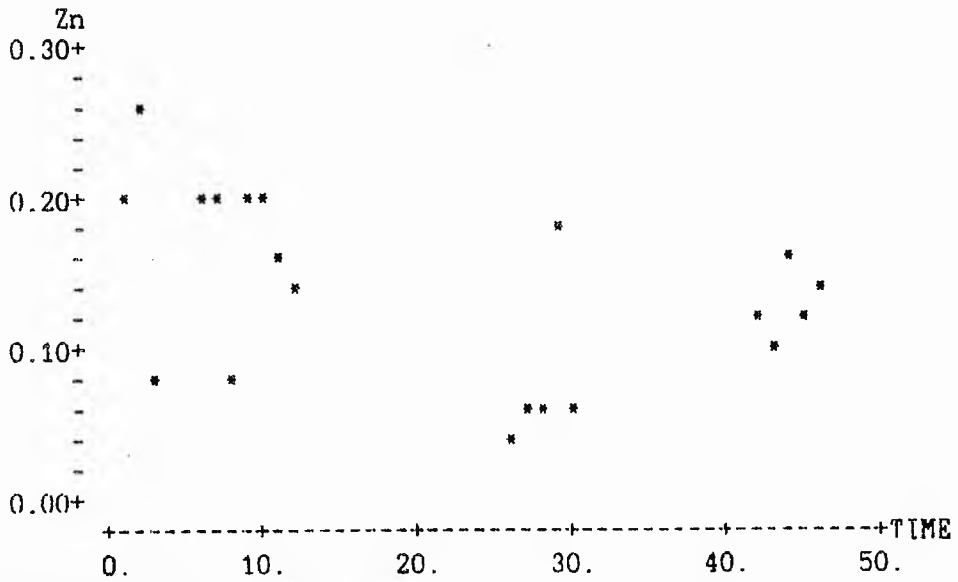
Figure 7.314



2 MISSING OBSERVATIONS

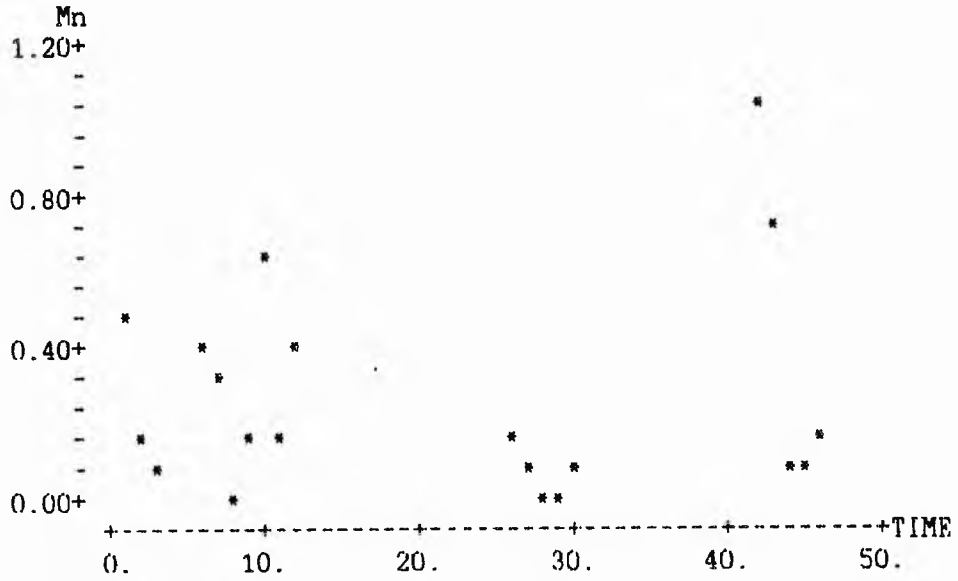
Figure 7.315

Graphs of Gully Pot Liquor Quality for Twyford 4 Gully Pot.



2 MISSING OBSERVATIONS

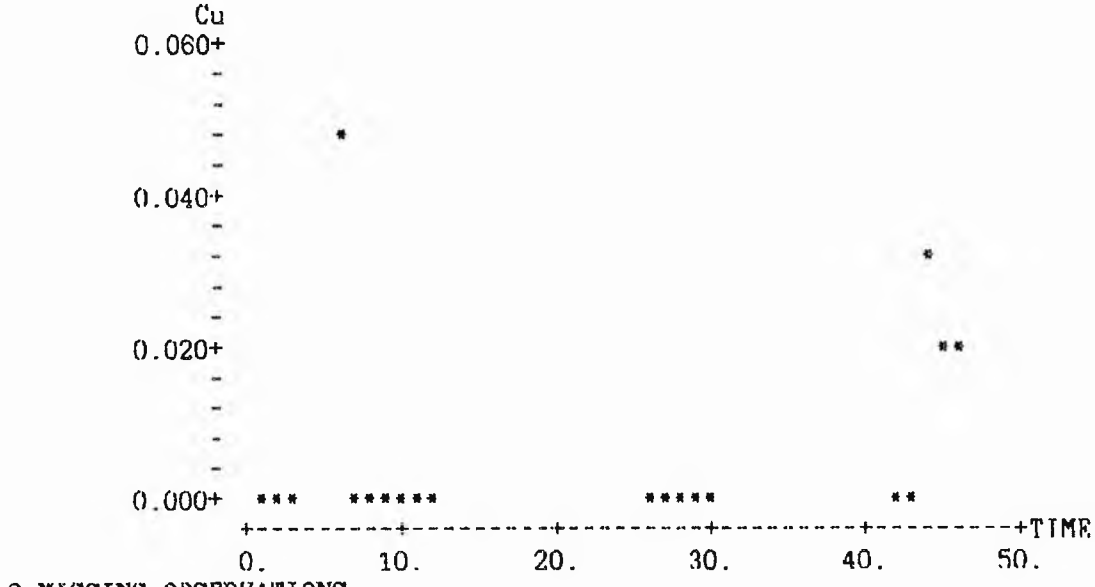
Figure 7.316



2 MISSING OBSERVATIONS

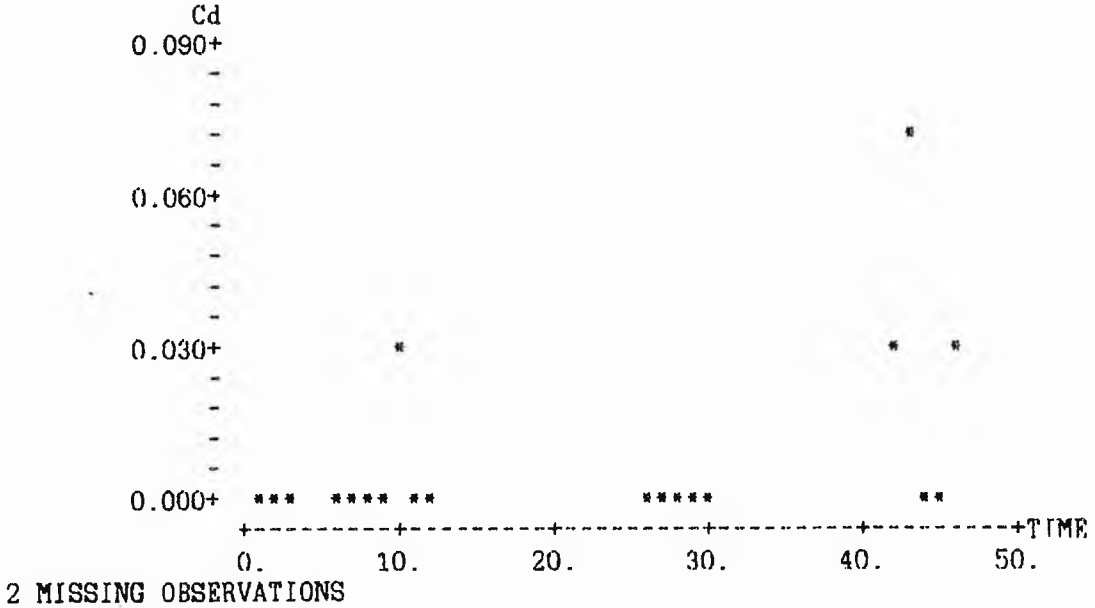
Figure 7.317

Graphs of Gully Pot Liquor Quality for Twyford 4 Gully Pot.



2 MISSING OBSERVATIONS

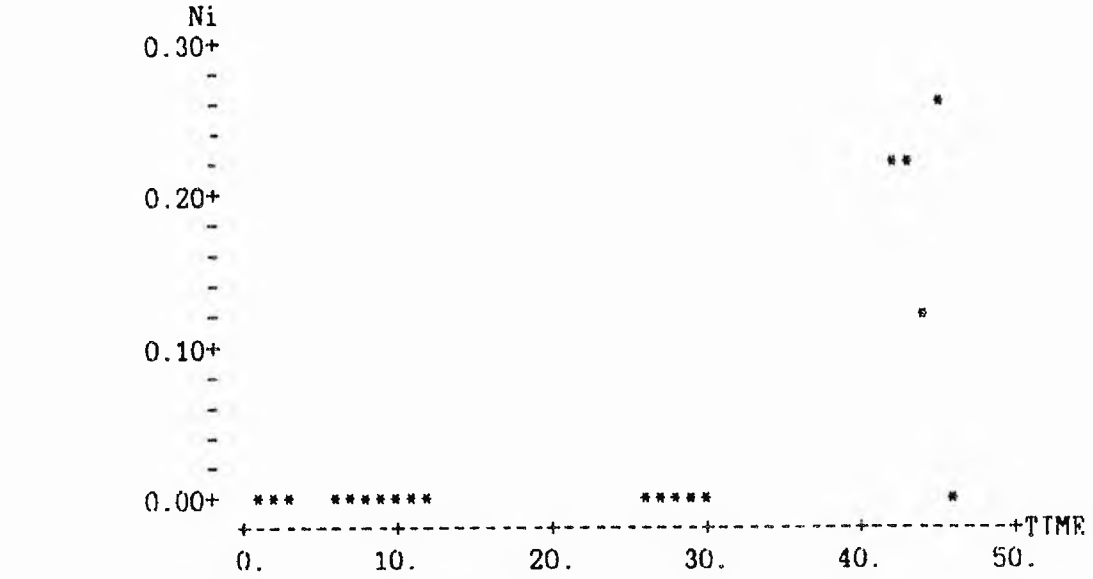
Figure 7.318



2 MISSING OBSERVATIONS

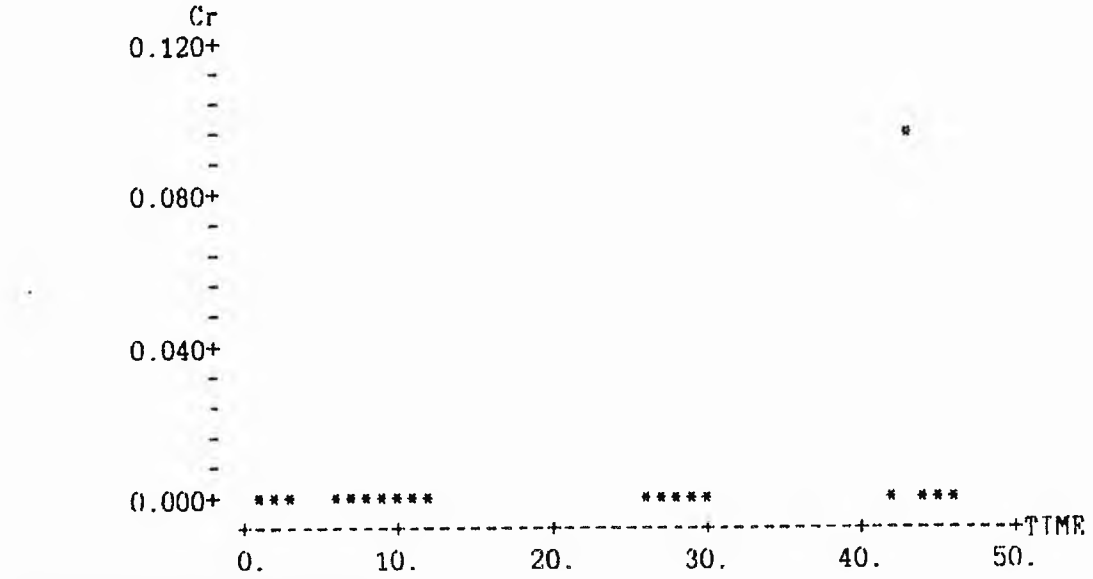
Figure 7.319

Graphs of Gully Pot Liquor Quality for Twyford 4 Gully Pot.



2 MISSING OBSERVATIONS

Figure 7.320



2 MISSING OBSERVATIONS

Figure 7.321

Statistical Summary of the Water Quality Data for the Standing Pot Liquor collected in the Four Gully Pots on the Tame Sub-catchment.

Table 7.37

	TEMP	DO	PH	ALK	TH	COND	SS	BOD
N	88	88	88	8Ø	8Ø	88	72	88
NMISS	Ø	Ø	Ø	8	8	Ø	16	Ø
MEAN	12.84	3.32	7.ØØ4	158	313	5.7	11Ø	22.3
MEDIAN	12.75	3.2Ø	6.9ØØ	13Ø	24Ø	Ø.2	52	16.5
TMEAN	12.77	3.23	6.962	149	284	2.3	92	21.5
STDEV	6.17	2.Ø1	Ø.9Ø3	1Ø6	271	17.7	134	17.6
SEMEAN	Ø.66	Ø.21	Ø.ØØ96	12	3Ø	1.9	16	1.9
MAX	25.ØØ	8.5Ø	1Ø.7ØØ	5ØØ	122Ø	93.3	61Ø	62.Ø
MIN	2.ØØ	Ø.6Ø	5.7ØØ	2Ø	4Ø	Ø.Ø	Ø	Ø.Ø
Q3	17.5Ø	4.82	7.4ØØ	22Ø	4Ø5	Ø.9	143	34.5
Q1	8.ØØ	1.48	6.5ØØ	8Ø	113	Ø.1	28	8.Ø

	COD	PHOS	CL	SUL	AMM	NIT	Na	K
N	77	8Ø	8Ø	76	8Ø	6Ø	8Ø	8Ø
NMISS	11	8	8	12	8	28	8	8
MEAN	173	2.54	1922	399	3.Ø2	2Ø.3	2236	5.46
MEDIAN	93	1.8Ø	39	283	1.ØØ	4.1	1Ø	3.ØØ
TMEAN	139	2.29	476	343	2.38	13.1	138Ø	4.25
STDEV	231	2.5Ø	7344	431	4.58	42.7	5432	7.8Ø
SEMEAN	26	Ø.28	821	49	Ø.51	5.5	6Ø7	Ø.87
MAX	976	13.ØØ	42894	2268	23.8Ø	266.Ø	225ØØ	45.ØØ
MIN	Ø	Ø.ØØ	7	Ø	Ø.ØØ	Ø.1	1	Ø.3Ø
Q3	168	3.8Ø	231	519	4.Ø2	15.6	451	6.28
Q1	41	Ø.75	21	99	Ø.2Ø	1.5	4	Ø.8Ø

	Fe	Pb	Ca	Mg	Zn	Mn	Cu	Cd
N	8Ø	8Ø	8Ø	8Ø	8Ø	8Ø	8Ø	8Ø
NMISS	8	8	8	8	8	8	8	8
MEAN	1.59	Ø.ØØ9	71.9	6.8	Ø.191	Ø.197	Ø.Ø165	Ø.Ø77
MEDIAN	Ø.36	Ø.ØØØ	45.Ø	2.2	Ø.16Ø	Ø.14Ø	Ø.ØØØØ	Ø.ØØØ
TMEAN	Ø.72	Ø.Ø66	56.8	3.9	Ø.175	Ø.173	Ø.ØØ62	Ø.Ø26
STDEV	5.78	Ø.17Ø	92.2	17.4	Ø.147	Ø.211	Ø.Ø52Ø	Ø.276
SEMEAN	Ø.65	Ø.Ø19	1Ø.3	1.9	Ø.Ø16	Ø.Ø24	Ø.ØØ58	Ø.Ø31
MAX	5Ø.ØØ	Ø.68Ø	46Ø.Ø	13Ø.Ø	Ø.84Ø	1.ØØØ	Ø.23ØØ	2.ØØØ
MIN	Ø.ØØ	Ø.ØØØ	6.8	Ø.Ø	Ø.Ø2Ø	Ø.ØØØ	Ø.ØØØØ	Ø.ØØØ
Q3	1.ØØ	Ø.1Ø7	95.Ø	4.7	Ø.245	Ø.268	Ø.ØØØØ	Ø.Ø28
Q1	Ø.Ø2	Ø.ØØØ	15.3	Ø.6	Ø.ØØØ	Ø.Ø6Ø	Ø.ØØØØ	Ø.ØØØ

	Ni	Cr
N	8Ø	8Ø
NMISS	8	8
MEAN	Ø.119	Ø.Ø212
MEDIAN	Ø.ØØØ	Ø.ØØØØ
TMEAN	Ø.Ø4Ø	Ø.ØØ56
STDEV	Ø.382	Ø.Ø964
SEMEAN	Ø.Ø43	Ø.Ø1Ø8
MAX	2.ØØØ	Ø.ØØØØ
MIN	Ø.ØØØ	Ø.ØØØØ
Q3	Ø.ØØØ	Ø.ØØØØ
Q1	Ø.ØØØ	Ø.ØØØØ

Table of the Correlation Coefficients between all Twenty-Six Water Quality Parameters for the Standing Pot Liquor for all Four Gully Pots on the Tame Sub-catchment.

Table 7.38

	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
DO	-0.423								
PH	-0.366	0.121							
ALK	0.285	-0.327	0.160						
TH	-0.350	0.142	0.000	0.328					
COND	-0.412	0.222	0.756	-0.025	0.746				
SS	-0.024	0.058	0.579	0.322	0.460	0.635			
BOD	0.252	-0.318	0.073	0.339	0.037	-0.008	0.154		
COD	0.327	-0.200	0.212	0.554	0.219	0.236	0.663	0.355	
PHOS	0.017	-0.274	0.197	0.354	0.161	0.053	0.227	0.397	0.435
CL	-0.336	0.211	0.600	-0.137	0.526	0.815	0.546	-0.050	0.113
SUL	-0.352	0.049	0.613	0.054	0.753	0.552	0.243	-0.082	-0.087
AMM	0.231	-0.366	0.087	0.249	-0.007	-0.013	0.193	0.350	0.223
NIT	0.090	-0.136	0.193	0.424	0.488	0.217	0.055	0.233	0.373
Na	-0.532	0.154	0.666	-0.045	0.639	0.799	0.434	-0.082	0.041
K	-0.096	-0.115	0.417	0.108	0.352	0.459	0.441	0.099	0.384
Fe	0.248	-0.204	-0.016	0.436	0.007	-0.023	0.316	0.228	0.431
Pb	-0.086	-0.002	0.464	0.022	0.596	0.684	0.299	-0.043	0.047
Ca	-0.307	0.097	0.774	0.090	0.772	0.871	0.667	-0.031	0.298
Mg	0.240	-0.243	0.028	0.117	0.005	-0.026	0.085	0.051	0.028
Zn	0.006	-0.329	0.052	0.060	0.101	0.040	-0.032	-0.049	0.066
Mn	-0.020	-0.372	0.088	0.412	0.280	0.096	0.257	0.146	0.354
Cu	-0.359	0.267	0.770	0.035	0.714	0.940	0.703	-0.026	0.317
Cd	0.115	-0.144	0.188	0.071	0.206	0.174	0.085	0.124	0.050
Ni	-0.384	0.280	0.768	-0.003	0.751	0.977	0.659	-0.027	0.238
Cr	-0.274	0.218	0.544	-0.032	0.466	0.679	0.435	-0.009	0.201

	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
CL	-0.037								
SUL	0.162	0.344							
AMM	0.297	0.020	-0.040						
NIT	0.062	0.047	0.165	-0.088					
Na	0.180	0.667	0.537	-0.040	0.148				
K	0.293	0.481	0.215	0.165	0.135	0.426			
Fe	0.123	-0.019	-0.106	0.201	-0.024	-0.050	0.052		
Pb	-0.004	0.537	0.501	-0.118	0.278	0.529	0.216	-0.037	
Ca	0.090	0.756	0.604	0.037	0.163	0.758	0.514	0.064	0.699
Mg	0.089	0.001	0.040	0.171	-0.097	-0.039	-0.029	0.078	0.226
Zn	-0.015	0.002	0.094	0.176	0.140	0.178	0.186	0.201	0.049
Mn	0.232	0.105	0.112	0.171	0.341	0.205	0.245	0.391	0.205
Cu	0.081	0.744	0.522	-0.017	0.168	0.779	0.395	-0.020	0.609
Cd	0.116	0.118	0.106	0.265	-0.030	0.104	0.078	0.235	0.164
Ni	0.046	0.725	0.572	-0.036	0.213	0.770	0.375	-0.027	0.675
Cr	0.023	0.739	0.227	0.017	0.109	0.468	0.507	-0.021	0.422

	Ca	Mg	Zn	Mn	Cu	Cd	Ni
Mg	0.139						
Zn	0.193	-0.018					
Mn	0.264	0.149	0.435				
Cu	0.863	0.019	-0.020	0.068			
Cd	0.166	-0.032	0.197	-0.067	0.171		
Ni	0.871	-0.019	0.001	0.053	0.954	0.176	
Cr	0.582	-0.017	-0.079	0.019	0.651	0.125	0.587

Statistical Summary of the Water Quality Data for the Standing Pot Liquor collected in the Four Gully Pots on the Churnet Sub-catchment.

Table 7.39

	TEMP	DO	PH	ALK	TH	COND	SS	BOD
N	88	88	88	8#	8#	88	72	88
NMISS	#	#	#	8	8	#	16	#
MEAN	12.68	3.64	7.14	131.3	3#6	5.7	111	19.5
MEDIAN	12.5#	3.4#	6.8#	125.#	235	#.2	49	16.#
TMEAN	12.6#	3.59	7.#3	128.6	279	2.5	66	18.5
STDEV	6.32	2.11	1.12	8#.#	276	18.3	294	16.4
SEMEAN	#.67	#.23	#.12	8.9	31	1.9	35	1.7
MAX	25.##	8.3#	11.4#	32#.#	124#	114.1	2449	62.#
MIN	2.5#	#.3#	5.8#	2#.#	2#	#.#	#	#.#
Q3	17.5#	5.7#	7.3#	19#.#	398	#.6	84	28.#
Q1	7.##	1.9#	6.43	5#.#	98	#.1	27	6.2

	COD	PHOS	CL	SUL	AMM	NIT	Na	K
N	75	8#	8#	76	8#	6#	8#	8#
NMISS	13	8	8	12	8	28	8	8
MEAN	85.9	1.63	2268	381	2.18	16.1	1875	5.52
MEDIAN	71.#	1.1#	35	216	#.5#	6.3	8	2.8#
TMEAN	76.1	1.45	5#8	343	1.35	12.7	816	4.28
STDEV	83.2	1.62	867#	38#	4.5#	25.2	6#46	7.85
SEMEAN	9.6	#.18	969	44	#.5#	3.3	676	#.88
MAX	537.#	8.2#	54593	171#	26.6#	1#9.2	45###	42.##
MIN	#.#	#.##	7	#	#.##	#.5	1	#.4#
Q3	118.#	1.9#	87	553	2.##	12.6	54	6.1#
Q1	34.#	#.6#	21	115	#.2#	1.5	3	1.1#

	Fe	Pb	Ca	Mg	Zn	Mn	Cu	Cd
N	8#	8#	8#	8#	8#	8#	8#	8#
NMISS	8	8	8	8	8	8	8	8
MEAN	1.26	#.12#	78	7.2	#.136	#.191	#.#226	#.#85
MEDIAN	#.4#	#.###	38	1.4	#.1##	#.1##	#.####	#.###
TMEAN	#.72	#.#94	64	3.8	#.116	#.172	#.#146	#.#31
STDEV	2.89	#.197	1#1	18.9	#.152	#.214	#.#513	#.282
SEMEAN	#.32	#.#22	11	2.1	#.#17	#.#24	#.##57	#.#32
MAX	17.##	#.78#	43#	115.#	1.18#	#.9##	#.22##	2.###
MIN	#.##	#.###	5	#.#	#.###	#.###	#.####	#.###
Q3	#.92	#.27#	1#2	4.9	#.16#	#.3##	#.####	#.#18
Q1	#.19	#.###	13	#.6	#.#5#	#.#3#	#.####	#.###

	Ni	Cr
N	8#	8#
NMISS	8	8
MEAN	#.1#4	#.#33
MEDIAN	#.###	#.###
TMEAN	#.#38	#.#15
STDEV	#.333	#.114
SEMEAN	#.#37	#.#13
MAX	2.#5#	#.9##
MIN	#.###	#.###
Q3	#.#38	#.###
Q1	#.###	#.###

Table of the Correlation Coefficients between all Twenty-Six Water Quality Parameters for the Standing Pot Liquor for all Four Gully Pots on the Churnet Sub-catchment.

Table 7.40

	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
DO	-0.365								
PH	-0.050	0.111							
ALK	0.498	-0.399	0.380						
TH	-0.362	0.196	0.522	0.145					
COND	-0.403	0.134	0.299	-0.136	0.786				
SS	0.047	-0.054	0.568	0.170	0.140	0.140			
BOD	0.088	-0.203	-0.007	0.124	-0.161	-0.046	0.247		
COD	0.091	-0.237	0.011	0.341	0.100	0.039	0.090	0.313	
PHOS	-0.108	0.036	0.143	0.158	0.278	0.200	-0.012	0.276	0.251
CL	-0.332	0.152	0.238	-0.209	0.674	0.942	0.125	-0.045	0.060
SUL	-0.325	0.078	0.406	0.034	0.826	0.690	0.109	-0.210	0.005
AMM	0.334	-0.265	0.236	0.306	-0.034	-0.079	0.366	0.235	0.226
NIT	0.224	-0.225	0.231	0.375	0.382	0.319	0.052	0.101	0.407
Na	-0.407	0.182	0.245	-0.188	0.692	0.912	0.066	-0.024	-0.018
K	-0.110	-0.109	0.306	0.161	0.363	0.320	0.268	0.111	0.374
Fe	0.341	-0.318	0.039	0.295	0.068	-0.016	-0.023	0.118	0.136
Pb	0.117	-0.182	0.130	0.066	0.508	0.549	0.014	-0.131	0.095
Ca	-0.296	0.057	0.494	0.005	0.808	0.809	0.200	-0.106	0.051
Mg	0.234	-0.126	-0.005	0.179	0.021	-0.014	-0.020	0.263	0.146
Zn	-0.026	-0.025	-0.069	-0.038	0.056	0.151	-0.048	0.001	-0.011
Mn	0.085	-0.235	0.040	0.351	0.432	0.370	0.002	0.249	0.324
Cu	-0.214	0.066	0.395	-0.021	0.565	0.726	0.381	-0.102	0.148
Cd	0.182	-0.260	0.002	0.143	0.168	0.134	-0.016	-0.041	0.121
Ni	-0.378	0.189	0.311	-0.156	0.748	0.960	0.128	-0.094	0.012
Cr	-0.285	0.185	0.179	-0.118	0.561	0.705	0.122	-0.143	-0.135

	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
CL	0.157								
SUL	0.225	0.595							
AMM	0.169	-0.069	-0.014						
NIT	0.201	0.284	0.279	0.553					
Na	0.221	0.922	0.655	-0.079	0.275				
K	0.136	0.306	0.345	0.033	0.173	0.388			
Fe	0.093	0.001	0.077	0.517	0.232	-0.019	0.057		
Pb	0.202	0.538	0.555	0.194	0.377	0.494	0.199	0.282	
Ca	0.172	0.759	0.738	-0.039	0.258	0.752	0.513	0.025	0.544
Mg	0.365	0.001	0.011	0.122	0.053	-0.018	-0.022	0.064	0.114
Zn	0.020	0.178	0.055	-0.055	-0.020	0.161	0.063	-0.009	-0.002
Mn	0.295	0.367	0.458	0.336	0.536	0.401	0.415	0.320	0.311
Cu	0.151	0.683	0.685	0.231	0.316	0.647	0.383	-0.030	0.635
Cd	0.071	0.137	0.140	0.452	0.204	0.105	0.018	0.789	0.388
Ni	0.181	0.959	0.670	-0.086	0.316	0.899	0.281	-0.018	0.543
Cr	0.156	0.705	0.422	-0.089	0.130	0.537	0.197	-0.026	0.437

	Ca	Mg	Zn	Mn	Cu	Cd	Ni
Mg	0.139						
Zn	0.074	0.026					
Mn	0.400	0.248	0.154				
Cu	0.640	-0.047	-0.003	0.306			
Cd	0.122	0.009	0.018	0.292	0.153		
Ni	0.789	-0.018	0.151	0.329	0.708	0.127	
Cr	0.581	0.055	0.126	0.213	0.440	0.101	0.685

Statistical Summary of the Water Quality Data for the Standing Pot Liquor collected in the Four Gully Pots on the Twyford Sub-catchment.

Table 7.41

	TEMP	DO	PH	ALK	TH	COND	SS	BOD
N	88	88	88	8Ø	8Ø	88	72	88
NMISS	Ø	Ø	Ø	8	8	Ø	16	Ø
MEAN	12.57	3.45	7.116	129.4	279	3.7	121	16.3
MEDIAN	12.25	3.2Ø	7.ØØØ	11Ø.Ø	23Ø	Ø.2	31	1Ø.Ø
TMEAN	12.48	3.39	7.Ø75	123.5	255	1.8	84	15.1
STDEV	6.18	2.Ø3	Ø.87Ø	85.7	232	1Ø.2	226	15.8
SEMEAN	Ø.66	Ø.22	Ø.Ø93	9.6	26	1.1	27	1.7
MAX	24.5Ø	7.9Ø	9.9ØØ	39Ø.Ø	1Ø6Ø	47.6	1256	6Ø.Ø
MIN	2.5Ø	Ø.2Ø	5.5ØØ	2Ø.Ø	4Ø	Ø.Ø	Ø	Ø.Ø
Q3	17.5Ø	4.87	7.6ØØ	18Ø.Ø	37Ø	Ø.8	68	22.8
Q1	8.ØØ	1.6Ø	6.425	52.5	92	Ø.1	12	5.Ø

	COD	PHOS	CL	SUL	AMM	NIT	Na	K
N	78	8Ø	8Ø	76	8Ø	6Ø	8Ø	8Ø
NMISS	1Ø	8	8	12	8	28	8	8
MEAN	57.3	1.33	1235	35Ø	2.46	19.3	677	5.29
MEDIAN	45.5	1.1Ø	43	211	Ø.6Ø	5.2	11	3.1Ø
TMEAN	5Ø.Ø	1.22	4Ø1	322	1.64	13.5	291	4.36
STDEV	6Ø.Ø	1.13	4Ø91	332	4.74	35.9	195Ø	6.42
SEMEAN	6.8	Ø.13	457	38	Ø.53	4.6	218	Ø.72
MAX	356.Ø	5.3Ø	2Ø916	1345	26.6Ø	217.Ø	12ØØØ	34.ØØ
MIN	Ø.Ø	Ø.ØØ	5	Ø	Ø.1Ø	Ø.3	Ø	Ø.4Ø
Q3	74.2	1.67	19Ø	591	1.78	19.2	144	7.2Ø
Q1	14.Ø	Ø.43	25	96	Ø.3Ø	1.8	4	1.13

	Fe	Pb	Ca	Mg	Zn	Mn	Cu	Cd
N	8Ø	8Ø	8Ø	8Ø	8Ø	8Ø	8Ø	8Ø
NMISS	8	8	8	8	8	8	8	8
MEAN	Ø.86	Ø.Ø75	69.3	8.1	Ø.1114	Ø.23Ø	Ø.ØØ89	Ø.Ø28
MEDIAN	Ø.24	Ø.ØØØ	47.Ø	2.Ø	Ø.ØØØØ	Ø.115	Ø.ØØØØ	Ø.ØØØ
TMEAN	Ø.49	Ø.Ø6Ø	59.5	4.7	Ø.1Ø63	Ø.162	Ø.ØØ44	Ø.Ø11
STDEV	2.21	Ø.131	79.1	19.Ø	Ø.Ø734	Ø.412	Ø.Ø247	Ø.115
SEMEAN	Ø.25	Ø.Ø15	8.8	2.1	Ø.ØØ82	Ø.Ø46	Ø.ØØ28	Ø.Ø13
MAX	16.ØØ	Ø.54Ø	42Ø.Ø	12Ø.Ø	Ø.35ØØ	2.5ØØ	Ø.12ØØ	1.ØØØ
MIN	Ø.ØØ	Ø.ØØØ	Ø.Ø	Ø.Ø	Ø.ØØ2Ø	Ø.ØØØ	Ø.ØØØØ	Ø.ØØØ
Q3	Ø.58	Ø.14Ø	98.8	4.9	Ø.16ØØ	Ø.2ØØ	Ø.ØØØØ	Ø.Ø25
Q1	Ø.ØØ	Ø.ØØØ	11.6	Ø.7	Ø.Ø6ØØ	Ø.Ø63	Ø.ØØØØ	Ø.ØØØ

	Ni	Cr
N	8Ø	8Ø
NMISS	8	8
MEAN	Ø.Ø57	Ø.ØØ87
MEDIAN	Ø.ØØØ	Ø.ØØØØ
TMEAN	Ø.Ø24	Ø.ØØ28
STDEV	Ø.163	Ø.Ø326
SEMEAN	Ø.Ø18	Ø.ØØ36
MAX	Ø.87Ø	Ø.2ØØØ
MIN	Ø.ØØØ	Ø.ØØØØ
Q3	Ø.ØØØ	Ø.ØØØØ
Q1	Ø.ØØØ	Ø.ØØØØ

Table of the Correlation Coefficients between all Twenty-Six Water Quality Parameters for the Standing Pot Liquor for all Four Gully Pots on the Twyford Sub-catchment.

Table 7.42

	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
DO	-0.266								
PH	-0.189	-0.219							
ALK	0.446	-0.391	0.359						
TH	-0.251	-0.144	0.706	0.261					
COND	-0.454	-0.048	0.518	-0.094	0.776				
SS	0.189	-0.237	0.115	0.330	0.200	0.161			
BOD	0.061	-0.157	-0.029	0.134	-0.106	-0.090	0.203		
COD	0.289	-0.264	0.233	0.448	0.215	0.080	0.098	-0.029	
PHOS	0.004	-0.166	0.073	0.111	0.185	0.132	0.154	0.481	0.101
CL	-0.377	-0.076	0.368	-0.201	0.580	0.798	0.105	-0.099	0.046
SUL	-0.245	-0.225	0.623	0.106	0.705	0.497	0.052	-0.146	0.192
AMM	0.200	-0.379	0.057	0.152	0.061	-0.009	0.467	0.452	0.031
NIT	-0.077	0.019	0.419	0.309	0.477	0.531	0.241	0.079	0.174
Na	-0.438	0.047	0.469	-0.097	0.660	0.830	0.069	-0.054	0.007
K	-0.078	-0.181	0.496	0.187	0.453	0.462	0.262	-0.078	0.323
Fe	0.324	-0.252	0.073	0.445	0.097	-0.049	0.713	0.225	0.153
Pb	0.015	-0.231	0.311	0.034	0.549	0.496	-0.018	-0.156	0.244
Ca	-0.095	-0.247	0.605	0.110	0.756	0.599	0.155	-0.151	0.184
Mg	0.233	-0.272	0.041	0.059	0.076	-0.036	0.110	0.319	-0.006
Zn	0.528	-0.177	0.107	0.407	0.084	-0.121	0.219	0.222	0.276
Mn	0.113	-0.321	0.049	0.347	0.200	0.073	0.565	0.410	0.115
Cu	-0.347	-0.014	0.536	-0.018	0.731	0.881	0.205	-0.065	0.058
Cd	0.022	-0.042	0.262	-0.079	0.192	0.225	0.017	-0.120	-0.030
Ni	-0.438	-0.066	0.515	-0.174	0.726	0.888	0.141	-0.181	0.047
Cr	-0.341	0.048	0.445	0.075	0.589	0.754	0.122	-0.065	0.109

	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
CL	0.107								
SUL	0.181	0.348							
AMM	0.305	0.017	0.070						
NIT	0.527	0.134	0.315	0.140					
Na	0.147	0.773	0.437	-0.042	0.540				
K	0.182	0.443	0.529	0.059	0.305	0.261			
Fe	0.057	-0.039	-0.005	0.387	0.044	-0.061	0.133		
Pb	0.278	0.416	0.473	-0.032	0.197	0.401	0.295	-0.060	
Ca	0.164	0.541	0.633	-0.008	0.265	0.454	0.453	0.015	0.650
Mg	0.466	-0.013	0.174	0.297	0.025	-0.027	-0.045	0.054	0.329
Zn	0.222	-0.081	0.000	0.312	0.082	-0.113	0.136	0.381	0.098
Mn	0.309	0.094	0.056	0.466	-0.018	0.058	0.102	0.640	0.052
Cu	0.106	0.679	0.433	0.035	0.454	0.744	0.301	-0.023	0.403
Cd	-0.090	0.196	0.092	0.097	0.033	0.167	0.068	0.096	0.096
Ni	-0.020	0.832	0.461	-0.033	0.150	0.746	0.355	-0.063	0.434
Cr	0.150	0.579	0.387	0.032	0.735	0.707	0.408	-0.034	0.415

	Ca	Mg	Zn	Mn	Cu	Cd	Ni
Mg	0.298						
Zn	0.118	0.267					
Mn	0.104	0.268	0.313				
Cu	0.551	0.160	-0.040	0.144			
Cd	0.124	-0.062	-0.046	-0.050	0.199		
Ni	0.632	-0.031	-0.112	0.049	0.835	0.217	
Cr	0.421	-0.035	-0.132	0.038	0.689	0.165	0.516

Statistical Summary of the Water Quality Data for the Standing Pot Liquor collected in the Twelve Gully Pots on the Three Sub-catchments.

Table 7.43

	TEMP	DO	PH	ALK	TH	COND	SS	BOD
N	264	264	264	240	240	264	216	264
NMISS	0	0	0	24	24	0	48	0
MEAN	12.70	3.47	7.101	139.5	299	5.04	114	19.4
MEDIAN	12.25	3.25	6.900	125.0	240	0.20	46	14.0
TMEAN	12.61	3.40	7.013	132.9	272	2.01	81	18.3
STDEV	6.20	2.05	0.966	91.7	260	15.80	227	16.7
SEMEAN	0.38	0.13	0.059	5.9	17	0.97	15	1.0
MAX	25.00	8.50	11.400	500.0	1240	114.10	2449	62.0
MIN	2.00	0.20	5.500	20.0	20	0.03	0	0.0
Q3	17.50	5.00	7.500	190.0	370	0.80	90	30.0
Q1	8.00	1.73	6.500	60.0	110	0.09	22	6.0

	COD	PHOS	CL	SUL	AMM	NIT	Na	K
N	230	240	240	228	240	180	240	240
NMISS	34	24	24	36	24	84	24	24
MEAN	105	1.83	1808	377	2.55	18.6	1596	5.42
MEDIAN	65	1.30	39	245	0.60	5.1	10	3.00
TMEAN	79	1.62	417	337	1.78	13.1	713	4.30
STDEV	154	1.90	6956	382	4.60	35.2	4852	7.36
SEMEAN	10	0.12	449	25	0.30	2.6	313	0.47
MAX	976	13.00	54593	2268	26.60	266.0	45000	45.00
MIN	0	0.00	5	0	0.00	0.1	0	0.30
Q3	118	2.10	157	562	2.35	13.1	111	6.50
Q1	26	0.60	21	99	0.20	1.5	4	1.08

	Fe	Pb	Ca	Mg	Zn	Mn	Cu	Cd
N	240	240	240	240	240	240	240	240
NMISS	24	24	24	24	24	24	24	24
MEAN	1.24	0.095	73.0	7.4	0.1461	0.206	0.0160	0.064
MEDIAN	0.30	0.000	42.0	2.0	0.1100	0.120	0.0000	0.000
TMEAN	0.63	0.072	59.7	4.1	0.1298	0.169	0.0076	0.020
STDEV	3.94	0.169	90.9	18.4	0.1331	0.293	0.0447	0.238
SEMEAN	0.25	0.011	5.9	1.2	0.0086	0.019	0.0029	0.015
MAX	50.00	0.780	460.0	130.0	1.1800	2.500	0.2300	2.000
MIN	0.00	0.000	0.0	0.0	0.0000	0.000	0.0000	0.000
Q3	0.80	0.150	98.8	4.8	0.1900	0.268	0.0000	0.020
Q1	0.10	0.000	13.0	0.6	0.0600	0.050	0.0000	0.000

	Ni	Cr
N	240	240
NMISS	24	24
MEAN	0.094	0.0211
MEDIAN	0.000	0.0000
TMEAN	0.032	0.0069
STDEV	0.307	0.0884
SEMEAN	0.020	0.0057
MAX	2.080	0.9000
MIN	0.000	0.0000
Q3	0.000	0.0000
Q1	0.000	0.0000

Table of the Correlation Coefficients between all Twenty-Six Water Quality Parameters for the Standing Pot Liquor for all Twelve Gully Pots on the Three Sub-catchments.

Table 7.44

	TEMP	DO	PH	ALK	TH	COND	SS	BOD	COD
DO	-0.351								
PH	-0.189	0.018							
ALK	0.394	-0.366	0.280						
TH	-0.323	0.077	0.658	0.252					
COND	-0.405	0.124	0.493	-0.069	0.759				
SS	0.078	-0.090	0.418	0.235	0.215	0.241			
BOD	0.138	-0.228	0.009	0.227	-0.063	-0.031	0.195		
COD	0.223	-0.186	0.104	0.472	0.171	0.152	0.192	0.278	
PHOS	-0.018	-0.147	0.132	0.274	0.201	0.120	0.078	0.383	0.421
CL	-0.329	0.125	0.374	-0.164	0.590	0.872	0.199	-0.048	0.077
SUL	-0.309	-0.020	0.530	0.068	0.765	0.589	0.116	-0.130	-0.015
AMM	0.255	-0.338	0.130	0.239	0.006	-0.036	0.351	0.348	0.173
NIT	0.064	-0.106	0.262	0.376	0.454	0.320	0.109	0.150	0.326
Na	-0.423	0.140	0.401	-0.082	0.636	0.846	0.136	-0.028	0.081
K	-0.095	-0.131	0.391	0.144	0.382	0.398	0.289	0.054	0.294
Fe	0.266	-0.224	0.014	0.393	0.041	-0.018	0.214	0.195	0.367
Pb	0.021	-0.127	0.275	0.037	0.546	0.589	0.062	-0.095	0.061
Ca	-0.241	-0.015	0.610	0.065	0.781	0.784	0.271	-0.088	0.163
Mg	0.235	-0.211	0.020	0.111	0.031	-0.024	0.045	0.204	0.031
Zn	0.093	-0.167	-0.001	0.117	0.087	0.080	0.004	0.055	0.135
Mn	0.068	-0.295	0.051	0.333	0.260	0.147	0.301	0.269	0.179
Cu	-0.283	0.130	0.538	0.008	0.639	0.835	0.382	-0.048	0.204
Cd	0.121	-0.165	0.105	0.075	0.186	0.166	0.011	0.029	0.070
Ni	-0.370	0.173	0.506	-0.070	0.725	0.954	0.243	-0.062	0.168
Cr	-0.263	0.169	0.321	-0.047	0.498	0.688	0.173	-0.060	0.091

	PHOS	CL	SUL	AMM	NIT	Na	K	Fe	Pb
CL	0.057								
SUL	0.187	0.440							
AMM	0.254	-0.018	0.005						
NIT	0.193	0.131	0.230	0.147					
Na	0.208	0.801	0.550	-0.048	0.242				
K	0.208	0.388	0.339	0.087	0.197	0.334			
Fe	0.124	-0.011	-0.037	0.297	0.035	-0.027	0.064		
Pb	0.109	0.518	0.514	0.022	0.263	0.486	0.226	0.056	
Ca	0.122	0.709	0.657	-0.006	0.217	0.684	0.497	0.042	0.620
Mg	0.231	-0.003	0.068	0.197	-0.015	-0.029	-0.031	0.060	0.202
Zn	0.091	0.111	0.072	0.117	0.090	0.170	0.121	0.162	0.035
Mn	0.209	0.159	0.152	0.342	0.172	0.178	0.209	0.356	0.150
Cu	0.111	0.706	0.556	0.083	0.249	0.709	0.366	-0.016	0.589
Cd	0.091	0.140	0.118	0.291	0.046	0.120	0.050	0.375	0.263
Ni	0.097	0.833	0.579	-0.048	0.213	0.820	0.326	-0.021	0.573
Cr	0.086	0.704	0.316	-0.030	0.249	0.520	0.328	-0.017	0.423

	Ca	Mg	Zn	Mn	Cu	Cd	Ni
Mg	0.182						
Zn	0.123	0.048					
Mn	0.211	0.225	0.227				
Cu	0.699	0.016	-0.002	0.133			
Cd	0.139	-0.021	0.105	0.048	0.175		
Ni	0.775	-0.019	0.070	0.109	0.837	0.165	
Cr	0.537	0.012	0.030	0.071	0.549	0.124	0.620

A Summary Table of the Descriptive Statistics for the Gully Pot Standing Liquor Quality from the Twelve Gully Pots under study on the Clifton Grove Housing Estate, Nottingham.

(The data were collected over a one year period)

Table 7.45

Parameter	Number of Samples.	Mean Value.	Range of Values.
Temperature	264	12.7	2.0-25.0
Dissolved Oxygen	264	3.5	0.2-8.5
pH	264	7.1	5.5-11.4
Alkalinity	240	140.0	20.0-500.0
Total Hardness	240	299.0	20.0-1240.0
Conductivity	264	5.04	0.03-114.1
SS	216	114.0	0-2449
BOD	264	19.0	0.0-62.0
COD	230	105.0	0.0-976.0
Phosphate	240	1.8	0.0-13.0
Chloride	240	1808.0	5.0-54593.0
Sulphate	228	377.0	0.0-2268.0
Ammonia	240	2.6	0.0-26.6
Nitrate	180	18.6	0.1-266.0
Sodium	240	1596.0	0.0-45000.0
Potassium	240	5.4	0.3-45.0
Iron	240	1.2	0.0-50.0
Lead	240	0.09	0.0-0.78
Calcium	240	73.0	0.0-460.0
Magnesium	240	7.4	0.0-130.0
Zinc	240	0.15	0.0-1.18
Manganese	240	0.21	0.0-2.50
Copper	240	0.02	0.0-0.23
Cadmium	240	0.06	0.0-2.00
Nickel	240	0.09	0.0-2.08
Chromium	240	0.02	0.0-0.90

7.17 Regression Analysis on the Gully Pot Standing Liquor Water Quality Dataset.

Water Quality data have been collected from twelve gully pots on three sub-catchments on the Clifton Grove Estate over a twenty-two week period during the year May 1984 to April 1985. A Rainfall-Runoff Model has been developed as part of the research programme (see Chapter 4) to simulate the flow into the gully pot from a given rainstorm event. This Rainfall-Runoff model has been calibrated for use in simulating the inflow conditions into three gully pots on the Clifton Grove Estate, which were used to study the role of the gully pot in determining the quality of outflow stormwater discharges under storm conditions. The model was therefore calibrated for each of the number 2 gully pots on the three sub-catchment areas, ie. Tame 2, Churnet 2 and Twyford 2 gully pots. This "linear reservoir" model (LRM) was used to convert a rainfall input, measured as a rainfall intensity into a simulated inflow hydrograph for each gully pot micro-catchment (see Chapter 4). The parameters relating to the micro-catchment characteristics including the micro-catchment area, depression storage and the runoff coefficient have been included in each model to produce three Rainfall-Runoff Models which each produce numerical and graphic output for each rainfall-runoff simulation. The parameters used were as follows:

Micro-catchment Name	Depression Storage (mm)	Runoff Coefficient	Area m^2
Table: 7.46			
TAME 2	0.76	0.90	228
CHURNET 2	0.66	0.81	241
TWYFORD 2	1.22	0.83	382

The models were run for each rainstorm event during the whole of the gully pot liquor sampling programme so that simulations of the flow through the gully pot between each sample taken on a weekly basis, could be known. The samples were taken at the same time each week and so by looking through the rainfall records, which were all recorded in real time, it was possible to know exactly how much rainfall fell over the Clifton Grove Estate Catchment area in any given period of one week. The Antecedent Dry Period (ADP) or period of no rainfall could also be worked out from these figures and it was more convenient to express this amount in hours rather than days due to the rainfall regime experienced in the Nottingham area. The rainfall total and the antecedent dry period will be the same for each of the micro-catchments under study, since one fundamental assumption in all of the rainfall analysis and the subsequent rainfall-runoff modelling, was that the rainfall fell evenly over the whole catchment area, so that the measurements made at one raingauge could be used to simulate flows anywhere within the same catchment area. The close proximity of all three sub-catchment areas to the raingauge sites gave this assumption some validity. The meteorological input to each of the three micro-catchment areas may be the same for each rainstorm event but it is the hydrological and hydraulic response which is different in each case, and this depends upon the catchment characteristics as presented in Table 7.46.

It was decided to adopt two simple hydrological parameters to describe the flow conditions within each micro-catchment during the one week period between which the samples of pot liquor were taken in the gully pot sampling programme. These were 1) the total runoff volume which had passed through the pot during that week and 2) the peak flow intensity of the inflow water going into the pot, and this was equal

to the maximum flow intensity simulated for the runoff conditions in that particular gully pot for that one week period. The hydrological processes (or lack of them during a completely dry period) operating within the micro-catchment for the one week inter-sampling time period therefore could be described by the following four parameters which could be used in a deterministic way to test if there was any relationship between the changes in the pot liquor quality due to the hydrological processes occurring within that micro-catchment. The difference in the value of a water quality parameter from one week to the next was a function of the activity within the micro-catchment area, a seasonality influence most associated with the appearance or disappearance of certain sources of pollutants within the micro-catchment (eg. grass cuttings acting as a source of organic matter during the summer months) or a physico-biochemical change within the pot liquor itself. The aim of the regression analysis was to attempt to derive a series of relationships between the changes in the values for the water quality parameters under study and the hydrological conditions which have prevailed within the micro-catchment during the previous week (ie. the exact time period that the change in the water quality parameter concentration or value has been observed to take place). This type of regression analysis is a deterministic modelling approach in order to try and predict changes in pot liquor quality in terms of the inflow characteristics both during a storm event, or indeed if, there is a completely dry period. The analysis was carried out for the following determinands:

BOD COD SS Phosphate Chloride Zn Cu and Pb

The regresssion analyses were carried out for each determinand on each of the three micro-catchment areas (ie. T2, C2 and TW2) for which a Runoff Model had been developed, as well as a combination of all three micro-catchments into a total dataset. A table was drawn up to show the dates that the samples were collected together with the values for the hydrological parameters during the previous one week period. The hydrological parameters chosen for inclusion in the regression analyses were selected with due regard to their ease of calculation, their relevence to the runoff process and the fact that these parameters may be commonly measured as part of any hydrometric programme, such that the regression models developed could be used on existing hydrometric data collection programmes. The hydrological parameters can be defined as follows: (see Tables 7.47 to 7.49).

RF = Total Rainfall (in mm) falling onto the micro-catchment during the previous seven day period.

RO = Total Runoff Volume (in litres) passing into the gully pot during the previous seven day period.

PFLOW = The peak (maximum) flow intensity (in litres/second) into the gully pot during the previous seven day period.

ADP = The Antecedent Dry Period. This is the number of hours between the end of the last rainstorm and the time of sampling. It was assumed that all samples were collected at 0900 hours on the dates as given in the table.

* = This is a missing value and was not included in the regression analysis.

The aim of the regression analysis was to determine a relationship between the value of a given chemical parameter sampled at a particular time with the previous value of the parameter together with the hydrological conditions prevailing within the micro-catchment over the given time period (ie. the time between which the samples were

taken). A stepwise multiple regression analysis was run, using the 'MINITAB' Statistical Package, to produce a series of regression equations whereby the chemical parameter value was made the dependent variable. A computer programme was written in FORTRAN IV to run the regression analysis using the Minitab Statistical Package for each of the micro-catchments and then by concatenating these data files into a total dataset. It was decided to discard those regression equations whose R-Squared Value (ie. the square of the correlation coefficient expressed as a percentage value) was less than 25%. Such relationships were not considered to be statistically significant, since the correlation coefficient was less than 0.5. A list was drawn up of all regression equations whose R-Squared value was above 25% for each chemical parameter on each micro-catchment and also for the total dataset.

The regression analysis was carried out on all the eight chemical parameters as listed above, but it was found that there were no meaningful regression relationships found for chloride, copper and lead on any of the micro-catchment areas, or for the total dataset. This was almost certainly due to the lack of variability in the metals data whereby a large number of zero (non-detectable) values were found; and the extremely high variability found in the chloride values within a relatively small dataset. The analysis therefore focussed upon five chemical parameters which could be deterministically modelled and these were:

i) BOD
ii) COD
iii) SS
iv) Phosphate
v) Zinc

Table of the Hydrological Conditions on the Tame 2 Gully Pot Micro-catchment during the Twenty-Two Week Period Analysis of the Gully Pot Standing Liquor Water Quality, which formed part of the Gully Pot Liquor Monitoring Programme.

Table 7.47

SAMPLE DATE	RAINFALL TOTAL	TOTAL RUNOFF VOLUME	PEAK FLOW INTENSITY	ADP
	(mm)	(l)	(ls-1)	(Hours)
840509	0.30	0	0	168
840516	8.83	1335.6	0.36	134
840523	14.90	2712.4	0.27	49
840530	17.90	2864.1	1.22	52
840606	30.02	5145.1	0.68	73
840613	0	0	0	168
840620	0.35	0	0	152
840627	20.52	3738.0	4.41	86
840704	0	0	0	168
840711	0	0	0	168
840718	21.19	1155.0	0.56	59
840725	0	0	0	168
841031	17.86	2277.4	0.41	12
841107	21.75	3571.1	1.02	25
841114	19.75	2935.3	0.27	*
841121	10.55	1672.0	0.26	10
841128	20.14	2818.2	0.41	9
850220	1.35	0	0	*
850227	0	0	0	168
850306	6.39	888.0	0.14	70
850313	21.39	3578.9	0.06	*
850320	4.90	611.4	*	*

* = Missing Value.

Table of the Hydrological Conditions on the Churnet 2 Gully Pot Micro-catchment during the Twenty-Two Week Period Analysis of the Gully Pot Standing Liquor Water Quality, which formed part of the Gully Pot Liquor Monitoring Programme.

Table 7.48

SAMPLE DATE	RAINFALL TOTAL	TOTAL RUNOFF VOLUME	PEAK FLOW INTENSITY	ADP
	(mm)	(l)	(ls-1)	(Hours)
840509	0.30	0	0	168
840516	8.83	1310.1	0.35	134
840523	14.90	2619.7	0.26	49
840530	17.90	2806.7	1.22	52
840606	30.02	5014.0	0.67	73
840613	0	0	0	168
840620	0.35	0	0	152
840627	20.52	3605.5	4.20	86
840704	0	0	0	168
840711	0	0	0	168
840718	21.19	1173.7	0.68	59
840725	0	0	0	168
241031	17.86	2272.9	0.40	12
841107	21.75	3497.2	0.99	25
841114	19.75	2891.0	0.26	*
841121	10.55	1629.9	0.25	10
841128	20.14	2797.2	0.42	9
850220	1.35	0	0	*
850227	0	0	0	168
850306	6.39	884.1	0.15	70
850313	21.39	3480.1	0.06	*
850320	4.90	620.7	*	*

* = Missing Value.

Table of the Hydrological Conditions on the Twyford 2 Gully Pot Micro-catchment during the Twenty-Two Week Period Analysis of the Gully Pot Standing Liquor Water Quality, which formed part of the Gully Pot Liquor Monitoring Programme.

Table 7.49

SAMPLE DATE	RAINFALL TOTAL (mm)	TOTAL RUNOFF VOLUME (l)	PEAK FLOW INTENSITY (ls-1)	ADP (Hours)
840509	0.30	0	0	168
840516	8.83	1761.4	0.35	134
840523	14.90	4006.6	0.38	49
840530	17.90	3802.6	1.52	52
840606	30.02	7031.2	0.92	73
840613	0	0	0	168
840620	0.35	0	0	152
840627	20.52	5441.9	6.68	86
840704	0	0	0	168
840711	0	0	0	168
840718	21.19	1321.5	0.69	59
840725	0	0	0	168
841031	17.86	2762.4	0.55	12
841107	21.75	4756.8	1.33	25
841114	19.75	3783.4	0.35	*
841121	10.55	2272.5	0.37	10
841128	20.14	3694.5	0.52	9
850220	1.35	0	0	*
850227	0	0	0	168
850306	6.39	1147.6	0.19	70
850313	21.39	5230.0	0.07	*
850320	4.90	653.1	*	*

* = Missing Value.

TAME 2 GULLY POT : Suspended Solids

ROW	DATE	RF	RO	PFLOW	ADP	DATES	SS	PRSS
1	840620	0.35	0.0	0.00	152	840620	21	0
2	840627	20.52	3738.0	4.41	86	840627	84	21
3	840704	0.00	0.0	0.00	168	840704	110	84
4	840711	0.00	0.0	0.00	168	840711	23	110
5	840718	21.19	1155.0	0.56	59	840718	24	23
6	840725	0.00	0.0	0.00	168	840725	29	24
7	841107	21.75	3571.1	1.02	25	841107	66	9
8	841114	19.75	2935.3	0.27	*	841114	30	66
9	841121	10.55	1672.0	0.26	10	841121	27	30
10	841128	20.14	2818.2	0.41	9	841128	141	27
11	850227	0.00	0.0	0.00	168	850227	87	27
12	850306	6.39	888.0	0.14	70	850306	81	87
13	850313	21.39	3578.9	0.06	*	850313	125	81
14	850320	4.90	611.4	*	*	850320	71	125

SS = - 23.6 + 0.349 PRSS + 0.0375 RO - 17.7 PFLOW + 0.370 ADP
R-SQUARED = 28.9 PERCENT

SS = - 17 + 0.337 PRSS - 0.54 RF + 0.0388 RO - 17.0 PFLOW + 0.332 ADP
R-SQUARED = 29.1 PERCENT

DIFSS = - 16.8 + 0.0233 RO + 0.105 ADP
R-SQUARED = 32.6 PERCENT

DIFSS = - 16.4 - 0.05 RF + 0.0235 RO + 0.102 ADP
R-SQUARED = 32.6 PERCENT

DIFSS = - 59.8 + 0.0449 RO - 18.8 PFLOW + 0.383 ADP
R-SQUARED = 37.9 PERCENT

DIFSS = - 67.6 + 0.66 RF + 0.0431 RO - 19.6 PFLOW + 0.429 ADP
R-SQUARED = 38.1 PERCENT

Table 7.50

TAME 2 GULLY POT : Chemical Oxygen Demand

ROW	DATE	RF	RO	PFLOW	ADP	DATES	COD	PRCOD
1	840516	0.30	0.0	0.00	168	840516	43	119
2	840523	8.83	1335.6	0.36	134	840523	42	43
3	840620	0.35	0.0	0.00	152	840620	79	5
4	840627	20.52	3738.0	4.41	86	840627	351	79
5	840704	0.00	0.0	0.00	168	840704	666	351
6	840711	0.00	0.0	0.00	168	840711	139	666
7	840718	21.19	1155.0	0.56	59	840718	5	139
8	840725	0.00	0.0	0.00	168	840725	27	5
9	841107	21.75	3571.1	1.02	25	841107	64	60
10	841114	19.75	2935.3	0.27	*	841114	0	64
11	841121	10.55	1672.0	0.26	10	841121	0	0
12	841128	20.14	2818.2	0.41	9	841128	99	0
13	850227	0.00	0.0	0.00	168	850227	173	30
14	850306	6.39	888.0	0.14	70	850306	98	173
15	850313	21.39	3578.9	0.06	*	850313	35	98
16	850320	4.90	611.4	*	*	850320	113	35

COD = 41.4 + 0.436 PRCOD + 53.5 PFLOW
R-SQUARED = 26.8 PERCENT

COD = 109 + 0.336 PRCOD - 6.79 RF + 78.8 PFLOW
R-SQUARED = 36.8 PERCENT

COD = 91.3 + 0.354 PRCOD - 0.0364 RO + 79.1 PFLOW
R-SQUARED = 32.8 PERCENT

COD = - 166 + 0.337 PRCOD + 0.0706 RO + 1.67 ADP
R-SQUARED = 29.0 PERCENT

COD = - 24 + 0.324 PRCOD + 60.3 PFLOW + 0.811 ADP
R-SQUARED = 31.8 PERCENT

COD = 107 + 0.346 PRCOD - 10.2 RF + 0.0265 RO + 73.0 PFLOW
R-SQUARED = 37.4 PERCENT

COD = - 111 + 0.344 PRCOD - 6.4 RF + 0.0978 RO + 1.35 ADP
R-SQUARED = 30.4 PERCENT

COD = 82 + 0.325 PRCOD - 5.9 RF + 78.0 PFLOW + 0.19 ADP
R-SQUARED = 33.3 PERCENT

COD = - 57 + 0.328 PRCOD + 0.015 RO + 50.7 PFLOW + 1.01 ADP
R-SQUARED = 32.0 PERCENT

Table 7.51

COD = 28 + 0.336 PRCOD - 8.1 RF + 0.041 RO + 58.0 PFLOW + 0.51 ADP
R-SQUARED = 34.2 PERCENT

COD = 171 - 8.86 RF + 80.2 PFLOW
R-SQUARED = 26.6 PERCENT

COD = 170 - 10.8 RF + 0.0147 RO + 76.9 PFLOW
R-SQUARED = 26.8 PERCENT

Table 7.51 cont'd.

TAME 2 GULLY POT : Phosphate

ROW	DATE	RF	RO	PFLOW	ADP	DATES	PHOS	PRPHOS
1	840516	0.30	0.0	0.00	168	840516	1.4	0.5
2	840523	8.83	1335.6	0.36	134	840523	0.6	1.4
3	840620	0.35	0.0	0.00	152	840620	1.4	2.0
4	840627	20.52	3738.0	4.41	86	840627	5.6	1.4
5	840704	0.00	0.0	0.00	168	840704	5.7	5.6
6	840711	0.00	0.0	0.00	168	840711	0.9	5.7
7	840718	21.19	1155.0	0.56	59	840718	3.0	0.9
8	840725	0.00	0.0	0.00	168	840725	0.6	3.0
9	841107	21.75	3571.1	1.02	25	841107	0.3	1.4
10	841114	19.75	2935.3	0.27	*	841114	0.3	0.3
11	841121	10.55	1672.0	0.26	10	841121	0.0	0.3
12	841128	20.14	2818.2	0.41	9	841128	1.6	0.0
13	850227	0.00	0.0	0.00	168	850227	1.7	1.9
14	850306	6.39	888.0	0.14	70	850306	0.2	1.7
15	850313	21.39	3578.9	0.06	*	850313	0.5	0.2
16	850320	4.90	611.4	*	*	850320	1.8	0.5

PHOS = 1.14 + 0.902 PFLOW
R-SQUARED = 30.7 PERCENT

PHOS = 0.279 + 0.458 PRPHOS + 1.01 PFLOW
R-SQUARED = 50.3 PERCENT

PHOS = 0.314 + 0.450 PRPHOS - 0.0025 RF + 1.02 PFLOW
R-SQUARED = 50.3 PERCENT

PHOS = - 3.28 + 0.375 PRPHOS + 0.209 RF + 0.0238 ADP
R-SQUARED = 39.8 PERCENT

PHOS = 0.854 + 0.328 PRPHOS -0.000310 RO + 1.21 PFLOW
R-SQUARED = 53.2 PERCENT

PHOS = - 1.56 + 0.322 PRPHOS +0.000925 RO + 0.0151 ADP
R-SQUARED = 27.2 PERCENT

PHOS = 0.021 + 0.345 PRPHOS + 1.04 PFLOW + 0.00459 ADP
R-SQUARED = 48.4 PERCENT

PHOS = 0.418 + 0.420 PRPHOS + 0.128 RF - 0.00103 RO + 1.25 PFLOW
R-SQUARED = 59.4 PERCENT

PHOS = - 3.30 + 0.372 PRPHOS + 0.197 RF +0.000092 RO + 0.0240 ADP
R-SQUARED = 39.9 PERCENT

Table 7.52

PHOS = - 1.60 + 0.364 PRPHOS + 0.090 RF + 0.771 PFLOW + 0.0137 ADP
R-SQUARED = 51.6 PERCENT

PHOS = 1.64 + 0.352 PRPHOS -0.000722 RO + 1.51 PFLOW - 0.0052 ADP
R-SQUARED = 51.8 PERCENT

PHOS = - 0.04 + 0.390 PRPHOS + 0.157 RF - 0.00123 RO + 1.37 PFLOW
+ 0.0037 ADP
R-SQUARED = 59.6 PERCENT

PHOS = 1.63 - 0.0613 RF + 1.15 PFLOW
R-SQUARED = 38.9 PERCENT

PHOS = - 3.03 + 0.200 RF + 0.0292 ADP
R-SQUARED = 32.0 PERCENT

PHOS = 1.76 -0.000587 RO + 1.34 PFLOW
R-SQUARED = 46.7 PERCENT

PHOS = 0.094 + 1.02 PFLOW + 0.0104 ADP
R-SQUARED = 41.8 PERCENT

PHOS = 1.65 + 0.084 RF - 0.00111 RO + 1.39 PFLOW
R-SQUARED = 49.6 PERCENT

PHOS = - 3.06 + 0.181 RF +0.000149 RO + 0.0294 ADP
R-SQUARED = 32.2 PERCENT

PHOS = - 1.33 + 0.079 RF + 0.785 PFLOW + 0.0187 ADP
R-SQUARED = 44.2 PERCENT

PHOS = 1.65 -0.000693 RO + 1.47 PFLOW + 0.0011 ADP
R-SQUARED = 44.9 PERCENT

PHOS = 0.14 + 0.140 RF - 0.00115 RO + 1.34 PFLOW + 0.0097 ADP
R-SQUARED = 51.2 PERCENT

DIFPHO = - 1.13 + 0.108 RF
R-SQUARED = 25.7 PERCENT

DIFPHO = - 0.734 + 1.14 PFLOW
R-SQUARED = 38.7 PERCENT

Table 7.52 cont'd.

DIFPHO = - 1.13 + 0.147 RF -0.000273 RO
R-SQUARED = 26.3 PERCENT

DIFPHO = - 1.29 + 0.0692 RF + 0.858 PFLOW
R-SQUARED = 47.0 PERCENT

DIFPHO = - 3.69 + 0.224 RF + 0.0149 ADP
R-SQUARED = 39.3 PERCENT

DIFPHO = - 1.01 +0.000257 RO + 0.944 PFLOW
R-SQUARED = 41.2 PERCENT

DIFPHO = - 1.73 +0.000946 RO + 0.0039 ADP
R-SQUARED = 26.9 PERCENT

DIFPHO = - 0.12 + 1.07 PFLOW - 0.00647 ADP
R-SQUARED = 44.0 PERCENT

DIFPHO = - 1.28 + 0.189 RF -0.000915 RO + 1.06 PFLOW
R-SQUARED = 52.8 PERCENT

DIFPHO = - 3.69 + 0.224 RF -0.000003 RO + 0.0149 ADP
R-SQUARED = 39.3 PERCENT

DIFPHO = - 2.08 + 0.109 RF + 0.746 PFLOW + 0.0050 ADP
R-SQUARED = 47.5 PERCENT

DIFPHO = 1.62 - 0.00078 RO + 1.57 PFLOW - 0.0169 ADP
R-SQUARED = 46.9 PERCENT

DIFPHO = - 0.32 + 0.182 RF - 0.00136 RO + 1.41 PFLOW - 0.0057 ADP
R-SQUARED = 54.8 PERCENT

Table 7.52 cont'd.

TAME 2 GULLY POT : Zinc.

ROW	DATE	RF	RO	PFLOW	ADP	DATES	ZINC	PRZINC
1	840516	0.30	0.0	0.00	168	840516	0.84	0.31
2	840523	8.83	1335.6	0.36	134	840523	0.08	0.84
3	840620	0.35	0.0	0.00	152	840620	0.45	0.20
4	840627	20.52	3738.0	4.41	86	840627	0.10	0.45
5	840704	0.00	0.0	0.00	168	840704	0.20	0.10
6	840711	0.00	0.0	0.00	168	840711	0.20	0.20
7	840718	21.19	1155.0	0.56	59	840718	0.06	0.20
8	840725	0.00	0.0	0.00	168	840725	0.26	0.06
9	841107	21.75	3571.1	1.02	25	841107	0.09	0.05
10	841114	19.75	2935.3	0.27	*	841114	0.05	0.09
11	841121	10.55	1672.0	0.26	10	841121	0.04	0.05
12	841128	20.14	2818.2	0.41	9	841128	0.02	0.04
13	850227	0.00	0.0	0.00	168	850227	0.37	0.63
14	850306	6.39	888.0	0.14	70	850306	0.58	0.37
15	850313	21.39	3578.9	0.06	*	850313	0.53	0.58
16	850320	4.90	611.4	*	*	850320	0.23	0.53

ZINC = 0.048 + 0.00192 ADP
R-SQUARED = 26.0 PERCENT

ZINC = 0.303 + 0.215 PRZINC - 0.0112 RF
R-SQUARED = 26.7 PERCENT

ZINC = 0.050 - 0.014 PRZINC + 0.00194 ADP
R-SQUARED = 26.0 PERCENT

ZINC = 0.306 + 0.204 PRZINC - 0.0160 RF +0.000033 RO
R-SQUARED = 27.3 PERCENT

ZINC = 0.296 + 0.279 PRZINC - 0.00963 RF - 0.0372 PFLOW
R-SQUARED = 31.2 PERCENT

ZINC = 0.414 + 0.103 PRZINC - 0.0179 RF - 0.00036 ADP
R-SQUARED = 38.4 PERCENT

ZINC = 0.263 + 0.306 PRZINC -0.000049 RO - 0.0405 PFLOW
R-SQUARED = 26.2 PERCENT

ZINC = 0.274 + 0.081 PRZINC -0.000080 RO + 0.00047 ADP
R-SQUARED = 33.5 PERCENT

ZINC = 0.088 + 0.046 PRZINC - 0.0415 PFLOW + 0.00165 ADP
R-SQUARED = 29.5 PERCENT

ZINC = 0.299 + 0.265 PRZINC - 0.0173 RF +0.000058 RO - 0.0493 PFLOW
R-SQUARED = 32.8 PERCENT

ZINC = 0.419 + 0.108 PRZINC - 0.0161 RF -0.000014 RO - 0.00039 ADP
R-SQUARED = 38.6 PERCENT

ZINC = 0.449 + 0.095 PRZINC - 0.0203 RF + 0.0165 PFLOW - 0.00055 ADP
R-SQUARED = 38.8 PERCENT

ZINC = 0.333 + 0.076 PRZINC -0.000110 RO + 0.028 PFLOW + 0.00012 ADP
R-SQUARED = 34.0 PERCENT

ZINC = 0.521 + 0.103 PRZINC - 0.0174 RF -0.000056 RO + 0.043 PFLOW
- 0.00101 ADP
R-SQUARED = 39.7 PERCENT

ZINC = 0.398 - 0.0164 RF - 0.00005 ADP
R-SQUARED = 37.6 PERCENT

ZINC = 0.265 -0.000074 RO + 0.00069 ADP
R-SQUARED = 33.0 PERCENT

ZINC = 0.091 - 0.0387 PFLOW + 0.00172 ADP
R-SQUARED = 29.3 PERCENT

ZINC = 0.378 - 0.0200 RF +0.000071 RO - 0.0403 PFLOW
R-SQUARED = 25.9 PERCENT

ZINC = 0.400 - 0.0154 RF -0.000008 RO - 0.00006 ADP
R-SQUARED = 37.6 PERCENT

ZINC = 0.441 - 0.0195 RF + 0.0197 PFLOW - 0.00031 ADP
R-SQUARED = 38.0 PERCENT

ZINC = 0.328 -0.000106 RO + 0.029 PFLOW + 0.00030 ADP
R-SQUARED = 33.5 PERCENT

ZINC = 0.507 - 0.0167 RF -0.000052 RO + 0.045 PFLOW - 0.00072 ADP
R-SQUARED = 38.9 PERCENT

DIFZN = 0.573 - 0.0223 RF -0.000061 RO - 0.00308 ADP
R-SQUARED = 26.0 PERCENT

Table 7.53 cont'd.

DIFZN = 0.642 - 0.0231 RF -0.000089 RO + 0.029 PFLOW - 0.00351 ADP
R-SQUARED = 26.3 PERCENT

Table 7.53 cont'd.

CHURNET 2 GULLY POT : Suspended Solids

ROW	DATE	RF	RO	PFLOW	ADP	DATES	SS	PRSS
1	840620	0.35	0.0	0.00	152	840620	17	0
2	840627	20.52	3605.5	4.20	86	840627	28	17
3	840704	0.00	0.0	0.00	168	840704	50	28
4	840711	0.00	0.0	0.00	168	840711	21	50
5	840718	21.19	1173.7	0.68	59	840718	28	21
6	840725	0.00	0.0	0.00	168	840725	14	28
7	841107	21.75	3497.2	0.99	25	841107	26	44
8	841114	19.75	2891.0	0.26	*	841114	11	26
9	841121	10.55	1629.9	0.25	10	841121	26	11
10	841128	20.14	2797.2	0.42	9	841128	28	26
11	850227	0.00	0.0	0.00	168	850227	230	124
12	850306	6.39	884.1	0.15	70	850306	71	230
13	850313	21.39	3480.1	0.06	*	850313	124	71
14	850320	4.90	620.7	*	*	850320	48	124

SS = 24.0 + 0.483 PRSS
R-SQUARED = 26.1 PERCENT

SS = 29.7 + 0.466 PRSS - 0.45 RF
R-SQUARED = 26.6 PERCENT

SS = 26.7 + 0.475 PRSS - 0.0016 RO
R-SQUARED = 26.3 PERCENT

SS = 27.2 + 0.521 PRSS - 4.5 PFLOW
R-SQUARED = 30.1 PERCENT

SS = - 1.7 + 0.487 PRSS + 0.255 ADP
R-SQUARED = 36.7 PERCENT

SS = 30.0 + 0.462 PRSS - 1.51 RF + 0.0075 RO
R-SQUARED = 27.2 PERCENT

SS = 31.4 + 0.514 PRSS - 0.43 RF - 2.8 PFLOW
R-SQUARED = 30.5 PERCENT

SS = - 20.3 + 0.509 PRSS + 0.83 RF + 0.354 ADP
R-SQUARED = 37.2 PERCENT

SS = 28.3 + 0.520 PRSS - 0.0009 RO - 3.8 PFLOW
R-SQUARED = 30.1 PERCENT

SS = - 12.0 + 0.498 PRSS + 0.0034 RO + 0.311 ADP

Table 7.54

R-SQUARED = 36.9 PERCENT

SS = - 2.0 + 0.488 PRSS + 0.3 PFLOW + 0.256 ADP
R-SQUARED = 36.7 PERCENT

SS = 31.9 + 0.504 PRSS - 1.63 RF + 0.0092 RO - 4.6 PFLOW
R-SQUARED = 31.2 PERCENT

SS = - 20.3 + 0.509 PRSS + 0.83 RF - 0.0001 RO + 0.354 ADP
R-SQUARED = 37.2 PERCENT

SS = - 31 + 0.512 PRSS + 1.55 RF - 4.5 PFLOW + 0.421 ADP
R-SQUARED = 37.5 PERCENT

SS = - 26 + 0.498 PRSS + 0.0109 RO - 6.7 PFLOW + 0.404 ADP
R-SQUARED = 37.4 PERCENT

SS = - 43 + 0.515 PRSS + 1.23 RF + 0.0079 RO - 8.6 PFLOW + 0.496 ADP
R-SQUARED = 37.9 PERCENT

Table 7.54 cont'd.

CHURNET 2 GULLY POT : Biochemical Oxygen Demand

ROW	DATE	RF	RO	PFLOW	ADP	DATES	BOD	PRBOD
1	840516	8.83	1310.1	0.35	134	840516	16	5
2	840523	14.90	2619.7	0.26	49	840523	0	16
3	840530	17.90	2806.7	1.22	52	840530	0	0
4	840606	30.02	5014.0	0.67	73	840606	5	0
5	840613	0.00	0.0	0.00	154	840613	59	5
6	840620	0.35	0.0	0.00	152	840620	18	59
7	840627	20.52	3605.5	4.20	86	840627	6	18
8	840704	0.00	0.0	0.00	168	840704	37	6
9	840711	0.00	0.0	0.00	168	840711	13	37
10	840718	21.19	1173.7	0.68	59	840718	18	13
11	840725	0.00	0.0	0.00	168	840725	20	18
12	841107	21.75	3497.2	0.99	25	841107	11	22
13	841114	19.75	2891.0	0.26	*	841114	39	11
14	841121	10.55	1629.9	0.25	10	841121	28	39
15	841128	20.14	2797.2	0.42	9	841128	3	28
16	850227	0.00	0.0	0.00	168	850227	7	40
17	850306	6.39	884.1	0.15	70	850306	8	7
18	850313	21.39	3480.1	0.06	*	850313	5	8
19	850320	4.90	620.7	*	*	850320	23	5

BOD = 31.0 - 0.271 PRBOD - 0.827 RF
R-SQUARED = 26.1 PERCENT

BOD = 30.8 - 0.274 PRBOD - 0.00547 RO
R-SQUARED = 29.3 PERCENT

BOD = 30.9 - 0.275 PRBOD - 0.05 RF - 0.00521 RO
R-SQUARED = 29.3 PERCENT

BOD = 31.4 - 0.277 PRBOD - 0.763 RF - 1.79 PFLOW
R-SQUARED = 26.6 PERCENT

BOD = 34.8 - 0.283 PRBOD - 1.07 RF - 0.0231 ADP
R-SQUARED = 35.6 PERCENT

BOD = 31.4 - 0.284 PRBOD - 0.00525 RO - 1.13 PFLOW
R-SQUARED = 29.2 PERCENT

BOD = 31.3 - 0.270 PRBOD - 0.00633 RO - 0.0045 ADP
R-SQUARED = 38.2 PERCENT

BOD = 31.5 - 0.286 PRBOD - 0.06 RF - 0.00488 RO - 1.14 PFLOW
R-SQUARED = 29.2 PERCENT

Table 7.55

BOD = 34.1 - 0.285 PRBOD - 0.34 RF - 0.00474 RO - 0.0186 ADP
R-SQUARED = 38.7 PERCENT

BOD = 34.3 - 0.280 PRBOD - 1.02 RF - 0.52 PFLOW - 0.020 ADP
R-SQUARED = 35.7 PERCENT

BOD = 31.4 - 0.270 PRBOD - 0.00643 RO + 0.20 PFLOW - 0.0054 ADP
R-SQUARED = 38.2 PERCENT

BOD = 34.4 - 0.286 PRBOD - 0.35 RF - 0.00487 RO + 0.32 PFLOW - 0.020 ADP
R-SQUARED = 38.7 PERCENT

BOD = 22.9 - 0.753 RF + 0.0083 ADP
R-SQUARED = 27.7 PERCENT

BOD = 21.8 - 0.00484 RO + 0.0145 ADP
R-SQUARED = 30.7 PERCENT

BOD = 22.1 - 0.04 RF - 0.00465 RO + 0.0129 ADP
R-SQUARED = 30.7 PERCENT

BOD = 22.1 - 0.675 RF - 0.98 PFLOW + 0.014 ADP
R-SQUARED = 28.0 PERCENT

BOD = 21.7 - 0.00474 RO - 0.21 PFLOW + 0.0154 ADP
R-SQUARED = 30.7 PERCENT

BOD = 22.0 - 0.04 RF - 0.00457 RO - 0.20 PFLOW + 0.014 ADP
R-SQUARED = 30.7 PERCENT

Table 7.55 cont'd.

CHURNET 2 GULLY POT : Chemical Oxygen Demand

ROW	DATE	RF	RO	PFLOW	ADP	DATES	COD	PRCOD
1	840516	8.83	1310.1	0.35	134	840516	70	289
2	840523	14.90	2619.7	0.26	49	840523	42	70
3	840620	0.35	0.0	0.00	152	840620	34	10
4	840627	20.52	3605.5	4.20	86	840627	170	34
5	840704	0.00	0.0	0.00	168	840704	93	170
6	840711	0.00	0.0	0.00	168	840711	75	93
7	840718	21.19	1173.7	0.68	59	840718	11	75
8	840725	0.00	0.0	0.00	168	840725	49	11
9	841107	21.75	3497.2	0.99	25	841107	25	80
10	841114	19.75	2891.0	0.26	*	841114	51	25
11	841121	10.55	1629.9	0.25	10	841121	0	51
12	841128	20.14	2797.2	0.42	9	841128	0	0
13	850313	21.39	3480.1	0.06	*	850313	45	118
14	850320	4.90	620.7	*	*	850320	77	45

COD = 35.5 + 27.2 PFLOW
R-SQUARED = 45.6 PERCENT

COD = 19.1 + 0.193 PRCOD + 29.3 PFLOW
R-SQUARED = 56.7 PERCENT

COD = 45.4 + 0.167 PRCOD - 2.37 RF + 37.6 PFLOW
R-SQUARED = 75.8 PERCENT

COD = - 90.2 + 0.002 PRCOD + 4.93 RF + 0.950 ADP
R-SQUARED = 48.9 PERCENT

COD = 35.6 + 0.180 PRCOD - 0.0110 RO + 36.3 PFLOW
R-SQUARED = 66.0 PERCENT

COD = - 108 - 0.001 PRCOD + 0.0407 RO + 1.05 ADP
R-SQUARED = 76.2 PERCENT

COD = - 22.1 + 0.109 PRCOD + 34.4 PFLOW + 0.456 ADP
R-SQUARED = 90.7 PERCENT

COD = 44.9 + 0.164 PRCOD - 4.17 RF + 0.0137 RO + 35.2 PFLOW
R-SQUARED = 78.9 PERCENT

COD = - 109 - 0.001 PRCOD + 0.12 RF + 0.0402 RO + 1.06 ADP
R-SQUARED = 76.2 PERCENT

COD = 13.2 + 0.141 PRCOD - 1.95 RF + 40.4 PFLOW + 0.235 ADP

Table 7.56

R-SQUARED = 92.6 PERCENT

COD = - 45.6 + 0.0864 PRCOD + 0.0099 RO + 28.4 PFLOW + 0.610 ADP
R-SQUARED = 91.8 PERCENT

COD = - 10.7 + 0.116 PRCOD - 2.43 RF + 0.0137 RO + 33.6 PFLOW + 0.393 ADP
R-SQUARED = 94.5 PERCENT

COD = 61.2 - 2.52 RF + 36.2 PFLOW
R-SQUARED = 67.6 PERCENT

COD = - 90.2 + 4.93 RF + 0.951 ADP
R-SQUARED = 48.9 PERCENT

COD = 52.1 - 0.0118 RO + 34.8 PFLOW
R-SQUARED = 56.4 PERCENT

COD = - 108 + 0.0407 RO + 1.05 ADP
R-SQUARED = 76.2 PERCENT

COD = - 16.5 + 33.6 PFLOW + 0.496 ADP
R-SQUARED = 87.7 PERCENT

COD = 60.5 - 4.41 RF + 0.0143 RO + 33.8 PFLOW
R-SQUARED = 71.0 PERCENT

COD = - 109 + 0.12 RF + 0.0402 RO + 1.06 ADP
R-SQUARED = 76.2 PERCENT

COD = 0.7 - 0.91 RF + 36.3 PFLOW + 0.398 ADP
R-SQUARED = 88.1 PERCENT

COD = - 51.8 + 0.0142 RO + 25.3 PFLOW + 0.703 ADP
R-SQUARED = 90.1 PERCENT

COD = - 27.9 - 1.78 RF + 0.0180 RO + 28.3 PFLOW + 0.568 ADP
R-SQUARED = 91.7 PERCENT

DIFCOD = - 49.8 + 38.3 PFLOW
R-SQUARED = 27.7 PERCENT

DIFCOD = - 33.4 - 1.61 RF + 44.1 PFLOW

R-SQUARED = 30.4 PERCENT

DIFCOD = - 39.6 - 0.0073 RO + 43.1 PFLOW
R-SQUARED = 28.9 PERCENT

DIFCOD = - 67.6 + 40.7 PFLOW + 0.135 ADP
R-SQUARED = 30.7 PERCENT

DIFCOD = - 34.0 - 2.97 RF + 0.0103 RO + 42.4 PFLOW
R-SQUARED = 30.9 PERCENT

DIFCOD = 90 - 8.34 RF + 65.5 PFLOW - 0.763 ADP
R-SQUARED = 43.2 PERCENT

DIFCOD = 20 - 0.0349 RO + 61.2 PFLOW - 0.375 ADP
R-SQUARED = 35.6 PERCENT

DIFCOD = 120 - 7.43 RF - 0.0188 RO + 73.9 PFLOW - 0.94 ADP
R-SQUARED = 44.4 PERCENT

Table 7.56 cont'd.

CHURNET 2 GULLY POT : Phosphate

ROW	DATE	RF	RO	PFLOW	ADP	DATES	PHOS	PRPHOS
1	840516	8.83	1310.1	0.35	134	840516	1.4	0.3
2	840523	14.90	2619.7	0.26	49	840523	0.5	1.4
3	840620	0.35	0.0	0.00	152	840620	1.1	1.5
4	840627	20.52	3605.5	4.20	86	840627	1.0	1.1
5	840704	0.00	0.0	0.00	168	840704	0.5	1.0
6	840711	0.00	0.0	0.00	168	840711	1.0	0.5
7	840718	21.19	1173.7	0.68	59	840718	2.6	1.0
8	840725	0.00	0.0	0.00	168	840725	0.8	2.6
9	841107	21.75	3497.2	0.99	25	841107	0.1	1.1
10	841114	19.75	2891.0	0.26	*	841114	0.8	0.1
11	841121	10.55	1629.9	0.25	10	841121	0.0	0.8
12	841128	20.14	2797.2	0.42	9	841128	0.6	0.0
13	850227	0.00	0.0	0.00	168	850227	2.1	1.9
14	850306	6.39	884.1	0.15	70	850306	8.2	2.1
15	850313	21.39	3480.1	0.06	*	850313	0.3	8.2
16	850320	4.90	620.7	*	*	850320	4.0	0.3

PHOS = 2.70 + 1.17 PRPHOS -0.000707 RO - 0.0163 ADP
R-SQUARED = 25.9 PERCENT

PHOS = 1.94 + 1.24 PRPHOS + 0.080 RF - 0.00104 RO - 0.0127 ADP
R-SQUARED = 27.5 PERCENT

PHOS = 4.21 + 1.07 PRPHOS - 0.00141 RO + 0.692 PFLOW - 0.0248 ADP
R-SQUARED = 30.7 PERCENT

PHOS = 3.69 + 1.11 PRPHOS + 0.040 RF - 0.00152 RO + 0.63 PFLOW -
0.0222 ADP
R-SQUARED = 31.0 PERCENT

Table 7.57

CHURNET 2 GULLY POT : Zinc

ROW	DATE	RF	RO	PFLOW	ADP	DATES	ZINC	PRZINC
1	840516	8.83	1310.1	0.35	134	840516	0.42	0.08
2	840523	14.90	2619.7	0.26	49	840523	0.08	0.42
3	840620	0.35	0.0	0.00	152	840620	0.10	0.16
4	840627	20.52	3605.5	4.20	86	840627	0.05	0.10
5	840704	0.00	0.0	0.00	168	840704	0.16	0.05
6	840711	0.00	0.0	0.00	168	840711	0.14	0.16
7	840718	21.19	1173.7	0.68	59	840718	0.16	0.14
8	840725	0.00	0.0	0.00	168	840725	0.05	0.16
9	841107	21.75	3497.2	0.99	25	841107	0.12	0.04
10	841114	19.75	2891.0	0.26	*	841114	0.04	0.12
11	841121	10.55	1629.9	0.25	10	841121	0.22	0.40
12	841128	20.14	2797.2	0.42	9	841128	0.03	0.22
13	850227	0.00	0.0	0.00	168	850227	0.16	0.16
14	850306	6.39	884.1	0.15	70	850306	0.04	0.16
15	850313	21.39	3480.1	0.06	*	850313	0.07	0.04
16	850320	4.90	620.7	*	*	850320	0.07	0.07

DIFZIN = - 0.414 + 0.0127 RF + 0.00259 ADP
R-SQUARED = 32.9 PERCENT

DIFZIN = - 0.402 + 0.0166 RF -0.000032 RO + 0.00252 ADP
R-SQUARED = 34.2 PERCENT

DIFZIN = - 0.500 + 0.0186 RF - 0.0395 PFLOW + 0.00312 ADP
R-SQUARED = 36.5 PERCENT

DIFZIN = - 0.497 + 0.0187 RF -0.000002 RO - 0.0385 PFLOW + 0.00310 ADP
R-SQUARED = 36.5 PERCENT

Table 7.58

TWYFORD 2 GULLY POT : Suspended Solids

ROW	DATE	RF	RO	PFLOW	ADP	DATES	SS	PRSS
1	840620	0.35	0.0	0.00	152	840620	9	14
2	840627	20.52	5441.9	6.68	86	840627	39	9
3	840704	0.00	0.0	0.00	168	840704	80	39
4	840711	0.00	0.0	0.00	168	840711	15	80
5	840718	21.19	1321.5	0.69	59	840718	21	15
6	840725	0.00	0.0	0.00	168	840725	9	21
7	841107	21.75	4756.8	1.33	25	841107	46	4
8	841114	19.75	3783.4	0.35	*	841114	17	46
9	841121	10.55	2272.5	0.37	10	841121	9	17
10	841128	20.14	3694.5	0.52	9	841128	45	9
11	850227	0.00	0.0	0.00	168	850227	361	85
12	850306	6.39	1147.6	0.19	70	850306	316	361
13	850313	21.39	5230.0	0.07	*	850313	332	316
14	850320	4.90	653.1	*	*	850320	288	332

SS = 29.6 + 0.870 PRSS
R-SQUARED = 67.5 PERCENT

SS = 40.2 + 0.863 PRSS - 0.95 RF
R-SQUARED = 67.9 PERCENT

SS = 33.8 + 0.869 PRSS - 0.0020 RO
R-SQUARED = 67.6 PERCENT

SS = 28.8 + 0.914 PRSS - 0.4 PFLOW
R-SQUARED = 63.4 PERCENT

SS = 9.4 + 0.867 PRSS + 0.258 ADP
R-SQUARED = 53.1 PERCENT

SS = 41.5 + 0.854 PRSS - 2.86 RF + 0.0097 RO
R-SQUARED = 68.4 PERCENT

SS = 40.0 + 0.924 PRSS - 1.34 RF + 2.9 PFLOW
R-SQUARED = 64.1 PERCENT

SS = - 25 + 0.901 PRSS + 1.53 RF + 0.442 ADP
R-SQUARED = 53.4 PERCENT

SS = 34.3 + 0.932 PRSS - 0.0045 RO + 2.9 PFLOW
R-SQUARED = 63.7 PERCENT

SS = - 22 + 0.900 PRSS + 0.0075 RO + 0.424 ADP

Table 7.59

R-SQUARED = 53.7 PERCENT

SS = 8.2 + 0.870 PRSS + 0.7 PFLOW + 0.262 ADP
R-SQUARED = 53.1 PERCENT

SS = 41.4 + 0.905 PRSS - 2.57 RF + 0.0072 RO + 0.7 PFLOW
R-SQUARED = 64.3 PERCENT

SS = - 27 + 0.905 PRSS + 0.43 RF + 0.0064 RO + 0.45 ADP
R-SQUARED = 53.7 PERCENT

SS = - 39 + 0.908 PRSS + 2.46 RF - 3.7 PFLOW + 0.53 ADP
R-SQUARED = 53.6 PERCENT

SS = - 81 + 0.929 PRSS + 0.0289 RO - 17.1 PFLOW + 0.80 ADP
R-SQUARED = 55.1 PERCENT

SS = - 109 + 0.952 PRSS + 1.7 RF + 0.0273 RO - 19.1 PFLOW + 0.95 ADP
R-SQUARED = 55.4 PERCENT

Table 7.59 cont'd.

TWYFORD 2 GULLY POT : Biochemical Oxygen Demand

ROW	DATE	RF	RO	PFLOW	ADP	DATES	BOD	PRBOD
1	840516	8.83	1761.4	0.35	134	840516	5	10
2	840523	14.90	4006.6	0.38	49	840523	2	5
3	840530	17.90	3802.6	1.52	52	840530	6	2
4	840606	30.02	7031.2	0.92	73	840606	8	6
5	840613	0.00	0.0	0.00	154	840613	36	8
6	840620	0.35	0.0	0.00	152	840620	6	36
7	840627	20.52	5441.9	6.68	86	840627	30	6
8	840704	0.00	0.0	0.00	168	840704	35	30
9	840711	0.00	0.0	0.00	168	840711	17	35
10	840718	21.19	1321.5	0.69	59	840718	11	17
11	840725	0.00	0.0	0.00	168	840725	33	11
12	841107	21.75	4756.8	1.33	25	841107	3	19
13	841114	19.75	3783.4	0.35	*	841114	41	3
14	841121	10.55	2272.5	0.37	10	841121	20	41
15	841128	20.14	3694.5	0.52	9	841128	2	20
16	850227	0.00	0.0	0.00	168	850227	0	8
17	850306	6.39	1147.6	0.19	70	850306	1	0
18	850313	21.39	5230.0	0.07	*	850313	6	1
19	850320	4.90	653.1	*	*	850320	23	6

BOD = - 4.09 + 0.264 PRBOD + 3.23 PFLOW + 0.111 ADP
R-SQUARED = 35.4 PERCENT

BOD = 3.6 + 0.218 PRBOD - 0.331 RF + 3.76 PFLOW + 0.0718 ADP
R-SQUARED = 37.2 PERCENT

BOD = 1.8 + 0.218 PRBOD - 0.00132 RO + 3.92 PFLOW + 0.0818 ADP
R-SQUARED = 37.1 PERCENT

BOD = 3.7 + 0.212 PRBOD - 0.214 RF - 0.00065 RO + 3.91 PFLOW + 0.0714 ADP
R-SQUARED = 37.4 PERCENT

BOD = 0.49 + 2.65 PFLOW + 0.112 ADP
R-SQUARED = 29.1 PERCENT

BOD = 10.5 - 0.484 RF + 3.57 PFLOW + 0.0546 ADP
R-SQUARED = 33.3 PERCENT

BOD = 8.1 - 0.00198 RO + 3.84 PFLOW + 0.0678 ADP
R-SQUARED = 33.2 PERCENT

BOD = 10.5 - 0.282 RF - 0.00107 RO + 3.83 PFLOW + 0.0547 ADP
R-SQUARED = 33.8 PERCENT

DIFBOD = - 16.8 + 4.83 PFLOW + 0.108 ADP
R-SQUARED = 28.9 PERCENT

DIFBOD = - 21.2 + 0.214 RF + 4.43 PFLOW + 0.134 ADP
R-SQUARED = 29.4 PERCENT

DIFBOD = - 20.9 + 0.00105 RO + 4.20 PFLOW + 0.132 ADP
R-SQUARED = 29.6 PERCENT

DIFBOD = - 21.2 + 0.04 RF + 0.00093 RO + 4.20 PFLOW + 0.134 ADP
R-SQUARED = 29.6 PERCENT

Table 7.60 cont'd.

TWYFORD 2 GULLY POT : Chemical Oxygen Demand

ROW	DATE	RF	RO	PFLOW	ADP	DATES	COD	PRCOD
1	840516	8.83	1761.4	0.35	134	840516	64	16
2	840523	14.90	4006.6	0.38	49	840523	11	64
3	840620	0.35	0.0	0.00	152	840620	30	5
4	840627	20.52	5441.9	6.68	86	840627	46	30
5	840704	0.00	0.0	0.00	168	840704	144	46
6	840711	0.00	0.0	0.00	168	840711	75	144
7	840718	21.19	1321.5	0.69	59	840718	43	75
8	840725	0.00	0.0	0.00	168	840725	49	43
9	841107	21.75	4756.8	1.33	25	841107	30	70
10	841114	19.75	3783.4	0.35	*	841114	0	30
11	841121	10.55	2272.5	0.37	10	841121	0	0
12	841128	20.14	3694.5	0.52	9	841128	0	0
13	850306	6.39	1147.6	0.19	70	850306	93	76
14	850313	21.39	5230.0	0.07	*	850313	80	93

COD = 9.6 + 0.428 ADP
R-SQUARED = 42.9 PERCENT

COD = 50.5 + 0.423 PRCOD - 2.02 RF
R-SQUARED = 39.7 PERCENT

COD = 44.8 + 0.421 PRCOD - 0.00761 RO
R-SQUARED = 34.1 PERCENT

COD = 1.8 + 0.241 PRCOD + 0.389 ADP
R-SQUARED = 48.5 PERCENT

COD = 50.4 + 0.424 PRCOD - 2.25 RF + 0.0012 RO
R-SQUARED = 39.8 PERCENT

COD = 50.0 + 0.444 PRCOD - 2.34 RF + 4.16 PFLOW
R-SQUARED = 42.2 PERCENT

COD = 7.9 + 0.245 PRCOD - 0.30 RF + 0.353 ADP
R-SQUARED = 48.6 PERCENT

COD = 45.0 + 0.445 PRCOD - 0.00991 RO + 5.31 PFLOW
R-SQUARED = 37.7 PERCENT

COD = 10.1 + 0.238 PRCOD - 0.00201 RO + 0.344 ADP
R-SQUARED = 48.9 PERCENT

COD = 0.9 + 0.243 PRCOD + 0.62 PFLOW + 0.391 ADP

R-SQUARED = 48.5 PERCENT

COD = 50.1 + 0.444 PRCOD - 2.06 RF - 0.0016 RO + 4.53 PFLOW
R-SQUARED = 42.3 PERCENT

COD = 9.0 + 0.236 PRCOD + 0.12 RF - 0.0023 RO + 0.351 ADP
R-SQUARED = 48.9 PERCENT

COD = 14.8 + 0.259 PRCOD - 0.79 RF + 2.11 PFLOW + 0.305 ADP
R-SQUARED = 49.1 PERCENT

COD = 24.3 + 0.249 PRCOD - 0.0072 RO + 4.91 PFLOW + 0.250 ADP
R-SQUARED = 50.7 PERCENT

COD = 27.9 + 0.255 PRCOD - 0.29 RF - 0.0067 RO + 5.2 PFLOW + 0.228 ADP
R-SQUARED = 50.7 PERCENT

COD = 11.9 - 0.11 RF + 0.415 ADP
R-SQUARED = 42.9 PERCENT

COD = 19.1 - 0.00232 RO + 0.375 ADP
R-SQUARED = 43.5 PERCENT

COD = 9.4 + 0.15 PFLOW + 0.428 ADP
R-SQUARED = 42.9 PERCENT

COD = 13.4 + 0.55 RF - 0.0037 RO + 0.407 ADP
R-SQUARED = 43.8 PERCENT

COD = 14.0 - 0.25 RF + 0.61 PFLOW + 0.402 ADP
R-SQUARED = 42.9 PERCENT

COD = 31.4 - 0.0067 RO + 4.13 PFLOW + 0.298 ADP
R-SQUARED = 44.7 PERCENT

COD = 27.9 + 0.27 RF - 0.0071 RO + 3.9 PFLOW + 0.318 ADP
R-SQUARED = 44.8 PERCENT

TWYFORD 2 GULLY POT : Phosphate

ROW	DATE	RF	RO	PFLOW	ADP	DATES	PHOS	PRPHOS
1	840516	8.83	1761.4	0.35	134	840516	1.3	0.2
2	840523	14.90	4006.6	0.38	49	840523	0.7	1.3
3	840620	0.35	0.0	0.00	152	840620	0.3	1.0
4	840627	20.52	5441.9	6.68	86	840627	0.4	0.3
5	840704	0.00	0.0	0.00	168	840704	0.6	0.4
6	840711	0.00	0.0	0.00	168	840711	1.5	0.6
7	840718	21.19	1321.5	0.69	59	840718	2.3	1.5
8	840725	0.00	0.0	0.00	168	840725	1.1	2.3
9	841107	21.75	4756.8	1.33	25	841107	0.3	1.5
10	841114	19.75	3783.4	0.35	*	841114	0.6	0.3
11	841121	10.55	2272.5	0.37	10	841121	0.0	0.6
12	841128	20.14	3694.5	0.52	9	841128	0.3	0.0
13	850227	0.00	0.0	0.00	168	850227	1.8	1.4
14	850306	6.39	1147.6	0.19	70	850306	0.6	1.8
15	850313	21.39	5230.0	0.07	*	850313	0.9	0.6
16	850320	4.90	653.1	*	*	850320	3.1	0.9

PHOS = 1.14 + 0.064 PRPHOS + 0.0679 RF -0.000441 RO
R-SQUARED = 30.3 PERCENT

PHOS = - 0.978 + 0.298 PRPHOS + 0.0538 RF + 0.0106 ADP
R-SQUARED = 39.3 PERCENT

PHOS = 0.579 + 0.194 PRPHOS -0.000080 RO + 0.00247 ADP
R-SQUARED = 26.0 PERCENT

PHOS = 0.840 + 0.132 PRPHOS + 0.0676 RF -0.000397 RO + 0.032 PFLOW
R-SQUARED = 39.8 PERCENT

PHOS = - 0.642 + 0.164 PRPHOS + 0.121 RF -0.000399 RO + 0.00953 ADP
R-SQUARED = 69.7 PERCENT

PHOS = - 1.62 + 0.202 PRPHOS + 0.103 RF - 0.229 PFLOW + 0.0152 ADP
R-SQUARED = 58.2 PERCENT

PHOS = 0.67 + 0.198 PRPHOS -0.000114 RO + 0.033 PFLOW + 0.00187 ADP
R-SQUARED = 26.3 PERCENT

PHOS = - 0.930 + 0.152 PRPHOS + 0.127 RF -0.000331 RO - 0.081 PFLOW
+ 0.0114 ADP
R-SQUARED = 71.2 PERCENT

PHOS = 1.21 + 0.0687 RF -0.000451 RO
R-SQUARED = 30.1 PERCENT

PHOS = - 0.580 + 0.0473 RF + 0.0101 ADP
R-SQUARED = 30.4 PERCENT

PHOS = 0.991 + 0.0690 RF -0.000416 RO + 0.028 PFLOW
R-SQUARED = 38.1 PERCENT

PHOS = - 0.414 + 0.123 RF -0.000427 RO + 0.00925 ADP
R-SQUARED = 67.2 PERCENT

PHOS = - 1.43 + 0.104 RF - 0.251 PFLOW + 0.0154 ADP
R-SQUARED = 54.3 PERCENT

PHOS = - 0.750 + 0.129 RF -0.000348 RO - 0.090 PFLOW + 0.0113 ADP
R-SQUARED = 69.0 PERCENT

DIFPHO = - 1.81 + 0.115 RF -0.000260 RO + 0.0110 ADP
R-SQUARED = 33.9 PERCENT

DIFPHO = - 2.39 + 0.100 RF - 0.140 PFLOW + 0.0144 ADP
R-SQUARED = 29.7 PERCENT

DIFPHO = - 1.93 + 0.117 RF -0.000231 RO - 0.033 PFLOW + 0.0117 ADP
R-SQUARED = 34.1 PERCENT

Table 7.62 cont'd.

TWYFORD 2 GULLY POT : Zinc

ROW	DATE	RF	RO	PFLOW	ADP	DATES	ZINC	PRZINC
1	840516	8.83	1761.4	0.35	134	840516	0.24	0.06
2	840523	14.90	4006.6	0.38	49	840523	0.08	0.24
3	840620	0.35	0.0	0.00	152	840620	0.10	0.26
4	840627	20.52	5441.9	6.68	86	840627	0.08	0.10
5	840704	0.00	0.0	0.00	168	840704	0.22	0.08
6	840711	0.00	0.0	0.00	168	840711	0.14	0.22
7	840718	21.19	1321.5	0.69	59	840718	0.16	0.14
8	840725	0.00	0.0	0.00	168	840725	0.10	0.16
9	841107	21.75	4756.8	1.33	25	841107	0.08	0.02
10	841114	19.75	3783.4	0.35	*	841114	0.03	0.08
11	841121	10.55	2272.5	0.37	10	841121	0.06	0.03
12	841128	20.14	3694.5	0.52	9	841128	0.03	0.06
13	850227	0.00	0.0	0.00	168	850227	0.09	0.12
14	850306	6.39	1147.6	0.19	70	850306	0.08	0.09
15	850313	21.39	5230.0	0.07	*	850313	0.07	0.08
16	850320	4.90	653.1	*	*	850320	0.06	0.07

ZINC = 0.0607 +0.000529 ADP
R-SQUARED = 30.6 PERCENT

ZINC = 0.0772 - 0.243 PRZINC +0.000664 ADP
R-SQUARED = 38.3 PERCENT

ZINC = 0.0124 - 0.235 PRZINC + 0.00304 RF + 0.00102 ADP
R-SQUARED = 44.6 PERCENT

ZINC = 0.158 - 0.136 PRZINC -0.000020 RO + 0.0068 PFLOW
R-SQUARED = 28.9 PERCENT

ZINC = 0.0848 - 0.245 PRZINC -0.000002 RO +0.000623 ADP
R-SQUARED = 38.5 PERCENT

ZINC = 0.0834 - 0.253 PRZINC - 0.00398 PFLOW +0.000646 ADP
R-SQUARED = 39.6 PERCENT

ZINC = 0.155 - 0.126 PRZINC + 0.00096 RF -0.000023 RO + 0.0071 PFLOW
R-SQUARED = 29.3 PERCENT

ZINC = 0.0199 - 0.242 PRZINC + 0.00620 RF -0.000018 RO +0.000985 ADP
R-SQUARED = 52.7 PERCENT

ZINC = - 0.0421 - 0.270 PRZINC + 0.00683 RF - 0.0169 PFLOW + 0.00139 ADP
R-SQUARED = 58.0 PERCENT

ZINC = 0.0624 - 0.258 PRZINC +0.000006 RO - 0.0079 PFLOW +0.000775 ADP
R-SQUARED = 40.3 PERCENT

ZINC = - 0.0314 - 0.267 PRZINC + 0.00723 RF -0.000006 RO - 0.0143 PFLOW + 0.00132 ADP
R-SQUARED = 58.4 PERCENT

ZINC = - 0.0060 + 0.00316 RF +0.000904 ADP
R-SQUARED = 37.5 PERCENT

ZINC = 0.138 -0.000017 RO + 0.0063 PFLOW
R-SQUARED = 26.6 PERCENT

ZINC = 0.0658 -0.000001 RO +0.000501 ADP
R-SQUARED = 30.7 PERCENT

ZINC = 0.0648 - 0.00292 PFLOW +0.000513 ADP
R-SQUARED = 31.3 PERCENT

ZINC = 0.135 + 0.00130 RF -0.000023 RO + 0.0068 PFLOW
R-SQUARED = 27.4 PERCENT

ZINC = 0.0008 + 0.00623 RF -0.000017 RO +0.000867 ADP
R-SQUARED = 45.1 PERCENT

ZINC = - 0.0580 + 0.00662 RF - 0.0153 PFLOW + 0.00122 ADP
R-SQUARED = 48.7 PERCENT

ZINC = 0.0481 +0.000005 RO - 0.0059 PFLOW +0.000611 ADP
R-SQUARED = 31.8 PERCENT

ZINC = - 0.0448 + 0.00711 RF -0.000007 RO - 0.0122 PFLOW
+ 0.00114 ADP
R-SQUARED = 49.3 PERCENT

Table 7.63 cont'd.

TOTAL DATASET : Suspended Solids

ROW	DATE	RF	RO	PFLOW	ADP	DATES	SS	PRSS
1	840620	0.35	0.0	0.00	152	840620	21	0
2	840627	20.52	3738.0	4.41	86	840627	84	21
3	840704	0.00	0.0	0.00	168	840704	110	84
4	840711	0.00	0.0	0.00	168	840711	23	110
5	840718	21.19	1155.0	0.56	59	840718	24	23
6	840725	0.00	0.0	0.00	168	840725	29	24
7	841107	21.75	3571.1	1.02	25	841107	66	9
8	841114	19.75	2935.3	0.27	*	841114	30	66
9	841121	10.55	1672.0	0.26	10	841121	27	30
10	841128	20.14	2818.2	0.41	9	841128	141	27
11	850227	0.00	0.0	0.00	168	850227	87	27
12	850306	6.39	888.0	0.14	70	850306	81	87
13	850313	21.39	3578.9	0.06	*	850313	125	81
14	850320	4.90	611.4	*	*	850320	71	125
15	840620	0.35	0.0	0.00	152	840620	17	0
16	840627	20.52	3605.5	4.20	86	840627	28	17
17	840704	0.00	0.0	0.00	168	840704	50	28
18	840711	0.00	0.0	0.00	168	840711	21	50
19	840718	21.19	1173.7	0.68	59	840718	28	21
20	840725	0.00	0.0	0.00	168	840725	14	28
21	841107	21.75	3497.2	0.99	25	841107	26	44
22	841114	19.75	2891.0	0.26	*	841114	11	26
23	841121	10.55	1629.9	0.25	10	841121	26	11
24	841128	20.14	2797.2	0.42	9	841128	28	26
25	850227	0.00	0.0	0.00	168	850227	230	124
26	850306	6.39	884.1	0.15	70	850306	71	230
27	850313	21.39	3480.1	0.06	*	850313	124	71
28	850320	4.90	620.7	*	*	850320	48	124
29	840620	0.35	0.0	0.00	152	840620	9	14
30	840627	20.52	5441.9	6.68	86	840627	39	9
31	840704	0.00	0.0	0.00	168	840704	80	39
32	840711	0.00	0.0	0.00	168	840711	15	80
33	840718	21.19	1321.5	0.69	59	840718	21	15
34	840725	0.00	0.0	0.00	168	840725	9	21
35	841107	21.75	4756.8	1.33	25	841107	46	4
36	841114	19.75	3783.4	0.35	*	841114	17	46
37	841121	10.55	2272.5	0.37	10	841121	9	17
38	841128	20.14	3694.5	0.52	9	841128	45	9
39	850227	0.00	0.0	0.00	168	850227	361	85
40	850306	6.39	1147.6	0.19	70	850306	316	361
41	850313	21.39	5230.0	0.07	*	850313	332	316
42	850320	4.90	653.1	*	*	850320	288	332

Table 7.64

SS = 23.6 + 0.781 PRSS
R-SQUARED = 54.9 PERCENT

SS = 20.3 + 0.785 PRSS + 0.29 RF
R-SQUARED = 55.0 PERCENT

SS = 17.3 + 0.785 PRSS + 0.00368 RO
R-SQUARED = 55.3 PERCENT

SS = 23.3 + 0.817 PRSS + 2.05 PFLOW
R-SQUARED = 50.9 PERCENT

SS = 21.2 + 0.708 PRSS + 0.091 ADP
R-SQUARED = 38.8 PERCENT

SS = 21.7 + 0.770 PRSS - 1.46 RF + 0.0108 RO
R-SQUARED = 55.8 PERCENT

SS = 23.3 + 0.817 PRSS - 0.01 RF + 2.07 PFLOW
R-SQUARED = 50.9 PERCENT

SS = - 11.8 + 0.746 PRSS + 1.49 RF + 0.268 ADP
R-SQUARED = 39.6 PERCENT

SS = 20.5 + 0.809 PRSS + 0.00256 RO + 0.15 PFLOW
R-SQUARED = 51.1 PERCENT

SS = - 9.3 + 0.744 PRSS + 0.0090 RO + 0.255 ADP
R-SQUARED = 40.1 PERCENT

SS = 17.7 + 0.718 PRSS + 2.56 PFLOW + 0.103 ADP
R-SQUARED = 39.0 PERCENT

SS = 25.3 + 0.784 PRSS - 1.51 RF + 0.0106 RO - 1.20 PFLOW
R-SQUARED = 51.6 PERCENT

SS = - 14.3 + 0.749 PRSS + 0.42 RF + 0.0077 RO + 0.282 ADP
R-SQUARED = 40.2 PERCENT

SS = - 16.2 + 0.748 PRSS + 1.78 RF - 1.5 PFLOW + 0.296 ADP
R-SQUARED = 39.6 PERCENT

SS = - 39.2 + 0.752 PRSS + 0.0226 RO - 11.9 PFLOW + 0.447 ADP

R-SQUARED = 41.2 PERCENT

SS = - 56.9 + 0.768 PRSS + 1.14 RF + 0.0210 RO - 13.5 PFLOW + 0.546 ADP
R-SQUARED = 41.5 PERCENT

Table 7.64 cont'd.

TOTAL DATASET : Chemical Oxygen Demand

ROW	DATE	RF	RO	PFLOW	ADP	DATES	COD	PRCOD
1	840516	0.30	0.0	0.00	168	840516	43	119
2	840523	8.83	1335.6	0.36	134	840523	42	43
3	840620	0.35	0.0	0.00	152	840620	79	5
4	840627	20.52	3738.0	4.41	86	840627	351	79
5	840704	0.00	0.0	0.00	168	840704	666	351
6	840711	0.00	0.0	0.00	168	840711	139	666
7	840718	21.19	1155.0	0.56	59	840718	5	139
8	840725	0.00	0.0	0.00	168	840725	27	5
9	841107	21.75	3571.1	1.02	25	841107	64	60
10	841114	19.75	2935.3	0.27	*	841114	0	64
11	841121	10.55	1672.0	0.26	10	841121	0	0
12	841128	20.14	2818.2	0.41	9	841128	99	0
13	850227	0.00	0.0	0.00	168	850227	173	30
14	850306	6.39	888.0	0.14	70	850306	98	173
15	850313	21.39	3578.9	0.06	*	850313	35	98
16	850320	4.90	611.4	*	*	850320	113	35
17	840516	8.83	1310.1	0.35	134	840516	70	289
18	840523	14.90	2619.7	0.26	49	840523	42	70
19	840620	0.35	0.0	0.00	152	840620	34	10
20	840627	20.52	3605.5	4.20	86	840627	170	34
21	840704	0.00	0.0	0.00	168	840704	93	170
22	840711	0.00	0.0	0.00	168	840711	75	93
23	840718	21.19	1173.7	0.68	59	840718	11	75
24	840725	0.00	0.0	0.00	168	840725	49	11
25	841107	21.75	3497.2	0.99	25	841107	25	80
26	841114	19.75	2891.0	0.26	*	841114	51	25
27	841121	10.55	1629.9	0.25	10	841121	0	51
28	841128	20.14	2797.2	0.42	9	841128	0	0
29	850313	21.39	3480.1	0.06	*	850313	45	118
30	850320	4.90	620.7	*	*	850320	77	45
31	840516	8.83	1761.4	0.35	134	840516	64	16
32	840523	14.90	4006.6	0.38	49	840523	11	64
33	840620	0.35	0.0	0.00	152	840620	30	5
34	840627	20.52	5441.9	6.68	86	840627	46	30
35	840704	0.00	0.0	0.00	168	840704	144	46
36	840711	0.00	0.0	0.00	168	840711	75	144
37	840718	21.19	1321.5	0.69	59	840718	43	75
38	840725	0.00	0.0	0.00	168	840725	49	43
39	841107	21.75	4756.8	1.33	25	841107	30	70
40	841114	19.75	3783.4	0.35	*	841114	0	30
41	841121	10.55	2272.5	0.37	10	841121	0	0
42	841128	20.14	3694.5	0.52	9	841128	0	0
43	850306	6.39	1147.6	0.19	70	850306	93	76
44	850313	21.39	5230.0	0.07	*	850313	80	93

Table 7.65

COD = 65.4 + 0.380 PRCOD - 3.49 RF + 27.8 PFLOW
R-SQUARED = 28.4 PERCENT

COD = 57.4 + 0.384 PRCOD - 0.0179 RO + 29.8 PFLOW
R-SQUARED = 27.0 PERCENT

COD = - 13.7 + 0.352 PRCOD + 21.2 PFLOW + 0.515 ADP
R-SQUARED = 27.8 PERCENT

COD = 65.7 + 0.378 PRCOD - 3.08 RF - 0.0029 RO + 28.6 PFLOW
R-SQUARED = 28.5 PERCENT

COD = 15.1 + 0.356 PRCOD - 1.55 RF + 24.9 PFLOW + 0.345 ADP
R-SQUARED = 28.1 PERCENT

COD = 6.5 + 0.352 PRCOD - 0.0075 RO + 25.9 PFLOW + 0.395 ADP
R-SQUARED = 28.0 PERCENT

COD = 25 + 0.355 PRCOD - 1.27 RF - 0.0054 RO + 27.6 PFLOW + 0.289 ADP
R-SQUARED = 28.2 PERCENT

Table 7.65 cont'd

The results of the stepwise multiple regression analysis where the R-Squared value exceeds the 25% imposed threshold for each micro-catchment and the total dataset, are given in Tables 7.50 to 7.65. The equations are listed below and are preceded by a table of the data used to perform the regression analysis. The chemical parameters used as the dependent variable can be explained as follows:

BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Deman
SS	Suspended Solids
PHOS	Phosphate
ZINC	Zinc

The prefix PR before one of the chemical variables (eg. PRCOD etc.) defines another variable which is called the 'previous value'. For example, PRSS means the value for SS sampled in the previous week. The regression analysis therefore set out to compare the value of the given chemical parameter taken at one time with the value for the parameter measured the previous week and to relate it through the stepwise multiple regression procedure to the hydrological conditions prevalent during the intervening period (ie. in this case a period of one week). Another dependent variable was created for each of the chemical parameters which was prefixed by DIF. This stood for the 'difference' in the value of the parameter from one period of sampling to the next, and it was equal to the difference between the values measured one week to the previous week. This parameter was used to study the changes in pot liquor quality in relation to hydrological conditions rather than in terms of absolute values. The DIF parameters (eg. DIFSS which is the difference in suspended solids values from one week to the next) were only regressed with the

hydrological parameters in the multiple regression. It should also be noted that the DIF parameters may also assume negative values. All combinations of the independent variables were stepwise regressed with the dependent variables.

Table to Show the Number of Regression Equations whose R-Squared Value Exceeds 25% in the Multiple Regression Analysis.

	BOD	COD	SS	PHOS	ZINC
T2	0	12	6	34	24
C2	18	30	16	4	4
TW2	12	22	16	17	20
TOTAL	0	7	16	0	0

Table: 7.66

A number of regression equations were derived for each of the three micro-catchments and the total datasets for the five chemical determinands (see Table 7.66), whose R-Squared values were in excess of 25%. The equations with the highest R-Squared value for each parameter for each micro-catchment gave been highlighted with brackets in Tables 7.50 to 7.65. It is these regression equations which can be used as predictive tools in water quality studies. It is interesting to note that for the total dataset, only equations for SS and COD yielded R-Squared values in excess of 25%. The equations derived for the total dataset take on a more important role since they were calibrated on a larger number of observations and their more

widespread applicability is more likely. It was decided to test the equations with the highest R-Squared values for both SS and COD with known data. The equations used were as follows:

SS = 21.7 + 0.770 PRSS - 1.46 RF + 0.0108 RO

(see Table 7.64)

COD = 65.7 + 0.378 PRCOD - 3.08 RF - 0.0029 RO + 28.6 PFLOW .

(see Table 7.65)

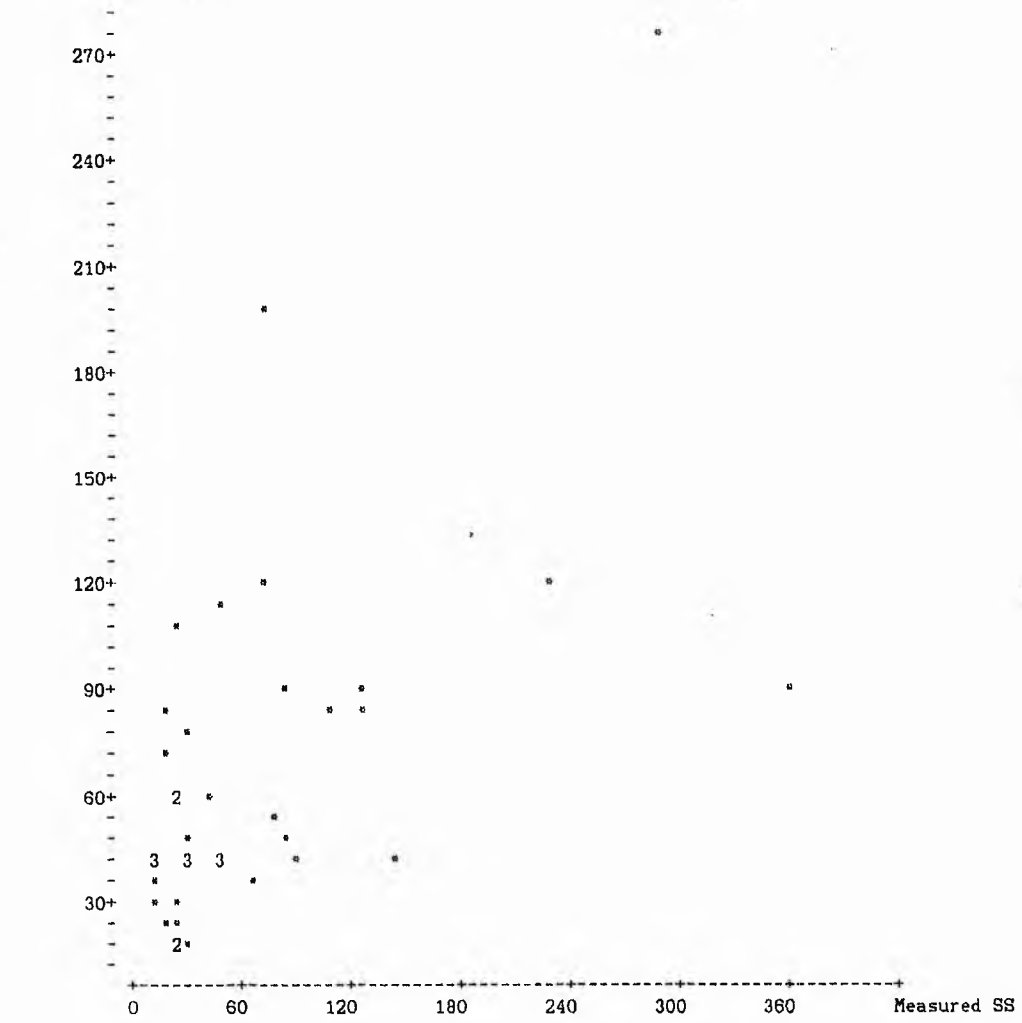
These two deterministic models may be used for predictive purposes and so the total dataset was used to predict values for both COD and SS based upon the previously recorded values and the hydrological conditions, prevalent in the micro-catchments during the intervening period. It was then possible to compare the predicted against the truly measured value and the results of this test run can be seen in Figures 7.322 to 7.325 and in Tables 7.64 to 7.65.

A plot of the predicted against the observed values should conform to a straight line relationship. Figures 7.322 and 7.323 show the deviation of the model from the ideal and Figures 7.324 to 7.325 show the predicted and the observed values plotted together on a common axis such that the residual values may be more closely observed vertically on the plot.

The value of the COD and the SS in the standing gully pot liquor at any one time is dependent upon a number of variables, but these

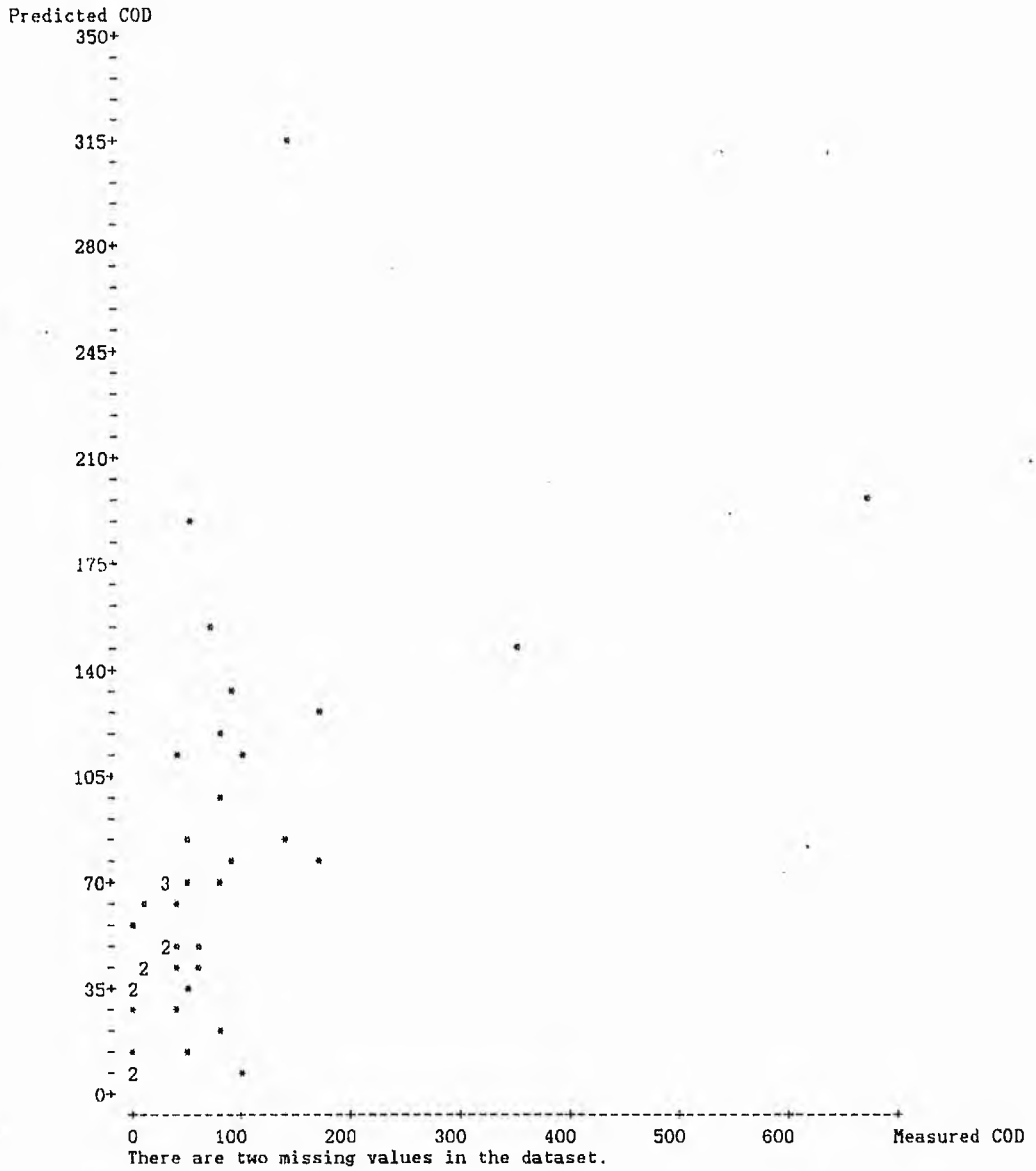
Graph of the Predicted SS Against the Measured SS Using The Model Derived for the Gully Pot Standing Liquor SS.

Figure 7.322



Graph of the Predicted COD Against the Measured COD Using The Model Derived for the Gully Pot Standing Liquor COD.

Figure 7.323



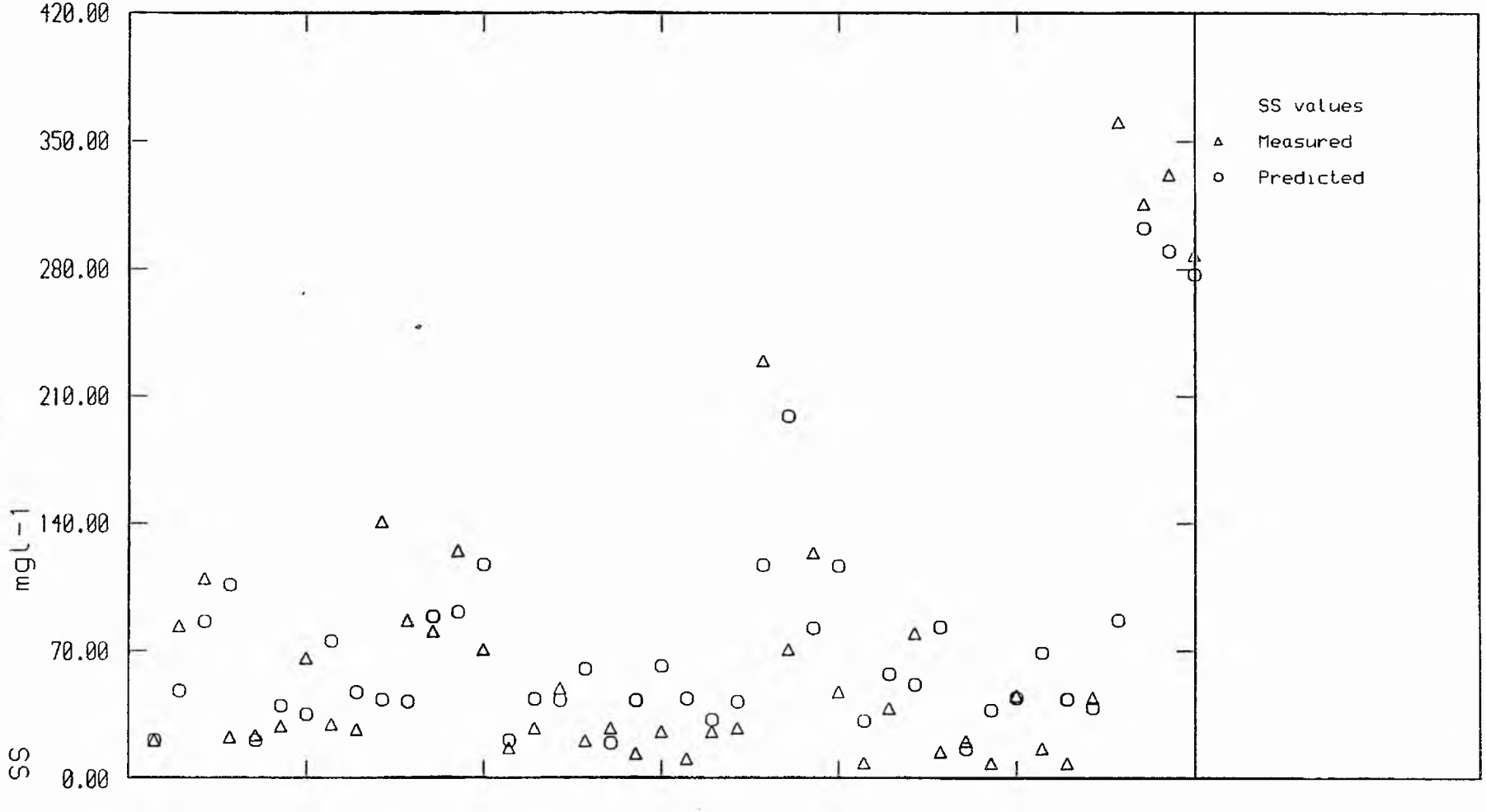


Figure 7.324

GRAPH OF THE PREDICTED AND MEASURED GULLY POT LIQUOR SUSPENDED SOLIDS CONCENTRATION

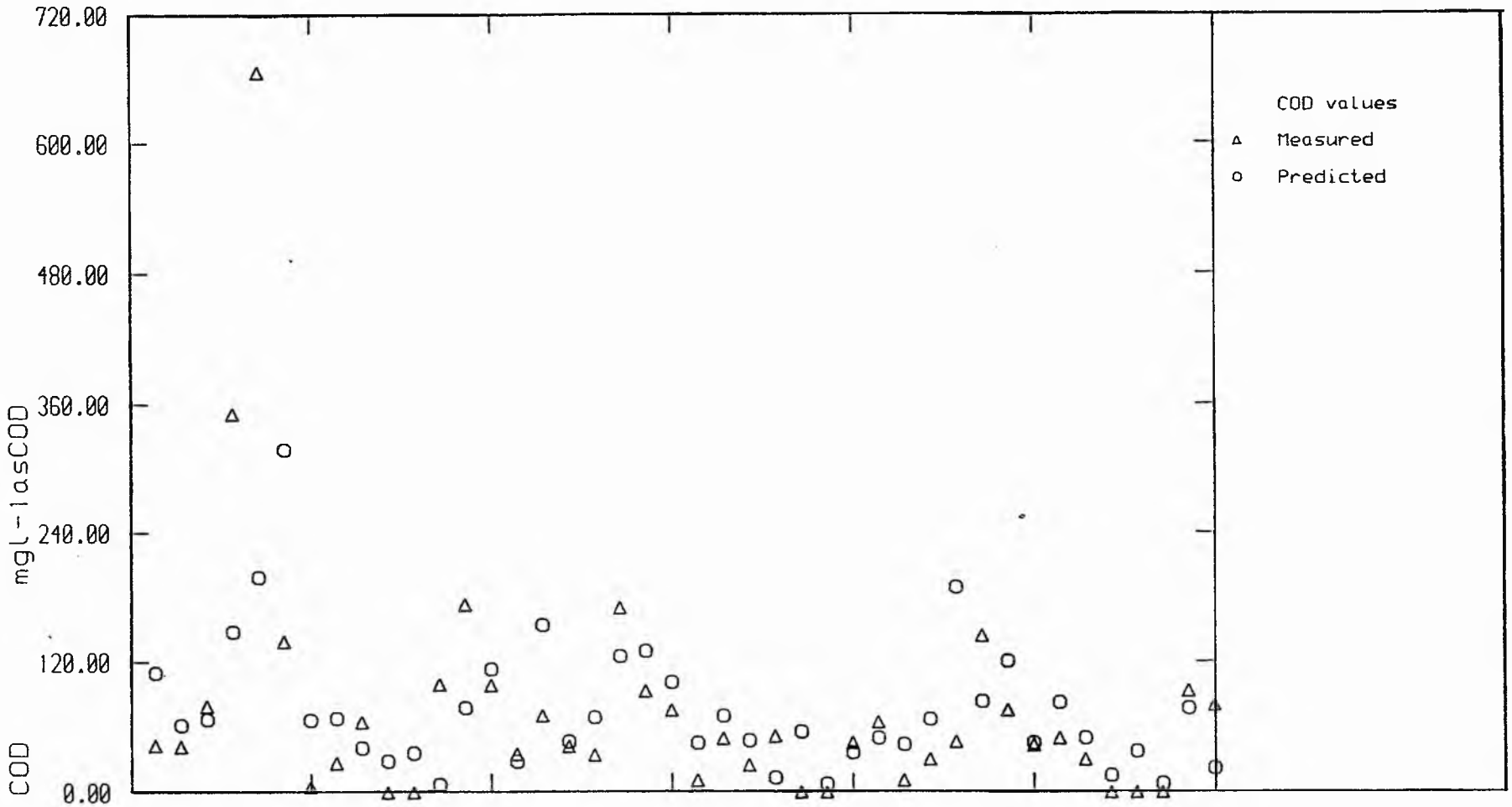


Figure 7.325

GRAPH OF THE PREDICTED AND MEASURED GULLY POT LIQUOR CHEMICAL OXYGEN DEMAND CONCENTRATION

deterministic relationships derived, do help to explain the importance of the previous value in the pot liquor and the hydrological processes operating within a micro-catchment area. The arbitrarily imposed 25% R-Squared value was selected because relationships derived deterministically with R-Squared values in excess of 25% were deemed to be significant relationships within environmental studies. The importance of the correlation coefficient and therefore the R-Squared value in water quality modelling has been discussed by Hemain (1986); Beck, Jowitt and Lumbers (1984); Beck and Van Straten (1983). Some of the very high R-Squared values obtained for some regression equations using the micro-catchment datasets, reflect local conditions or may be biased heavily by a limited number of observations in the stepwise multiple regression analysis. The models developed by the regression analysis on the total dataset have a wider application and it was quite surprising that of all the water quality determinand data used in the analysis, it was the COD and SS which produced the most meaningful statistical relationships. The development of models to predict SS and BOD would have the most widespread use within the modelling of surface water quality and so it was significant that models developed from the gully pot liquor monitoring programme were for SS and COD. The COD and BOD are usually closely related through a consistent ratio relationship. The unique relationships between COD and BOD for different types of natural waters can be used to translate the COD values into the equivalent measures of BOD. The ratio of COD:BOD for all the gully pot liquor analysis carried out was approximately 8:1.

The main conclusion to draw from this part of the research programme is that a number of deterministic models have been developed to

predict the concentration of certain determinand values (most notably SS and COD but also for BOD, Zinc and Phosphate) from knowledge of the previous values and the relationships of the chemical parameters with the prevailing hydrological conditions. The attainment of such high R-Squared values for field data collected under natural, environmental conditions has been a very encouraging aspect of the research programme. These deterministic models can be used to predict the state or condition of standing gully pot liquors at any particular time, so long as there is a measurement or realistic appreciation (through the use of well calibrated Rainfall-Runoff Models) of the hydrological conditions. The regression models have been derived from hydrological variables (namely total rainfall, total runoff, peak flow intensity into the gully pot and the antecedent dry period) which are all determinands which are fairly easy to measure. Some previous research work in France (Desbordes et al 1983. [see Chapter 3]) used parameters such as the maximum five minute rainfall intensities, which although valuable hyrological parameters describing the processes at work, are difficult to measure and involve a more detailed rainfall data collection programme.

It has already been stated that a general "Stormwater Quality Discharge Model" should incorporate both above-ground and below-ground phases and the regression equations presented above can be put forward as extremely useful components in the development of an above-ground phase model of stormwater quality. It is important to note, however, that the deterministic equations developed are used to predict the determinand concentration of the pot liquor in its quiescent state. It is envisaged that this process is the starting point of an above-ground phase sub-model which predicts the state of a number of gully pot liquors on a given storm sewer network and the quality of

such liquors can be routed through the system during a rainfall event to provide the input data to a below-ground phase which in itself would influence the resultant water quality to give an overall appreciation of stormwater discharge quality at the stormwater outfall. The "Stormwater Quality Discharge Model" is made up of a number of interrelated components and it can be postulated that a large number of research studies will be needed to provide sufficient data and understanding to calibrate such individual component models. These views have been discussed by Grottker (1986). The development of the deterministic models in this research study, should be seen as a contribution towards the task of the prediction of the standing pot liquor quality in any gully pot at any time to within a reasonable degree of confidence.

The two most important water quality parameters used in surface water quality modelling are SS and BOD. It is for this reason that special attention was given to these two parameters in order to investigate the range of their concentrations in the gully pot liquor and to study the temporal and spatial distributions of SS and BOD concentrations. It was readily observed that both the SS and the BOD concentrations varied a great deal and there was little evidence of seasonal influences within the data. The SS values would themselves be influenced by a variety of solids sources within the urban catchment and these sources would be dependent upon seasonality factors in many cases eg. leaf fall, grass cuttings etc., but it seems that a number of factors relating to the provision of the solids, as a source of SS supply and the kinematic sediment deposition/transport mechanisms can act synergistically and antagonistically to dampen any true seasonal influence. The plots of SS over the one year period for the gully pot liquors exemplify this point. Pratt, Elliott and Fulcher (1986)

collected together SS data over a ten year period from various studies carried out on the Clifton Grove Housing Estate in Nottingham, which were all part of the Storm Drainage Research Group Projects based at the Trent Polytechnic in Nottingham. Figure 7.326 is taken from Pratt, Elliott and Fulcher (1986) and it shows the SS concentrations in gully pot liquors in mgl-1 against the month in which the sample was collected. Peaks were observed in the months of February, June and November and the reasons why these peaks occurred are outlined in the paper. The sources of solids supply to the individual gully pots is of paramount importance and the factors of seasonality help to explain this. Figure 7.326 also reflects the great variability in the SS data within any one month for gully pots which are all in close proximity. It seems that the "Gully Liquor Monitoring Programme" did not reveal any true seasonal effects in the SS nor the BOD data but the results reported over the ten year period (Pratt, Elliott and Fulcher 1986) do infer some periods of the year when the SS values in the pot liquor are higher. The lack of seasonality though does make it easier to model these parameters, since there is no need for a "seasonality index" or change in the coefficient changes to accommodate the time of year, as found in some other water quality models. The deterministic models derived, therefore can be regarded as "General Models" and the close relationship between the COD and the BOD means that the COD values can be treated in a similar way. Figures 7.327 and 7.328 show the ranges found for the SS and the BOD in the gully pot liquors. The high variability in these ranges between the twelve pots under study means that such concentrations are difficult to model but the deterministic approach has proved to be reasonably successful in this case.

Data combined from studies over several years showing the variation in suspended solids concentration in highway gully pot liquors

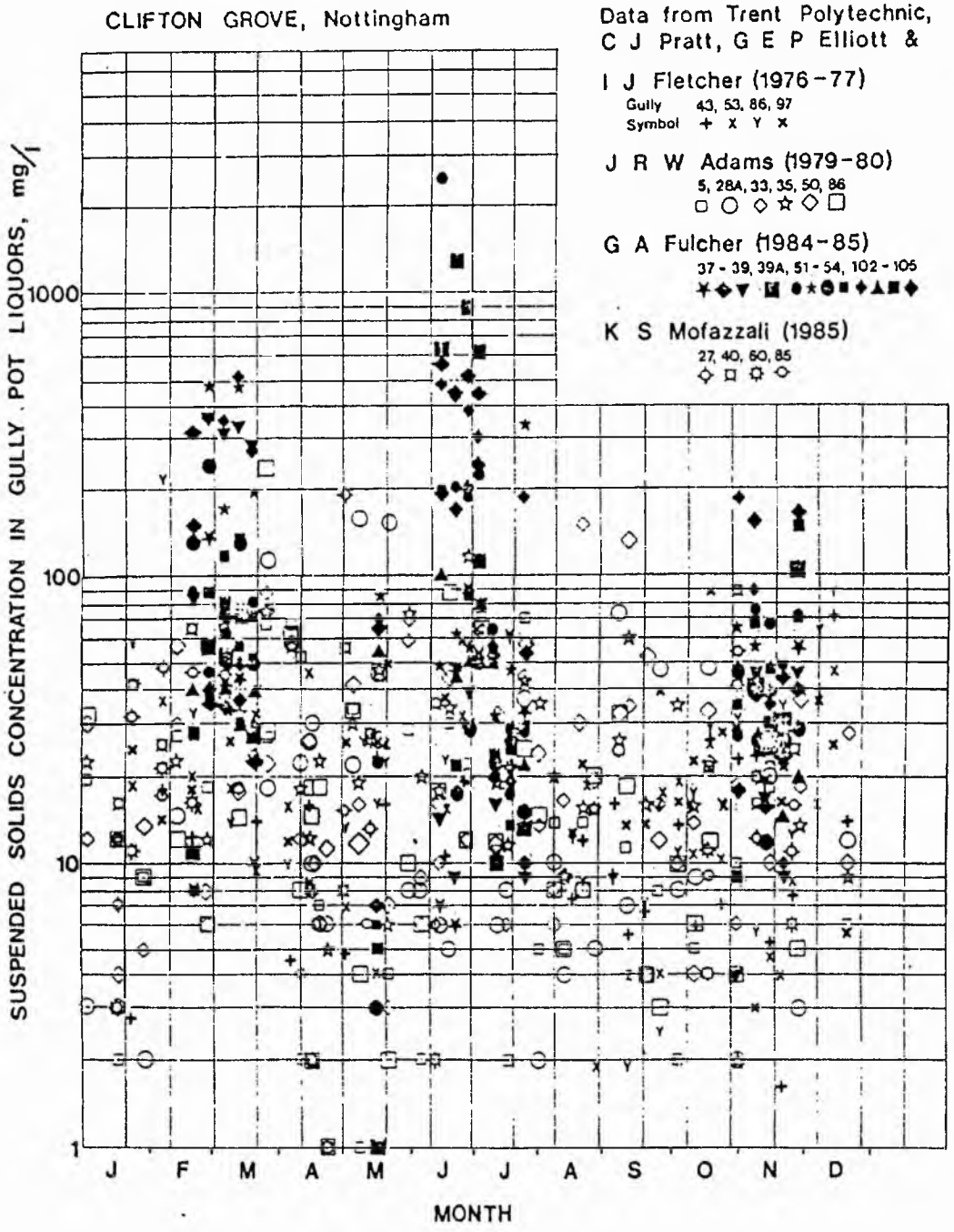


Figure 7.326 Pratt, Elliott and Fulcher (1987)

Diagram to Show the Distribution of Suspended Solids Values for all Twelve Gully Pots and the Total Dataset.

Figure 7.327

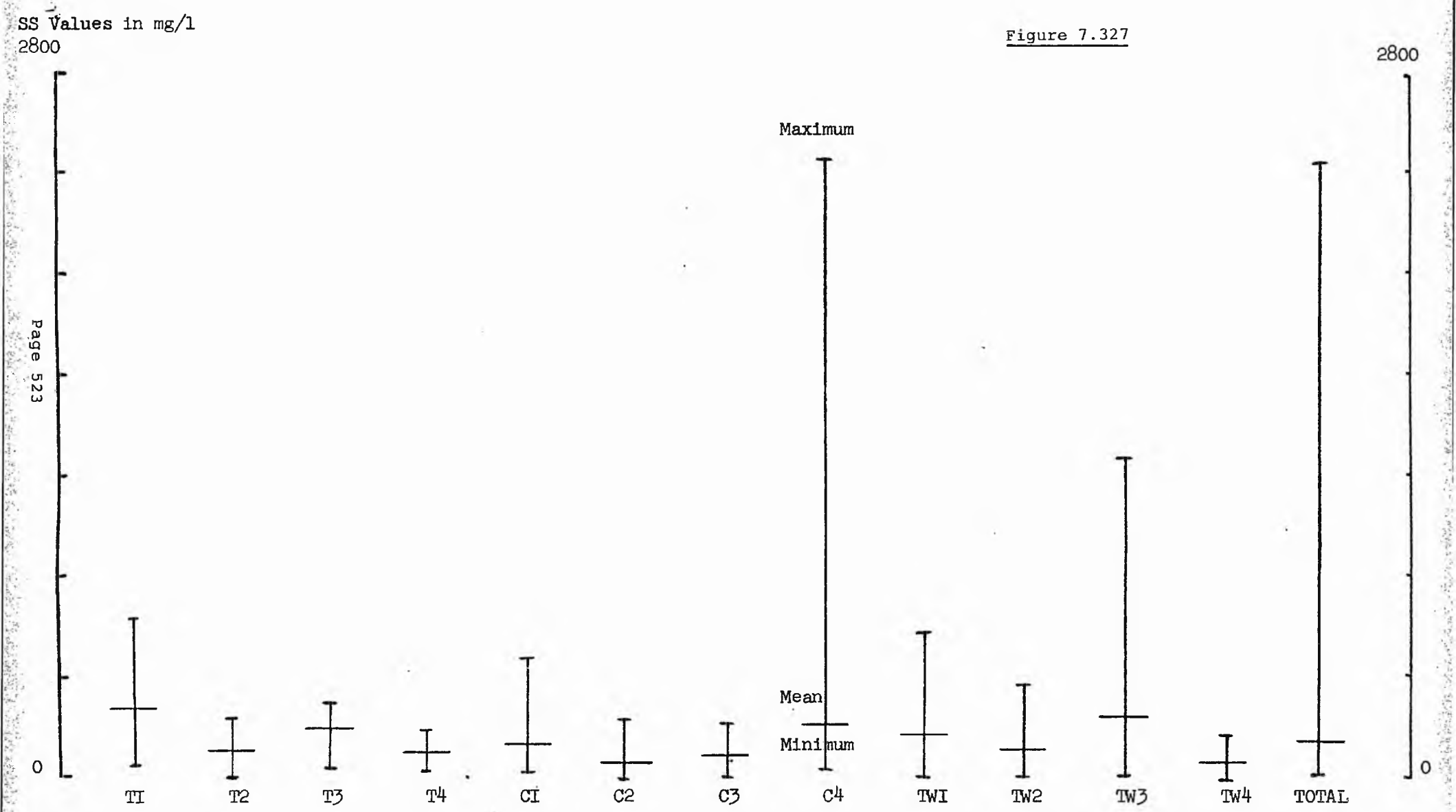


Diagram to Show the Distribution of BOD Values for all Twelve Gully Pots and the Total Dataset.

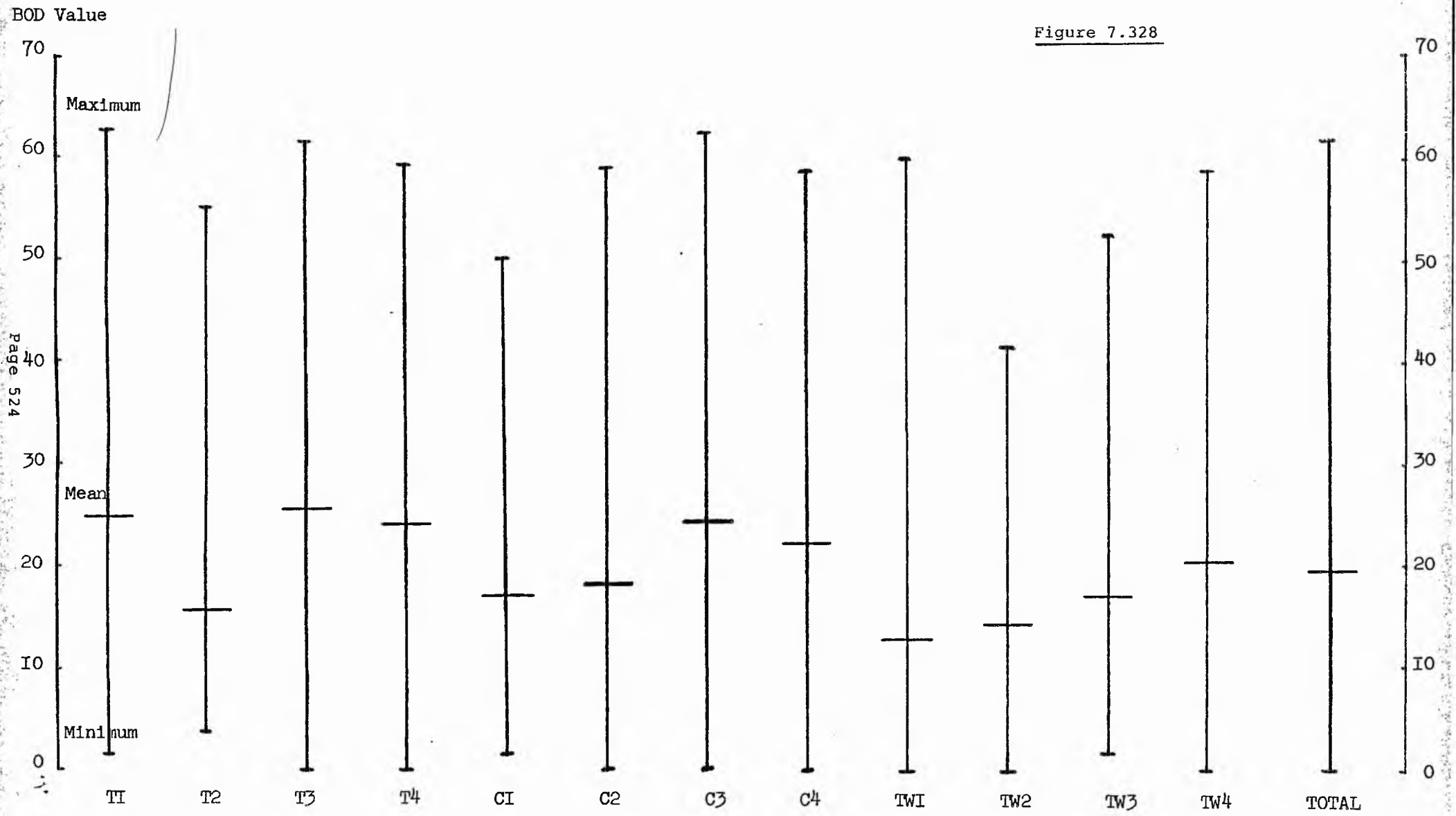


Figure 7.328

7.18 Students t Test Statistical Analysis.

Table 7.45 shows the complete range of values for all the twenty-six physiochemical parameters under study in the research programme. The total dataset is comprised of the data collected from all the twelve individual gully pots and a statistical test was carried out to see if there was any significant difference between the values for each of the twenty-six parameters on each sub-catchment area (ie. each group of four gully pots). A two sample Students t test was carried out using the null hypothesis that there is no significant difference at the 5% significance level between the two datasets.

Table 7.67 gives the values for the t test statistic. An asterisk marks the t values where the 5% significane level is exceeded and the null hypothesis is rejected. The results in Table 7.67 clearly show that in general there was no significant difference between the values from the three sub-catchments for the majority of the water quality parameters. The notable exceptions are for COD, phosphate and zinc and one may infer from these statitical tests that local factors (ie. local sources) are operating within the sub-catchment areas (or in some cases within a single micro-catchment area which severely biases the data), such as to biase the data so that a statistical test designed to show that the datasets are from a common parent population, has failed and the connection between the datasets is rejected against a certain degree of significance.

The Equation for the Two-Sample Students t Test.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

where:

$\bar{x}_1$ is the mean value of sample one.
$\bar{x}_2$ is the mean value of sample two.
s_1 is the standard deviation of sample one.
s_2 is the standard deviation of sample two.
n_1 is the number of samples in sample one.
n_2 is the number of samples in sample two.
t is the test statistic.

At the 5% significance level or the 95% confidence level, the value for the test statistic t for an infinite number of samples is t=1.96.

Values for the t test Statistic in the Two Sample t test Analysis of the Gully Pot Standing Liquor Water Quality from the Three Sub-catchments under study on the Clifton Grove Estate, Nottingham.

Table 7.67

Parameter	Test Analysis between:		
	Tame/Churnet	Tame/Twyford	Churnet/Twyford.
Temperature	0.17	0.29	0.12
Dissolve Oxygen	1.03	0.43	0.61
pH	0.63	0.54	0.16
Alkalinity	1.80	1.87	0.14
Total Hardness	0.16	0.85	0.67
Conductivity	0.00	0.92	0.90
SS	0.03	0.36	0.23
BOD	1.09	2.38 (*)	1.32
COD	3.11 (*)	4.26 (*)	2.43 (*)
Phosphate	2.73 (*)	3.94 (*)	1.35
Chloride	0.27	0.73	0.96
Sulphate	0.27	0.79	0.54
Ammonia	1.17	0.76	0.38
Nitrate	0.66	0.14	0.57
Sodium	0.40	2.41 (*)	1.69
Potassium	0.05	0.15	0.20
Iron	0.46	1.06	0.98
Lead	1.03	0.63	1.70
Calcium	0.40	0.19	0.61
Magnesium	0.14	0.45	0.30
Zinc	2.32 (*)	4.33 (*)	1.30
Manganese	0.18	0.64	0.75
Copper	0.75	1.18	2.15 (*)
Cadmium	0.18	1.47	1.67
Nickel	0.26	1.34	1.13
Chromium	0.71	1.10	1.83

NOTE: (*) means that the t value exceeds the value of t=1.96 which is the 5% significance level for the null hypothesis.

7.19 Log-Normal Distributions in the Gully Pot Standing Liquor.

A general review of the data derived in the standing pot liquor analysis reveals that some water quality parameters show a great deal of variation in their concentration both within one gully pot (ie. one micro-catchment) and between micro-catchments over a one year period. Table 7.45 shows the range of values observed in the Total Dataset (from all twelve gully pots) and Figures 7.10 to 7.321 show the temporal variation of the parameters within a single gully pot system. Some of the chemical parameters such as Sodium, Chloride, Conductivity, Cadmium, Nickel, Chromium and Copper showed a marked seasonal variation which makes them more difficult to model unless a "seasonality factor" is included in such a model. The influence of these parameters over a general time period is also more difficult to assess since their strict absence or presence in the gully pot liquor (in most cases) is directly related to the time of the year. Other parameters showed greater fluctuations in their concentration or magnitude throughout the one year period whereby no seasonal trend could be readily detected. This was particularly evident for the BOD and the SS analyses. The BOD and SS take on a greater degree of significance within the whole dataset because of their inclusion in the "Royal Commission Standards on Sewage Disposal to Watercourses", which express the quantity of effluent discharges in terms of the BOD and the SS. The analysis of sewage discharges and subsequent river water analysis therefore has evolved through an appreciation of the BOD and the SS concentrations which are taken to be indicative of the general quality condition of surface waters. Most river water quality classifications are based on the BOD and the SS.

It has already been stated that there is a need to be able to predict the quality of the gully pot liquor at a given time in order to run a simulation to predict the quality of an urban stormwater discharge from a separately-sewered catchment area. Results have already been presented from the deterministic modelling approach whereby the concentration of certain water quality parameters can be predicted from the hydrological conditions prevailing within the catchment area over a given period of time. Some of the deterministic models presented also had variables relating to previous measurements of the quality parameter at a given time. This is the "deterministic approach" whereby a relationship of "cause and effect" is obtained such that a change in the input characteristics would be reflected in a change in the output parameter. The dependent variable is influenced by the series of independent variables expressed in the model. An alternative approach to this type of modelling is to adopt a "probabilistic model" whereby the outcome of a particular process may be subject to random influences from both an internal and an external environment. In such a methodology, it is only possible to assess the probable behaviour of a system since the effect of random variations or influences can not be predicted with any degree of accuracy (eg. the dumping of pollutants within a catchment area). In general, a probabilistic system is one in which stochastic processes dominate and it is not certain what the outcome will be from a specified input or set of inputs. The predicted outcome in a probabilistic model can only be described within a given set of limits (which is defined by the size and accuracy of the dataset from which it was calibrated). The collection of field data is a process whereby the results merely reflect a snapshot of the environmental system at a given time and the extent to which the dataset represents the

environmental system is indicative of the extent to which such a probabilistic model may be applied.

The probabilistic modelling approach is best suited to a parameter which is highly variable but it must conform to a distribution to which probability theory can be applied. The value of the parameter at any particular time may be influenced by a number of internal and external forces, but the values obtained over a given time period may themselves conform to a distribution to which normal probability theory can be applied. Such a model can therefore predict a given value for the parameter with a known certainty of occurrence, most usually expressed as a "probability".

It was decided to test probabilistic models for the BOD and the SS parameters for the gully pot standing liquor as an alternative means of describing the state of the pot liquor in terms of the BOD and the SS at any given time. The BOD and SS data showed a great deal of variation both spatially and temporally and were thus ideal datasets on which to obtain a "probabilistic model" (see Figures 7.327 and 7.328). A frequency histogram was drawn up and plotted for both the BOD and the SS data for all three sub-catchments and it was evident that these distributions did not conform to the "Gaussian Curve" or "Normal Distribution Curve". In such cases, it is usual to transform the data such that a close approximation to the normal distribution can be obtained so that probability theory can be applied to the transformed data and the relationships can be described in terms of the transformed data parameters. A number of previous studies have recognised the importance of the "log-normal distribution" in water quality studies for mathematical modelling work (Bender and Terstriep 1984; Beck, Jowitt and Lumbers 1984; Ellis and Harrop 1984; Pratt

and Adams 1981; Hemain 1986). The "log-normal distribution" can be defined in its simplest form as the distribution of a variate whose logarithm obeys the normal law of probability. It is sometimes referred to as the "Galton-McAlister Distribution" and it is a fundamental distribution in statistics, as is the normal distribution.

The use of the graphical approach of plotting data on probability log paper can hardly be regarded as a vigourous statistical test of log-normality, although its value lies in the fact that it is a quick method of judging whether or not the sample data may feasibly be log-normally distributed. The log-normal distribution has gained increasing use in many subjects and some examples of its application in water quality studies have been reviewed by Bender and Terstriep (1983); Beck, Jowitt and Lumbers (1984); Ellis in Torno, Marsalek and Desbordes (1986). An analysis was carried out to determine whether the transformed data conformed to a log-normal distribution. This analysis was carried out on the BOD and the SS data for each of the three sub-catchment areas under study and on the total dataset (derived by concatenating the three sub-catchment datasets). The analysis involved listing the data points in ascending order and then log-transforming the data (to base ten) to give the transformed log values. It should be noted that a zero value can not be expressed as a log value and so all zero values were deleted from the datasets. There are two ways of expressing a normal probability plot:

1. to plot the raw data on probability paper. The raw (untransformed) data can be plotted on log probability paper or the log values (transformed) data can be plotted on normal probability paper.

2. to plot the log values (transformed data) against the "NSCORE" value of the raw data value. The NSCORE is called the "normal score" and can be expressed as:

$$NSCORE = \frac{x - \bar{x}}{\sigma}$$

where:

x = data value.
$\bar{x}$ = mean value of the distribution.
σ = standard deviation of the distribution.

In each case, if the points on the plot fall roughly as a straight line we can say that the sample data form a normal population or in this case a log-normal distribution. The visual impact of such a plot can lead with experience, to a justification that the distribution is normal or log-normal, but the "straightness" of the line on the probability plot can be measured statistically through the "Shapiro-Wilk Test". This test measures the correlation coefficient between the raw data (ie. the log value) and the NSCORE value. A very high correlation is consistent with normality so that we can statistically reject the hypothesis of normality if the correlation falls below the appropiate value in the look-up table (see Table 7.68).

Simplified Table of the Correlation Coefficient Values at the 5% Significance Level for the Shapiro-Wilk Test.

Number of Values	Correlation Coefficient.
5	0.8804
10	0.9180
20	0.9503
30	0.9639
40	0.9715
50	0.9764
60	0.9799
>75	0.9835

Table: 7.68 (Ryan et al 1985).

The procedure adopted was to test for a log-normal distribution by plotting the log value of the BOD and SS quality data against the NSCORE value (see Tables 7.69 to 7.76 and Figures 7.329 to 7.336). These Figures show the straightness of the probability plots and the numerical values on the plot represent a repeated value (ie. a 3 means that three values should be represented at this point on the plot). A + symbol shows that there are more than nine values to be represented at this point. A regression analysis was carried out for the BOD and the SS data in order to determine the equation of the probability relationship and a correlation coefficient was calculated and was compared with the value in Table 7.68, in order to perform the Shapiro-Wilk Test. The aim of the test was to accept or reject the hypothesis that the data conformed to a log-normal distribution at the 5% significance level. The results of these regression and correlation analyses are given below. All the correlation coefficients calculated for the various distributions were used in the Shapiro-Wilk Test in order to determine whether the distributions conformed to a log-normal distribution at the 5% significance level.

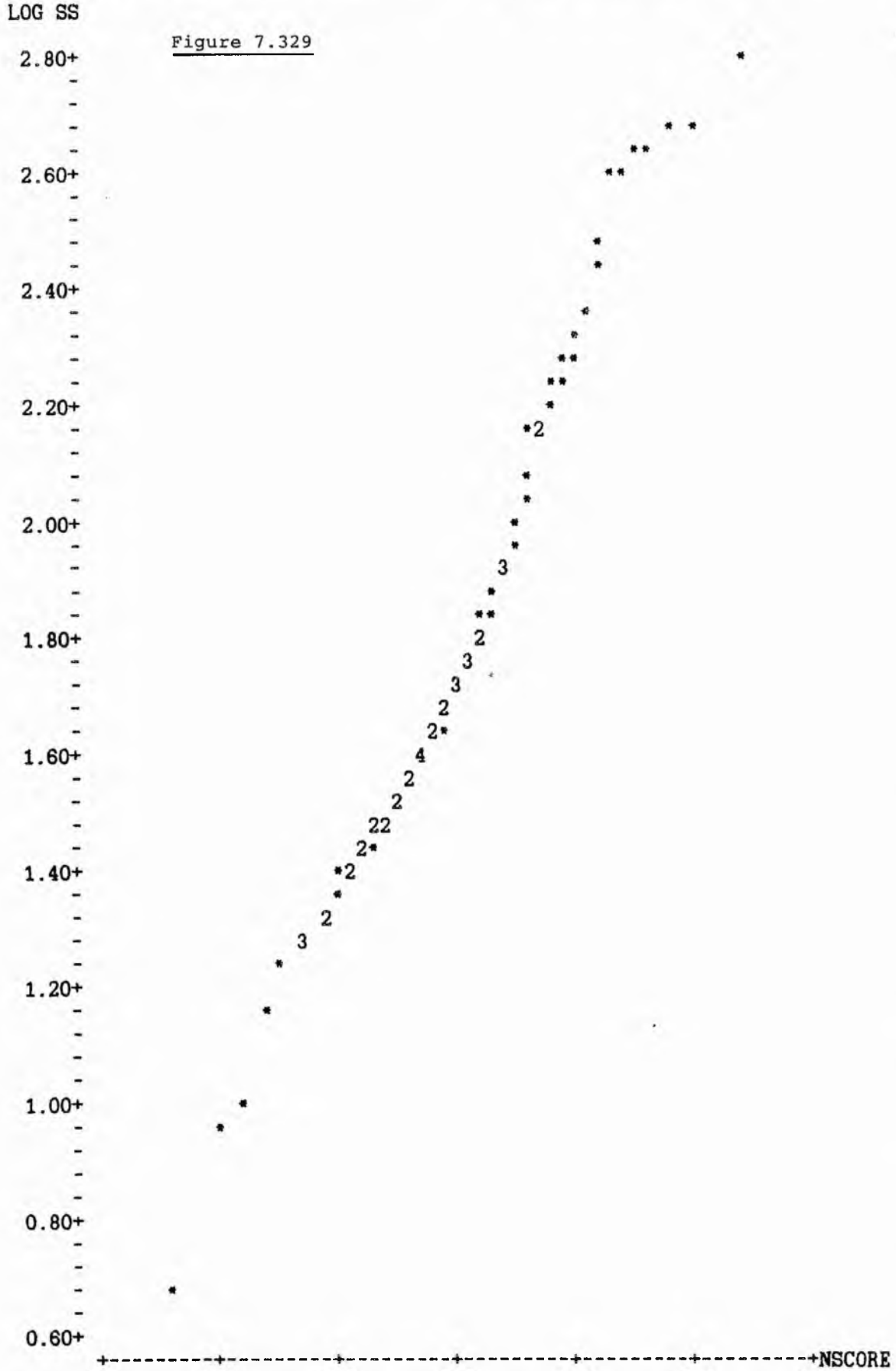
Table of Data for the Log-Normal Distribution Plots for all Suspended Solids (SS) Determinations for all Four Gully Pots on the Tame Close Sub-catchment.

Table 7.69

No.	SS	LOG SS	NSCORE
1	5	0.69897	-2.37398
2	9	0.95424	-2.00208
3	10	1.00000	-1.79134
4	14	1.14613	-1.63834
5	18	1.25527	-1.51591
6	19	1.27875	-1.32244
7	19	1.27875	-1.32244
8	19	1.27875	-1.32244
9	21	1.32222	-1.13435
10	21	1.32222	-1.13435
11	23	1.36173	-1.03860
12	24	1.38021	-0.97976
13	26	1.41497	-0.89743
14	26	1.41497	-0.89743
15	27	1.43136	-0.79640
16	27	1.43136	-0.79640
17	28	1.44716	-0.72575
18	29	1.46240	-0.65862
19	29	1.46240	-0.65862
20	30	1.47712	-0.57353
21	30	1.47712	-0.57353
22	34	1.53148	-0.49249
23	34	1.53148	-0.49249
24	36	1.55630	-0.43384
25	38	1.57978	-0.39558
26	39	1.59106	-0.33928
27	39	1.59106	-0.33928
28	40	1.60206	-0.26585
29	40	1.60206	-0.26585
30	43	1.63347	-0.19386
31	43	1.63347	-0.19386
32	45	1.65321	-0.14056
33	49	1.69020	-0.10527
34	50	1.69897	-0.07010
35	52	1.71600	-0.03503
36	53	1.72428	0.01751
37	53	1.72428	0.01751
38	55	1.74036	0.07010
39	56	1.74819	0.10527
40	57	1.75587	0.14056
41	64	1.80618	0.17604
42	66	1.81954	0.21175
43	69	1.83885	0.24773
44	71	1.85126	0.28405
45	77	1.88649	0.32076
46	81	1.90849	0.35791
47	84	1.92428	0.39558
48	87	1.93952	0.43384
49	90	1.95424	0.47276
50	98	1.99123	0.51242
51	110	2.04139	0.55293
52	125	2.09691	0.59438
53	141	2.14922	0.63691
54	144	2.15836	0.68064
55	147	2.16732	0.72575
56	159	2.20140	0.77241
57	166	2.22011	0.82085
58	180	2.25527	0.87133
59	184	2.26482	0.92417
60	192	2.28330	0.97976
61	201	2.30320	1.03860
62	230	2.36173	1.10130
63	268	2.42813	1.16870
64	305	2.48430	1.24189
65	390	2.59106	1.32244
66	409	2.61172	1.41260
67	432	2.63548	1.51591
68	455	2.65801	1.63834
69	459	2.66181	1.79134
70	484	2.68485	2.00208
71	610	2.78533	2.37398

Graph to Show the Log-Normal Distribution Plot of all Suspended Solids (SS) Determinations in the Gully Pot Standing Liquor for the Four Gully Pots on The Tame Close Sub-catchment.

Figure 7.329



CORRELATION OF LOG SS AND NSCORE = 0.988

LOG SS = 1.80 + 0.462 NSCORE

Table of Data for the Log-Normal Distribution Plots for all Suspended Solids (SS) Determinations for all Four Gully Pots on The Churnet Close Sub-catchment.

Table 7.70

No.	SS	LOG SS	NSCORE
1	3	0.47712	-2.37398
2	6	0.77815	-2.00208
3	8	0.90309	-1.79134
4	10	1.00000	-1.63834
5	11	1.04139	-1.51591
6	13	1.11394	-1.41260
7	14	1.14613	-1.32244
8	17	1.23045	-1.16870
9	17	1.23045	-1.16870
10	17	1.23045	-1.16870
11	21	1.32222	-1.00874
12	21	1.32222	-1.00874
13	22	1.34242	-0.92417
14	26	1.41497	-0.82085
15	26	1.41497	-0.82085
16	26	1.41497	-0.82085
17	27	1.43136	-0.70302
18	27	1.43136	-0.70302
19	28	1.44716	-0.57353
20	28	1.44716	-0.57353
21	28	1.44716	-0.57353
22	28	1.44716	-0.57353
23	30	1.47712	-0.47276
24	32	1.50515	-0.43384
25	34	1.53148	-0.39558
26	37	1.56820	-0.35791
27	40	1.60206	-0.32076
28	44	1.64345	-0.28405
29	46	1.66276	-0.22970
30	46	1.66276	-0.22970
31	47	1.67210	-0.14056
32	47	1.67210	-0.14056
33	47	1.67210	-0.14056
34	48	1.68124	-0.07010
35	49	1.69020	-0.01751
36	49	1.69020	-0.01751
37	50	1.69897	0.03503
38	52	1.71600	0.07010
39	53	1.72428	0.10527
40	55	1.74036	0.14056
41	56	1.74819	0.19386
42	56	1.74819	0.19386
43	62	1.79239	0.26585
44	62	1.79239	0.26585
45	63	1.79934	0.32076
46	64	1.80618	0.35791
47	66	1.81954	0.39558
48	70	1.84510	0.45321
49	70	1.84510	0.45321
50	71	1.85126	0.51242
51	75	1.87506	0.55293
52	81	1.90849	0.59438
53	82	1.91381	0.63691
54	84	1.92428	0.68064
55	88	1.94448	0.72575
56	90	1.95424	0.77241
57	112	2.04922	0.82085
58	116	2.06446	0.87133
59	124	2.09342	0.95159
60	124	2.09342	0.95159
61	167	2.22272	1.03860
62	184	2.26482	1.10130
63	195	2.29003	1.16870
64	199	2.29885	1.24189
65	202	2.30535	1.32244
66	227	2.35603	1.41260
67	230	2.36173	1.51591
68	333	2.52244	1.63834
69	479	2.68034	1.79134
70	482	2.68305	2.00208
71	2449	3.38899	2.37398

Graph to Show the Log-Normal Distribution Plot of all Suspended Solids (SS) Determinations in the Gully Pot Standing Liquor for the Four Gully Pots on The Churnet Close Sub-catchment.

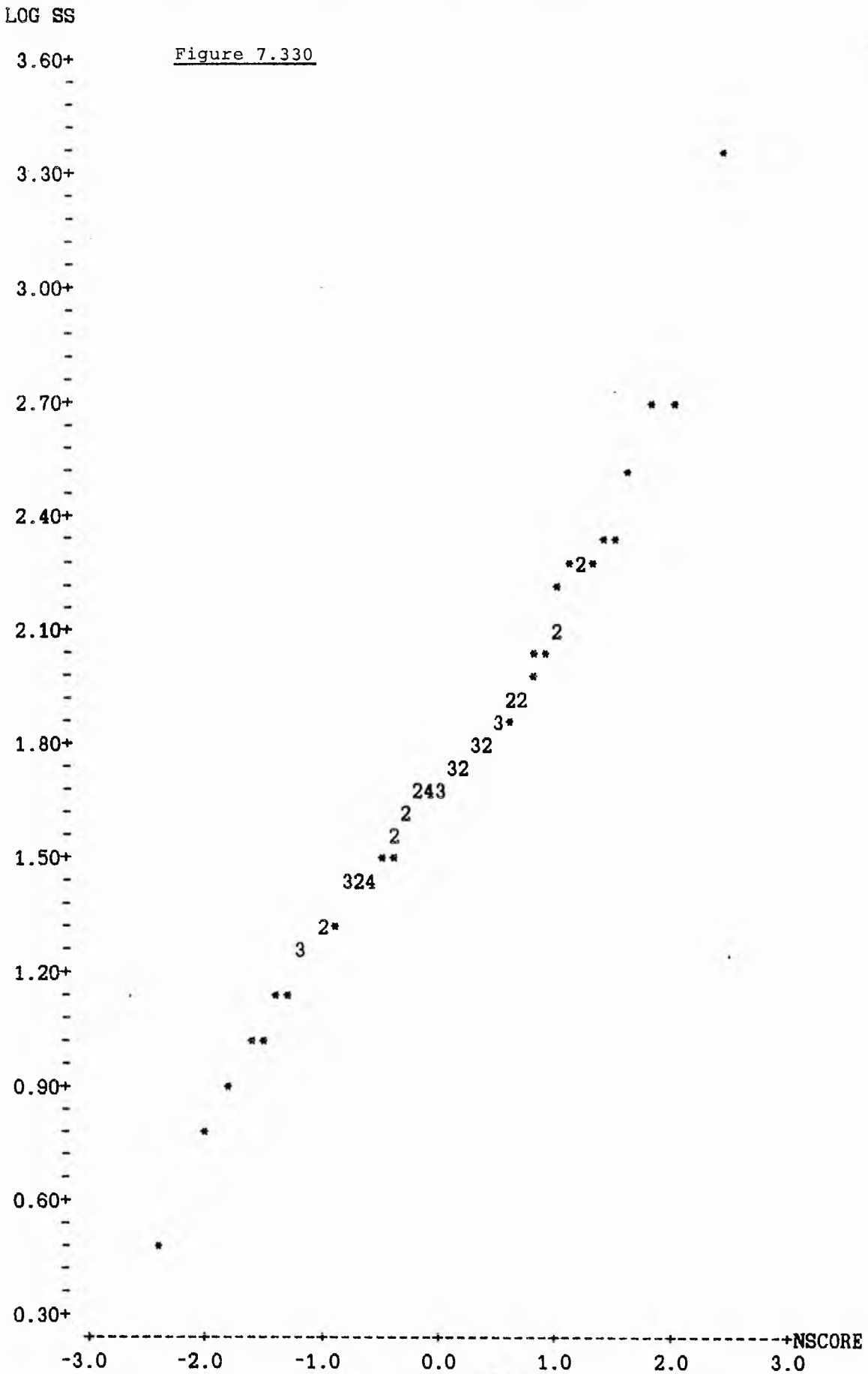


Figure 7.330

Table of Data for the Log-Normal Distribution Plots for all Suspended Solids (SS) Determinations for all Four Gully Pots on The Twyford Gardens Sub-catchment.

Table 7.71

No.	SS	LOG SS	NSCORE
1	1	0.00000	-2.35843
2	4	0.60206	-1.98391
3	6	0.77815	-1.77150
4	7	0.84510	-1.55246
5	7	0.84510	-1.55246
6	8	0.90309	-1.38925
7	9	0.95424	-1.21663
8	9	0.95424	-1.21663
9	9	0.95424	-1.21663
10	10	1.00000	-1.01068
11	10	1.00000	-1.01068
12	10	1.00000	-1.01068
13	11	1.04139	-0.86737
14	11	1.04139	-0.86737
15	13	1.11394	-0.78950
16	14	1.14613	-0.74019
17	15	1.17609	-0.66947
18	15	1.17609	-0.66947
19	17	1.23045	-0.60201
20	18	1.25527	-0.55856
21	19	1.27875	-0.51617
22	20	1.30103	-0.47470
23	21	1.32222	-0.43405
24	22	1.34242	-0.37441
25	22	1.34242	-0.37441
26	23	1.36173	-0.31610
27	24	1.38021	-0.27784
28	25	1.39794	-0.23999
29	27	1.43136	-0.20250
30	28	1.44716	-0.16530
31	29	1.46240	-0.12833
32	30	1.47712	-0.09153
33	33	1.51851	-0.05487
34	35	1.54407	-0.01828
35	37	1.56820	0.01828
36	38	1.57978	0.05487
37	39	1.59106	0.09153
38	40	1.60206	0.14679
39	40	1.60206	0.14679
40	41	1.61278	0.20250
41	43	1.63347	0.23999
42	45	1.65321	0.27784
43	46	1.66276	0.31610
44	50	1.69897	0.37441
45	50	1.69897	0.37441
46	52	1.71600	0.43405
47	54	1.73239	0.47470
48	55	1.74036	0.53724
49	55	1.74036	0.53724
50	62	1.79239	0.60201
51	70	1.84510	0.64665
52	80	1.90309	0.69265
53	85	1.92942	0.74019
54	105	2.02119	0.78950
55	136	2.13354	0.84084
56	288	2.45939	0.89454
57	310	2.49136	0.95098
58	316	2.49969	1.01068
59	332	2.52114	1.07425
60	361	2.55751	1.14253
61	440	2.64345	1.21663
62	445	2.64836	1.29811
63	507	2.70501	1.38925
64	562	2.74974	1.49361
65	612	2.78675	1.61718
66	623	2.79449	1.77150
67	873	2.94101	1.98391
68	1256	3.09899	2.35843

Graph to Show the Log-Normal Distribution Plot of all Suspended Solids (SS) Determinations in the Gully Pot Standing Liquor for the Four Gully Pots on The Twyford Gardens Sub-catchment.

Figure 7.331

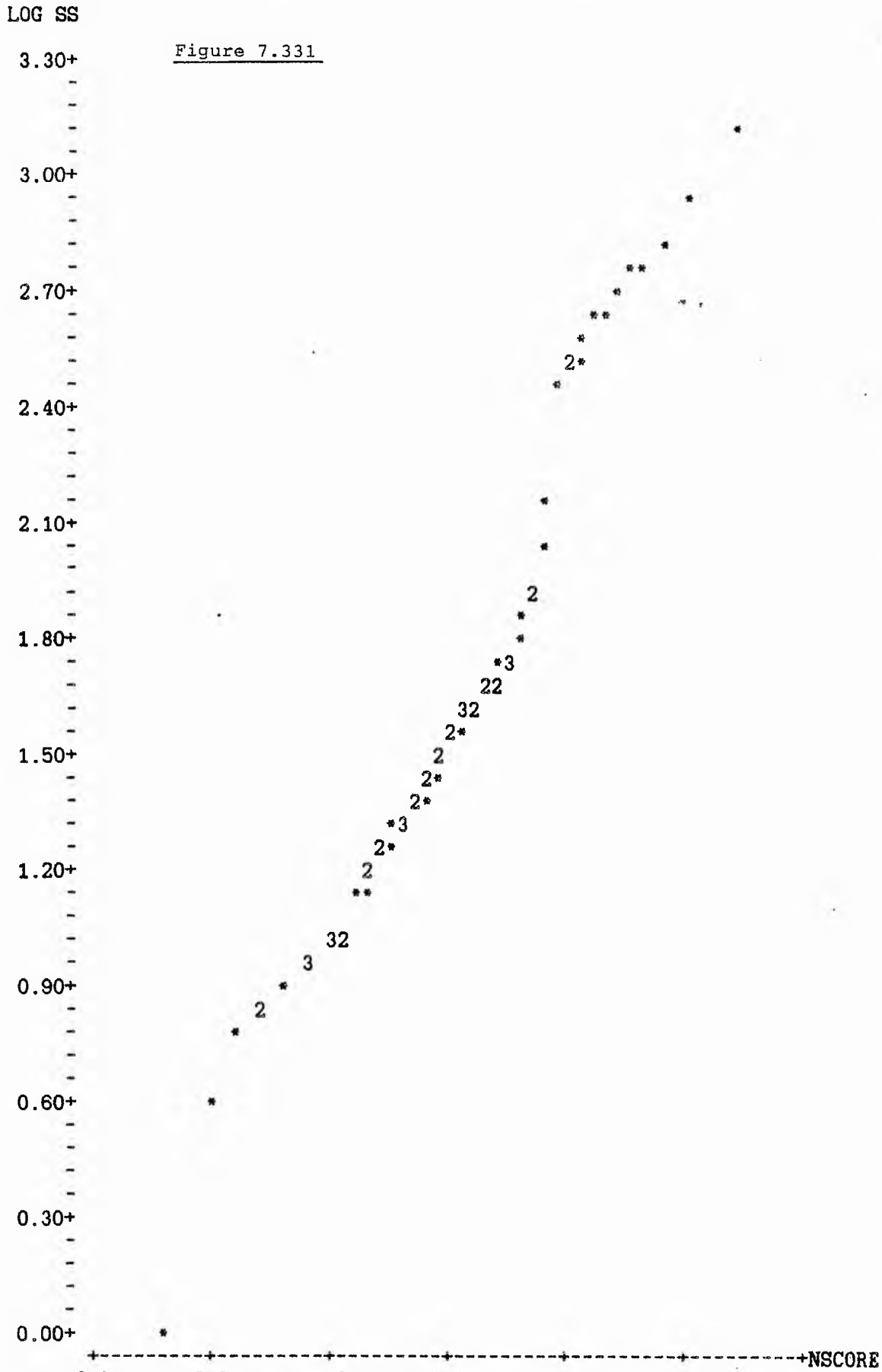


Table of Data for the Log-Normal Distribution Plots for all Suspended Solids (SS) Determinations for all Twelve Gully Pots on the Three Sub-catchments.

Table 7.72

No.	SS	LOG SS	NSCORE	No.	SS	LOG SS	NSCORE
1	1	0.00000	-2.73364	51	24	1.38021	-0.69401
2	3	0.47712	-2.41915	52	24	1.38021	-0.69401
3	4	0.60206	-2.24324	53	25	1.39794	-0.67141
4	5	0.69897	-2.11706	54	26	1.41497	-0.62723
5	6	0.77815	-1.97392	55	26	1.41497	-0.62723
6	6	0.77815	-1.97392	56	26	1.41497	-0.62723
7	7	0.84510	-1.82941	57	26	1.41497	-0.62723
8	7	0.84510	-1.82941	58	26	1.41497	-0.62723
9	8	0.90309	-1.71491	59	27	1.43136	-0.55622
10	8	0.90309	-1.71491	60	27	1.43136	-0.55622
11	9	0.95424	-1.57617	61	27	1.43136	-0.55622
12	9	0.95424	-1.57617	62	27	1.43136	-0.55622
13	9	0.95424	-1.57617	63	27	1.43136	-0.55622
14	9	0.95424	-1.57617	64	28	1.44716	-0.48127
15	10	1.00000	-1.41175	65	28	1.44716	-0.48127
16	10	1.00000	-1.41175	66	28	1.44716	-0.48127
17	10	1.00000	-1.41175	67	28	1.44716	-0.48127
18	10	1.00000	-1.41175	68	28	1.44716	-0.48127
19	10	1.00000	-1.41175	69	28	1.44716	-0.48127
20	11	1.04139	-1.29211	70	29	1.46240	-0.42197
21	11	1.04139	-1.29211	71	29	1.46240	-0.42197
22	11	1.04139	-1.29211	72	29	1.46240	-0.42197
23	13	1.11394	-1.22585	73	30	1.47712	-0.37688
24	13	1.11394	-1.22585	74	30	1.47712	-0.37688
25	14	1.14613	-1.16458	75	30	1.47712	-0.37688
26	14	1.14613	-1.16458	76	30	1.47712	-0.37688
27	14	1.14613	-1.16458	77	32	1.50515	-0.34516
28	15	1.17609	-1.10742	78	33	1.51851	-0.33257
29	15	1.17609	-1.10742	79	34	1.53148	-0.30755
30	17	1.23045	-1.04329	80	34	1.53148	-0.30755
31	17	1.23045	-1.04329	81	34	1.53148	-0.30755
32	17	1.23045	-1.04329	82	35	1.54407	-0.28273
33	17	1.23045	-1.04329	83	36	1.55630	-0.27038
34	18	1.25527	-0.98323	84	37	1.56820	-0.25195
35	18	1.25527	-0.98323	85	37	1.56820	-0.25195
36	19	1.27875	-0.92656	86	38	1.57978	-0.22750
37	19	1.27875	-0.92656	87	38	1.57978	-0.22750
38	19	1.27875	-0.92656	88	39	1.59106	-0.19713
39	19	1.27875	-0.92656	89	39	1.59106	-0.19713
40	20	1.30103	-0.88153	90	39	1.59106	-0.19713
41	21	1.32222	-0.82979	91	40	1.60206	-0.14892
42	21	1.32222	-0.82979	92	40	1.60206	-0.14892
43	21	1.32222	-0.82979	93	40	1.60206	-0.14892
44	21	1.32222	-0.82979	94	40	1.60206	-0.14892
45	21	1.32222	-0.82979	95	40	1.60206	-0.14892
46	22	1.34242	-0.76411	96	41	1.61278	-0.11300
47	22	1.34242	-0.76411	97	43	1.63347	-0.08913
48	22	1.34242	-0.76411	98	43	1.63347	-0.08913
49	23	1.36173	-0.72471	99	43	1.63347	-0.08913
50	23	1.36173	-0.72471	100	44	1.64345	-0.06532

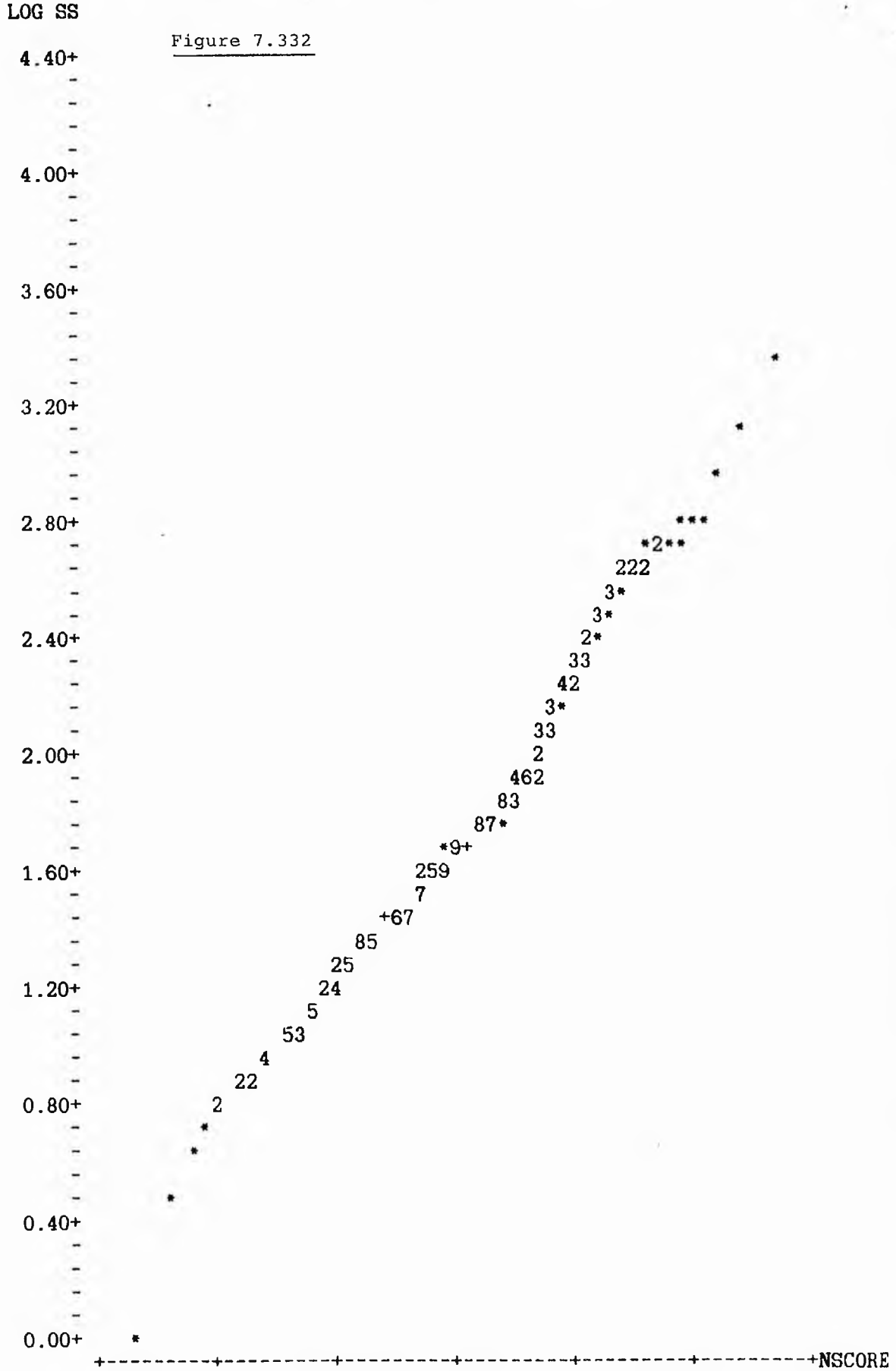
cont'd.

Table 7.72

No.	SS	LOG SS	NSCORE
101	45	1.65321	-0.04749
102	45	1.65321	-0.04749
103	46	1.66276	-0.01780
104	46	1.66276	-0.01780
105	46	1.66276	-0.01780
106	47	1.67210	0.01780
107	47	1.67210	0.01780
108	47	1.67210	0.01780
109	48	1.68124	0.04155
110	49	1.69020	0.06532
111	49	1.69020	0.06532
112	49	1.69020	0.06532
113	50	1.69897	0.10702
114	50	1.69897	0.10702
115	50	1.69897	0.10702
116	50	1.69897	0.10702
117	52	1.71600	0.14892
118	52	1.71600	0.14892
119	52	1.71600	0.14892
120	53	1.72428	0.18504
121	53	1.72428	0.18504
122	53	1.72428	0.18504
123	54	1.73239	0.20925
124	55	1.74036	0.23970
125	55	1.74036	0.23970
126	55	1.74036	0.23970
127	55	1.74036	0.23970
128	56	1.74819	0.28273
129	56	1.74819	0.28273
130	56	1.74819	0.28273
131	57	1.75587	0.30755
132	62	1.79239	0.33257
133	62	1.79239	0.33257
134	62	1.79239	0.33257
135	63	1.79934	0.35780
136	64	1.80618	0.37688
137	64	1.80618	0.37688
138	66	1.81954	0.40254
139	66	1.81954	0.40254
140	69	1.83885	0.42197
141	70	1.84510	0.44813
142	70	1.84510	0.44813
143	70	1.84510	0.44813
144	71	1.85126	0.48127
145	71	1.85126	0.48127
146	75	1.87506	0.50142
147	77	1.88649	0.51497
148	80	1.90309	0.52862
149	81	1.90849	0.54928
150	81	1.90849	0.54928
151	82	1.91381	0.57018
152	84	1.92428	0.59134
153	84	1.92428	0.59134
154	85	1.92942	0.61278
155	87	1.93952	0.62723
156	88	1.94448	0.64181
157	90	1.95424	0.66396
158	90	1.95424	0.66396
159	98	1.99123	0.68644
160	105	2.02119	0.70162
161	110	2.04139	0.71697
162	112	2.04922	0.73250
163	116	2.06446	0.74821
164	124	2.09342	0.77213
165	124	2.09342	0.77213
166	125	2.09691	0.79651
167	136	2.13354	0.81303
168	141	2.14922	0.82979
169	144	2.15836	0.84678
170	147	2.16732	0.86402
171	159	2.20140	0.88153
172	166	2.22011	0.89932
173	167	2.22272	0.91740
174	180	2.25527	0.93579
175	184	2.26482	0.96399
176	184	2.26482	0.96399
177	192	2.28330	0.99299
178	195	2.29003	1.01280
179	199	2.29885	1.03302
180	201	2.30320	1.05368
181	202	2.30535	1.07480
182	227	2.35603	1.09641
183	230	2.36173	1.12984
184	230	2.36173	1.12984
185	268	2.42813	1.16458
186	288	2.45939	1.18855
187	305	2.48430	1.21323
188	310	2.49136	1.23867
189	316	2.49969	1.26494
190	332	2.52114	1.29211
191	333	2.52244	1.32027
192	361	2.55751	1.34952
193	390	2.59106	1.37997
194	409	2.61172	1.41175
195	432	2.63548	1.44501
196	440	2.64345	1.47995
197	445	2.64836	1.51678
198	455	2.65801	1.55576
199	459	2.66181	1.59725
200	479	2.68034	1.64164
201	482	2.68305	1.68948
202	484	2.68485	1.74147
203	507	2.70501	1.79856
204	562	2.74974	1.86207
205	610	2.78533	1.93396
206	612	2.78675	2.01724
207	623	2.79449	2.11706
208	873	2.94101	2.24324
209	1256	3.09899	2.41915
210	2449	3.38899	2.73364

Graph to Show the Log-Normal Distribution Plot of all Suspended Solids (SS) Determinations in the Gully Pot Standing Liquor for all Twelve Gully Pots on the Three Sub-catchments.

Figure 7.332



CORRELATION OF LOG SS AND NSCORE = 0.990

LOG SS = 1.71 + 0.527 NSCORE

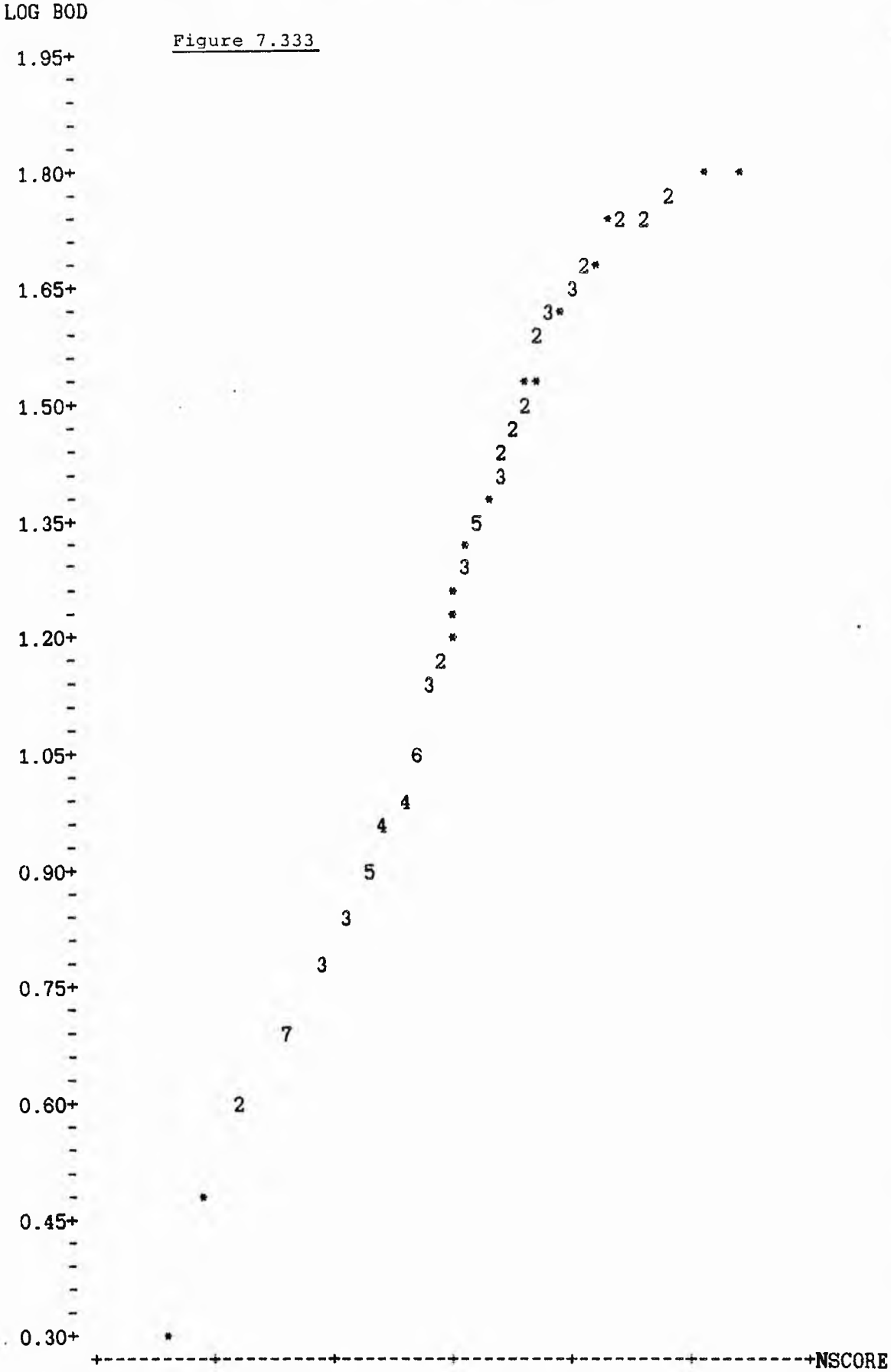
Table of Data for the Log-Normal Distribution Plots for all Biochemical Oxygen Demand (BOD) Determinations for all Four Gully Pots on The Tame Close Sub-catchment.

Table 7.73

No.	BOD	LOG BOD	NSCORE
1	2	0.30103	-2.44181
2	3	0.47712	-2.08119
3	4	0.60206	-1.79899
4	4	0.60206	-1.79899
5	5	0.69897	-1.35064
6	5	0.69897	-1.35064
7	5	0.69897	-1.35064
8	5	0.69897	-1.35064
9	5	0.69897	-1.35064
10	5	0.69897	-1.35064
11	5	0.69897	-1.35064
12	6	0.77815	-1.05054
13	6	0.77815	-1.05054
14	6	0.77815	-1.05054
15	7	0.84510	-0.90898
16	7	0.84510	-0.90898
17	7	0.84510	-0.90898
18	8	0.90309	-0.74482
19	8	0.90309	-0.74482
20	8	0.90309	-0.74482
21	8	0.90309	-0.74482
22	8	0.90309	-0.74482
23	9	0.95424	-0.58166
24	9	0.95424	-0.58166
25	9	0.95424	-0.58166
26	9	0.95424	-0.58166
27	10	1.00000	-0.44898
28	10	1.00000	-0.44898
29	10	1.00000	-0.44898
30	10	1.00000	-0.44898
31	11	1.04139	-0.29359
32	11	1.04139	-0.29359
33	11	1.04139	-0.29359
34	11	1.04139	-0.29359
35	11	1.04139	-0.29359
36	11	1.04139	-0.29359
37	14	1.14613	-0.15982
38	14	1.14613	-0.15982
39	14	1.14613	-0.15982
40	15	1.17609	-0.08691
41	15	1.17609	-0.08691
42	16	1.20412	-0.04341
43	17	1.23045	-0.01447
44	18	1.25527	0.01447
45	19	1.27875	0.07239
46	19	1.27875	0.07239
47	19	1.27875	0.07239
48	21	1.32222	0.13057
49	22	1.34242	0.17449
50	22	1.34242	0.17449
51	23	1.36173	0.24852
52	23	1.36173	0.24852
53	23	1.36173	0.24852
54	24	1.38021	0.30874
55	25	1.39794	0.35466
56	25	1.39794	0.35466
57	26	1.41497	0.40137
58	27	1.43136	0.44898
59	27	1.43136	0.44898
60	29	1.46240	0.49767
61	30	1.47712	0.53080
62	32	1.50515	0.58166
63	32	1.50515	0.58166
64	33	1.51851	0.63410
65	35	1.54407	0.67007
66	38	1.57978	0.70694
67	40	1.60206	0.74482
68	41	1.61278	0.82408
69	41	1.61278	0.82408
70	41	1.61278	0.82408
71	43	1.63347	0.90898
72	44	1.64345	0.95401
73	45	1.65321	1.02550
74	45	1.65321	1.02550
75	47	1.67210	1.12997
76	47	1.67210	1.12997
77	48	1.68124	1.21730
78	54	1.73239	1.28113
79	55	1.74036	1.38799
80	55	1.74036	1.38799
81	56	1.74819	1.56108
82	56	1.74819	1.56108
83	59	1.77085	1.79899
84	59	1.77085	1.79899
85	61	1.78533	2.08119
86	62	1.79239	2.44181

Graph to Show the Log-Normal Distribution Plot of all BOD Determinations in the Gully Pot Standing Liquor for the Four Gully Pots on The Tame Close Sub-catchment.

Figure 7.333



CORRELATION OF LOG BOD AND NSCORE = 0.983

LOG BOD = 1.22 + 0.372 NSCORE

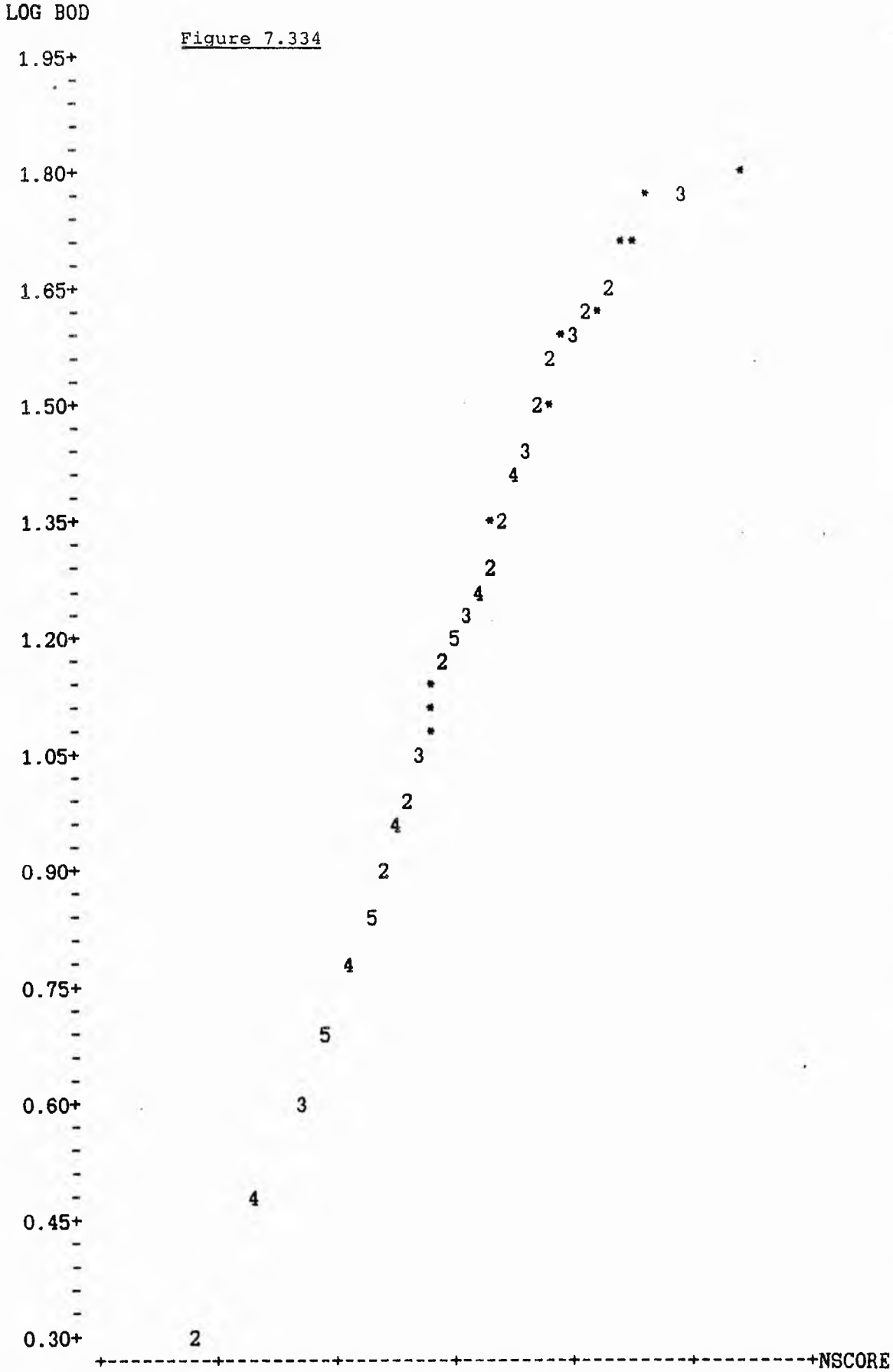
Table of Data for the Log-Normal Distribution Plots for all Biochemical Oxygen Demand (BOD) Determinations for all Four Gully Pots on The Churnet Close Sub-catchment.

Table 7.74

NO.	BOD	LOG BOD	NSCORE
1	2	0.30103	-2.21751
2	2	0.30103	-2.21751
3	3	0.47712	-1.65706
4	3	0.47712	-1.65706
5	3	0.47712	-1.65706
6	3	0.47712	-1.65706
7	4	0.60206	-1.33758
8	4	0.60206	-1.33758
9	4	0.60206	-1.33758
10	5	0.69897	-1.08801
11	5	0.69897	-1.08801
12	5	0.69897	-1.08801
13	5	0.69897	-1.08801
14	5	0.69897	-1.08801
15	6	0.77815	-0.87072
16	6	0.77815	-0.87072
17	6	0.77815	-0.87072
18	6	0.77815	-0.87072
19	7	0.84510	-0.68877
20	7	0.84510	-0.68877
21	7	0.84510	-0.68877
22	7	0.84510	-0.68877
23	7	0.84510	-0.68877
24	8	0.90309	-0.56207
25	8	0.90309	-0.56207
26	9	0.95424	-0.46044
27	9	0.95424	-0.46044
28	9	0.95424	-0.46044
29	9	0.95424	-0.46044
30	10	1.00000	-0.36347
31	10	1.00000	-0.36347
32	11	1.04139	-0.28530
33	11	1.04139	-0.28530
34	11	1.04139	-0.28530
35	12	1.07918	-0.22405
36	13	1.11394	-0.19376
37	14	1.14613	-0.16365
38	15	1.17609	-0.11876
39	15	1.17609	-0.11876
40	16	1.20412	-0.01481
41	16	1.20412	-0.01481
42	16	1.20412	-0.01481
43	16	1.20412	-0.01481
44	16	1.20412	-0.01481
45	17	1.23045	0.10385
46	17	1.23045	0.10385
47	17	1.23045	0.10385
48	18	1.25527	0.20888
49	18	1.25527	0.20888
50	18	1.25527	0.20888
51	18	1.25527	0.20888
52	19	1.27875	0.28530
53	20	1.30103	0.31632
54	22	1.34242	0.34767
55	23	1.36173	0.39536
56	23	1.36173	0.39536
57	25	1.39794	0.46044
58	25	1.39794	0.46044
59	26	1.41497	0.52758
60	26	1.41497	0.52758
61	27	1.43136	0.57957
62	28	1.44716	0.63320
63	28	1.44716	0.63320
64	31	1.49136	0.70777
65	31	1.49136	0.70777
66	32	1.50515	0.76644
67	36	1.55630	0.80708
68	37	1.56820	0.84912
69	38	1.57978	0.89274
70	39	1.59106	0.96162
71	39	1.59106	0.96162
72	40	1.60206	1.03545
73	41	1.61278	1.08801
74	42	1.62325	1.14379
75	43	1.63347	1.20340
76	44	1.64345	1.26764
77	45	1.65321	1.33758
78	50	1.69897	1.41474
79	51	1.70757	1.50134
80	58	1.76343	1.60082
81	59	1.77085	1.86709
82	59	1.77085	1.86709
83	59	1.77085	1.86709
84	62	1.79239	2.43359

Graph to Show the Log-Normal Distribution Plot of all BOD Determinations in the Gully Pot Standing Liquor for the Four Gully Pots on The Churnet Close Sub-catchment.

Figure 7.334



CORRELATION OF LOG BOD AND NSCORE = 0.989

LOG BOD = 1.16 + 0.392 NSCORE

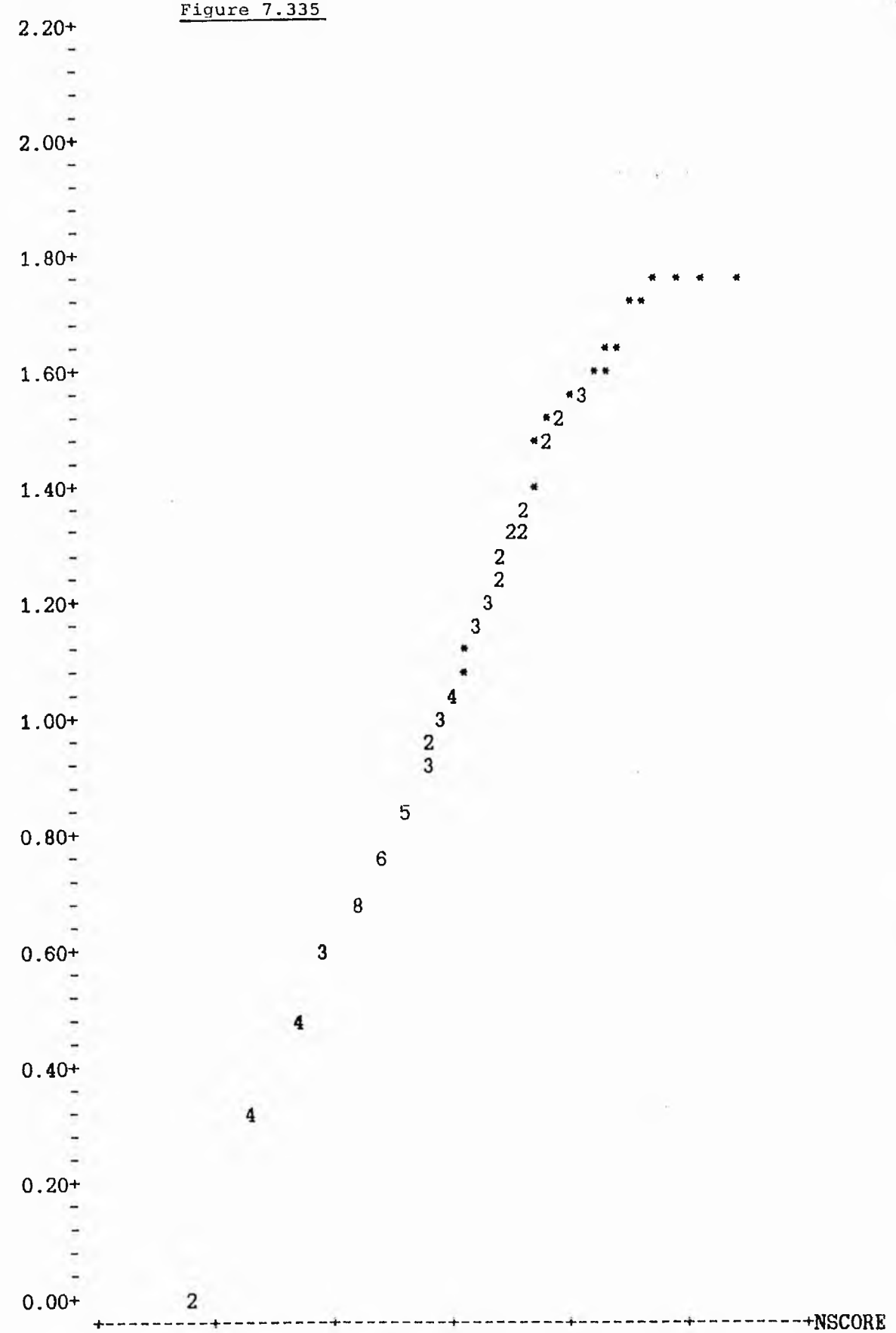
Table of Data for the Log-Normal Distribution Plots for all Biochemical Oxygen Demand (BOD) Determinations for all Four Gully Pots on The Twyford Gardens Sub-catchment.

Table 7.75

NO.	BOD	LOG BOD	NSCORE
1	1	0.00000	-2.21291
2	1	0.00000	-2.21291
3	2	0.30103	-1.65125
4	2	0.30103	-1.65125
5	2	0.30103	-1.65125
6	2	0.30103	-1.65125
7	3	0.47712	-1.29502
8	3	0.47712	-1.29502
9	3	0.47712	-1.29502
10	3	0.47712	-1.29502
11	4	0.60206	-1.08049
12	4	0.60206	-1.08049
13	4	0.60206	-1.08049
14	5	0.69897	-0.81930
15	5	0.69897	-0.81930
16	5	0.69897	-0.81930
17	5	0.69897	-0.81930
18	5	0.69897	-0.81930
19	5	0.69897	-0.81930
20	5	0.69897	-0.81930
21	5	0.69897	-0.81930
22	6	0.77815	-0.55200
23	6	0.77815	-0.55200
24	6	0.77815	-0.55200
25	6	0.77815	-0.55200
26	6	0.77815	-0.55200
27	6	0.77815	-0.55200
28	7	0.84510	-0.36804
29	7	0.84510	-0.36804
30	7	0.84510	-0.36804
31	7	0.84510	-0.36804
32	7	0.84510	-0.36804
33	8	0.90309	-0.24220
34	8	0.90309	-0.24220
35	8	0.90309	-0.24220
36	9	0.95424	-0.16563
37	9	0.95424	-0.16563
38	10	1.00000	-0.09005
39	10	1.00000	-0.09005
40	10	1.00000	-0.09005
41	11	1.04139	0.01499
42	11	1.04139	0.01499
43	11	1.04139	0.01499
44	11	1.04139	0.01499
45	12	1.07918	0.09005
46	13	1.11394	0.12019
47	14	1.14613	0.16563
48	14	1.14613	0.16563
49	15	1.17609	0.21142
50	16	1.20412	0.27322
51	16	1.20412	0.27322
52	16	1.20412	0.27322
53	17	1.23045	0.35202
54	17	1.23045	0.35202
55	19	1.27875	0.41670
56	19	1.27875	0.41670
57	20	1.30103	0.48322
58	20	1.30103	0.48322
59	21	1.32222	0.55200
60	21	1.32222	0.55200
61	22	1.34242	0.60538
62	23	1.36173	0.64197
63	25	1.39794	0.67945
64	30	1.47712	0.71792
65	31	1.49136	0.77777
66	31	1.49136	0.77777
67	32	1.50515	0.84060
68	33	1.51851	0.90699
69	33	1.51851	0.90699
70	35	1.54407	0.97771
71	36	1.55630	1.05374
72	36	1.55630	1.05374
73	37	1.56820	1.13648
74	39	1.59106	1.19629
75	41	1.61278	1.26074
76	42	1.62325	1.33090
77	45	1.65321	1.40829
78	51	1.70757	1.49513
79	53	1.72428	1.59487
80	55	1.74036	1.71335
81	56	1.74819	1.86177
82	59	1.77085	2.06672
83	60	1.77815	2.42939

Graph to Show the Log-Normal Distribution Plot of all BOD Determinations in the Gully Pot Standing Liquor for the Four Gully Pots on The Twyford Gardens Sub-catchment.

Figure 7.335



CORRELATION OF LOG BOD AND NSCORE = 0.991

LOG BOD = 1.05 + 0.437 NSCORE

Table of Data for the Log-Normal Distribution Plots for all Biochemical Oxygen Demand (BOD) Determinations for all Twelve Gully Pots on the Three Sub-catchments.

Table 7.76

No.	BOD	LOG BOD	NSCORE	No.	BOD	LOG BOD	NSCORE
1	1	0.00000	-2.60684	51	6	0.77815	-0.81196
2	1	0.00000	-2.60684	52	6	0.77815	-0.81196
3	2	0.30103	-2.01320	53	6	0.77815	-0.81196
4	2	0.30103	-2.01320	54	6	0.77815	-0.81196
5	2	0.30103	-2.01320	55	6	0.77815	-0.81196
6	2	0.30103	-2.01320	56	6	0.77815	-0.81196
7	2	0.30103	-2.01320	57	6	0.77815	-0.81196
8	2	0.30103	-2.01320	58	6	0.77815	-0.81196
9	2	0.30103	-2.01320	59	6	0.77815	-0.81196
10	3	0.47712	-1.61083	60	7	0.84510	-0.64390
11	3	0.47712	-1.61083	61	7	0.84510	-0.64390
12	3	0.47712	-1.61083	62	7	0.84510	-0.64390
13	3	0.47712	-1.61083	63	7	0.84510	-0.64390
14	3	0.47712	-1.61083	64	7	0.84510	-0.64390
15	3	0.47712	-1.61083	65	7	0.84510	-0.64390
16	3	0.47712	-1.61083	66	7	0.84510	-0.64390
17	3	0.47712	-1.61083	67	7	0.84510	-0.64390
18	3	0.47712	-1.61083	68	7	0.84510	-0.64390
19	4	0.60206	-1.35722	69	7	0.84510	-0.64390
20	4	0.60206	-1.35722	70	7	0.84510	-0.64390
21	4	0.60206	-1.35722	71	7	0.84510	-0.64390
22	4	0.60206	-1.35722	72	7	0.84510	-0.64390
23	4	0.60206	-1.35722	73	8	0.90309	-0.50947
24	4	0.60206	-1.35722	74	8	0.90309	-0.50947
25	4	0.60206	-1.35722	75	8	0.90309	-0.50947
26	4	0.60206	-1.35722	76	8	0.90309	-0.50947
27	5	0.69897	-1.06701	77	8	0.90309	-0.50947
28	5	0.69897	-1.06701	78	8	0.90309	-0.50947
29	5	0.69897	-1.06701	79	8	0.90309	-0.50947
30	5	0.69897	-1.06701	80	8	0.90309	-0.50947
31	5	0.69897	-1.06701	81	8	0.90309	-0.50947
32	5	0.69897	-1.06701	82	8	0.90309	-0.50947
33	5	0.69897	-1.06701	83	9	0.95424	-0.39988
34	5	0.69897	-1.06701	84	9	0.95424	-0.39988
35	5	0.69897	-1.06701	85	9	0.95424	-0.39988
36	5	0.69897	-1.06701	86	9	0.95424	-0.39988
37	5	0.69897	-1.06701	87	9	0.95424	-0.39988
38	5	0.69897	-1.06701	88	9	0.95424	-0.39988
39	5	0.69897	-1.06701	89	9	0.95424	-0.39988
40	5	0.69897	-1.06701	90	9	0.95424	-0.39988
41	5	0.69897	-1.06701	91	9	0.95424	-0.39988
42	5	0.69897	-1.06701	92	9	0.95424	-0.39988
43	5	0.69897	-1.06701	93	10	1.00000	-0.30016
44	5	0.69897	-1.06701	94	10	1.00000	-0.30016
45	5	0.69897	-1.06701	95	10	1.00000	-0.30016
46	5	0.69897	-1.06701	96	10	1.00000	-0.30016
47	6	0.77815	-0.81196	97	10	1.00000	-0.30016
48	6	0.77815	-0.81196	98	10	1.00000	-0.30016
49	6	0.77815	-0.81196	99	10	1.00000	-0.30016
50	6	0.77815	-0.81196	100	10	1.00000	-0.30016

cont'd.

Table 7.76

No.	BOD	LOG BOD	NSCORE	No.	BOD	LOG BOD	NSCORE
101	10	1.00000	-0.30016	151	19	1.27875	0.25403
102	11	1.04139	-0.18835	152	19	1.27875	0.25403
103	11	1.04139	-0.18835	153	19	1.27875	0.25403
104	11	1.04139	-0.18835	154	19	1.27875	0.25403
105	11	1.04139	-0.18835	155	19	1.27875	0.25403
106	11	1.04139	-0.18835	156	20	1.30103	0.30016
107	11	1.04139	-0.18835	157	20	1.30103	0.30016
108	11	1.04139	-0.18835	158	20	1.30103	0.30016
109	11	1.04139	-0.18835	159	21	1.32222	0.33127
110	11	1.04139	-0.18835	160	21	1.32222	0.33127
111	11	1.04139	-0.18835	161	21	1.32222	0.33127
112	11	1.04139	-0.18835	162	22	1.34242	0.36799
113	11	1.04139	-0.18835	163	22	1.34242	0.36799
114	11	1.04139	-0.18835	164	22	1.34242	0.36799
115	12	1.07918	-0.11356	165	22	1.34242	0.36799
116	12	1.07918	-0.11356	166	23	1.36173	0.42137
117	13	1.11394	-0.09375	167	23	1.36173	0.42137
118	13	1.11394	-0.09375	168	23	1.36173	0.42137
119	14	1.14613	-0.05422	169	23	1.36173	0.42137
120	14	1.14613	-0.05422	170	23	1.36173	0.42137
121	14	1.14613	-0.05422	171	23	1.36173	0.42137
122	14	1.14613	-0.05422	172	24	1.38021	0.45946
123	14	1.14613	-0.05422	173	25	1.39794	0.49266
124	14	1.14613	-0.05422	174	25	1.39794	0.49266
125	15	1.17609	0.00000	175	25	1.39794	0.49266
126	15	1.17609	0.00000	176	25	1.39794	0.49266
127	15	1.17609	0.00000	177	25	1.39794	0.49266
128	15	1.17609	0.00000	178	26	1.41497	0.53783
129	15	1.17609	0.00000	179	26	1.41497	0.53783
130	16	1.20412	0.06903	180	26	1.41497	0.53783
131	16	1.20412	0.06903	181	27	1.43136	0.57244
132	16	1.20412	0.06903	182	27	1.43136	0.57244
133	16	1.20412	0.06903	183	27	1.43136	0.57244
134	16	1.20412	0.06903	184	28	1.44716	0.60184
135	16	1.20412	0.06903	185	28	1.44716	0.60184
136	16	1.20412	0.06903	186	29	1.46240	0.61973
137	16	1.20412	0.06903	187	30	1.47712	0.63782
138	16	1.20412	0.06903	188	30	1.47712	0.63782
139	17	1.23045	0.14337	189	31	1.49136	0.67468
140	17	1.23045	0.14337	190	31	1.49136	0.67468
141	17	1.23045	0.14337	191	31	1.49136	0.67468
142	17	1.23045	0.14337	192	31	1.49136	0.67468
143	17	1.23045	0.14337	193	32	1.50515	0.72532
144	17	1.23045	0.14337	194	32	1.50515	0.72532
145	18	1.25527	0.19839	195	32	1.50515	0.72532
146	18	1.25527	0.19839	196	32	1.50515	0.72532
147	18	1.25527	0.19839	197	33	1.51851	0.77124
148	18	1.25527	0.19839	198	33	1.51851	0.77124
149	18	1.25527	0.19839	199	33	1.51851	0.77124
150	19	1.27875	0.25403	200	35	1.54407	0.80508

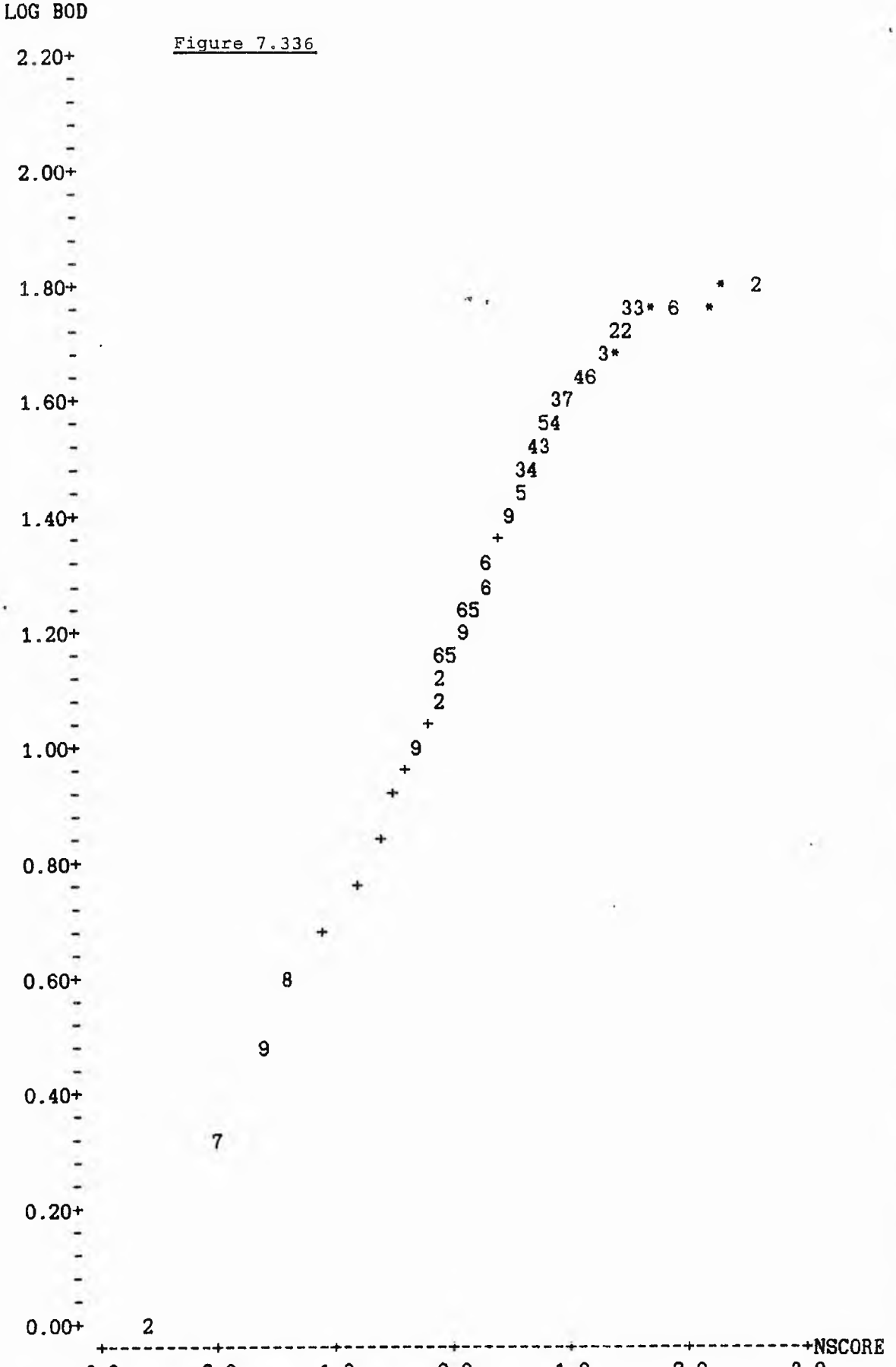
cont'd.

Table 7.76

No.	BOD	LOG BOD	NSCORE
201	35	1.54407	0.80508
202	36	1.55630	0.83988
203	36	1.55630	0.83988
204	36	1.55630	0.83988
205	37	1.56820	0.87575
206	37	1.56820	0.87575
207	38	1.57978	0.90528
208	38	1.57978	0.90528
209	39	1.59106	0.94337
210	39	1.59106	0.94337
211	39	1.59106	0.94337
212	40	1.60206	0.98290
213	40	1.60206	0.98290
214	41	1.61278	1.04099
215	41	1.61278	1.04099
216	41	1.61278	1.04099
217	41	1.61278	1.04099
218	41	1.61278	1.04099
219	42	1.62325	1.10287
220	42	1.62325	1.10287
221	43	1.63347	1.14022
222	43	1.63347	1.14022
223	44	1.64345	1.17924
224	44	1.64345	1.17924
225	45	1.65321	1.24140
226	45	1.65321	1.24140
227	45	1.65321	1.24140
228	45	1.65321	1.24140
229	47	1.67210	1.30878
230	47	1.67210	1.30878
231	48	1.68124	1.34481
232	50	1.69897	1.36983
233	51	1.70757	1.40906
234	51	1.70757	1.40906
235	53	1.72428	1.45057
236	54	1.73239	1.47968
237	55	1.74036	1.54197
238	55	1.74036	1.54197
239	55	1.74036	1.54197
240	56	1.74819	1.64829
241	56	1.74819	1.64829
242	56	1.74819	1.64829
243	58	1.76343	1.73092
244	59	1.77085	1.91208
245	59	1.77085	1.91208
246	59	1.77085	1.91208
247	59	1.77085	1.91208
248	59	1.77085	1.91208
249	59	1.77085	1.91208
250	60	1.77815	2.19061
251	61	1.78533	2.31306
252	62	1.79239	2.60684
253	62	1.79239	2.60684

Graph to Show the Log-Normal Distribution Plot of all BOD Determinations in the Gully Pot Standing Liquor for all Twelve Gully Pots on the Three Sub-catchments.

Figure 7.336



CORRELATION OF LOG BOD AND NSCORE = 0.988

LOG BOD = 1.14 + 0.403 NSCORE

Table to Show the Results of the Regression Analyses between the Log Values and the Normal Scores (NSCORES) for the BOD Data.

Tame Sub-catchment:

log BOD = 1.22 + 0.372 NSCORE (r=0.983)

Churnet Sub-catchment:

log BOD = 1.16 + 0.392 NSCORE (r=0.989)

Twyford Sub-catchment:

log BOD = 1.05 + 0.437 NSCORE (r=0.991)

TOTAL DATASET:

log BOD = 1.14 + 0.403 NSCORE (r=0.988)

Table: 7.77

Table to Show the Results of the Regression Analyses between the Log Values and the Normal Scores (NSCORES) for the SS Data.

Tame Sub-catchment:

log SS = 1.80 + 0.462 NSCORE (r=0.988)

Churnet Sub-catchment:

log SS = 1.72 + 0.467 NSCORE (r=0.981)

Twyford Sub-catchment:

log SS = 1.62 + 0.630 NSCORE (r=0.975)

TOTAL DATASET:

log SS = 1.71 + 0.527 NSCORE (r=0.990)

Table: 7.78

The results of the Shapiro-Wilk Statistical tests for normality in the transformed datasets showed that all the log-transformed data conformed to normal distributions. The value of this finding is that the regression equations form a probability distribution. For the total datasets, the probabilistic relationships were developed for both the BOD and the SS data.

log BOD = 1.14 + 0.403 NSCORE (see Table 7.77)

log SS = 1.71 + 0.527 NSCORE (see Table 7.78)

These relationships may be used to predict the value of the BOD and/or the SS concentration in a gully pot standing liquor from a given probability distribution. The NSCORE value can be calculated from a knowledge of the desired level of probability of occurrence and the mean (assumed) and the standard deviation of the distribution. The equations may therefore be used in the same form as a "probability generating function", whereby an assumed value may be derived for a given probability of occurrence. The NSCORE therefore would be generated as a probability function and the regression equations, as stated above, are then used to predict the BOD and the SS values. It is necessary to antilog the results of the calculations from the equations, otherwise they will remain in the transformed state. It is considered that there is some value in approaching the problem of predicting the state of the gully pot liquor quality through the use of such probabilistic modelling techniques. Such proof that the transformed datasets do comply to the normal distribution (or in this case the log-normal distribution), means that probability theory may be used to achieve a probabilistic approach to modelling the quality

of the gully pot liquors. It is envisaged that such a probabilistic model could be used in a manner similar to the 'Monte Carlo Simulation Method', whereby a procedure could be used to generate random variables from a uniform probability distribution. This approach would offer a new dimension to the modelling of the above-ground phase in 'Stormwater Quality Discharge Models'. A basis for such a model would be to randomly generate a probability for each gully pot liquor on a separate storm sewer network and the relationships derived above, could be used to translate that probability factor into a value for the concentration of BOD and SS in the pot liquor. The quality of the pot liquor is known to influence the resultant outflow from the pot chamber during runoff events and so the results from the probabilistic models would be used as a starting point for a model more closely concerned with the outflow waters from the gully pot chamber during a storm event. The fundamental difference in approach between the probabilistic models derived for BOD and SS in the pot liquor and the deterministic models developed above, is that the probabilistic models do not take account of what is happening within the micro-catchment at any particular time, rather it is a more theoretical approach to state the quality of the pot liquor to a known, but randomly generated probability function. The probabilistic approach is likely to give greater fluctuations in the predicted quality of individual gully pot liquors, but its value is on a collective basis whereby the values obtained through random, probability generation are more meaningful over a large number of gully pots on a storm sewer network and over a long time period (ie. several storm events).

7.20 The Modelling of Gully Pot Standing Liquor.

The modelling of gully pot liquor quality has focussed upon the BOD and SS determinands and this is due to the value of determining the predicted BOD and SS concentrations in the final stormwater discharges. The prediction of BOD and SS concentrations in stormwater discharges at the outfall is seen as a necessary step to ensure the eventual integration of stormwater discharge models as components of more general surface water quality models (ie. river and estuarine quality models). It is important to note that a similar analysis (probability modelling) could have been adopted to other water quality parameters under study in the gully pot liquor monitoring programme, but time did not permit a full and thorough treatment of all the data in the log-transformed datasets to the determination of the probabilistic derived relationships.

7.21 Quality Modelling in Storm Sewers.

Moys and Henderson (1987) describe the planning and future development of a model to predict pollutant discharges from storm sewer overflows. This work is currently being conducted at the Hydraulics Research Station at Wallingford, England. The model is made up of two parts. The first is known as the "inner core" in which the processes associated with sediment and pollutant transport upon the catchment surfaces and within the sewer pipes are represented. The second part of the proposed quality discharge model is to be known as the "outer shell" whereby the probabilities associated with a specific prediction are derived. The model will be used to simulate the quality conditions with respect to SS, BOD, COD, DO (Dissolved Oxygen), Ammoniacal Nitrogen and Hydrogen Sulphide in the storm sewer system. Moys and Henderson (1987) emphasise the need to incorporate both deterministic and probabilistic components into the general model and the results expressed above, do provide a valuable predictive tool to simulate the quality of gully pot liquor within a separately sewered, urban residential catchment area.

Chapter 8: The Storm Event Sampling Programme.

8.1 Introduction.

The second part of the research programme was concerned with the study of the gully pot liquor quality under dynamic conditions in order to analyse the changes in the gully pot liquor quality during a storm event. A storm event sampling programme was set up to investigate the relationships between the inflow runoff waters and the discharge waters from the gully pot to the storm sewer pipe network. The aim of the sampling programme was to capture samples of both inflow and outflow waters during a storm event and to compare the quality of the inflow and outflow waters with a view to establishing relationships between the quality and the hydrological conditions for each storm event. This would lead to the modelling of the changes in water quality in the outflow waters as a function of the inflow quality and the hydrological conditions within the storm event. The aim was to provide a deterministic model of gully pot outflow water quality and, if sufficient data could be collected during the research programme, a probabilistic model would also be postulated.

It was realised at an early stage, that the sampling of stormwater flows had many inherent difficulties, and some previous research studies into the analysis of storm events have emphasised the problems of "storm capture" eg. Fletcher (1981); Adams (1983); Ellis, Harrop and Revitt (1986); Hall and Ellis (1985); Harrop (1983); Halverson, De Walle and Sharpe (1984); and Desbordes and Servat (1984). It is essential to make regular checks on all sampling equipment in the field and to maintain the equipment at all times to ensure that the

sampling machines have a sufficient power supply, are free from blockage, are free from vandalism and that the electrical and mechanical mechanisms are in full working order.

8.2 The Planning of the Storm Sampling Programme.

The storm sampling programme was conducted over a period of eighteen months from June 1984 to December 1985. Three gully pots were selected for analysis and these were the "number two" gully pots in each of the three sub-catchments under study on the Clifton Grove Estate in Nottingham (see Chapter 7). The three gully pots included in the storm analysis part of the research programme have previously been called "Tame 2", "Churnet 2" and "Twyford 2" (the names being derived from the road names for each sub-catchment), but for convenience, they will be known as the "Tame", "Churnet" and "Twyford" gully pots in the storm event analysis (since only one gully pot is being sampled during the storm events on each sub-catchment area). The sampling programme involved the collection of both inflow (ie. runoff water from the urban surfaces into the gully pot) and outflow waters (ie. water discharging from the gully pot chamber to the storm sewer pipe network). The sampling was carried out using vacuum sampling machines manufactured by 'Automatic Liquid Samplers Ltd.'. Each machine was powered by a 6 volt dry battery and contained 24 glass sample bottles which sat in a metal crate underneath the sampling machine mechanisms. Two machines were set up over each gully pot, so that one machine sampled the inflow water whilst the second sampled the pot outflow waters. The two machines were set up in pairs and were powered by a joint battery source, activated by a common timer unit and float switch device. The sample bottles were connected

to the sample hoses by lengths of rubber tubing which were screwed onto the top of the sample bottle with an attached screw top lid. The sample hoses were fixed rigidly into a sampler head and a 2 metre length of 3 mm. diameter polythene tubing was provided for each sample bottle. It should be stressed that each sample was drawn through a separate sampling tube into the bottle and, unlike some sampling machines, there was no common feeder tube to collect the samples. The sampler head was protected by a thin metal gauze. Each sampling machine was fitted with an electronic timer unit which could be pre-set to sample at a given time interval. The system was primed to a vacuum equivalent of one atmospheric pressure unit using a standard foot pump. The clock mechanism triggered the machine to sample at the required sample interval and the whole sampling sequence was initiated by a float switch device set within the gully pot which detected the presence of inflow water into the pot chamber and, therefore, a storm runoff event.

8.3 Experimental Hardware.

A plastic box was hand-made for each of the three gully pots (due to the different dimensions and positioning of the individual gully grates and pots) and this was fixed on the upstream side of the gully, just beneath the grating in order to collect the incoming runoff water during a storm event (see Figure 8.1). The box was of welded plastic and was a V-shape with holes in the side of the box to allow the inflow water to pass through, and a small orifice was inserted into the bottom of the box to allow the whole box to drain fully at the end of the runoff event. A deflection plate was fixed to the side of the box so that the water from the orifice was deflected along the side

walls of the gully pot chamber. This was done to prevent any turbulent mixing of the pot liquor beneath, caused by the presence of the box (over and above the normal mixing due to the water inflow during a storm event). A float switch was positioned inside the receiving box and this was used to activate the sampling machine when a storm had produced some runoff into the gully pot. The float was connected to the battery by means of a switching circuit. The float switch was protected from above by a small plastic plate so that it could not be dislodged from its position by the inflow water, although the position of the plate did not in any way affect the ability of the float to detect a rise in water level within the box, which was used as the sensing mechanism to activate the sampling machines at the start of the runoff event. The inflow water sampler head was positioned vertically inside the receiving box and it was fixed to the sides of the box using fishing line so as to maintain a consistent position at all times (see Figure 8.2). The receiving box was positioned such that the inflow waters fell into the box and were allowed to build up to a depth of several centimetres. The water was allowed to drain out of the bottom orifice at all times, but a sufficient inflow discharge rate allowed the water to build up inside the box. Once a sufficient depth had been established to enable a full sample to be collected, the sampling machines would be activated by the float switch. The inflow waters would continue to flow into the box, whereupon they would drain out of the side holes (or even out over the top of the box). The system for collecting the inflow waters was considered to give a representative sample due to the mixing of the inflow waters within the box, together with the self-cleansing provided by the draining of the box after each storm runoff event. A plastic gauze was placed over the top of the box and this was held in

Photograph of the Box Housing the Sampling Machines Used in the Storm Event Sampling Programme.

Figure 8.1

Photograph of the Box Housing the Sampling Machines Used in The Storm Event Sampling Programme, Showing the Position of the Sampling Machines and the Sample Bottles.

Figure 8.2.

position by some clips. The gauze was used to filter out any large debris which may have been washed into the gully pot in the inflow waters and it was found to be successful in preventing the blockage of the orifice in the box and damage and obstruction to the inflow water sampler head. The plastic gauze also helped to maintain the position of the sampler head.

The outflow sampler head was tied to the side of the outflow sampling machine so that the head was immersed in the pot liquor at a point adjacent to the gully pot discharge point. The samples taken at this point were considered to be representative of all the liquor outflow and the sampler head was held in a vertical position by a series of ties. The sampler tubing connecting the sampler head to the sample bottles was kept as straight and as rigid as was possible at all times. (Figure 8.3 shows that the sampling machines were positioned in a confined space). The position of the sampler heads and the condition of the sampler tubing was a main priority in the maintenance programme and spot checks made on the sampling equipment. The sampling machines and all the associated sampling equipment were housed in a steel instrument box which stood about 1.6m high and covered an area of approximately one quarter to one half of a square metre (see Figure 8.4). The steel box was painted green in compliance with the local council requirements. Planning permission was obtained from the local authority because these boxes were standing adjacent to a highway surface. White fluorescent paint was used to mark distictive chevrons across the box as an added safety feature. This would highlight the presence of the box next to the pavement and the road for passing motorists and pedestrians at night. The box was fixed to the kerb in three corners using 6" metal bolts with the back

Photograph to Show the Position of the Receiving Box Used to Sample the Inflow Waters in the Storm Event Sampling Programme.

Figure 8.3.

Photograph to Show the Position of the Sampler Head Used to Sample the Inflow Waters in the Storm Event Sampling Programme.

Figure 8.4.

and one side of the box being fixed to the top of the corner kerbstones (see Figure 8.4). A reinforced metal door opened outward above the road surface and this was secured by two heavy duty padlocks. A metal plate was fixed to the bottom of the door and this sat just a few millimetres above the surface of the road. This plate was installed for added security such that the sampling equipment could not be interfered with and to prevent any animals from becoming trapped inside the box. On the upstream (upslope) side of the box where the storm inflow waters would be received, the base of the box stood at kerb height level. A series of steel rods were fixed inside the box with an adjustable height screw mechanism. These rods were placed individually at the time that the box was installed at the study site such that the rods were about 1" apart and they sat just on the road surface. The reasons for placing these rods were to ensure the uninhibited passage of water into the gully pot; to prevent any large objects from blocking the sampling equipment; to prevent vandalism; to prevent animals from getting inside the box; and above all, to simulate the inflow conditions of the runoff waters through the gully grating system which would have normally covered the gully pot. One pair of sampling machines was installed at each of the three gully pots under study and the whole instrument box was made as secure as possible. There was no vandalism to any of the equipment during the whole of the eighteen month period of the storm event analysis programme.

8.4 The Sampling Strategy.

The aim of the programme was to set up sampling machines so that they caught storm events which produced a substantial runoff regime. It

was deemed advantageous to activate the samplers with a known runoff regime rather than a rainfall regime (it would be possible to link the sampler units to the tipping bucket raingauge for example), because some rainfall events do not produce any quantifiable runoff discharge (ie. the depression storage may not be exceeded). The receiving boxes were all approximately the same size but they were made individually for each of the three gully pots due to the local circumstances and to ensure a tight and secure fitting underneath the lip of the gully pot entrance. A laboratory trial prior to the field installation showed that the float switch would be activated when an inflow water discharge rate of about 0.05 ls-1 was achieved. Previous knowledge of the hydrological characteristics of gully inflow waters on the Clifton Grove sub-catchments (Pratt and Adams (1981); Pratt, Henderson and Adams (1984)), showed that such a runoff regime was very acceptable and would be likely to occur with some frequency and this made the above figure (0.05 ls-1) an acceptable "threshold" for sampling a Rainfall-Runoff event. An inflow discharge of that level of magnitude would be expected to occur quite readily for the type of storm events experienced in the United Kingdom. It was considered that this arbitrarily defined threshold inflow discharge rate to initiate the sampling would provide a sampling regime such that a number of storm events could be captured during the eighteen month period. The sampling units were set up such that the sampling machines could be activated as soon as an inflow water reached a discharge rate of about 0.05 ls-1. The inflow sampler head would then draw off its first 500 millilitre sample. The sample volume was determined by the size of the sample bottles and this volume could easily be obtained over the draw-off head by the vacuum samplers, according to the manufacturer's technical instructions. At the same

time, an outflow water sample would be collected from the gully pot liquor at a point adjacent to the discharge pipe. This sampling sequence would then continue at the rate predetermined by the timer unit. Once activated, the pair of sampling machines worked in tandem and continued to take the full quota of 24 samples at the given time interval. Once the inflow waters had ceased, the receiving box would then drain down within a few seconds and at this time the sampler head would draw off a sample of reduced volume. Once the box had fully drained, an air sample would be collected by the inflow sampler head. Therefore it is possible to use the number of inflow samples obtained as a check on the stormwater runoff duration, but this depends upon the sample time interval used, if this evaluation is to be used to any degree of accuracy. It would then be known to within one sample frequency time unit, the exact time when the urban runoff finished. A clock was installed in the sampling machines and this was set to real time. The clock was installed so as to stop when the sampling machine was activated by the float switch and this gave a clear indication of the time that the first sample was taken. There may be some discrepancy between the time recorded on the clock and the time predicted by the Rainfall-Runoff Model and this had to be resolved in some cases.

8.5 Sampling Machine Maintenance.

The three study sites for storm analysis were visited on an almost daily basis throughout the whole eighteen month study period. The machines were set up such that they would be activated by any inflow water discharge rate of the order of 0.05 ls-1 and so a constant watch was made on all the sample bottles. One consequence of having the

sampling machines primed at all times was that a small rainfall event (a fine drizzle for a few minutes) would sometimes be enough to activate the samplers. This type of event would only produce one or two inflow samples and these samples were discarded because not enough quality data could be established for the inflow waters on this type of event, to make the analysis of such data meaningful. It would be very difficult to compare inflow and outflow sample data for this type of rainfall event. The aim was to capture storms of at least 1.0 mm. runoff depth with a duration lasting several minutes. The sampling machines on Tame Close were found to have been activated on at least two occasions by water from car washing and so these samples were discarded. On such occasions, all 24 samples are obtained for the outflow waters and all the samples had to be discarded and the bottles washed before being returned to the gully pot site and primed ready for the next storm event. A regular check was made on the state and condition of the sampler tubing: the battery condition and the receiving boxes were regularly removed and cleaned. These procedures, as outlined above, exemplify and illustrate the problems involved and experienced with "storm capture". A log was kept of each visit to the sampling machines at each of the three sites and it is estimated that the results presented below for the fifteen storm events analysed over the study period represent only above 20% of the total number of visits made to the sites.

8.6 The Storm Hyetograph and Inlet Storm Hydrograph.

Once a storm event had occurred, a site visit was made to ensure that the samples had been successfully collected. The clock time was recorded (time that the machines were activated) and the samples were

then taken to the laboratory for analysis. The time on the clock was then cross-referenced with the real-time rainfall record so as to identify the particular storm whose runoff water had activated the sampling units. Each storm sampled could then be numbered and the rainfall record of that particular storm could be processed and a storm hyetograph produced. The Rainfall-Runoff Models developed for the "number two" gully pots (see Chapter 4 and Chapter 7) were then run for each of the micro-catchments in turn where water samples had been collected, so that an inlet storm hydrograph could be established for each storm event. The inlet storm hydrographs for each of the fifteen storm events where the analysis was possible, can be found in the Appendices.

The aim of the storm event analysis was to study the relationships between the inflow and outflow waters and to look at the relationships between the outflow waters from the gully pot with the hydrological conditions. Altogether 15 storm events were analysed over the eighteen month period and these storms differed considerably in their characteristics. All 15 storms were considered to be representative of the Rainfall-Runoff Regimes experienced at the study sites and the storm characteristics (in terms of rainfall depth, duration, peak rainfall intensity etc.) were all representative of storm conditions found in the United Kingdom. The storm numbering sequence was chronological and the date of the storm event is given as that date when the rainfall which produced the runoff started. This is an important point, since rainstorms which overlap the midnight hour need to be classified in a consistent manner. (The dates of the storm events in Table 8.1 are given in the form adopted throughout the research programme ie. an American date notation written as YYMMDD).

Table to Show the Dates of the Storm Events Captured and the Events Captured by the Three Gully Pot Sampling Units.

STORM NUMBER	DATE	TAME	CHURNET	TWYFORD
I	840620	*		*
II	840712	*		*
III	840802	*		*
IV	840913	*	*	*
V	841008	*	*	*
VI	841102	*	*	*
VII	850726	*		*
VIII	850913	*		
IX	851006	*		*
X	851105	*	*	
XI	851107	*		*
XII	851114	*		
XIII	851130	*		*
XIV	851205		*	
XV	851206	*	*	*

NOTE: * means that water quality data was collected.

Table: 8.1

It should be noted that at the beginning of the storm event sampling programme, one storm was fully analysed each month for the first six months. During the period from Winter 1984 to Spring 1985, a combination of heavy snowfall and operational difficulties caused by the cold weather and exceptionally cold temperatures, meant that very few storms were actually captured. Vacuum leakage, mechanical/electrical failures and problems encountered with the timer units rendered some sample collection highly unreliable and the sampling systems failed on many occasions. It was not until the summer of 1985 that reliable sampling was resumed. A concentrated effort was then made to catch as many storms as possible during the second half of 1985 and a combination of favourable (ie. warm and wet) climatic conditions and improved sampling machine performance led to 10 storm events being sampled between July and December 1985. The storm event sampling programme was terminated at Christmas 1985 and a dataset of 15 storm events was established. Several problems with the electrical contacts and the performance of the float switch were encountered with the equipment installed on the Churnet micro-catchment, and this resulted in a data loss for the first three storm events for this gully pot. The Tame equipment was found to be the most successful in terms of sample collection and subsequent data production, although the capture of storm samples can be viewed as a combination of equipment performance and the prevailing hydrological conditions which enable the system to be activated by the float switch. It should be stressed that the 0.05 ls-1 inflow water discharge rate threshold was only an approximate guide to the likelihood of storm capture and the individual hydrological conditions at each of the three micro-catchments were responsible for the storm event sampling performance (see Table 8.1). Indeed on some occasions

(eg. Storm V), the sampling machines were activated by an inflow discharge but the computer models used to simulate the flow conditions of the storm runoff predicted no runoff from the storm. This is a shortcoming in the use of a model in simulation analyses which takes depression storage into account in preference to a belief that a small contributing area adjacent to the gully pot may itself be responsible for producing the runoff water sufficient in flow rate to activate the sampling machines. Likewise, there was no hydrological flow data for Storms VIII and IX due to a data capture problem on the tipping bucket raingauges and the Rainfall-Runoff Models could not be utilised. In these cases, a calculation of the total flow volume was made using a rainfall depth (provided by a standard Meteorological Office raingauge) and knowledge of the micro-catchment area draining to the gully pot and the depression storage capacity of the road surfaces.

The dataset produced from the storm event monitoring programme provided a varied range of rainstorms in terms of both rainfall depth and duration, the peak rainfall intensity and the antecedent dry period. The rainfall depths vary from 0.26 mm. (Storm VII) to 25.1 mm. (Storm IX), the rainstorm duration varies from 13 minutes (Storm II) to 662 minutes (Storm XII), the antecedent dry period ranges from 6 minutes (Storm XV) to 660 minutes (Storm X) and the peak rainfall intensity from 0.76 mm/hr (Storm V) to 54.86 mm/hr (Storm I) [see Tables 8.2 and 8.3]. Hyetographs for all 15 storm events analysed can be seen in Figures 8.5 to 8.17. The simulated hydrological data has been summarised in Table 8.4 and the individual gully pot storm inlet hydrographs can be seen in the Appendices.

A full chemical analysis was carried out on the samples collected for the first six storm events. The full analysis was conducted so that

Explanation of the Variable Names Used in the Multiple Regression Analysis for the Storm Event Analysis.

VARIABLE NAME	DESCRIPTION
NUMBER	The Storm Number (ie. 1 to 15)
BODIFM	The mean BOD value in the inflow waters.
BODOFM	The mean BOD value in the outflow waters.
BODIFX	The maximum BOD value in the inflow waters.
BODOFX	The maximum BOD value in the outflow waters.
SSIFM	The mean SS value in the inflow waters.
SSOFM	The mean SS value in the outflow waters.
SSIFX	The maximum SS value in the inflow waters.
SSOFX	The maximum SS value in the outflow waters.
RF	The rainfall depth of the storm event in mm.
DUR	The storm duration in minutes.
PRINT	The peak rainfall intensity in mm/hr.
ADP	The antecedent dry period in hours.
PIFINT	The peak inflow intensity in litres per second.
VOL	The total runoff volume into the pot in litres.

NOTE: All SS and BOD values are expressed in mgl-1

Table: 8.2

Table to Show the Hydrological Conditions of the Fifteen Storms Analysed in the Storm Event Analysis Programme.

STORM NUMBER	RF	DUR	PRINT	ADP
1	7.99	105.5	54.86	158
2	1.48	13.0	40.24	23
3	14.22	341.0	26.12	41
4	3.41	282.5	12.51	96
5	0.76	115.0	0.76	106
6	5.04	134.0	26.12	59
7	0.26	19.5	2.59	112
8	1.30	*	*	*
9	25.10	*	*	*
10	0.35	53.0	0.94	660
11	13.14	302.0	12.51	49
12	5.44	662.5	2.07	108
13	2.33	188.5	3.45	37
14	13.74	544.0	26.12	20
15	9.69	423.5	12.51	6

* = Data not available.

Table: 8.3 (see Table 8.2 for explanation of the Variables).

The Simulated Inflow Hydrological Conditions for the Three Gully Pots for the Fifteen Storms Analysed.

	TAME		CHURNET		TWYFORD	
STORM NUMBER	PFLOW	VOL	PFLOW	VOL	PFLOW	VOL
1	1.15	1468.6	1.15	1418.3	1.52	2108.4
2	0.56	142.6	0.68	155.2	0.22	66.8
3	0.59	2736.0	0.57	2623.0	0.79	4073.2
4	0.31	529.2	0.30	523.2	0.39	665.4
5	X	X	X	X	X	X
6	0.84	869.5	0.81	847.4	1.10	1191.7
7	X	X	X	X	X	X
8	*	110.8	*	124.9	*	25.4
9	*	4994.6	*	4770.9	*	7571.4
10	X	X	X	X	X	X
11	0.64	2518.1	0.61	2415.8	0.95	3736.8
12	0.08	946.8	0.08	920.5	0.11	1307.6
13	0.12	314.3	0.11	318.7	0.15	333.7
14	0.59	2637.5	0.58	2529.0	0.71	3914.1
15	0.23	1814.8	0.22	1746.0	0.33	2650.0

* = Data not available.

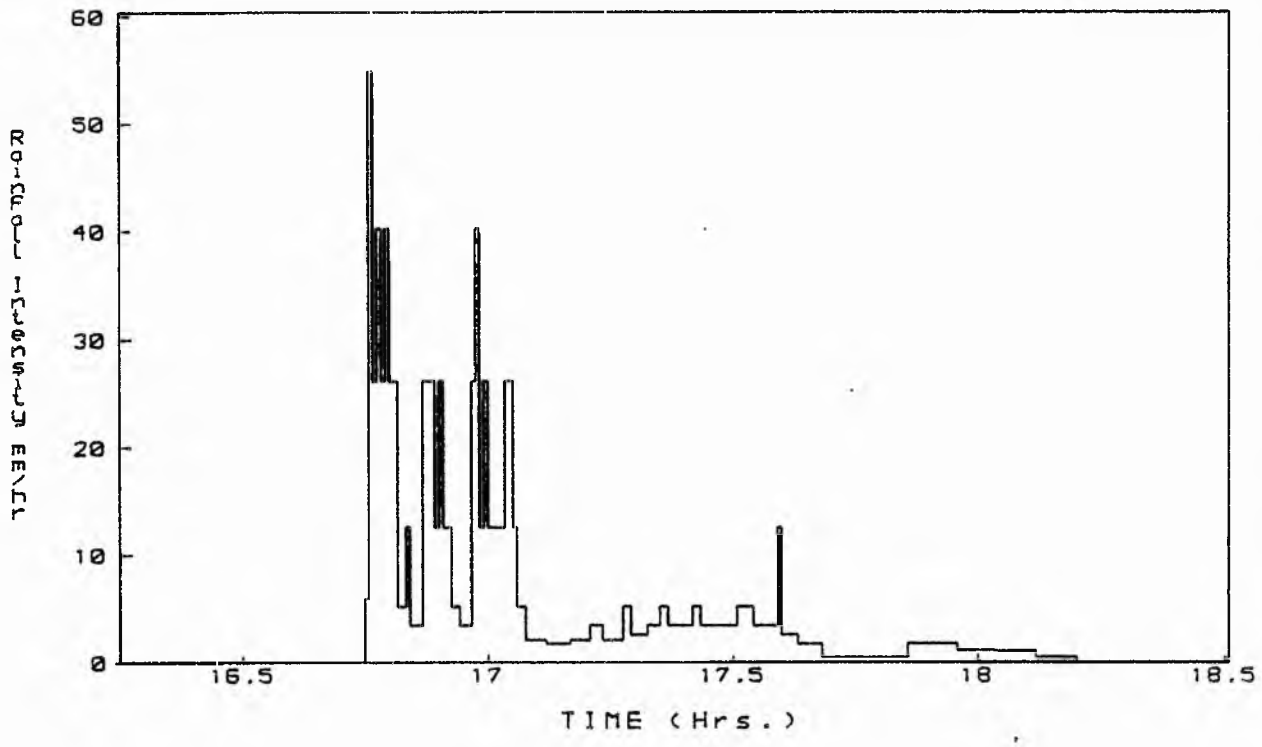
X = NO RUNOFF SIMULATED through the Rainfall-Runoff Model.

Table: 8.4 (see Table 8.2 for details of the Variables).

RAINFALL HYETOGRAPH FOR TAME CLOSE RAINGAUGE

Date of Event : 20-06-84

Figure 8.5 STORM I

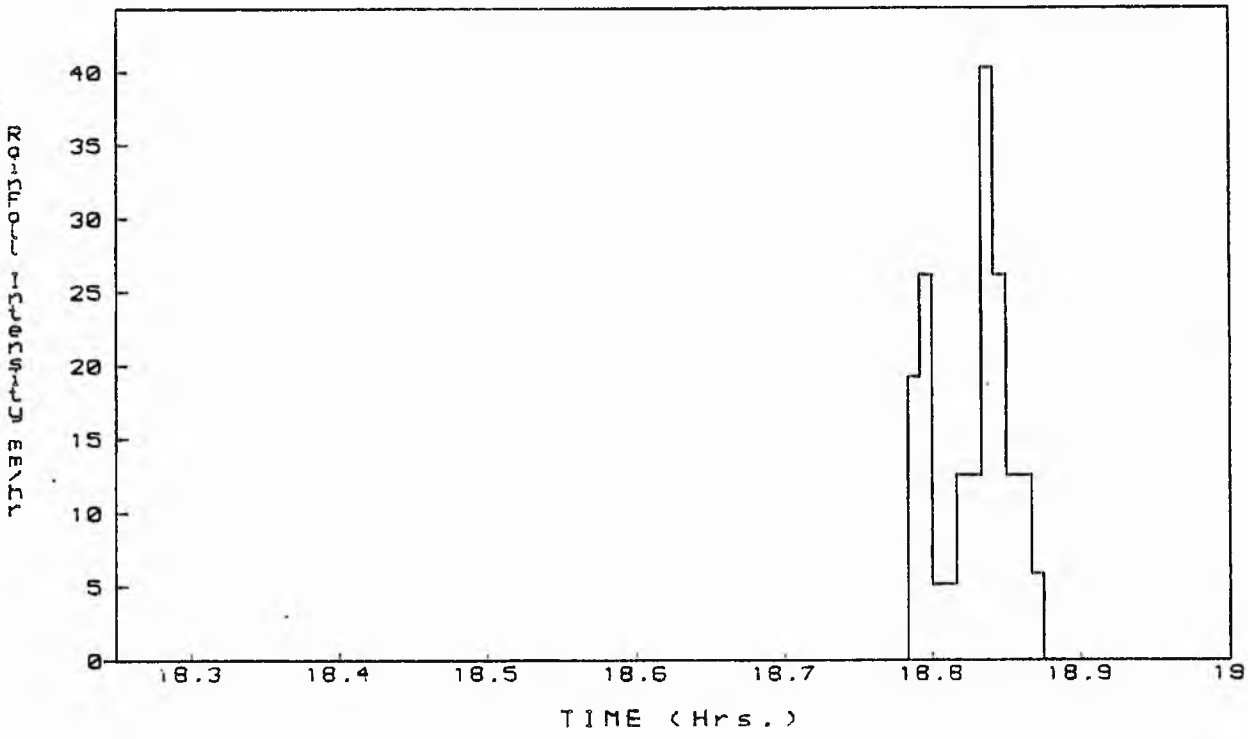


RAINFALL HYETOGRAPH FOR TAME CLOSE RAINGAUGE

Date of Event : 12-07-84

Figure 8.6

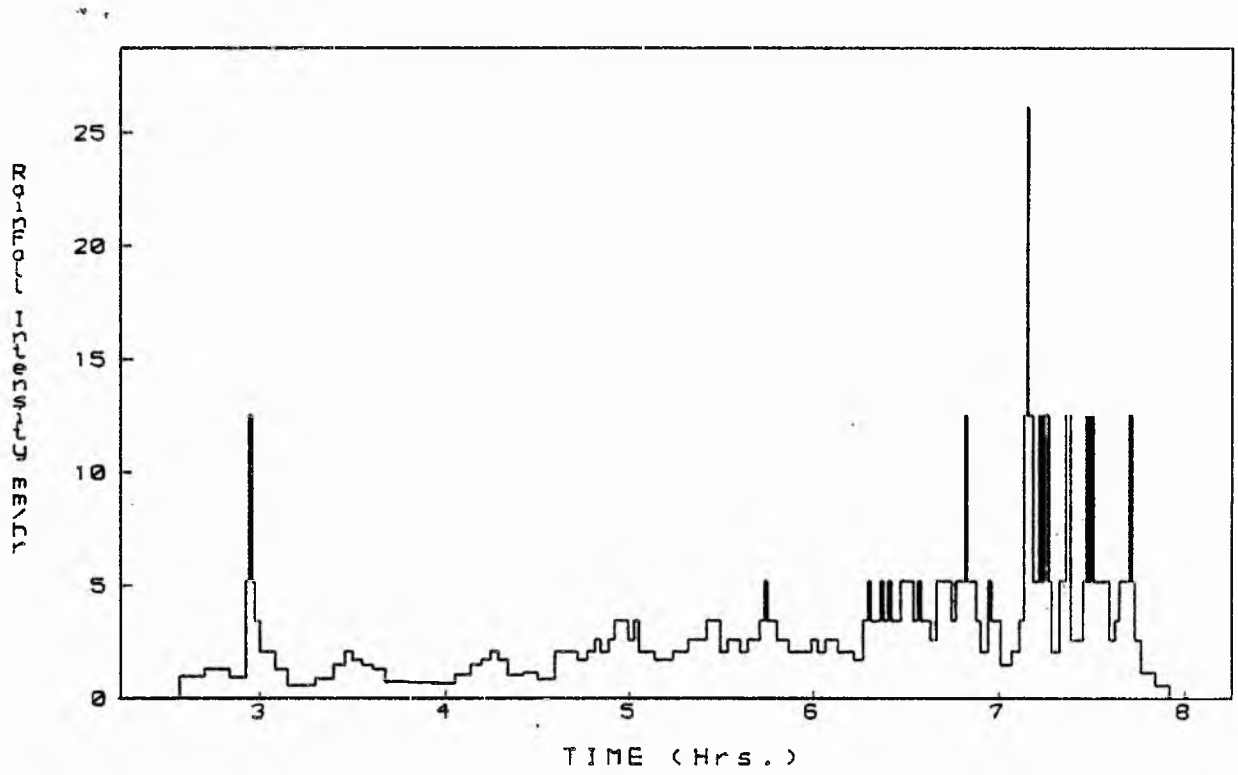
STORM II



RAINFALL HYETOGRAPH FOR TAME CLOSE RAINGAUGE

Date of Event : 02-08-84

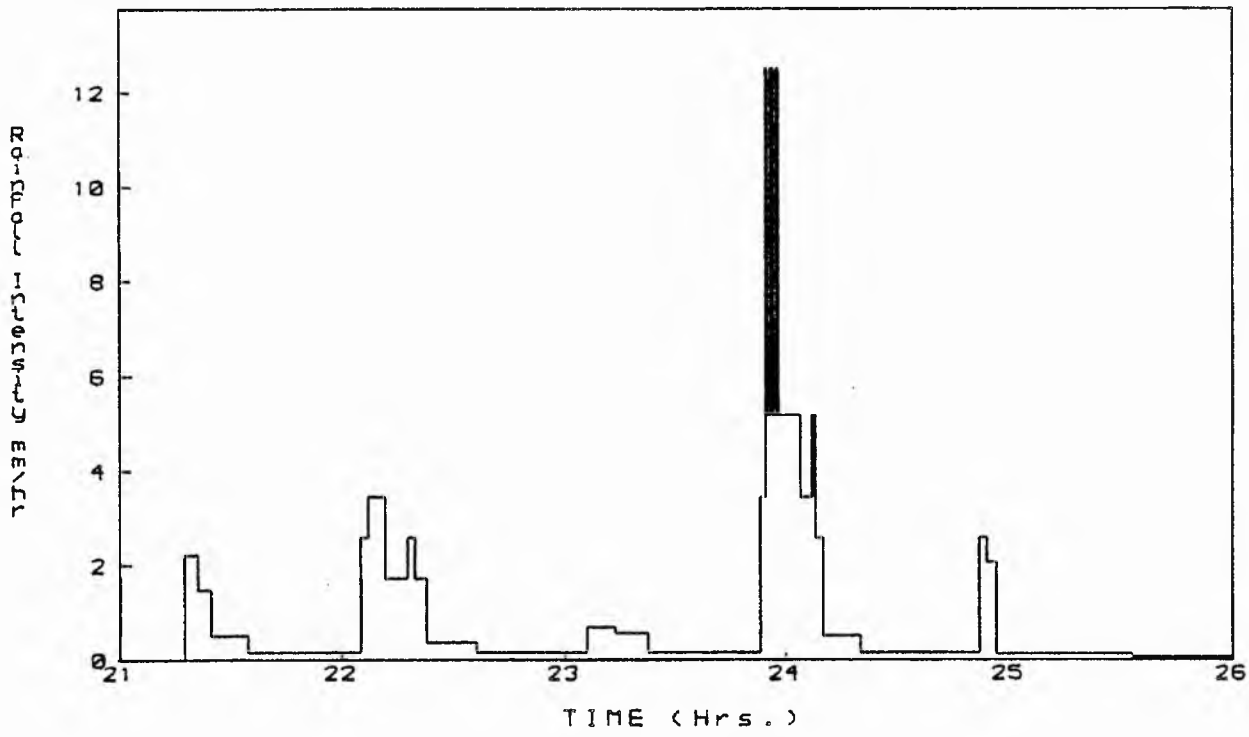
Figure 8.7 STORM III



RAINFALL HYETOGRAPH FOR TAME CLOSE RAINGAUGE

Date of Event : 13-09-84

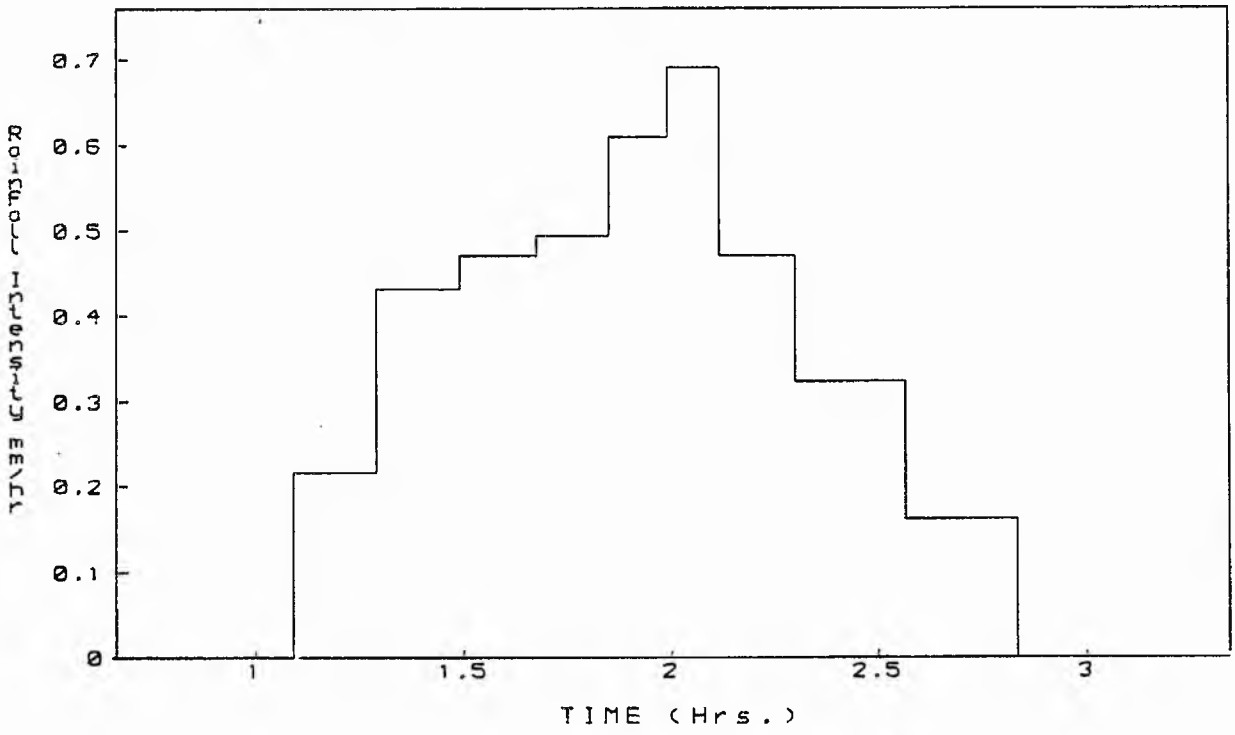
Figure 8.8 STORM IV



RAINFALL HYETOGRAPH FOR TAME CLOSE RAINGAUGE

Date of Event : 08-10-84

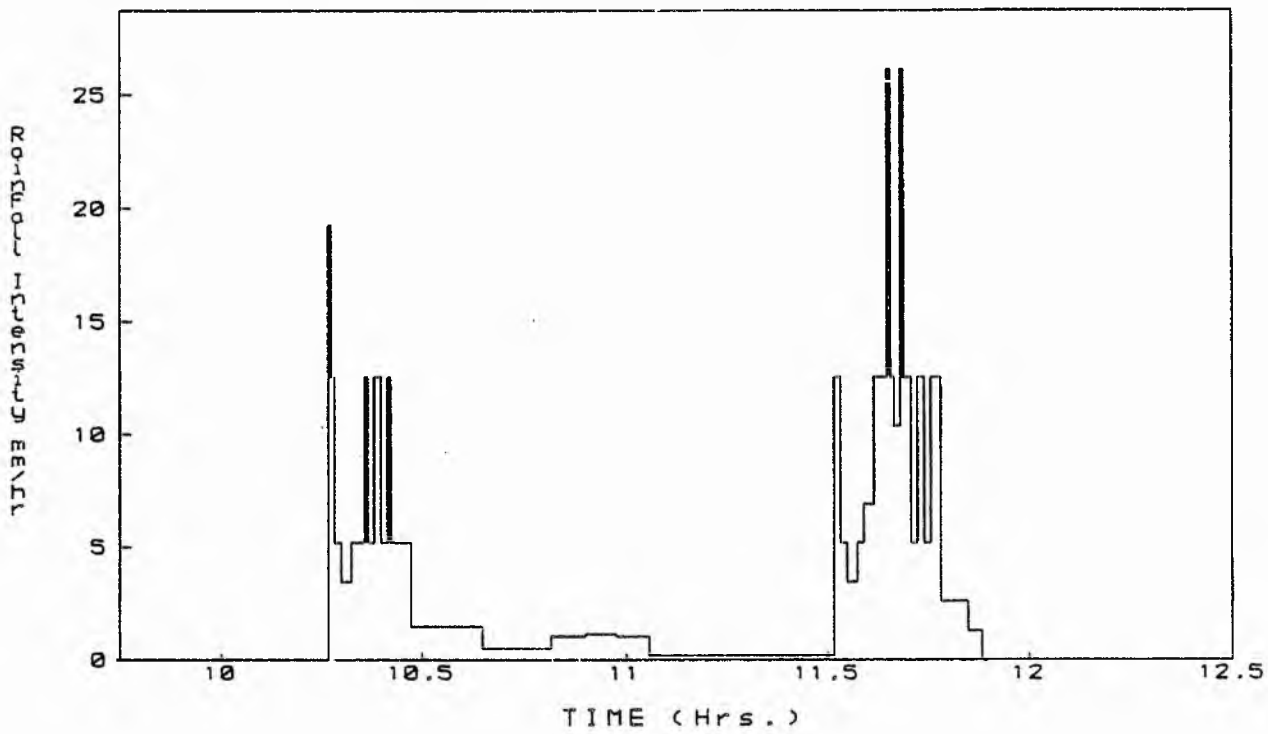
Figure 8.9 STORM V



RAINFALL HYETOGRAPH FOR TAME CLOSE RAINGAUGE

Date of Event : 02-11-84

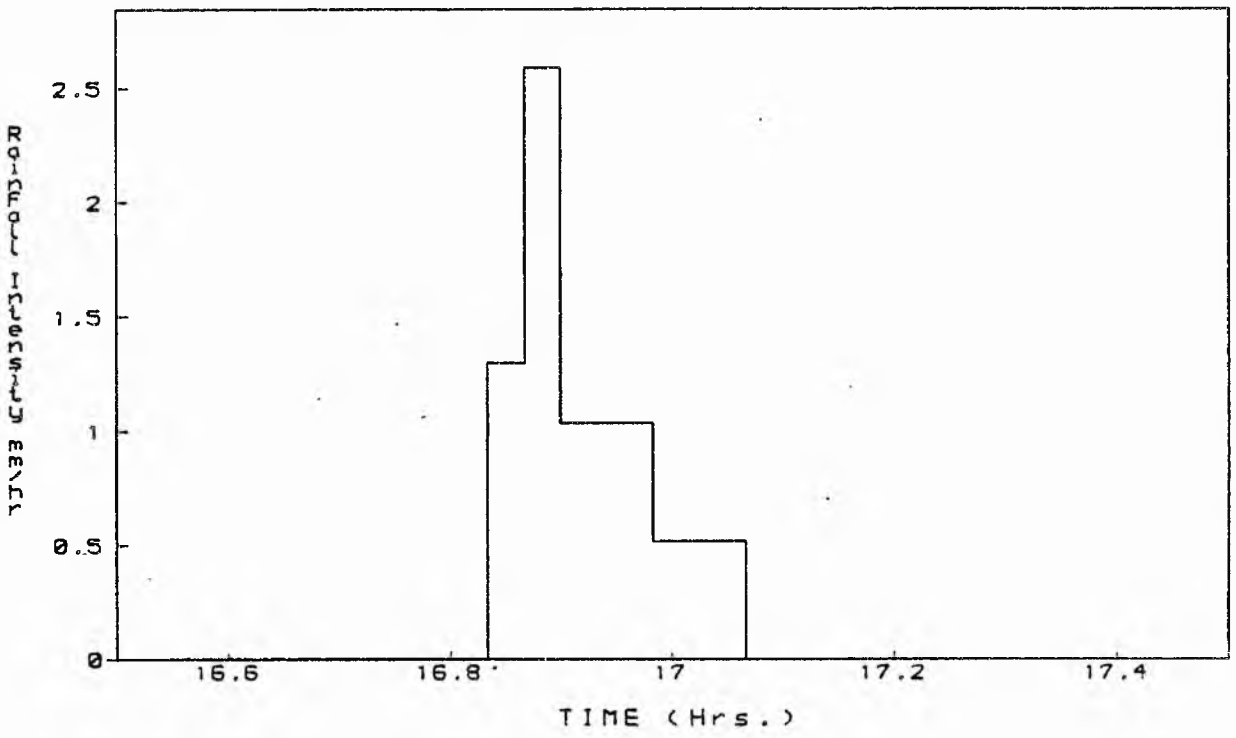
Figure 8.10 STORM VI



RAINFALL HYETOGRAPH FOR TAME CLOSE RAINGAUGE

Date of Event : 26-07-85

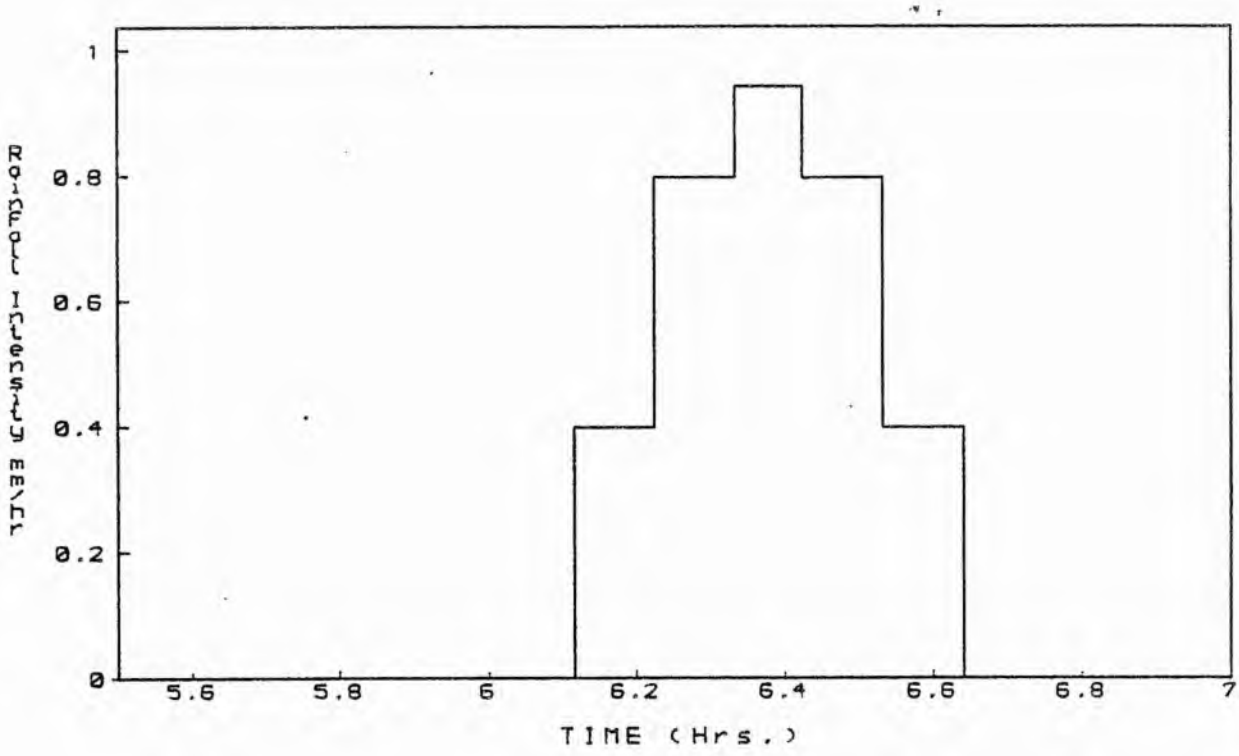
Figure 8.11 STORM VII



RAINFALL HYETOGRAPH FOR TAME CLOSE RAINGAUGE

Date of Event : 05-11-85

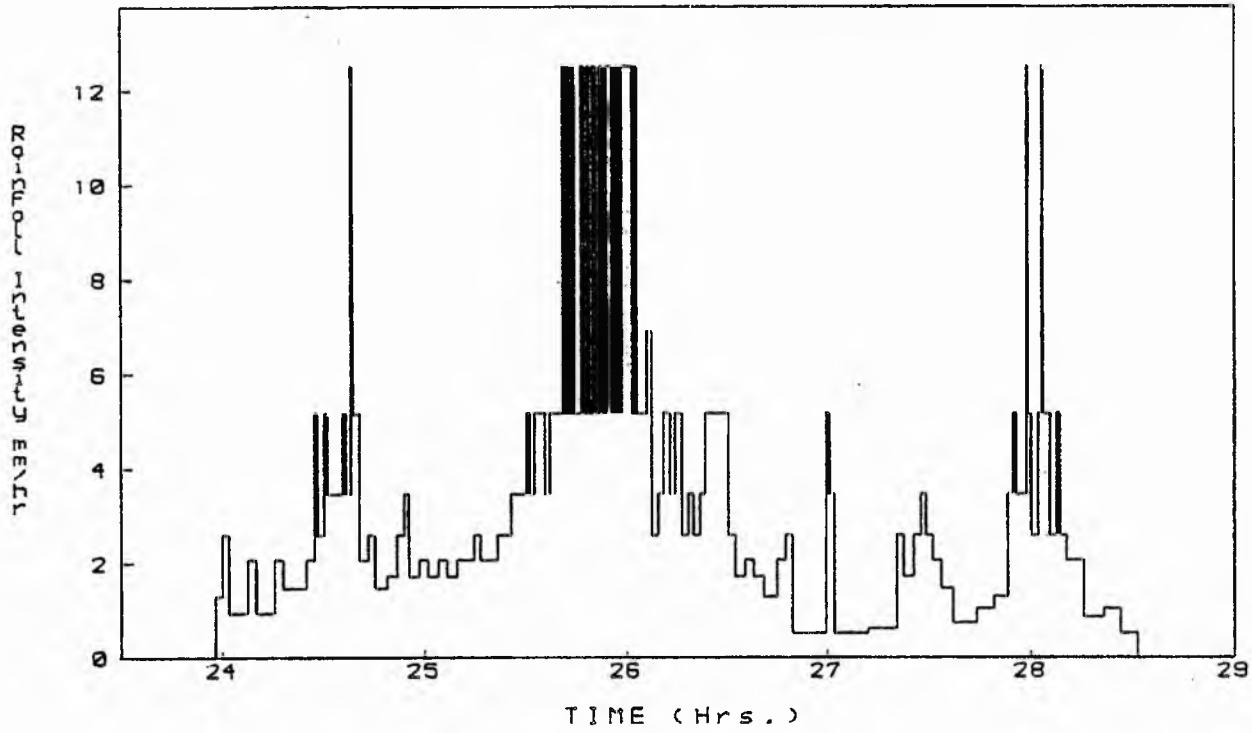
Figure 8.12 STORM X



RAINFALL HYETOGRAPH FOR TAME CLOSE RAINGAUGE

Date of Event : 07-11-85

Figure 8.13 STORM XI

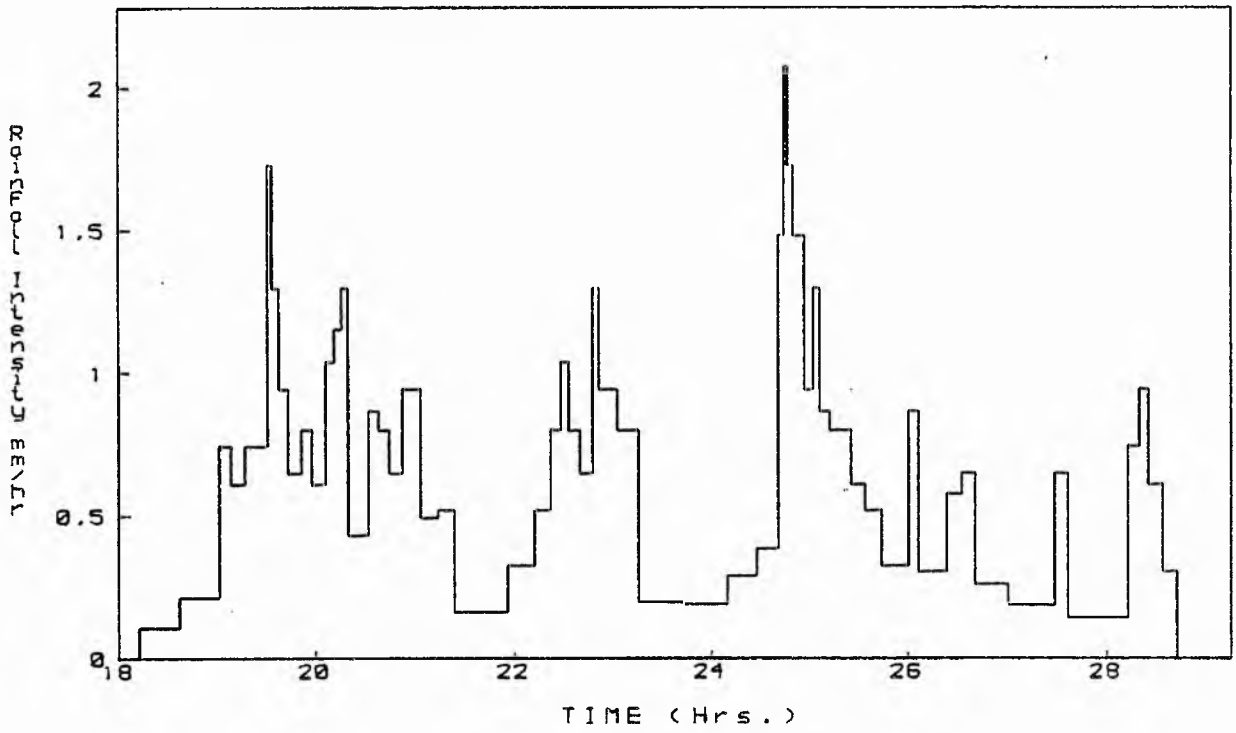


RAINFALL HYETOGRAPH FOR TAME CLOSE RAINGAUGE

Date of Event : 14-11-85

Figure 8.14

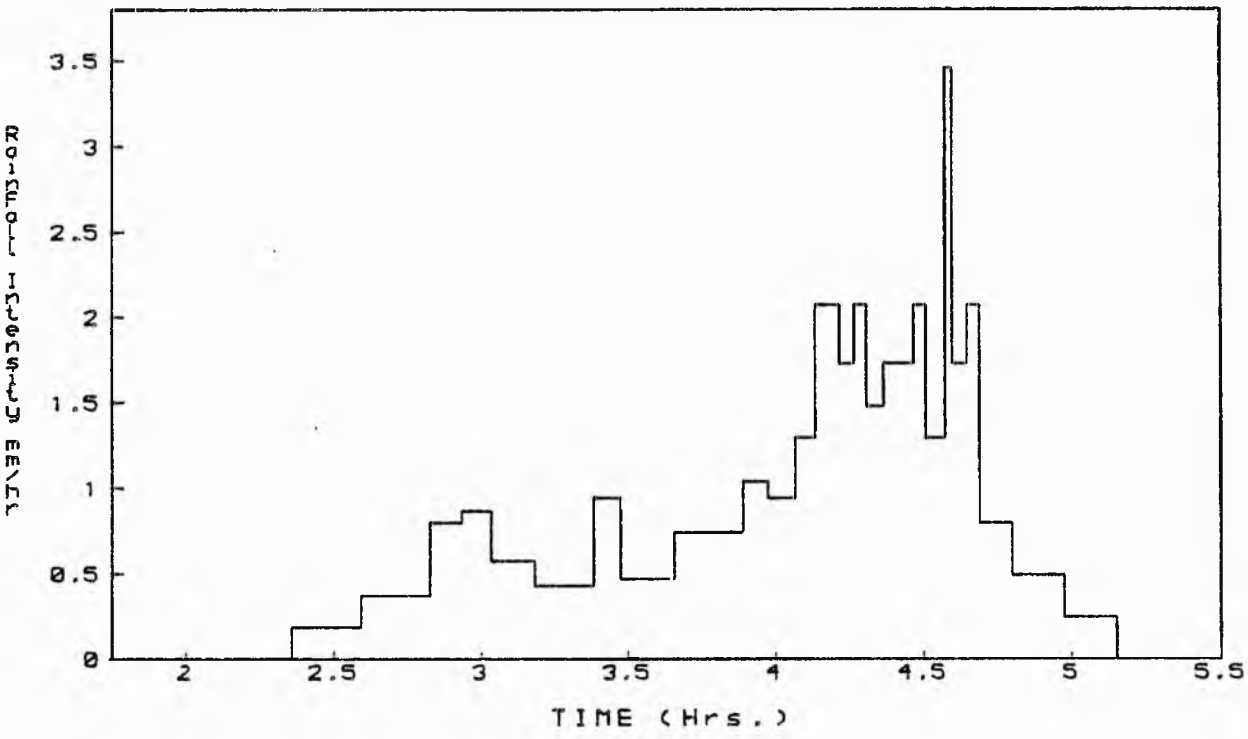
STORM XII



RAINFALL HYETOGRAPH FOR TAME CLOSE RAINGAUGE

Date of Event : 30-11-85

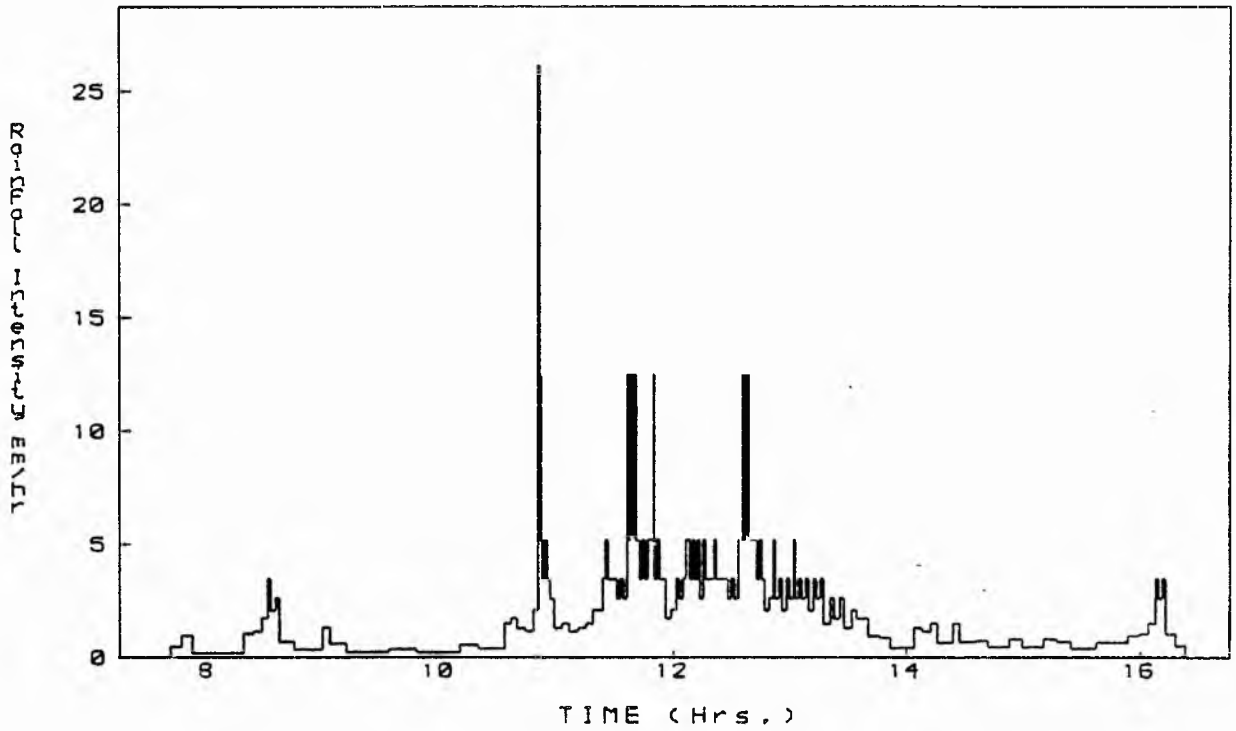
Figure 8.15 STORM XIII



RAINFALL HYETOGRAPH FOR TAME CLOSE RAINGAUGE

Date of Event : 05-12-85

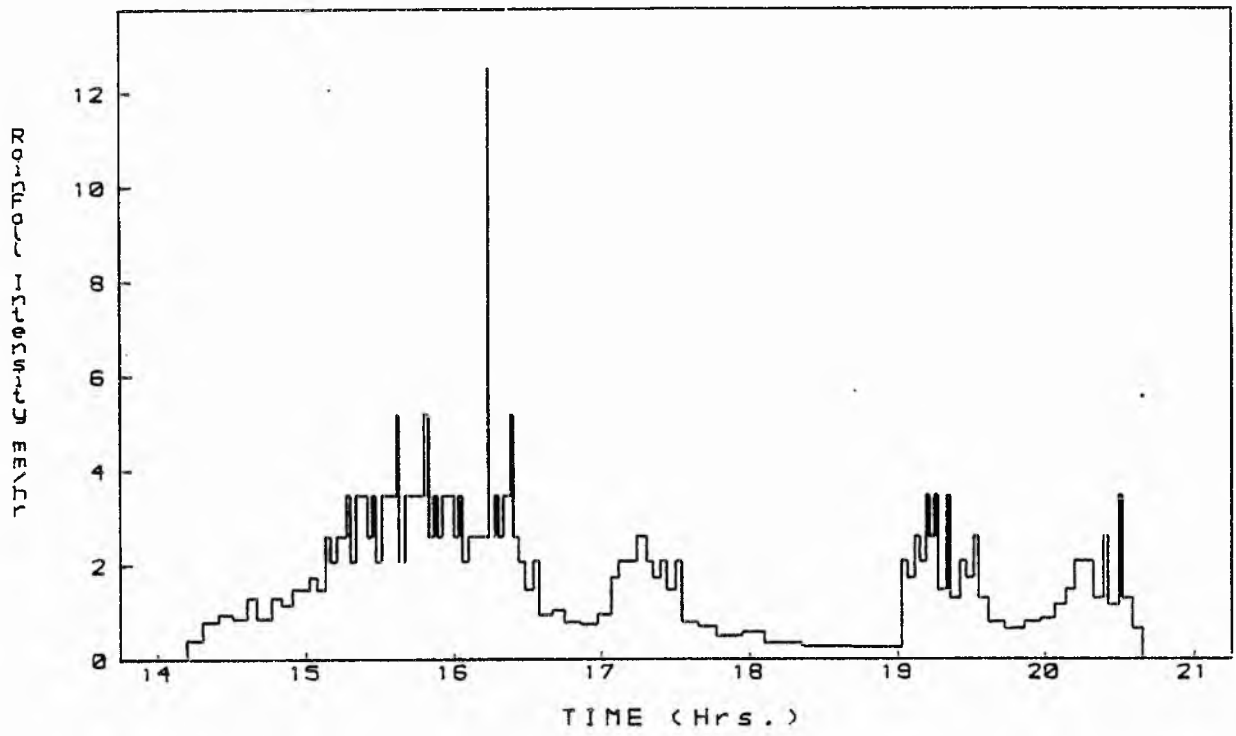
Figure 8.16 STORM XIV



RAINFALL HYETOGRAPH FOR TAME CLOSE RAINGAUGE

Date of Event : 06-12-85

Figure 8.17 STORM XV



some comparison could be made with the analysis carried out in the 'Gully Liquor Monitoring Programme' (see Chapter 7). This analysis proved to be very time-consuming for a large number of samples and some chemical parameters (eg. pH, sulphate, Total Alkalinity and Total Hardness), did not show much variation between storm events for both the inflow and outflow waters. A number of the metals did not show much variation and indeed some metals (eg. cadmium, chromium and nickel) were not detected to any significant level. A combination of the need to reduce the laboratory analysis and a survey of the data obtained from the first six events, led to a change in the chemical analysis carried out in the storm event sampling programme. There was a scale-down in the amount of analysis carried out and the main emphasis was switched to the analysis of BOD, COD, SS, Zinc, Copper and Lead. These parameters were considered to be the most environmentally significant (as far as stormwater discharges were concerned) and the development of models to predict the BOD and the SS in gully pot outflow waters was essential to the implementation of the storm event sampling programme. The inability (as explained above) to capture a greater number of storm events during the earlier stages of the storm sampling programme meant that the chemical analysis had to be limited to those parameters of most interest rather than to extend the wider analysis which set out to look at trends in some of the earth-alkali metals, heavy metals and nutrients during a storm event. The results of the chemical analyses for all 15 storm events can be seen in the Appendices. (The storm events are listed chronologically and all the chemical data tables and graphs of the chemical data with the hydrological data, are presented in the Appendices).

It should also be noted that the sample time interval was changed

during the programme. The inflow and outflow sample time interval was fixed at 6 minutes for each of the first six storm events but the sampling frequencies were changed to one minute for the inflow and to ten minutes for the outflow waters for all subsequent storm events. The reasons for such a change were that a number of short duration storm events were captured, but an insufficient number of samples were collected to enable a thorough analysis of the results. The rapid response of the urban surfaces to overland flow were such that a degree of fine-tuning of the sample time interval was necessary to ensure that the sampling was representative of the runoff character-istics as experienced in the field. The time interval between samples should try to reflect the hydrological dynamics experienced at the gully pot so that the impending quality changes can be revealed through a substantial number of samples. The variability between storm events in terms of magnitude and duration means that a suitable sample time interval for all types of event is difficult to achieve, but the experiences gained during the first year of the 'Storm Event Sampling Programme' were such that a compromise had to be reached.

A summary of the analysis of the results for each storm event is presented below and the storm number is followed by the names of the gully pot (ie. Tame, Churnet and Twyford), where samples were collected for either the inflow or outflow waters, or both.

STORM ANALYSIS: (See the Appendices for a Full Set of Data Tables).

8.7 STORM I: Tame and Twyford.

The SS concentrations in the inflow waters showe fairly consistent values throughout the sampling period for both micro-catchments with the values being slightly higher for the Twyford micro-catchment. In both cases, the outflow waters had higher SS concentrations but the two micro-catchments displayed different characteristics with respect to the change in the SS concentration of the outflow waters with time. The SS concentration of the Tame outflow waters showed a steady increase in concentration whereas a distinctive rising and recession limb SS pollutograph was found for the Twyford micro-catchment. The BOD values were found to be of a similar order of mag nitude for both the inflow and outflow waters and the BOD concentrations did not show any particular relationship with respect to time. The COD values showed a similar response to the SS concentrations, with the exception of the Tame micro-catchment where the inflow waters had higher COD values than the outflow waters. In each case, the outflow waters showed a distinctive bell-shaped pollutograph. The Conductivity response to the storm event showed that for both micro-catchments, the outflow waters had much higher Conductivity levels and these levels changed during the storm event, whereas the Conductivity of inflow waters remained fairly constant. The Dissolved Oxygen (DO) values were less for the inflow waters than the outflow waters for both micro-catchments, but the DO concentrations were in each case consistent throughout the duration of the sampling period. The pH of both the inflow and the outflow waters remained almost the same

throughout the sampling period for both micro-catchments. The analysis of the Total Alkalinity and the Total Hardness values show distinct differences between the two micro-catchments under study. The Tame data showed the inflow waters to have slightly higher values for Total Alkalinity and Total Hardness, but the outflow waters had fairly constant levels throughout the sampling period. In the Twyford micro-catchment, the inflow waters again had higher values than the outflow waters but the outflow waters increased in value for Total Alkalinity and Total Hardness before decreasing again during the storm event. The sulphate concentrations for the Tame micro-catchment were higher for the outflow waters, which was the reverse situation to that found for the Twyford micro-catchment. The chloride values showed very little change for both gully pots and no distinctive pattern emerged for the chloride data collected. The ammonia and nitrate data for the Tame gully pot showed the importance of the atmospheric input of pollutants for this particular storm event. The inflow values were in each case higher than the concentrations found in the outflow waters which were seen to rise steadily before receding again. The Twyford micro-catchment showed an inflow water nitrate concentration well in excess of the outflow waters, but the ammonia concentrations were higher in the outflow waters showing further evidence of the effects of denitrification during the summer months (see Chapter 7). The sodium and potassium concentrations showed differing characteristics between the two micro-catchments with the outflow waters for the Tame gully pot having values well in excess of those found in the inflow waters for both metals. The sodium values for the Twyford gully pot system were found to be higher in the inflow waters but a steady rise was seen in the outflow concentrations until they reached values very close to those found in the inflow waters at the

end of the sampling period. The potassium concentrations were found to be roughly equivalent for both the inflow and the outflow waters. The calcium and magnesium concentrations showed similar trends between the micro-catchments. The calcium concentrations were higher in the inflow waters in both cases and a steady rise was observed in the outflow concentrations. There was less of a marked difference in the concentrations of magnesium, but the inflow values were found to be very consistent, while a slight increase in the outflow concentrations in the outflow waters was observed. Zinc was the only heavy metal which displayed any sort of response with time during the storm event. In each micro-catchment, a significant zinc concentration was found in the inflow waters of around 1.0 mgl-1 and the zinc values in the outflow waters was seen to increase steadily throughout the sampling period to a concentration in excess of 1.0 mgl-1. The concentrations of both lead and iron did not show any distinct pattern during the storm event and a number of non-detectable levels were found in the samples. Occasional samples showed detectable levels during the storm event for both the inflow and outflow waters. It should be noted that iron was not detected at all in the inflow waters into the Tame gully pot system.

8.8 Storm II: Tame and Twyford.

The SS concentrations for both micro-catchments showed a gradual rise in value for the inflow waters and a steep rise in the SS concentrations in the outflow waters to a peak value followed by a recession limb on the pollutograph, giving a distictive bell-shaped pollutograph SS distribution for each gully pot outflow water. A similar trend was also observed for the BOD concentrations and to a lesser extent for the COD values, where enhanced outflow concentrations were observed within a distinctive pollutograph shape. The BOD and COD concentrations of the Twyford gully pot inflow waters were seen to decrease during the sampling period. The distinctive pulses of SS, BOD and COD concentrations in the outflow waters are characteristic of a short duration, high rainfall intensity storm event with a rapid storm runoff response. These storm characteristics can be used to describe Storm II which occurred on the 12th. July 1984. The Conductivity values rose considerably for the inflow waters to the Tame gully pot and a less progressive rise was observed for the outflow waters. The values found in the Twyford gully pot samples showed an increase in the Conductivity in the inflow waters but a gradual reduction in the values for the outflow waters. The DO concentrations were higher in the inflow waters for both gully pots with a steady rise being observed in the outflow waters. The relatively high DO concentrations observed in the inflow waters showed that these waters were well aerated, and this was probably due to the high rainfall intensity over a relatively short storm duration and the quick passage of the runoff over the urban surfaces into the gully pot. The pH values in both the inflow and outflow waters remained very consistent throughout the whole of the sampling period. The

values for the Total Alkalinity and the Total Hardness for the Tame micro-catchment both showed very similar distributions for the inflow and the outflow waters. The concentrations in the inflow waters were generally above those in the outflow waters. This was in contrast to the data obtained from the Twyford gully pot, where the outflow water concentrations were well in excess of those in the inflow waters. Iron was detected in a large number of samples taken for the Tame gully pot and the iron concentration in the inflow waters was seen to decrease gradually, whilst a slight increase was found in the outflow waters. The samples taken at the Twyford gully pot had a larger number with non-detectable iron levels, although a few samples with detectable levels were obtained for the inflow and outflow waters, but no distinctive pattern in the iron concentrations could be found. Cadmium was detected in a few outflow samples taken at the Tame gully pot. The sodium and potassium concentrations in both gully pots showed the same characteristic patterns. The concentrations in the outflow waters were higher than those in the inflow waters, which remained fairly consistent. A distinctive rise and fall of the outflow potassium pollutograph was observed for both gully pots, but this was illustrated to a lesser extent by the sodium outflow concentrations. The calcium and magnesium concentrations in the inflow waters for the Tame gully pot both showed a gradual decrease during the sampling period, while at the same time, an increase was observed in the outflow waters to a maximum at a time just after the end of the runoff event. The Twyford micro-catchment experienced an increase in the calcium and magnesium concentrations in the inflow waters before a gradual decrease in concentration to a level similar to that found at the beginning of the runoff event. The concentrations for the outflow waters remained at a consistent level

for both metals and the concentrations of calcium and magnesium were higher in the inflow waters than the outflow waters for the Twyford gully pot. The concentration of zinc was higher in the outflow waters of both gully pots with a slight rise at the beginning of the runoff event, to be followed by a gradual decrease towards the end of the sampling period. Indeed, zinc was not detected in the final outflow sample collected from the Tame gully pot. The inflow waters had very consistent values of about 1.0 mgl-1 throughout the sampling period. The nitrate values were similar for both the inflow and outflow waters in the two micro-catchments, with a similar pattern emerging in the nitrate pollutographs which illustrated a slight time lag between the inflow and outflow nitrate data. The ammonia concentrations in the outflow waters were higher than those in the inflow waters for the Tame micro-catchment, but both sets of samples showed a steep increase in ammonia concentrations followed by a gradual decrease. A similar pattern emerged for the Twyford gully pot, although the rise in the outflow levels could be attributed to some relatively high inflow concentrations of ammonia at the start of the runoff event.

8.9 Storm III: Tame and Twyford.

The SS concentrations for both the inflow and outflow waters showed a steady rise and then a gradual reduction in value during the sampling period on the Tame micro-catchment. The SS values in the outflow waters were always higher, but a similar trend was observed in both sets of data. The Twyford gully pot data showed a slight decrease in the inflow SS concentration and the outflow values were in excess of the inflow concentrations. The BOD and COD values observed for the Twyford micro-catchment showed a similar pattern, with the outflow waters having a higher concentration at the beginning of the storm event. The inflow waters had consistent BOD and COD values, and throughout the sampling period the BOD and COD concentrations of the outflow waters were seen to decrease to values well below those in the inflow waters. This was caused by a dilution effect as the volume of stormwater runoff increased. Storm III had a very long duration in comparison with the other storm events captured as part of the storm event analysis programme. The BOD values for the Tame gully pot showed a great deal of variation in both the inflow and the outflow waters. All the COD values obtained from the Tame gully pot showed an increase during the sampling period, but there was very little difference in the COD values between the inflow and outflow waters. The Conductivity values for both micro-catchments showed that the values for the outflow waters were at all times greater than those in the inflow waters. The Conductivity values were very consistent with both the inflow and outflow waters retaining near constant values. The DO concentrations of the inflow waters on the Tame micro-catchment showed a steady rise and then a gradual fall during the sampling period and this led to the higher concentrations found in the outflow

waters. The outflow waters from the Twyford gully pot showed a similar response, but there was little difference in the DO levels between the inflow and the outflow waters for this gully pot system during this particular storm event. Once again, the pH values remained very consistent for both the inflow and outflow waters. The analysis of the Total Alkalinity and the Total Hardness data showed some differences between the two gully pots. The Total Hardness values in the inflow waters were generally higher than the outflow waters for both micro-catchments and a cyclical trend was found in the concentrations in the outflow waters. The trends shown by the Total Alkalinity data showed different concepts. The Tame gully pot inflow waters had high Total Alkalinity levels at the start of the runoff event, with a gradual reduction throughout the storm event. The values in the outflow waters showed a cyclic response, with the concentrations being less than those in the inflow waters, in most cases. The Total Alkalinity data for the Twyford gully pot showed little change in the concentrations at the start of the runoff event, but this was followed by a gradual increase in the Total Alkalinity levels throughout the remainder of the sampling period. The sulphate concentrations were found to be highly variable in both the inflow and the outflow waters for both the gully pot systems under analysis. The chloride concentrations for the Tame gully pot showed a very distinctive pattern. The inflow waters had a very consistent chloride level which was well in excess of the levels found in the outflow waters, but these were seen to rise and fall gradually throughout the sampling period. The chloride concentrations in the outflow waters from the Twyford micro-catchment showed a gradual increase throughout the sampling period to reach values which were roughly equivalent to those in the inflow waters observed at the beginning of the runoff

event. The ammonia concentrations of both inflow waters showed a marked decrease during the runoff event as a result of a diminishing source of ammonia within the micro-catchment area and a dilution effect upon the runoff inflow waters. At the same time, the outflow waters showed a marked increase in ammonia concentration although the rate of increase was seen to level off towards the end of the sampling period. The outflow waters from the Twyford gully pot had ammonia levels well above those of the inflow waters at all times. The nitrate data obtained from the Tame micro-catchment again illustrated the impact of atmospheric nitrogen as nitrate in rainwater, since the nitrate was found in sizeable concentrations in the inflow waters but was not detected to any great degree in the outflow waters. The lead, manganese and iron concentrations were found to be erratic for both gully pot systems with a large number of samples exhibiting non-detectable concentrations. There was no distinct pattern to the data which was collected for these three metals. The sodium and potassium concentrations showed very similar characteristics for both the micro-catchments. The inflow water concentrations were all less than those in the outflow waters. The concentration of the two metals in the outflow waters were fairly consistent throughout the sampling period with an almost identical curve for potassium on both outflow waters. The trend of the potassium concentration in each gully pot outflow water was the same for the two micro-catchment areas. The calcium concentrations showed a stepped decrease in value through the sampling period for both the gully pots, with the outflow concentrations exceeding those of the inflow waters at all times. A distinction could be drawn between the two gully pots with respect to the magnesium values. For the Tame micro-catchment, the magnesium concentrations in the inflow waters were less than those in the

outflow waters, which themselves rose gently and then gradually decreased again. The outflow waters from the Twyford gully pot showed a very gradual decrease in magnesium levels throughout the sampling period and these levels were not enhanced by the high values in the inflow waters sampled at the beginning of the runoff event. The zinc concentrations showed a degree of consistency for both the inflow and the outflow waters in both gully pot systems. The concentrations in the outflow waters were higher than those observed in the inflow waters, but no distinctive trend could be observed in the zinc data obtained for Storm III.

8.10 Storm IV: Tame, Churnet and Twyford.

It should be noted that there were no inflow samples collected from the Tame gully pot due to a mechanical breakdown of the sampling equipment. The usual analysis was, however, carried out on the outflow water samples which were collected from the Tame gully pot system. The SS concentrations showed a gradual reduction in value after three distinct peaks in the distribution, which roughly corresponded with the peaks in the inlet storm hydrograph. The BOD values in the outflow waters showed a steadily decreasing level due to a dilution effect during the sampling period. A similar trend was also observed for the COD concentrations. The concentrations of sodium and the pH values stayed at a consistent level throughout the sampling period, but a cyclic trend was observed for the potassium, magnesium and calcium concentrations. Two distinct peak values were obtained for both the zinc and manganese in the outflow waters and these peaks coincided with those found on the inlet hydrograph, which infers that the zinc and manganese were carried into the gully pot by the incoming storm runoff water and were not from a source within the pot liquor itself.

The analysis of both the inflow and outflow waters for the Churnet and Twyford gully pots showed that the SS concentrations of the Churnet inflow waters showed a great deal of variation in their value, but the peaks did coincide with those on the inlet hydrograph. The SS concentrations in the Twyford inflow waters were more sporadic and there was a longer lag time between the peak of the inlet hydrograph and the peak of the SS pollutograph. The outflow waters for both gully pots showed very little variation in SS values which were all

close to zero. The BOD and COD concentrations showed a more variable distribution throughout the sampling period, although the COD values in the outflow from the Twyford gully pot did show a gradual decrease in value due to a dilution effect. The inflow BOD and COD concentrations for both gully pots showed a series of high and low values which did not conform to a particular trend sequence. The pH values showed a remarkable degree of similarity between the inflow and the outflow waters in the Churnet micro-catchment, whereas for the Twyford gully pot system the inflow waters had pH values less than those of the outflow waters, with an average value of just below pH 6.0. This was probably due to the acidic rainwater, whereas the outflow waters were influenced by the salts and ammonia present in the gully pot liquor and associated sediments at the start of the runoff event. Iron concentrations for the inflow waters for the two gully pot systems both showed peak values at the beginning of the runoff event with a gradual reduction in the concentrations with time. Iron was not detected at all in the outflow waters from the Twyford gully pot, whereas those iron values detected in the Churnet outflow waters were quite small at first and then became negligible and even non-detectable during the duration of the storm event. The sodium values for both gully pots showed very consistent values for both the inflow and the outflow waters with the concentrations in the inflow waters always being less. The potassium levels in the inflow waters in the Churnet micro-catchment showed a response which followed the inlet hydrograph response with a subsequent increase in the outflow concentrations. A similar effect for potassium concentrations was found for the Twyford gully pot system, but in a less pronounced manner. The calcium concentrations in both outflow waters showed a cyclic response with a well-defined lag behind the inflow water

calcium levels for the Churnet gully pot. The inflow concentrations were always higher in the Churnet gully pot, whereas they were generally of the same order of magnitude for the Twyford micro-catchment. The magnesium concentrations were found to be of the same order of magnitude in both the inflow and outflow waters for both the Churnet and the Twyford gully pot systems. The concentrations of zinc in both inflow waters proved to be negligible, with most samples having a non-detectable value. The zinc concentrations for the outflow waters both had a similar distribution with a bell-shaped curve when the zinc concentration was plotted against time. The Rainfall-Runoff Model used to simulate the inlet hydrological flow conditions produced a small pulse of flow for the inflow waters for the Churnet gully pot ahead of the main peak of the storm hydrograph which occurred at midnight. This smaller peak did not appear in the simulation analysis for the Twyford inflow waters. The values of zinc in the outflow waters were clearly related to the prevailing hydrological conditions with a well established pattern of a slight lag behind the hydrological responses. It was difficult to establish any meaningful relationships for the manganese and lead data collected during the Storm IV sampling period.

8.11 Storm V: Tame, Churnet and Twyford.

The Rainfall-Runoff Model was run for all three micro-catchments under study and the models did not produce any storm runoff water within the computer simulation. This was due to the fact that the simulated effective rainfall did not satisfy the depression storage values within the Rainfall-Runoff Models and, therefore, no runoff was produced from the simulation models.

The Twyford gully pot outflow waters showed a similar trend for the SS and BOD values, with a gradual decrease in concentration over time due to the dilution effect. The COD values were highly variable and did not conform to any particular pattern. The Conductivity values showed a gradual decrease during the storm event from an initial peak value, but the pH values remained constant throughout the sampling period. The Total Alkalinity and the Total Hardness values followed a similar trend to each other with a gradual reduction in the concentration, illustrating a dilution effect upon these particular parameters. The data obtained for sulphate, ammonia and chloride in the Twyford outflow waters did not show any set pattern, although a quasi-cyclical trend could be seen for the ammonia concentrations, initiated with each cyclic segment with an extremely high ammonia concentration. The nitrate values for the outflow waters showed a marked decrease during the storm event and this provided further evidence that the nitrate was chiefly derived from the atmosphere and hence had a higher value at the beginning of the storm when the initial runoff waters contributed directly to the gully pot liquor quality and hence to the quality of the initial outflow waters. It seemed that there was little if any contribution to the nitrate in the outflow waters from

the pot liquor itself. The phosphate values obtained from this storm event did show a marked increase during the sampling period with an upward jump in the phosphate concentration at the end of the sampling period. As far as the metals analysis was concerned for the outflow waters from the Twyford gully pot, the concentrations of calcium, magnesium, sodium and, most notably, manganese did not show any great variations during the sampling period. Slight deviations could be seen, but no apparent trend could be readily observed. A gradual decrease in concentrations could be seen for the potassium and zinc metals due to a dilution effect from the relatively high initial values in the outflow waters to levels at the end of the sampling period, being roughly equivalent to half those at the start of the runoff event.

Some data were obtained for the inflow waters into the Tame and Churnet gully pots but very few inflow samples were obtained, or could be analysed (due to the small sample volume collected). This hindered any direct comparison between the trends established during the storm event for given determinands, and the absence of the inlet hydrological data compounded the problem of trying to explain the trends in the data for this particular storm event. The SS and COD values for both the gully pots were quite variable with no distinctive trend apparent. The BOD values for the inflow waters were initially high, but a gradual decrease was observed in the outflow waters to give a steady decline in BOD concentration with time during the sampling period. The Conductivity and pH values remained almost constant for both the inflow and the outflow waters for both gully pots. The Total Hardness values for the outflow waters showed a cyclic trend in each gully pot and a similar response was observed for

the Total Alkalinity values in the Tame outflow waters. This was in contrast to the Total Alkalinity values in the Churnet outflow waters, which remained constant after an initial change in concentration. The sulphate, ammonia and nitrate concentrations in the outflow waters from the two gully pots (Tame and Churnet) both exhibited a wide range of values with no apparent trends within the data. Meanwhile, the phosphate and chloride values were fairly consistent and a series of pulses in the data distribution probably reflected slight changes in the inlet flow conditions into the gully pot (this was impossible to prove since no flow conditions could be simulated for this rainfall-runoff event). The metals analysis revealed very little change in any of the metal concentrations in the outflow waters (except perhaps for the sodium concentrations in the outflow waters from the Churnet gully pot), and the fluctuations were generally quite small and were probably explained by the prevailing hydrological conditions.

8.12 Storm VI: Tame, Churnet and Twyford.

There were no inflow water samples collected from the Churnet gully pot but outflow samples were collected. The SS concentrations in the Churnet outflow waters were found to be quite variable and they did not seem to follow any of the characteristics displayed by the inlet hydrograph. The BOD concentrations were gradually reduced in value during the sampling period but only a few samples were analysed for BOD. The COD values steadily decreased due to a dilution effect, but the concentrations rose sharply to coincide with the secondary major peak of the inlet hydrograph. The Total Hardness values decreased gradually in contrast to the Total Alkalinity concentrations which varied greatly both above and below the 100 mgl-1 as $CaCO_3$ level. The Conductivity and DO concentrations showed a steady decrease in value in the outflow waters during the runoff event, and the pH values showed a very slight decrease from their values at the start of the sampling period. The chloride and phosphate values in the outflow waters showed considerable variation, whereas the sulphate concentrations were seen to rise steadily throughout the sampling period, although it must be said that this trend has been inferred from a very limited number of samples in comparison to other determinands which have been described above. The concentrations of ammonia, sodium, potassium, calcium and magnesium all showed a steady decline during the runoff event, whereas the nitrate levels rose substancially in the outflow waters to reach a peak value at the end of the sampling period. The zinc and manganese concentrations increased gradually at the beginning of the storm event to reach their maxima just prior to the secondary peak of the inlet hydrograph. The concentrations of both metals then decreased to values similar to

those found in the outflow waters at the beginning of the storm event sampling period.

Both inflow and outflow waters were successfully collected for the Tame and Twyford micro-catchments. The SS concentrations for both gully pots showed the concentrations to be always greater in the inflow waters, and the inflow SS values were highly variable. Both sets of outflow waters exhibited a similar characteristic in that a gradual reduction due to dilution followed the peaks on the inlet hydrograph. The BOD values did not show any particular trends, except that the inflow BOD concentrations into the Tame gully pot were significantly higher than those inflowing to the Twyford gully pot. The COD concentrations in the inflow waters for the Tame micro-catchment showed a gradual decrease at the beginning of the storm event, whilst at the same time the COD values in the outflow waters showed a steady rise. This sequence was one of the clearest illustrations of the effect of incoming runoff waters on the liquor quality discharging from the gully pot system. The effect was not marked for the Twyford gully pot, whereby the inflow COD values closely mirrored the flow regime of the runoff waters, whilst the outflow waters showed a steady decline in their COD values due to dilution effects. A similar observation was made for the Conductivity values in the Twyford gully pot waters which showed a gradual decrease in both the inflow and the outflow waters during the sampling period. This was in contrast to the Conductivity values measured for the Tame gully pot system, whereby the values remained constant throughout the sampling period with those for the inflow waters being less than the Conductivity values in the outflow waters. The DO and pH values were constant for all the samples collected from both the gully pot

systems. The Total Hardness values for the inflow waters showed a similar trend for both the Tame and Twyford gully pots. The concentrations were seen to be fairly constant at the beginning of the storm runoff but they then dipped downward at the onset of the peak of the storm hydrograph, after which they settled down to a lower concentration. Meanwhile, both outflow waters showed a decrease in Total Hardness concentrations due to dilution. There was no distinctive pattern for the Total Alkalinity data for the two gully pot systems and the chloride data showed the same response. Storm VI provided one of the few examples of sulphate in the inflow waters. For both gully pots, the inflow and outflow waters had sulphate concentrations which decreased gradually, and the outflow waters had less sulphate than their respective inflow waters at all times. The ammonia concentrations showed a slight cyclical distribution for both the inflow and the outflow waters, which may have been caused by a turnover of the upper part of the gully pot liquor, and the corresponding inflow of ammonia in the storm runoff, which was dictated by the storm characteristics showed two peaks on the inlet hydrograph. The nitrate concentrations were found to be higher in the outflow waters for both the gully pots with a steady rise in the outflow concentrations at a time just after the inlet storm hydrograph peaks. This pattern was not so well-defined for the inflow waters. The inflow and outflow waters both exhibited decreases in the phosphate concentrations during the storm runoff and the same response was found for sodium, potassium, calcium, magnesium, zinc and manganese. Some manganese was detected at the beginning of the storm runoff event in both gully pots (Tame and Twyford) in both the inflow and outflow waters. These concentrations were found to decrease sharply until non-detectable values (at the <0.1 mgl^{-1} level) were

obtained towards the end of the sampling period. The pollutograph profiles for zinc showed a gradual reduction in concentration in both the inflow and outflow waters, and the concentrations of the zinc in the inflow and outflow waters was generally of the same order of magnitude.

8.13 Storm VII: Tame and Twyford.

The Rainfall-Runoff Models used to simulate the flow conditions did not produce any runoff for this storm event and the reasons for this have been explained in the text under Storm V. The only water quality data available for the Tame micro-catchment were for the two inflow samples which were collected at the beginning of the storm event. A more comprehensive sample collection for both inflow and outflow waters was made for the Twyford gully pot system. The data obtained for the Twyford gully pot showed there to be a very highly variable inflow quality with respect to the SS, BOD and COD, which all varied enormously at the beginning of the storm event. This was followed by an outflow water quality which followed no logical pattern. The Conductivity in the inflow waters decreased quite sharply at the beginning of the runoff event, whilst the Conductivity of the outflow waters was fairly constant. The DO concentrations in the outflow waters did show a steady rise but they were all well below those of the inflow waters, which were consistently around the 8.0 mgl-1 level. The pH values held steady throughout the sampling period with the pH of the outflow waters just higher than those in the inflow waters. The concentrations of Total Alkalinity and Total Hardness fell dramatically in the inflow waters at the beginning of the storm event and the response in the outflow waters was found to be highly variable. The ammonia, sulphate and chloride concentrations decreased very sharply due to a dilution effect and an almost cyclic response was observed in the quality of the outflow waters for those two determinands. The nitrate concentrations in the inflow waters were seen to rise steadily at the beginning of the storm to reach a peak value at the end of the inflow sampling period. The outflow water

nitrate concentrations were consistently low throughout the sampling period and they were substantially less than the nitrate concentrations measured in the inflow waters. The phosphate levels showed a dilution effect in the inflow waters which was followed by an increase in the concentrations in the outflow waters, which were later observed to decrease and increase again in a cyclic manner. The sodium and potassium levels decreased markedly in the inflow waters with a resulting variable trend in the outflow waters. The potassium concentrations in the inflow and outflow waters were generally of the same order of magnitude, whilst the outflow water sodium levels were well above those in the inflow waters throughout the sampling period. The steady fall in the inflow concentrations of calcium and magnesium was also observed, but there was little effect upon the quality of the outflow waters for these two metals since the concentrations remained almost constant during the storm runoff event. A similar trend was observed for the zinc and manganese concentrations in Storm VII for both the inflow and outflow waters.

8.14 Storm VIII: Tame.

The Rainfall-Runoff Models did not simulate any runoff flow for this storm event and the reasons are given in the text under Storm V. Both inflow and outflow samples were collected from the Tame gully pot system for this storm event.

The SS concentrations in the inflow waters were seen to rise at the beginning of the storm runoff event, but with only three samples collected it was difficult and, indeed, unwise to infer any particular trend, even though the rising SS concentrations in the outflow waters did reflect a substancial input of solids in the runoff waters. TOC analysis was performed on these samples of storm runoff inflow and outflow waters and this was part of a trial to test whether there was a relationship between the BOD and TOC in the form of a stable ratio, such that the time-consuming BOD analysis could be substituted by the quicker TOC analysis (see Chapter 5) in the laboratory analysis. The BOD, COD and TOC inflow water concentrations were initially quite high but were seen to decrease, and the concentrations in the outflow waters declined gradually due to dilution effects. The pH values in the inflow waters dropped slightly at the beginning of the sampling period, but the outflow water pH values stayed constant for the remainder of the sampling period. The Conductivity levels and the chloride concentrations (not unrelated) showed an identical response for Storm VIII. The inflow water concentrations were quite high in comparison to those in the outflow waters and were consistent, whereas the Conductivity and chloride concentrations in the outflow waters showed a very gradual decrease to level out towards the end of the sampling period. Copper was detected in the inflow waters (0.07

mgl-1) but was not detected in any of the outflow water samples. The zinc concentrations in the outflow waters were seen to rise steadily throughout the sampling period, but the levels were all well below those measured in the inflow waters sampled at the beginning of the storm runoff event.

8.15 Storm IX: Tame and Twyford.

There was no hydrological data available for this storm event due to a breakdown in the tipping bucket raingauge logging equipment. A rainfall depth was obtained from a nearby Meteorological Office raingauge and the flow volume was estimated using the runoff coefficient, depression and catchment area data for the Tame and Twyford micro-catchment areas. It was not possible therefore to run the Rainfall-Runoff Models and so there was no storm hydrograph produced for Storm IX.

Due to a sampling machine fault, it was only possible to sample the inflow waters for the Tame gully pot system, although an analysis of all 24 samples collected was carried out for some of the determinands under study. The inflow quality results are presented for the Tame gully pot, but it was difficult to infer any particular relationships in this dataset due to the absence of any outflow water quality data and the inlet storm hydrograph from the Rainfall-Runoff simulation. Owing to the absence of a number of samples, it was decided to carry out a fuller analysis (ie a greater number) of the inflow and outflow waters collected from the Twyford gully pot system, than had normally been the case for the other storm events analysed. All samples collected from the Twyford gully pot system were analysed for some of the determinands under study.

The inflow waters showed a number of samples with very similar SS, BOD and COD concentrations with no apparent trend in the datasets. The data points when plotted showed a clustered effect within a fairly limited concentration range. The SS and COD concentrations in the

ouflow waters, meanwhile, showed a very gradual decrease during the sampling period (being more marked for the COD than the SS values). The BOD levels in the outflow waters showed an increase before decreasing back to the concentrations observed at the beginning of the storm event, before falling to zero at the end of the sampling period, which was presumably due to a dilution of the pot liquor with the incoming storm runoff water. The pH of the inflow waters rose steadily throughout the sampling period to reach values equivalent to those found in the outflow waters, which themselves remained fairly consistent throughout. The DO concentrations of the inflow waters were well in excess of those observed in the outflow waters, which themselves rose sharply at the beginning of the storm event only to decline and then to show a more gradual increase in the DO concentrations. The chloride, Conductivity and Total Alkalinity concentrations all showed very similar trends for both the inflow and the outflow waters, with the levels in the inflow waters being constant at the start but showing a slight increase towards the end of the inflow sampling period. Zinc was detected in both the inflow and outflow waters sampled at the Twyford gully pot with a steady decrease observed in the inflow concentrations from a peak value at the start of the storm event sampling. The outflow water zinc concentrations fluctuated greatly in a cyclic manner, but all the values observed were roughly equivalent to the concentrations observed in the inflow water samples.

8.16 Storm X: Tame and Churnet.

There was no hydrological data available for this storm event due to the same reasons as outlined in the text for Storm IX. The Rainfall-Runoff Models therefore could not be used to simulate the flow conditions and so there was no hydrological data (except rainfall depth and estimated flow volume into the gully pot which were not measured in real time) to compare with the water quality data collected from the Tame and Churnet gully pot systems. There were no inflow water samples collected from the Tame gully pot since only one sample bottle contained any water sample when the site was visited after the storm event, and the volume obtained was not sufficient to carry out any chemical analysis.

The Tame outflow water samples showed a steady reduction in the SS and COD concentrations during the sampling period. This trend was also evident for the TOC results, but the decrease in the TOC values was far less marked. The Tame outflow zinc concentrations showed some variation around a mean value of about 0.40 mgl-1. It was difficult to summarise the trends illustrated in the outflow waters owing to the absence of any water quality data for the inflow waters and the lack of any real-time hydrological data.

The data obtained for the Churnet inflow and outflow waters showed some interesting trends. Some fairly high SS concentrations were found in the inflow waters and this resulted in a gradual increase in the outflow SS concentrations over the runoff event. The TOC values in the inflow and outflow waters were roughly the same value at the beginning of the storm sampling period, but the TOC outflow

concentrations showed a very gradual reduction in their values on a consistent basis. The COD data showed the most pronounced influence of the dilution effect during this particular storm runoff event. The inflow COD values rose initially and then decreased slightly during the inflow sampling period, while the outflow COD concentrations showed a rapid decrease due to dilution, such that the COD was not detected beyond the fourth sample taken. The zinc inflow concentrations decreased markedly from an initial peak value and this caused a very gradual increase in the outflow zinc concentrations.

8.17 Storm XI: Tame and Twyford.

The inlet storm hydrographs produced for the Tame and Twyford micro-catchments showed that Storm XI was a multi-peaked hydrological storm runoff event.

The analysis of the results from the Tame gully pot showed that the inflow waters had very high concentrations of SS and COD at the beginning of the storm runoff, but these high levels decreased sharply towards the end of the sampling period for the inflow waters. At the same time, the SS concentrations in the outflow waters rose dramatically from near non-detectable levels to much higher values in a response which lagged closely behind the trends shown in the inlet storm hydrograph. The outflow waters showed a near identical response in their concentrations of COD and TOC and the response closely followed that of the inlet hydrograph. The TOC levels in the inflow waters were well below those of the outflow waters at all times, whereas the COD inflow values greatly exceeded those in the outflow waters. This led to the conclusion that the TOC concentrations in the outflow waters were mainly due to an influx of material of a non-organic nature, but which nevertheless produced a high COD response. The pattern of response of the TOC and the COD concentrations in the outflow waters was nearly identical. This particular storm event was one of the very few where copper and lead were detected in any samples. Copper was found in one inflow sample (0.02 mgl-1) while lead was detected in both the inflow and the outflow samples. A number of samples yielded a non-detectable lead concentration while those results obtained did not show any real pattern or relationship with the hydrological data. The zinc

concentrations in the inflow waters decreased rapidly from the peak values at the start of the sampling period. The zinc levels found in the outflow waters were relatively high and were generally higher than those measured in the inflow waters. The zinc concentrations showed a cyclic response whose peaks lagged behind those of the inlet hydrograph, but a similar trend to that shown in the storm hydrograph was not observed.

Few samples were analysed for the Twyford gully pot system. The results obtained did not show a reduction in the SS and COD values in the outflow samples due to the dilution effect. The TOC results did not show any real trends, and the TOC concentrations in both the inflow and the outflow waters were roughly equivalent. Lead and zinc were both detected in the inflow and outflow samples but the data obtained did not conform to any particular pattern. The lead and zinc concentrations in the inflow waters were generally in excess of those measured in the outflow waters.

8.18 Storm XII: Tame.

The simulated inlet storm hydrograph for the Tame gully pot showed two distinctive peaks during the storm runoff event and the flow intensity was quite small when compared to those obtained through the Rainfall-Runoff Model simulations for the other storm events analysed.

The SS and COD concentrations followed very similar patterns with a gradual decrease in the SS and COD concentrations in the inflow waters from the peak values measured at the start of the sampling period. The SS concentrations in the outflow waters were fairly consistent, but a slight increase was seen after each peak on the inlet hydrograph. This trend was far more pronounced for the outflow COD data, where a double dilution trend curve was observed following the two peaks on the storm hydrograph. The TOC concentrations in the inflow waters were found to decrease at the start of the runoff event and they were below those observed in the outflow waters at all times. The zinc concentrations found in the inflow and outflow waters were roughly equivalent in magnitude and they did not follow any particular trend with time.

8.19 Storm XIII: Tame and Twyford.

Storm XIII had a single peak simulated storm hydrograph and it was a relatively short duration and small magnitude rainfall-runoff event. Only inflow waters were sampled for the Tame and Twyford gully pot systems and this was due to a problem with the sampling machines. It was very unfortunate that this mechanical problem occurred on both sets of sampling machines at the same time. The sampling machines on both micro-catchments malfunctioned due to a loss of vacuum in the sample bottles. This was an infrequent problem, but it happened on both the Tame and the Twyford outflow water sampling machines for Storm XIII.

The inflow water quality data collected did not show any particularly important trends. The Tame inflow waters showed a degree of variation in the SS and COD concentrations, whilst the TOC concentrations gradually decreased due to the incoming dilution waters from the storm runoff event. Zinc, copper and lead were all detected in the inflow waters into the Tame gully pot.

The inflow waters into the Twyford gully pot showed similar characteristics to those described above for the Tame gully pot system. The COD concentrations were less variable but a distinctive trend did emerge which showed an increase in the COD concentration during the storm runoff event. The gradual decrease in TOC concentrations was again evident though to a lesser degree and the three toxic metals under analysis (zinc, copper and lead) were all detected in the Twyford inflow waters to varying degrees.

8.20 Storm XIV: Churnet.

This particular storm event was part of a prolonged period of rainfall and the individual storm event was identified by the time at which the first sample was taken, which was shown on the clock installed and linked to the sampling machine. This storm event had been preceded by a prolonged period of very light drizzle which did not produce runoff waters at a sufficient discharge rate into the gully pot to activate the sampling machines via the float switch mechanisms. The storm runoff simulation did produce storm runoff discharge rates for the inlet hydrographs in excess of those which were estimated to activate the system for those storm events or periods of drizzle which preceded the event analysed here. This was an example of a discrepancy between the simulations run by the models and the true flow conditions of the storm runoff waters into the gully pots. The failure of the Churnet sampling machines to be activated by a previous number of storm events suggested that the rate discharge threshold needed to activate the machines was well above the 0.05 ls-1 value quoted above, which was derived from laboratory trials. There were obvious difficulties in reconciling the flow rates produced by the computer simulation models and the real flow regimes found in the micro-catchment areas under study.

Both inflow and outflow waters were sampled at the Churnet gully pot system for Storm XIV. The SS and TOC concentrations in the inflow waters did not show much variation, whilst the concentrations in the outflow waters showed a cyclic trend with the concentrations being greater than those observed in the inflow waters. The peaks and troughs in the outflow SS and TOC pollutographs did not mirror any

apparent trend in the inflow flow regime as represented by the storm inlet hydrograph. The COD values rose sharply during the inflow sampling period and this was during a peak in the inlet hydrograph. The COD concentrations in the outflow waters remained fairly consistent but they did show a small amount of variation in a near-cyclic trend. The zinc concentrations in the inflow waters did not show much variation, but those in the outflow waters were seen to fluctuate greatly. There was no obvious pattern to the zinc concentrations in the outflow waters, although as a whole they did increase slightly from the values observed at the start of the sampling period even though there was a good deal of variation in the zinc data.

8.21 Storm XV: Tame, Churnet and Twyford.

The inlet hydrographs for Storm XV showed a large peak value followed by a smaller one for each of the three gully pot systems under analysis. The storm event was quite long in duration with a medium to low peak rainfall intensity and a total of 9.7 mm. of rainfall.

Only five inflow samples were collected from the Churnet gully pot system and the lack of data collected for this micro-catchment meant that it was very difficult and, indeed, was unwise to infer any apparent trends in the datasets.

The SS concentrations for the Tame and Twyford micro-catchments showed a marked increase in the inflow waters which coincided with the rising limb of the inlet hydrograph. Very low SS levels were found in both the outflow waters and they did not show a great deal of variation. The low SS concentrations in the outflows were likely to be explained by the short antecedent dry period before the start of Storm Event XV whereby a previous runoff event (be it only a minor runoff event) diluted the gully pot liquor. A similar trend was also observed in the COD concentrations for both the Tame and the Twyford gully pots, although the inflow and outflow COD concentrations were of the same order of magnitude for the Twyford micro-catchment, whilst the COD concentrations in the outflow from the Tame gully pot were considerably lower than those in the inflow waters. The results of the TOC analysis showed very different trends between the two gully pots. The TOC concentrations in the outflow waters from the Tame gully pot system decreased quite dramatically at the beginning of the storm event and then attained a fairly constant value, which was close

to the TOC concentrations found in the inflow waters. For the Twyford gully pot system, the inflow waters had a more variable TOC concentration but these TOC values were always greater than those measured in the outflow waters. The TOC concentrations in the outflow waters remained constant at the beginning of the sampling period before gradually decreasing due to the dilution effects by the incoming storm runoff waters. The zinc concentrations in both the inflow and the outflow waters were highly variable for both the gully pot systems and no real trends emerged from the zinc data collected. The only difference in response found between the Tame and the Twyford micro-catchments for zinc was that for the Tame gully pot, the zinc concentration in the outflow waters were always higher than those in the inflow waters, whereas the reverse was true for the samples taken fom the Twyford gully pot system. Some copper was detected in the outflow waters from the Tame gully pot, but there was not enough copper data collected to reveal any particular trend for this metal.

8.22 The Results of the Storm Event Sampling Programme.

The storm event sampling programme provided an opportunity to study the chemical quality of both inflow and ouflow waters into and out of a gully pot under dynamic conditions. The results showed that the responses between the three micro-catchments under study for each storm event were at times quite different, but a number of important conclusions could be drawn. The concentrations of some of the chemical parameters did not show any degree of consistency during a storm event and no particular patterns nor trends could be seen to operate. On some occasions, the presence of a few heavy metals in the inflow waters, and their absence in the outflow waters, meant that the gully pot liquor and, more importantly, the gully pot basal sediments were acting as a sink for these metals. Some SS outflow water concentrations were greater than the corresponding inflow waters and so the solids concentrations were enhanced from within the pot chamber. The dilution effect due to the incoming volume of storm runoff was also evident in some cases. The response shown by a variable water quality to the different hydrological conditions was generally found to be highly variable, and the difficulties in studying the changes in quality under dynamic conditions were clear. The results are presented in the Appendices and they provided further evidence of the difficulties in modelling stormwater quality due to the variability both between and within individual rainfall-runoff events. The dataset for the fifteen storm events was considered to be representative of the type of storm conditions likely to be experienced in an urban area within a temperate climatic zone. The results reflected the changes within the gully pot under storm conditions and these changes were themselves reflected in the outflow

quality from the gully pot and, therefore subsequently, in the stormwater discharge at the catchment outfall.

The main aim of the 'Storm Event Sampling Programme' was to derive a deterministic model to predict the BOD and SS quality in the discharges from the gully pot under storm conditions. It was decided that four deterministic models would be developed for both the BOD and the SS. The four models would be developed to predict the mean value and the maximum value of each chemical parameter so as to provide a general prediction model which could be used to predict loadings, plus an alternative model incorporating a prediction of the maximum value likely to occur, so that an appreciation of the "worst possible condition" in the gully pot discharge water could be ascertained. The maximum and mean value models would be developed to include one model based solely upon the hydrological conditions and one which incorporated some measure of the inflow quality of the storm runoff as it entered the gully pot chamber.

Table 8.2 describes the parameters used in the stepwise multiple regression analysis and Tables 8.1 to 8.4 show a summary of the water quality and the hydrological parameters collected for each of the fifteen storm events from the three gully pots under study. Table 8.4 shows the inflow water hydrological conditions (in terms of the peak inflow intensity and the inflow volume) for the fifteen events and Table 8.4 shows the events where the Rainfall-Runoff Models did not simulate any runoff and the events when the Models could not be run due to a breakdown in the collection of the real-time rainfall data (see Chapter 4). The flow volumes for Storms VIII and IX were estimates from known rainfall depth and catchment characteristics.

TAME GULLY POT:

STORM NUMBER	BODIFM	BODOFM	BODIFX	BODOFX
1	10	7	13	12
2	29	34	40	40
3	14	15	22	25
4	*	7	*	20
5	16	4	16	8
6	45	12	63	16
7	83	*	101	*
8	55	16	66	25
9	5	*	27	*
10	*	24	*	28
11	6	16	16	18
12	14	14	17	16
13	7	*	10	*
14	*	*	*	*
15	4	6	4	18

* = Missing Value

Table: 8.5

TAME GULLY POT:

STORM NUMBER	SSIFM	SSOFM	SSIFX	SSOFX
1	31	118	41	147
2	47	106	68	149
3	79	109	120	220
4	*	15	*	47
5	102	12	102	35
6	92	38	154	78
7	124	*	160	*
8	116	104	137	134
9	161	*	322	*
10	*	76	*	117
11	163	18	357	52
12	191	39	455	54
13	50	*	128	*
14	*	*	*	*
15	407	21	563	64

* = Missing Value

Table: 8.6

CHURNET GULLY POT:

STORM NUMBER	BODIFM	BOFOFM	BODIFX	BODOFX
1	*	*	*	*
2	*	*	*	*
3	*	*	*	*
4	2	6	9	14
5	28	13	51	23
6	*	10	*	14
7	*	*	*	*
8	*	*	*	*
9	*	*	*	*
10	25	24	27	28
11	*	*	*	*
12	*	*	*	*
13	*	*	*	*
14	6	5	8	7
15	6	*	3	*

* = Missing Value

Table: 8.7

CHURNET GULLY POT:

STORM	SSIFM	SSOFM	SSIFX	SSOFX
1	*	*	*	*
2	*	*	*	*
3	*	*	*	*
4	81	18	274	72
5	69	11	202	25
6	*	16	*	*
7	*	*	*	*
8	*	*	*	*
9	*	*	*	*
10	119	80	149	91
11	*	*	*	*
12	*	*	*	*
13	*	*	*	*
14	9	19	24	41
15	24	*	48	*

* = Missing Value

Table: 8.8

TWYFORD GULLY POT:

STORM NUMBER	RODIFM	RODOFM	RODIFX	RODOFX
1	22	23	26	26
2	21	43	28	59
3	53	43	54	67
4	6	11	18	20
5	*	5	*	11
6	2	4	7	6
7	7	3	10	14
8	*	*	*	*
9	6	7	8	12
10	*	*	*	*
11	9	7	14	9
12	*	*	*	*
13	2	*	3	*
14	*	*	*	*
15	4	3	5	5

* = Missing Value

Table: 8.9

TWYFORD GULLY POT:

STORM NUMBER	SSIFM	SSOFM	SSIFX	SSOFX
1	88	130	111	231
2	28	95	38	147
3	61	51	75	101
4	159	6	477	19
5	*	13	*	32
6	50	21	92	39
7	34	35	60	46
8	*	*	*	*
9	72	69	312	124
10	*	*	*	*
11	57	14	132	23
12	*	*	*	*
13	69	*	94	*
14	*	*	*	*
15	51	6	161	10

* = Missing Value.

Table: 8.10

Tables 8.5 to 8.10 show a summary of the mean and maximum BOD and SS values in the inflow and outflow waters from the three gully pots. It should be noted that it was not possible to conduct any BOD analysis for the last five storm events due to a problem with the electrode used to measure the Dissolved Oxygen, which showed some erratic behaviour. Some TOC (Total Organic Carbon) analysis was conducted as an alternative measurement of oxygen demand and the ratio of TOC:BOD was established from other stormwater samples, where both determinands were measured, so that the BOD could be predicted from the TOC results. The ratio of TOC:BOD was 2.11:1. It was felt that this calculation of the BOD from the TOC results was advisable, since the aim was to maximise the number of storm events within the modelling procedures and the BOD was one of the chemical parameters for which a deterministic model was required. The regression modelling therefore, would be based on a higher number of observations which would prove to be statistically more significant. The close relationship between the TOC and the BOD (in many types of water and wastewater) meant that there was good justification to calculate the BOD results in this way for the last five storm events.

8.23 Estimation of BOD and SS Loadings for the Storm Events.

The mean values for BOD and SS concentrations in the outflow waters, as presented in Tables 8.5 and 8.10 for each of the fifteen storm events, were used together with the hydrological data to produce some estimates of the BOD and SS loadings for the storm events. The mean BOD and SS concentrations were multiplied by the flow volume for each gully pot where the data were collected and an estimate of the load from an individual gully pot was then obtained. For some storm

events, data was collected from one or more gully pots and in this situation an average load from each individual gully pot was calculated from the available data. This "average load from an individual pot" was then multiplied by 108 for each storm event, because there are 108 gully pots on the Clifton Grove Estate (see Chapter 7). The results of this calculation give an estimate of the load of BOD and SS from the whole housing estate to the receiving watercourse for all the storm events. It must be stressed that these are only estimates based on average figures and no account was taken of any deposition or resuspension of material from within the storm sewer pipe network. The loadings were based on the assumption that all the BOD and SS in the gully pot outflow waters will be directly discharged through the outfall to the receiving watercourse during the storm event. This may be a rather simplistic approach in trying to extend the data collected at the gully pot into a means of providing estimates of loadings at the outfall, but the results obtained are not dissimilar to those presented by Ellis (in Hollis 1979) and Nechaev (1985). The loadings are all in kilogrammes and are presented in Table 8.11.

Table to Show the Estimated BOD and SS Loadings from the Clifton Grove Estate for the 15 Storm Events under Study.

(All values are based on averaged data and are in kg.)

STORM NUMBER	BOD LOAD	SS LOAD
1	3.17	24.15
2	0.41	1.15
3	11.67	27.32
4	0.51	0.76
5	*	*
6	0.85	2.57
7	*	*
8	0.19	1.24
9	5.72	56.40
10	*	*
11	3.58	5.27
12	1.43	3.98
13	*	*
14	1.36	5.18
15	1.30	2.92

* = Data not available

Table: 8.11

8.24 The Deterministic Modelling of Gully Pot Outflow Quality.

A stepwise multiple regression analysis was performed using the data contained in Tables 8.3 to 8.10, using the MINITAB Statistical Package on the mainframe DEC-20 Computer. The equations yielding the highest R-squared values (or explained variance) are presented in Table 8.12. The equations are expressed in the same order for both BOD and SS and the order is as follows:

1. prediction of the mean outflow value without consideration of the inflow quality.
2. prediction of the mean outflow value with consideration of the inflow quality.
3. prediction of the maximum outflow value without consideration of the inflow quality.
4. prediction of the maximum outflow value with consideration of the inflow quality.

The regression equations used to predict the maximum BOD and SS concentrations could be used to express the "worst case situation", for a given stormwater runoff event and knowledge of such an occurrence would be particularly helpful in any determination of the "impact" of a stormwater discharge upon a receiving watercourse. The models developed to predict the mean BOD and SS concentrations in the gully pot outflow waters could be used as an intermediate phase within a model to predict the quality in the overall rainfall-runoff process, as a means of ascertaining the influence that a gully pot exercises over the quality of the stormwater discharge at the outfall. It can be envisaged that an above-ground and a below-ground component could be added to provide a general stormwater quality model which would incorporate or, at least, take account of the processes occurring on the urban surfaces within the gully pot and within the storm sewer

network, which all go to influence the final quality of the stormwater discharge at the outfall. The outline of such a model has been discussed by Moys and Henderson (1987).

The results of the stepwise multiple regression analysis showed that the antecedent dry period and the storm runoff volume were both important hydrological parameters in influencing the BOD and SS quality in the gully pot outflow waters. The deterministic models presented (which in some cases include parameters relating to the inflow quality as an independent variable) were considered to have provided a valuable means of relating the inflow and outflow quality. However, it is unlikely that the quality of the inflow waters into the gully pot would be known and this would limit the use of such a model within an operational field. The models developed which include the inflow quality parameters therefore would have only limited application (see Table 8.12).

The deterministic models to predict the mean BOD and mean SS concentrations in the gully pot outflow water (excluding the inflow quality parameters) were as follows:

$$BODOFM = 21.9 - 2.54\,RF - 0.0302\,DUR + 0.656\,PRINT + 0.0069\,ADP - 32.2\,PIFINT + 0.0150\,VOL$$

$$R\text{-}sq = 56.8\% \quad (r=0.75)$$

$$SSOFM = -18.1 + 1.94\,RF - 0.0338\,DUR + 3.07\,PRINT + 0.284\,ADP - 67.5\,PIFINT + 0.0056\,VOL$$

$$R\text{-}sq = 79.5\% \quad (r=0.89)$$

The Regression Equations with the Highest R-Squared Values for each Chemical Variable in the Step-Wise Multiple Regression Analysis.

BODOFM = 21.9 - 2.54 RF - 0.0302 DUR + 0.656 PRINT + 0.0069 ADP
- 32.2 PIFINT + 0.0150 VOL

R-sq = 56.8%

BODOFM = 17.8 - 1.04 RF - 0.0331 DUR + 0.429 PRINT + 0.0375 ADP
- 30.9 PIFINT + 0.00852 VOL + 0.458 BODIFM

R-sq = 76.8%

BODOFX = 36.1 - 2.87 RF - 0.0583 DUR + 0.800 PRINT + 0.058 ADP
- 53.8 PIFINT + 0.0209 VOL

R-sq = 57.3%

BODOFX = 20.0 - 2.05 RF - 0.0403 DUR + 0.712 PRINT + 0.075 ADP
- 51.5 PIFINT + 0.0171 VOL + 0.507 BODIFX

R-sq = 75.7%

* * * * * * * * * *

SSOFM = - 18.1 + 1.94 RF - 0.0338 DUR + 3.07 PRINT + 0.284 ADP
- 67.5 PIFINT + 0.0056 VOL

R-sq = 79.5%

SSOFM = - 15.3 + 1.93 RF - 0.0434 DUR + 2.97 PRINT + 0.279 ADP
- 62.3 PIFINT + 0.0042 VOL + 0.0371 SSIFM

R-sq = 80.6%

SSOFX = 5.6 + 8.72 RF - 0.118 DUR + 3.74 PRINT + 0.460 ADP
- 97.6 PIFINT - 0.0072 VOL

R-sq = 67.4%

SSOFX = - 9.0 + 8.0 RF - 0.119 DUR + 4.06 PRINT + 0.419 ADP
- 95.8 PIFINT - 0.0039 VOL + 0.047 SSIFX

R-sq = 67.4%

Table 8.12

The relatively high values for the correlation coefficients (the r value) and the fact that the models were calibrated on a relatively large number of independent storm events meant that these models can be proposed as "General Gully Pot Outflow Water Quality Models", with a fair degree of confidence in their application.

The Models expressed in Table 8.12 were those which explained the greatest amount of variance in the dependent variable, but a number of other regression equations were obtained in the multiple regression analysis which, although exhibiting a lower R-squared value than those in Table 8.12, did perform well in the amount of variance explained (ie. they had relatively large R-squared values themselves). A decision was made to use one of the models developed (but not presented in Table 8.12) in the multiple regression analysis on data derived from another study. Revitt et al (1987) carried out a study to investigate the quality of water discharging from a gully pot which was located on a car park area in Goteborg, Sweden. This work has been reviewed in Chapter 3. The aim of the exercise was to run a model calibrated on the Clifton Grove data against the data presented by Revitt et al (1987) and the following model was used, since it included the hydrological parameters used in the Swedish study.

The regression equation was:

SSOFM = 40.0 - 0.152 DUR + 7.77 RF - 0.0188 VOL + 0.295 ADP

R-sq = 39.9% (r=0.63) based on 18 storm events.

This mean SS model developed from the data collected from the 'Storm Event Sampling Programme' on the Clifton Grove Estate in Nottingham

would be used to predict the mean SS values in the outflow waters for the five storm events as presented by Revitt et al (1987) and to compare the predicted values against those actually measured in the field. The dataset presented by Revitt et al (1987) was not comprehensive, but it was one of the very few published studies which showed the hydrological and water quality data for gully pot outflow waters. This exercise would be one of the very few attempts to run a SS Quality Model for stormwater against real data from a different catchment area in order to test the performance of the SS model developed.

The values presented in Table 3.10 in Chapter 3 (Revitt et al 1987) were converted to the same units as the SS Model developed in the research programme, involving the conversion of days to hours for the antecedent dry period and the calculation of mean SS concentrations from loadings. Revitt et al (1987) reported the SS loadings in grams for each of the five storm events and these SS loadings were converted to concentrations as mgl^{-1} using the storm runoff volume data. The Model was run for each of the five storm events to provide a predicted mean SS concentration in the gully pot outflow waters and the results were as follows:

STORM NUMBER	MEASURED MEAN SS CONCENTRATION (Revitt et al 1987)	PREDICTED MEAN SS CONCENTRATION (Using Derived Model).
A	67	71
B	14	-27
C	13	3
D	79	103
E	12	0

(NOTE: All values are quoted to the nearest whole number) and all values are in mgl-1.)

Table: 8.13

The results showed that for those storm events where the measured mean SS concentrations were within the range 0 to 20 mgl-1 the model underestimated the SS values, whilst for those storm events with measured mean SS concentrations in the range 60 to 80 mgl-1 were found to have overestimated mean SS concentrations in the model predictions. The model gave predictions of mean SS concentrations of -27 and 0 mgl-1 for two storm events (B and E) as measured in the Swedish study. These are rogue values and there was obviously a problem with the model working within the lower range of anticipated mean SS values (ie. with the range 0 to 20 mgl-1.). If these two events were

ignored, then the predictions for the other three storm events were quite good. A plot was made of the measured mean SS concentration against the predicted mean SS concentration for the three storm events which were Storms A, C and D. This plot was nearly a straight line and so, for this working range, the model can be seen to be working quite well. Very few attempts have been made to apply stormwater quality models to areas other than those where they were calibrated, and there were obvious limitations to the use of some models. The results expressed above were seen as an encouraging sign that the models developed from the data obtained in the 'Storm Event Sampling Programme' could be applied more widely and may be accepted as part of a fuller stormwater quality model as discussed by Moys and Henderson (1987).

	Mean SS Concentration (mgl-1.)	
STORM EVENT	MEASURED	PREDICTED
A	67	71
C	13	3
D	79	103

Table: 8.14

Graph of the Measured against the Predicted SS Concentrations for Three Storm Events from the Swedish Study.

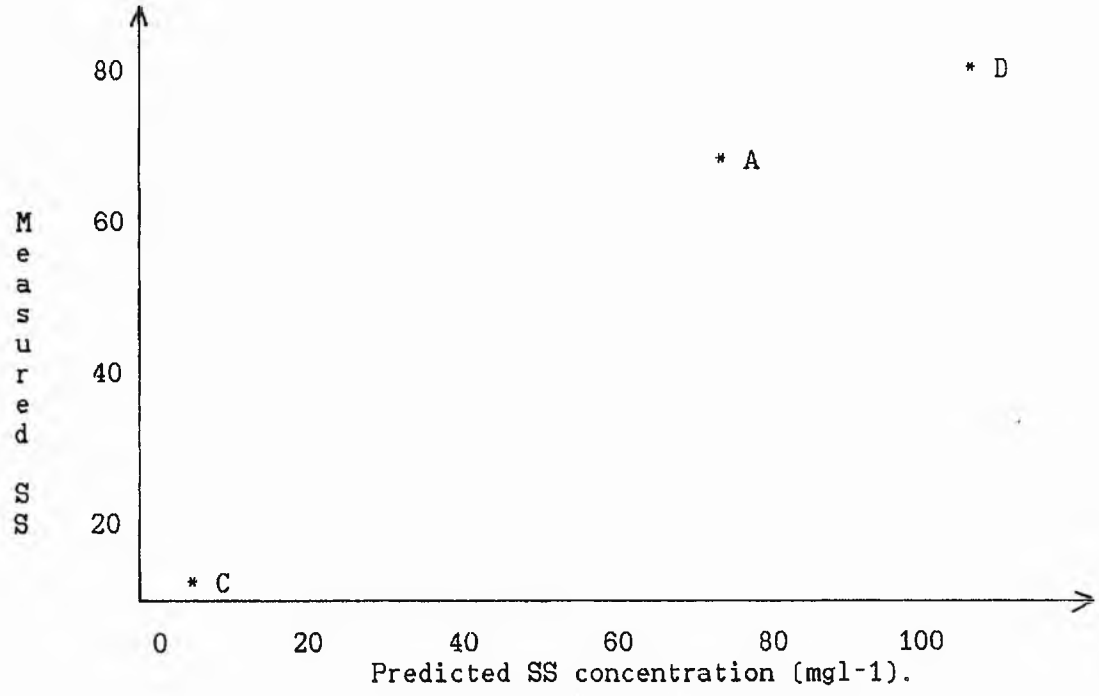


Figure: 8.18

The results of the deterministic modelling of the gully pot outflow quality (in terms of the BOD and the SS) showed that a number of regression models were obtained from the field data which all had quite large R-squared (ie. the correlation coefficient) values and so all such models could be applied for operational purposes. These models showed that a large part of the variance in the outflow quality could be explained by the changes in the hydrological variables between storm events and also by the quality of the incoming storm runoff waters. Eight regression models (see Table 8.12) were presented and they all had relatively high R-squared values for

empirically derived models. Another model developed using only those hydrological variables measured in the study carried out by Revitt et al (1987) in Sweden, showed a good deal of agreement between the predicted and the measured mean SS concentrations. This was thought to be an encouraging development within stormwater quality modelling and provided an important conclusion to the 'Storm Event Sampling Programme', which formed an integral part of the whole research programme. The models developed within the research programme (see Table 8.12) could be used to predict the quality of outflow waters discharging from a gully pot during a storm event. Those models excluding the inflow quality parameters were more likely to obtain further use since the inflow quality is unlikely to be measured in real-time, and so the outflow quality would then be considered to be a function of the hydrological characteristics of the individual storm event. Hemain (1986) has outlined the difficulties in developing deterministic models for stormwater quality and he has suggested that more models should be calibrated on larger datasets so that their use may be more widespread. The lack of a co-ordinated research programme, covering common methods of analysis and the measurement of common hydrological and chemical parameters, has led to the development of stormwater models which could not realistically be applied outside the catchment areas on which they were calibrated. The application of a model, developed as part of the research programme, to data derived from another study proved to be successful and added credance to the use of deterministic models to other catchment areas.

8.25 The Probabilistic Modelling of Gully Pot Outflow Quality.

The extensive dataset built up for the fifteen storm events analysed also provided an opportunity to develop probabilistic models, since a large number of samples were collected from the three gully pot systems over the eighteen month period. Hemain (1986) provided an excellent review of some probabilistic models, previously developed in stormwater analysis and he stated that there was a need to expand this work so that stochastic modelling for quality could be incorporated, perhaps, in the stochastic hydraulic/hydrologic models currently under development.

The aim of the exercise was to collect together all the BOD and SS results measured in the outflow waters from all three gully pots for the fifteen storm events. The data were grouped according to the individual gully pot and these datasets were concatenated into a total dataset. The purpose of the probability modelling was to obtain a predicted concentration of both BOD and SS in the gully pot outflow water from a given level of probability or liklihood of occurrence. The probabilistic quality model could then be incorporated into a wider probabilistic model which would be used to generate given levels of probability, as a means of stochastically predicting the outflow quality from a pot (or a series of gully pots) for a given storm event. The Monte-Carlo Simulation Model Technique is an example of this type of model and has been reviewed in Chapter 7.

The BOD and the SS outflow data for each of the three gully pots and for the total dataset were listed in ascending order and they were individually plotted on probability paper. The plots obtained were

very variable and did not constitute any particular trend or pattern. The data did not conform, therefore, to a 'normal distribution' and so normal probability theory could not be applied. It was then decided to log transform the data (see Chapter 7) to test whether or not the data conformed to a log-normal distribution. The values of log BOD and log SS were again plotted and a near-straight line was obtained showing that the outflow BOD and SS concentrations did conform to a 'log-normal distribution'. Similarly, when the log values for BOD and SS were plotted against the NSCORE (normalised score - see Chapter 7), a straight line was also obtained. (This should give the same effect as plotting on probability paper). The Shapiro-Wilk Statistical Test was performed on the log BOD and log SS data for the three gully pots and for the total dataset, in order to test statistically for log-normality in the data. A regression analysis was performed between the quality data (ie. log BOD and log SS) and the NSCORE and the value of the resultant correlation coefficient provided a test for normality using the Shapiro-Wilk Test. If the data were accepted as those which conformed to a log-normal distribution, then the regression equation could be used as a probability model, since it included a term relating to a given level of probability (ie. the NSCORE value). The data can be seen in Figures 8.19 to 8.26 and in Tables 8.15 to 8.22. The probabilistic models to predict the BOD and SS in gully pot outflow waters during a storm event are presented and summarised in Tables 8.23 to 8.25 inclusive.

Graph to Show the Log-Normal Distribution of all BOD Determinations in the Gully Pot Outflow Waters from the Tame Close Gully Pot Number 2.

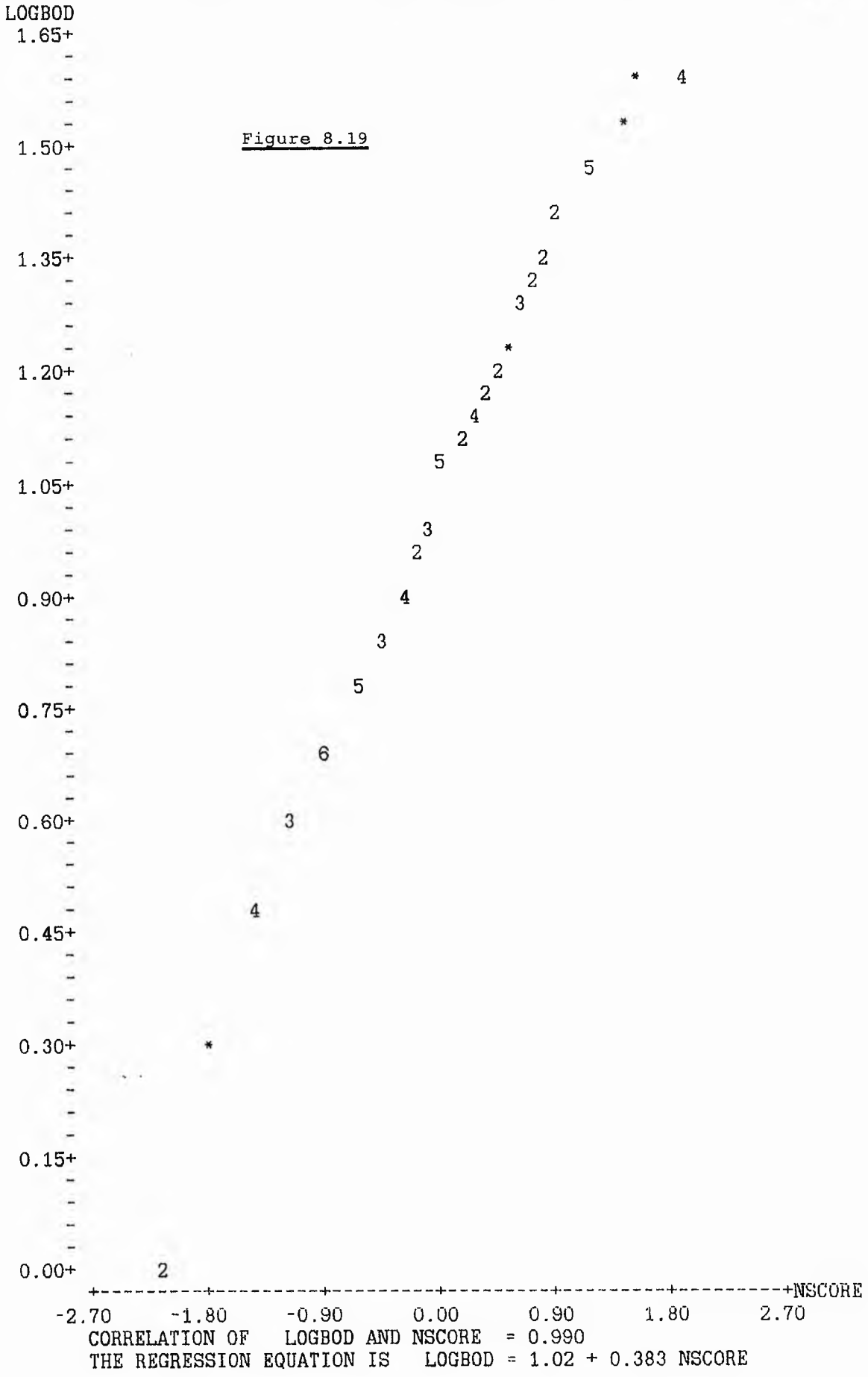


Figure 8.19

Graph to Show the Log-Normal Distribution of all SS Determinations in the Gully Pot Outflow Waters from Tame Close Gully Pot Number 2.

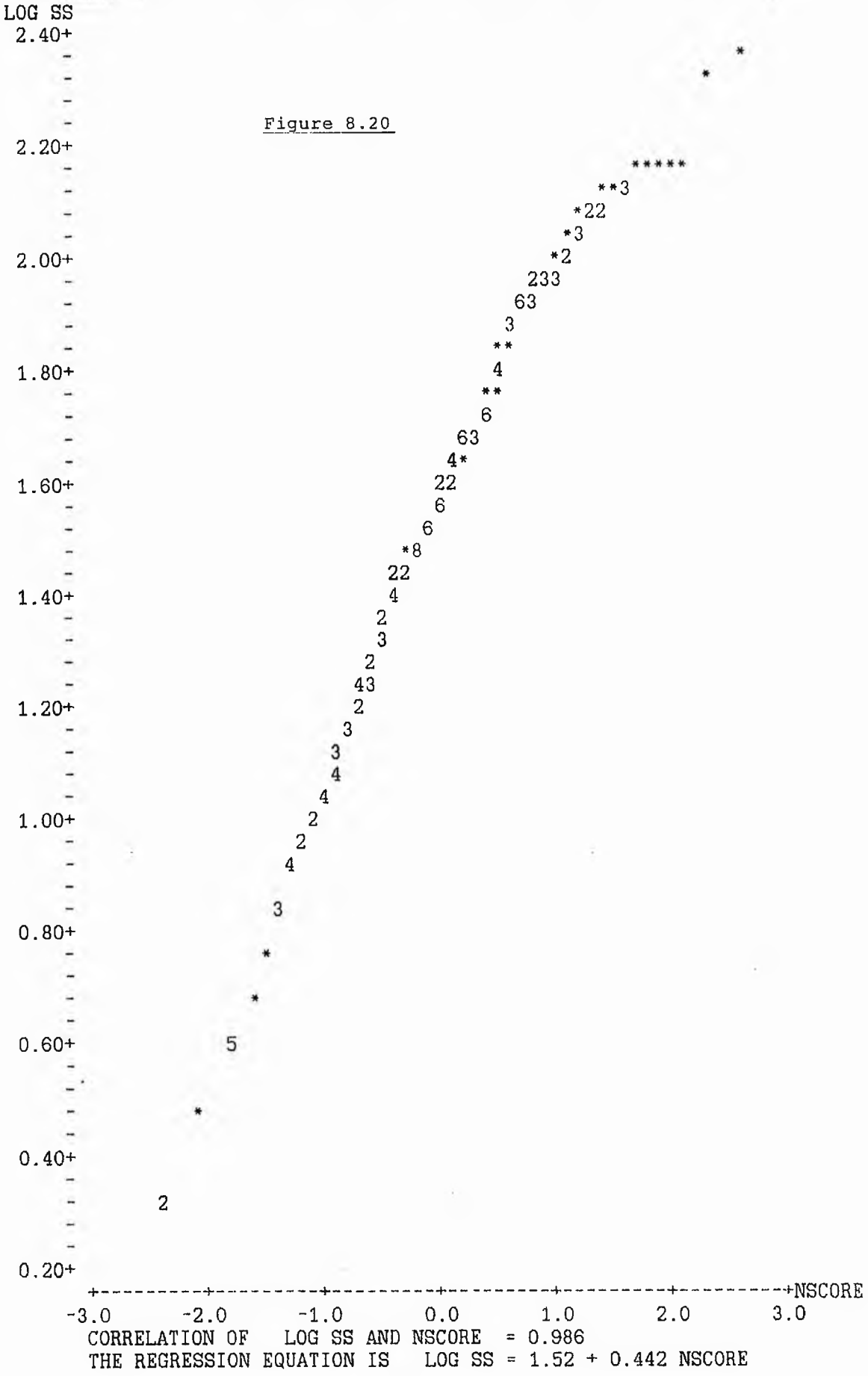


Figure 8.20

CORRELATION OF LOG SS AND NSCORE = 0.986
THE REGRESSION EQUATION IS LOG SS = 1.52 + 0.442 NSCORE

Graph to Show the Log-Normal Distribution of all BOD Determinations in the Gully Pot Outflow Waters from the Churnet Close Gully Pot Number 2.

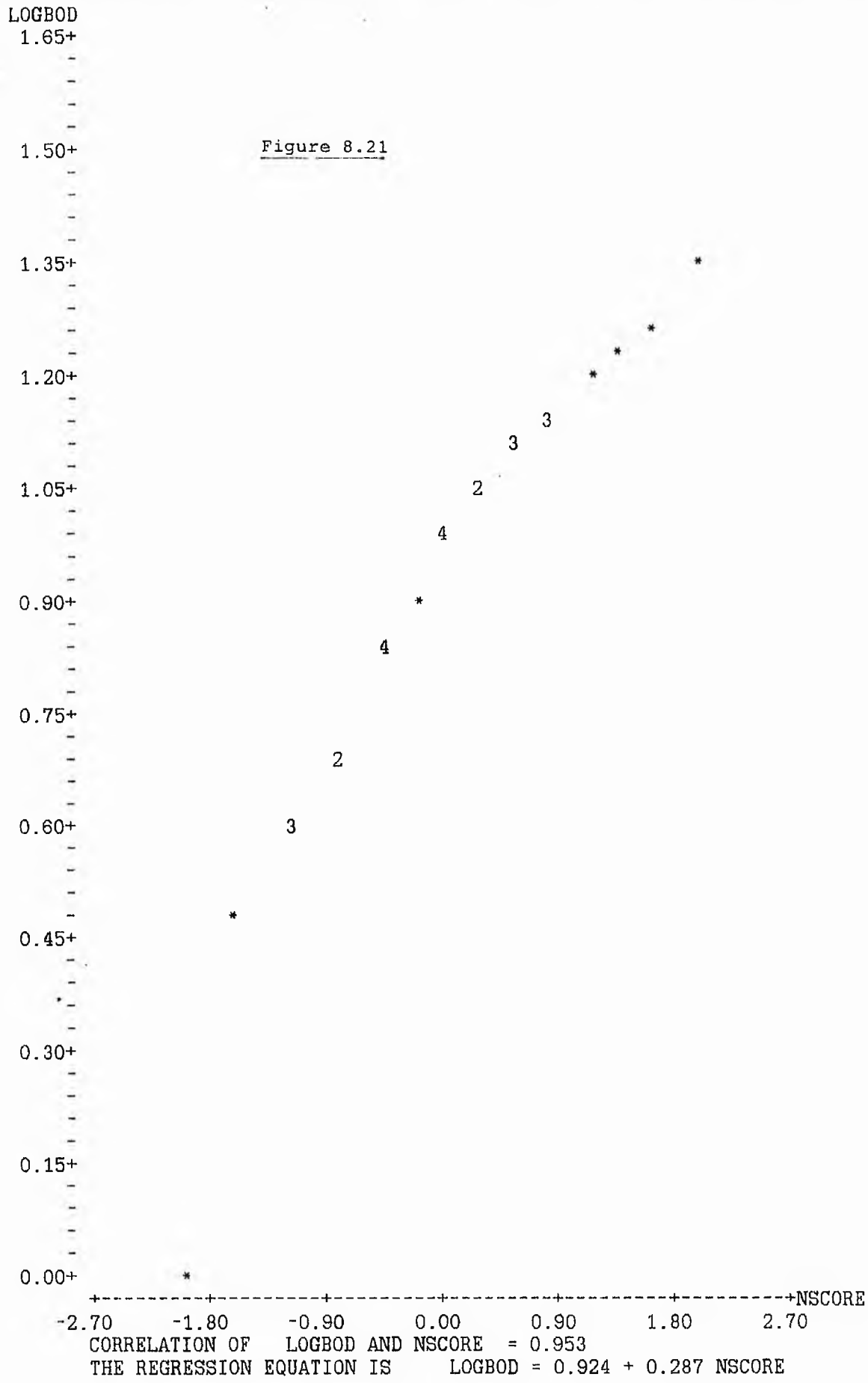


Figure 8.21

CORRELATION OF LOGBOD AND NSCORE = 0.953

THE REGRESSION EQUATION IS LOGBOD = 0.924 + 0.287 NSCORE

Graph to Show the Log-Normal Distribution of all SS Determinations in the Gully Pot Outflow Waters from the Churnet Close Number 2 Gully Pot.

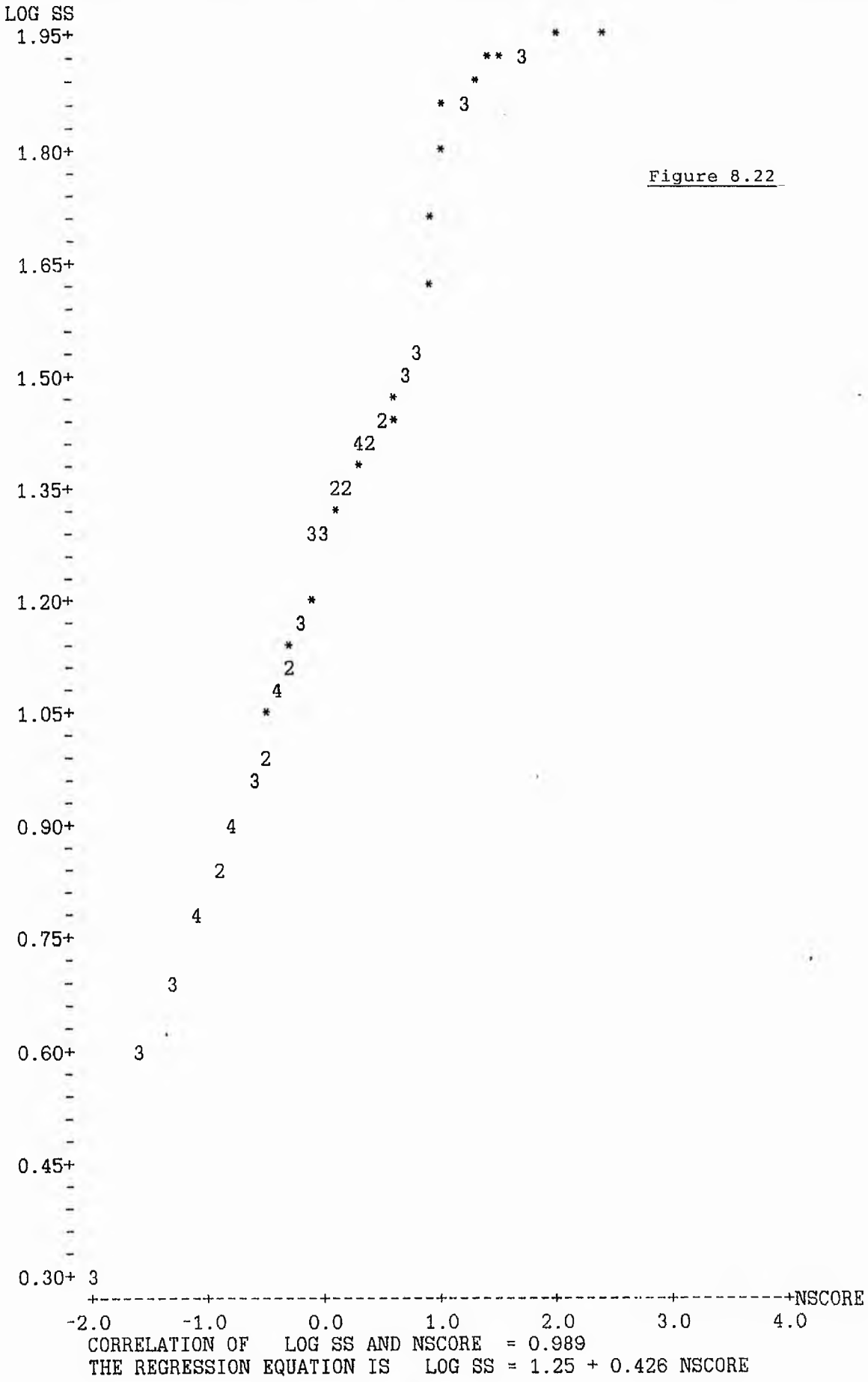


Figure 8.22

CORRELATION OF LOG SS AND NSCORE = 0.989
THE REGRESSION EQUATION IS LOG SS = 1.25 + 0.426 NSCORE

Graph to Show the Log-Normal Distribution for all BOD Determinations in the Gully Pot Outflow Water from the Twyford Gardens Number 2 Gully Pot.

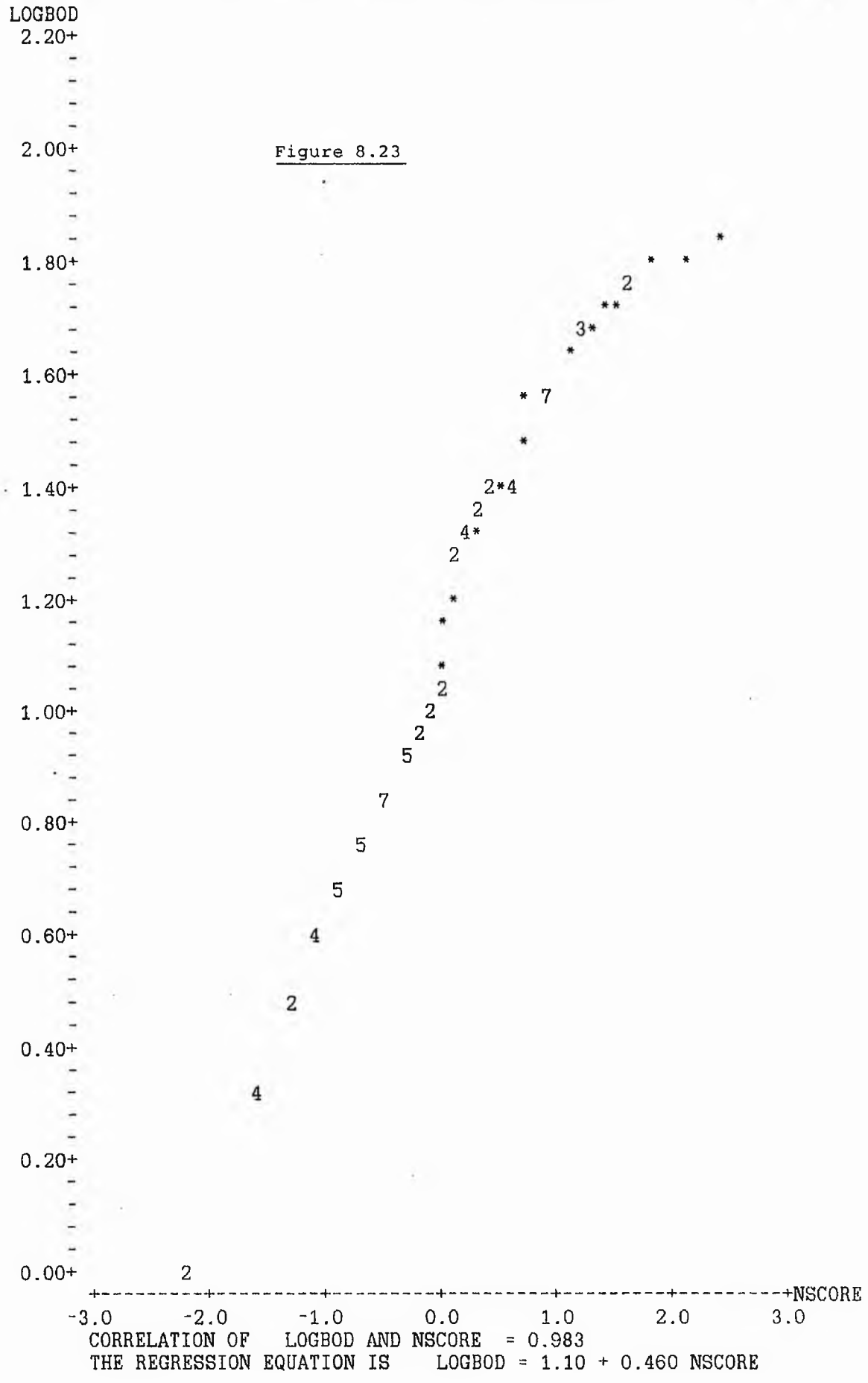


Figure 8.23

Graph to Show the Log-Normal Distribution for all SS Determinations in the Gully Pot Outflow Waters from the Twyford Gardens Number 2 Gully Pot.

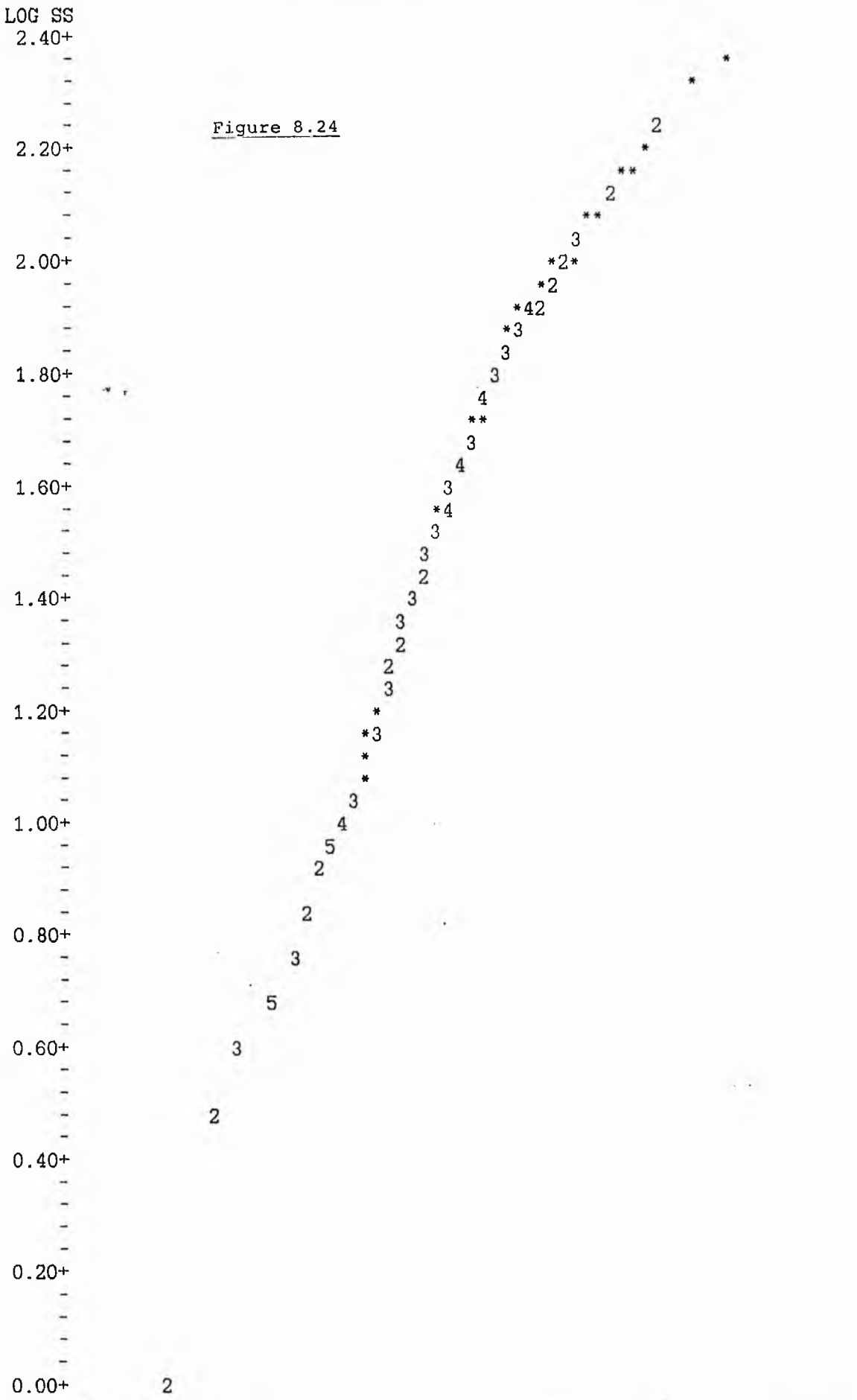


Figure 8.24

CORRELATION OF LOG SS AND NSCORE = 0.985

THE REGRESSION EQUATION IS LOG SS = 1.45 + 0.508 NSCORE

Graph to Show the Log-Normal Distribution for all the BOD Determinations in the Gully Pot Outflow Waters Sampled in the Research Programme.

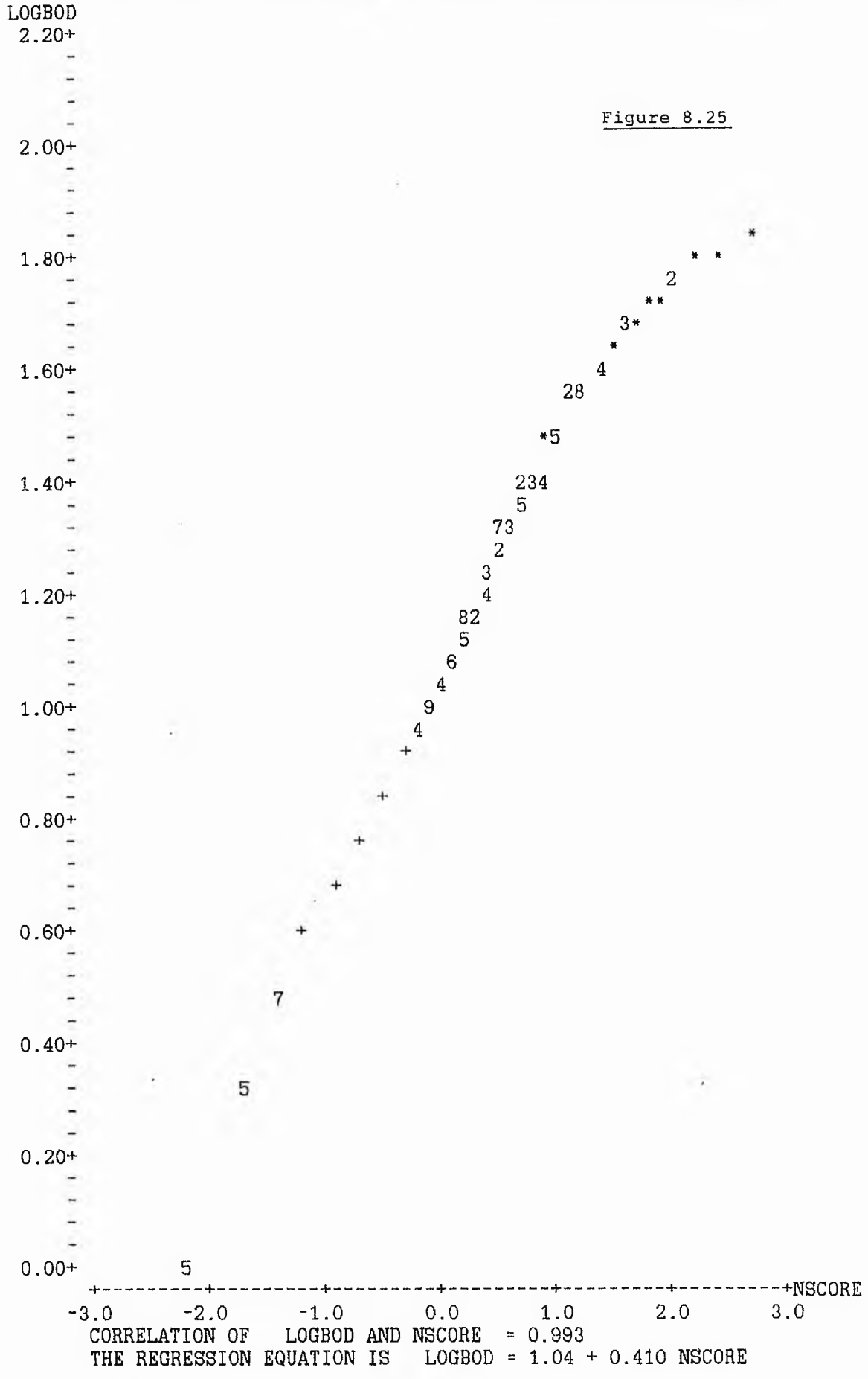


Figure 8.25

Graph to Show the Log-Normal Distribution for all the SS Determinations in the Gully Pot Outflow Waters Sampled in the Research Programme.

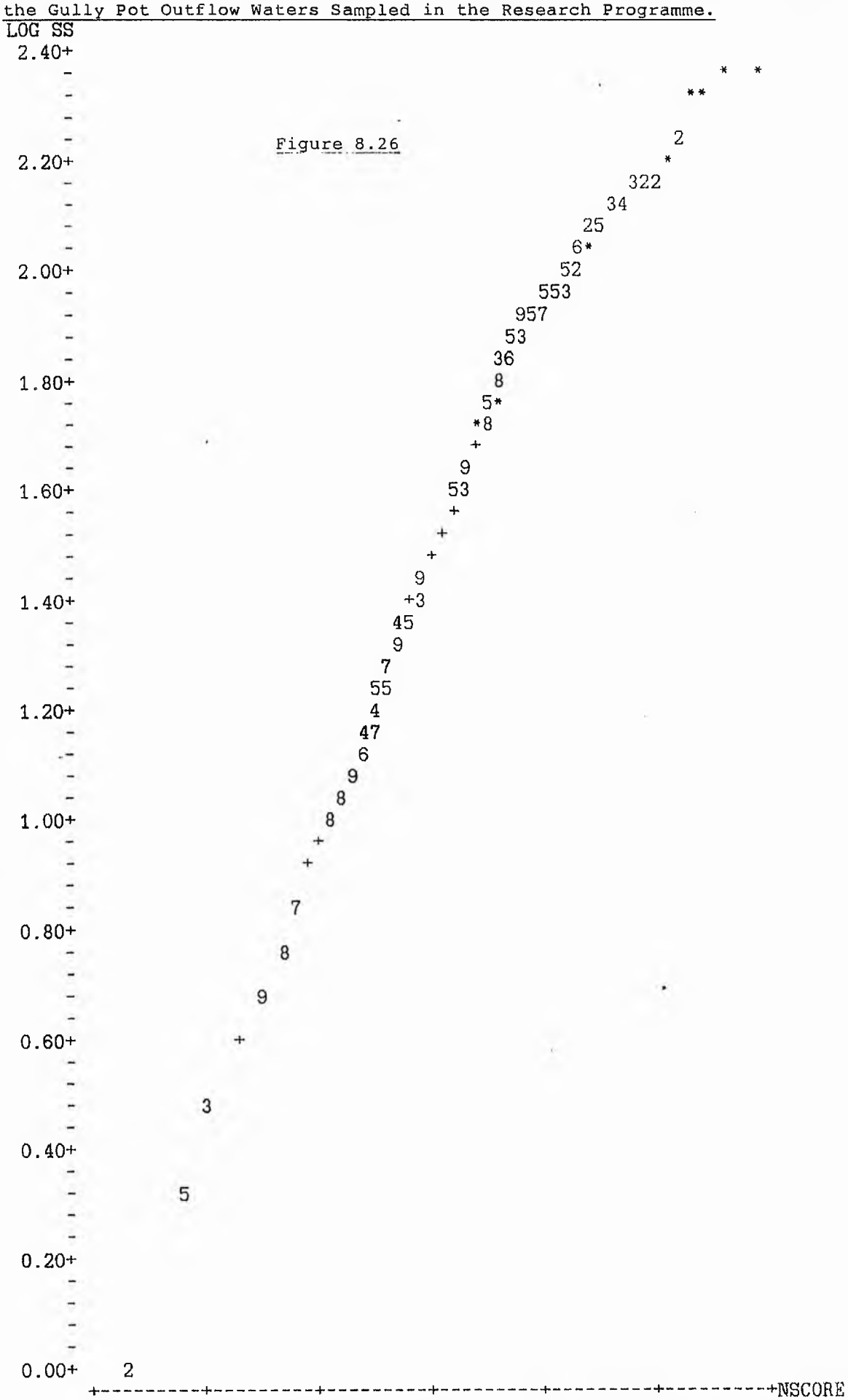


Figure 8.26

CORRELATION OF LOG SS AND NSCORE = 0.990

THE REGRESSION EQUATION IS LOG SS = 1.44 + 0.471 NSCORE

Table to Show All BOD Outflow Data from The Tame Close Gully Pot.

Table 8.15 (see Figure 8.19)

ROW	BOD	LOGBOD	NSCORE
1	1	0.00000	-2.14082
2	1	0.00000	-2.14082
3	2	0.30103	-1.77823
4	3	0.47712	-1.44723
5	3	0.47712	-1.44723
6	3	0.47712	-1.44723
7	3	0.47712	-1.44723
8	4	0.60206	-1.15141
9	4	0.60206	-1.15141
10	4	0.60206	-1.15141
11	5	0.69897	-0.87759
12	5	0.69897	-0.87759
13	5	0.69897	-0.87759
14	5	0.69897	-0.87759
15	5	0.69897	-0.87759
16	5	0.69897	-0.87759
17	6	0.77815	-0.61389
18	6	0.77815	-0.61389
19	6	0.77815	-0.61389
20	6	0.77815	-0.61389
21	6	0.77815	-0.61389
22	7	0.84510	-0.44725
23	7	0.84510	-0.44725
24	7	0.84510	-0.44725
25	8	0.90309	-0.31138
26	8	0.90309	-0.31138
27	8	0.90309	-0.31138
28	8	0.90309	-0.31138
29	9	0.95424	-0.19954
30	9	0.95424	-0.19954
31	10	1.00000	-0.10832
32	10	1.00000	-0.10832
33	10	1.00000	-0.10832
34	12	1.07918	0.03604
35	12	1.07918	0.03604
36	12	1.07918	0.03604
37	12	1.07918	0.03604
38	12	1.07918	0.03604
39	13	1.11394	0.16289
40	13	1.11394	0.16289
41	14	1.14613	0.27372
42	14	1.14613	0.27372
43	14	1.14613	0.27372
44	14	1.14613	0.27372
45	15	1.17609	0.38813
46	15	1.17609	0.38813
47	16	1.20412	0.46730
48	16	1.20412	0.46730
49	17	1.23045	0.52869
50	20	1.30103	0.61389
51	20	1.30103	0.61389
52	20	1.30103	0.61389
53	21	1.32222	0.72732
54	21	1.32222	0.72732
55	23	1.36173	0.82541

56	23	1.36173	0.82541
57	25	1.39794	0.93231
58	25	1.39794	0.93231
59	30	1.47712	1.15141
60	30	1.47712	1.15141
61	30	1.47712	1.15141
62	30	1.47712	1.15141
63	30	1.47712	1.15141
64	35	1.54407	1.39717
65	38	1.57978	1.50117
66	40	1.60206	1.87386
67	40	1.60206	1.87386
68	40	1.60206	1.87386
69	40	1.60206	1.87386

Table 8.15 cont'd (see Figure 8.19).

Table to Show All SS Outflow Data from the Tame Close Gully Pot.

No.	SS	LOG SS	NSCORE
1	2	0.30103	-2.44406
2	2	0.30103	-2.44406
3	3	0.47712	-2.12744
4	4	0.60206	-1.80193
5	4	0.60206	-1.80193
6	4	0.60206	-1.80193
7	4	0.60206	-1.80193
8	4	0.60206	-1.80193
9	5	0.69897	-1.59807
10	6	0.77815	-1.54278
11	7	0.84510	-1.44441
12	7	0.84510	-1.44441
13	7	0.84510	-1.44441
14	8	0.90309	-1.29969
15	8	0.90309	-1.29969
16	8	0.90309	-1.29969
17	8	0.90309	-1.29969
18	9	0.95424	-1.19431
19	9	0.95424	-1.19431
20	10	1.00000	-1.13085
21	10	1.00000	-1.13085
22	11	1.04139	-1.04346
23	11	1.04139	-1.04346
24	11	1.04139	-1.04346
25	11	1.04139	-1.04346
26	12	1.07918	-0.93812
27	12	1.07918	-0.93812
28	12	1.07918	-0.93812
29	12	1.07918	-0.93812
30	13	1.11394	-0.85392
31	13	1.11394	-0.85392
32	13	1.11394	-0.85392
33	14	1.14613	-0.79736
34	14	1.14613	-0.79736
35	15	1.17609	-0.76464
36	16	1.20412	-0.73274
37	16	1.20412	-0.73274
38	17	1.23045	-0.67109
39	17	1.23045	-0.67109
40	17	1.23045	-0.67109
41	17	1.23045	-0.67109
42	18	1.25527	-0.60229
43	18	1.25527	-0.60229
44	18	1.25527	-0.60229
45	19	1.27875	-0.55489
46	19	1.27875	-0.55489
47	20	1.30103	-0.52706
48	21	1.32222	-0.49964
49	21	1.32222	-0.49964
50	22	1.34242	-0.47260
51	23	1.36173	-0.45477
52	24	1.38021	-0.43708
53	25	1.39794	-0.40212
54	25	1.39794	-0.40212
55	25	1.39794	-0.40212

Table 8.16 (see Figure 8.20).

56	27	1.43136	-0.35911
57	27	1.43136	-0.35911
58	28	1.44716	-0.32519
59	28	1.44716	-0.32519
60	29	1.46240	-0.30000
61	30	1.47712	-0.22553
62	30	1.47712	-0.22553
63	30	1.47712	-0.22553
64	30	1.47712	-0.22553
65	30	1.47712	-0.22553
66	30	1.47712	-0.22553
67	30	1.47712	-0.22553
68	30	1.47712	-0.22553
69	32	1.50515	-0.14424
70	32	1.50515	-0.14424
71	33	1.51851	-0.11203
72	33	1.51851	-0.11203
73	34	1.53148	-0.07994
74	34	1.53148	-0.07994
75	35	1.54407	-0.03195
76	35	1.54407	-0.03195
77	35	1.54407	-0.03195
78	35	1.54407	-0.03195
79	36	1.55630	0.01597
80	36	1.55630	0.01597
81	39	1.59106	0.04793
82	39	1.59106	0.04793
83	40	1.60206	0.07994
84	40	1.60206	0.07994
85	42	1.62325	0.10400
86	43	1.63347	0.12007
87	44	1.64345	0.14424
88	44	1.64345	0.14424
89	45	1.65321	0.16850
90	46	1.66276	0.19286
91	46	1.66276	0.19286
92	47	1.67210	0.24195
93	47	1.67210	0.24195
94	47	1.67210	0.24195
95	47	1.67210	0.24195
96	50	1.69897	0.30000
97	50	1.69897	0.30000
98	50	1.69897	0.30000
99	52	1.71600	0.35059
100	52	1.71600	0.35059

Table 8.16 (see Figure 8.20). cont'd.

101	52	1.71600	0.35059
102	53	1.72428	0.39346
103	53	1.72428	0.39346
104	54	1.73239	0.41954
105	55	1.74036	0.43708
106	56	1.74819	0.45477
107	62	1.79239	0.47260
108	63	1.79934	0.49059
109	64	1.80618	0.50874
110	66	1.81954	0.52706
111	67	1.82607	0.54557
112	71	1.85126	0.56427
113	74	1.86923	0.58317
114	78	1.89209	0.61194
115	78	1.89209	0.61194
116	80	1.90309	0.66107
117	80	1.90309	0.66107
118	80	1.90309	0.66107
119	81	1.90849	0.70157
120	84	1.92428	0.72227
121	85	1.92942	0.74329
122	86	1.93450	0.76464
123	87	1.93952	0.79736
124	87	1.93952	0.79736
125	89	1.94939	0.84239
126	89	1.94939	0.84239
127	90	1.95424	0.87733
128	91	1.95904	0.90124
129	93	1.96848	0.92569
130	94	1.97313	0.97634
131	94	1.97313	0.97634
132	94	1.97313	0.97634
133	100	2.00000	1.02966
134	102	2.00860	1.05746
135	104	2.01703	1.08611
136	106	2.02531	1.11569
137	110	2.04139	1.16199
138	110	2.04139	1.16199
139	111	2.04532	1.21095
140	117	2.06819	1.24527
141	118	2.07188	1.28113
142	120	2.07918	1.31871
143	122	2.08636	1.35826
144	123	2.08991	1.40004
145	129	2.11059	1.44441
146	132	2.12057	1.49181
147	134	2.12710	1.59807
148	134	2.12710	1.59807
149	134	2.12710	1.59807
150	140	2.14613	1.72594
151	141	2.14922	1.80193
152	147	2.16732	1.88980
153	149	2.17319	1.99488
154	151	2.17898	2.12744
155	217	2.33646	2.31183
156	220	2.34242	2.64067

Table 8.16 cont'd (see Figure 8.20).

Table to Show All BOD Data in the Outflow Waters from the Churnet Gully.

No.	BOD	LOGBOD	NSCORE
1	1	0.00000	-2.01485
2	3	0.47712	-1.57746
3	4	0.60206	-1.13316
4	4	0.60206	-1.13316
5	4	0.60206	-1.13316
6	5	0.69897	-0.78085
7	5	0.69897	-0.78085
8	7	0.84510	-0.45752
9	7	0.84510	-0.45752
10	7	0.84510	-0.45752
11	7	0.84510	-0.45752
12	8	0.90309	-0.22270
13	10	1.00000	0.00000
14	10	1.00000	0.00000
15	10	1.00000	0.00000
16	10	1.00000	0.00000
17	11	1.04139	0.26826
18	11	1.04139	0.26826
19	13	1.11394	0.50728
20	13	1.11394	0.50728
21	13	1.11394	0.50728
22	14	1.14613	0.84270
23	14	1.14613	0.84270
24	14	1.14613	0.84270
25	16	1.20412	1.13316
26	17	1.23045	1.32281
27	18	1.25527	1.57746
28	23	1.36173	2.01485

Table 8.17 (see Figure 8.21).

Table to Show All SS Outflow Data from the Churnet Gully Pot.

No.	SS	LOG SS	NSCORE
1	2	0.30103	-2.04646
2	2	0.30103	-2.04646
3	2	0.30103	-2.04646
4	4	0.60206	-1.57018
5	4	0.60206	-1.57018
6	4	0.60206	-1.57018
7	5	0.69897	-1.30314
8	5	0.69897	-1.30314
9	5	0.69897	-1.30314
10	6	0.77815	-1.07716
11	6	0.77815	-1.07716
12	6	0.77815	-1.07716
13	6	0.77815	-1.07716
14	7	0.84510	-0.92016
15	7	0.84510	-0.92016
16	8	0.90309	-0.78333
17	8	0.90309	-0.78333
18	8	0.90309	-0.78333
19	8	0.90309	-0.78333
20	9	0.95424	-0.64045
21	9	0.95424	-0.64045
22	9	0.95424	-0.64045
23	10	1.00000	-0.54615
24	10	1.00000	-0.54615
25	11	1.04139	-0.49193
26	12	1.07918	-0.40464
27	12	1.07918	-0.40464
28	12	1.07918	-0.40464
29	12	1.07918	-0.40464
30	13	1.11394	-0.30386
31	13	1.11394	-0.30386
32	14	1.14613	-0.25469
33	15	1.17609	-0.19009
34	15	1.17609	-0.19009
35	15	1.17609	-0.19009
36	16	1.20412	-0.12629
37	19	1.27875	-0.06302
38	19	1.27875	-0.06302
39	19	1.27875	-0.06302
40	20	1.30103	0.03149
41	20	1.30103	0.03149
42	20	1.30103	0.03149
43	21	1.32222	0.09460
44	22	1.34242	0.14218
45	22	1.34242	0.14218
46	23	1.36173	0.20615
47	23	1.36173	0.20615
48	24	1.38021	0.25469
49	25	1.39794	0.33705
50	25	1.39794	0.33705
51	25	1.39794	0.33705
52	25	1.39794	0.33705
53	26	1.41497	0.43914
54	26	1.41497	0.43914
55	27	1.43136	0.50983

Table 8.18 (see Figure 8.22).

56	27	1.43136	0.50983
57	28	1.44716	0.56459
58	30	1.47712	0.60208
59	31	1.49136	0.66000
60	31	1.49136	0.66000
61	32	1.50515	0.72027
62	34	1.53148	0.78333
63	34	1.53148	0.78333
64	35	1.54407	0.84973
65	41	1.61278	0.89618
66	53	1.72428	0.94469
67	65	1.81291	0.99556
68	70	1.84510	1.04918
69	72	1.85733	1.16671
70	72	1.85733	1.16671
71	72	1.85733	1.16671
72	77	1.88649	1.30314
73	83	1.91908	1.38149
74	85	1.92942	1.46935
75	86	1.93450	1.68987
76	86	1.93450	1.68987
77	86	1.93450	1.68987
78	89	1.94939	2.04646
79	91	1.95904	2.41201

Table 8.18 cont'd (see Figure 8.22).

Table to Show All BOD Outflow Data from the Twyford Gully Pot.

No.	BOD	LOGBOD	NSCORE
1	1	0.00000	-2.19871
2	1	0.00000	-2.19871
3	2	0.30103	-1.63331
4	2	0.30103	-1.63331
5	2	0.30103	-1.63331
6	2	0.30103	-1.63331
7	3	0.47712	-1.34827
8	3	0.47712	-1.34827
9	4	0.60206	-1.14352
10	4	0.60206	-1.14352
11	4	0.60206	-1.14352
12	4	0.60206	-1.14352
13	5	0.69897	-0.90486
14	5	0.69897	-0.90486
15	5	0.69897	-0.90486
16	5	0.69897	-0.90486
17	5	0.69897	-0.90486
18	6	0.77815	-0.68959
19	6	0.77815	-0.68959
20	6	0.77815	-0.68959
21	6	0.77815	-0.68959
22	6	0.77815	-0.68959
23	7	0.84510	-0.46781
24	7	0.84510	-0.46781
25	7	0.84510	-0.46781
26	7	0.84510	-0.46781
27	7	0.84510	-0.46781
28	7	0.84510	-0.46781
29	7	0.84510	-0.46781
30	8	0.90309	-0.26754
31	8	0.90309	-0.26754
32	8	0.90309	-0.26754
33	8	0.90309	-0.26754
34	8	0.90309	-0.26754
35	9	0.95424	-0.15612
36	9	0.95424	-0.15612
37	10	1.00000	-0.09342
38	10	1.00000	-0.09342
39	11	1.04139	-0.03110
40	11	1.04139	-0.03110

Table 8.19 (see Figure 8.23).

41	12	1.07918	0.01555
42	14	1.14613	0.04666
43	16	1.20412	0.07782
44	19	1.27875	0.12471
45	19	1.27875	0.12471
46	20	1.30103	0.21946
47	20	1.30103	0.21946
48	20	1.30103	0.21946
49	20	1.30103	0.21946
50	21	1.32222	0.29995
51	23	1.36173	0.34919
52	23	1.36173	0.34919
53	24	1.38021	0.41624
54	24	1.38021	0.41624
55	25	1.39794	0.46781
56	26	1.41497	0.55676
57	26	1.41497	0.55676
58	26	1.41497	0.55676
59	26	1.41497	0.55676
60	29	1.46240	0.65046
61	35	1.54407	0.68959
62	38	1.57978	0.85862
63	38	1.57978	0.85862
64	38	1.57978	0.85862
65	38	1.57978	0.85862
66	38	1.57978	0.85862
67	38	1.57978	0.85862
68	38	1.57978	0.85862
69	44	1.64345	1.05720
70	47	1.67210	1.17428
71	47	1.67210	1.17428
72	47	1.67210	1.17428
73	50	1.69897	1.31024
74	51	1.70757	1.38835
75	52	1.71600	1.47594
76	59	1.77085	1.63331
77	59	1.77085	1.63331
78	63	1.79934	1.84535
79	64	1.80618	2.05164
80	67	1.82607	2.41645

Table 8.19 cont'd (see Figure 8.23).

Table to Show All SS Outflow Data from the Twyford Gully Pot.

No.	SS	LOG SS	NSCORE
1	1	0.00000	-2.34455
2	1	0.00000	-2.34455
3	3	0.47712	-1.93927
4	3	0.47712	-1.93927
5	4	0.60206	-1.67103
6	4	0.60206	-1.67103
7	4	0.60206	-1.67103
8	5	0.69897	-1.39605
9	5	0.69897	-1.39605
10	5	0.69897	-1.39605
11	5	0.69897	-1.39605
12	5	0.69897	-1.39605
13	6	0.77815	-1.19832
14	6	0.77815	-1.19832
15	6	0.77815	-1.19832
16	7	0.84510	-1.09542
17	7	0.84510	-1.09542
18	8	0.90309	-1.02081
19	8	0.90309	-1.02081
20	9	0.95424	-0.90247
21	9	0.95424	-0.90247
22	9	0.95424	-0.90247
23	9	0.95424	-0.90247
24	9	0.95424	-0.90247
25	10	1.00000	-0.76690
26	10	1.00000	-0.76690
27	10	1.00000	-0.76690
28	10	1.00000	-0.76690
29	11	1.04139	-0.67068
30	11	1.04139	-0.67068
31	11	1.04139	-0.67068
32	12	1.07918	-0.61847
33	13	1.11394	-0.59301
34	14	1.14613	-0.56793
35	15	1.17609	-0.51883
36	15	1.17609	-0.51883
37	15	1.17609	-0.51883
38	16	1.20412	-0.47097
39	17	1.23045	-0.44746
40	18	1.25527	-0.41265
41	18	1.25527	-0.41265
42	19	1.27875	-0.36702
43	19	1.27875	-0.36702
44	20	1.30103	-0.33331
45	21	1.32222	-0.31106
46	22	1.34242	-0.28896
47	23	1.36173	-0.25607
48	23	1.36173	-0.25607
49	24	1.38021	-0.22347
50	25	1.39794	-0.20187

Table 8.20 (see Figure 8.24).

51	26	1.41497	-0.18037
52	28	1.44716	-0.14827
53	28	1.44716	-0.14827
54	29	1.46240	-0.11633
55	31	1.49136	-0.08451
56	31	1.49136	-0.08451
57	32	1.50515	-0.04222
58	32	1.50515	-0.04222
59	34	1.53148	-0.01055
60	36	1.55630	0.01055
61	37	1.56820	0.05278
62	37	1.56820	0.05278
63	37	1.56820	0.05278
64	38	1.57978	0.09511
65	39	1.59106	0.13761
66	39	1.59106	0.13761
67	39	1.59106	0.13761
68	42	1.62325	0.20187
69	42	1.62325	0.20187
70	42	1.62325	0.20187
71	43	1.63347	0.24517
72	46	1.66276	0.26700
73	48	1.68124	0.28896
74	50	1.69897	0.31106
75	51	1.70757	0.33331
76	54	1.73239	0.35574
77	57	1.75587	0.38973
78	57	1.75587	0.38973
79	59	1.77085	0.42420
80	60	1.77815	0.44746
81	61	1.78533	0.47097
82	64	1.80618	0.49475
83	65	1.81291	0.51883
84	69	1.83885	0.55553
85	69	1.83885	0.55553
86	72	1.85733	0.59301
87	76	1.88081	0.61847
88	77	1.88649	0.65746
89	77	1.88649	0.65746
90	79	1.89763	0.69750
91	80	1.90309	0.72483
92	81	1.90849	0.79573
93	81	1.90849	0.79573
94	81	1.90849	0.79573
95	81	1.90849	0.79573
96	84	1.92428	0.87095
97	86	1.93450	0.90247
98	88	1.94448	0.93493
99	89	1.94939	0.96841
100	90	1.95424	1.00304

Table 8.20 cont'd (see Figure 8.24).

101	98	1.99123	1.03892
102	100	2.00000	1.07620
103	101	2.00432	1.11505
104	103	2.01284	1.15568
105	110	2.04139	1.24327
106	110	2.04139	1.24327
107	110	2.04139	1.24327
108	123	2.08991	1.34162
109	124	2.09342	1.39605
110	132	2.12057	1.45495
111	135	2.13033	1.51934
112	141	2.14922	1.59067
113	147	2.16732	1.67103
114	152	2.18184	1.76373
115	175	2.24304	1.93927
116	175	2.24304	1.93927
117	201	2.30320	2.20643
118	231	2.36361	2.54961

Table 8.20 cont'd (see Figure 8.24).

Table to Show All BOD Outflow Data Collected in the Research Programme.

No.	BOD	LOGBOD	NSCORE
1	1	0.00000	-2.17732
2	1	0.00000	-2.17732
3	1	0.00000	-2.17732
4	1	0.00000	-2.17732
5	1	0.00000	-2.17732
6	2	0.30103	-1.71910
7	2	0.30103	-1.71910
8	2	0.30103	-1.71910
9	2	0.30103	-1.71910
10	2	0.30103	-1.71910
11	3	0.47712	-1.42696
12	3	0.47712	-1.42696
13	3	0.47712	-1.42696
14	3	0.47712	-1.42696
15	3	0.47712	-1.42696
16	3	0.47712	-1.42696
17	3	0.47712	-1.42696
18	4	0.60206	-1.15007
19	4	0.60206	-1.15007
20	4	0.60206	-1.15007
21	4	0.60206	-1.15007
22	4	0.60206	-1.15007
23	4	0.60206	-1.15007
24	4	0.60206	-1.15007
25	4	0.60206	-1.15007
26	4	0.60206	-1.15007
27	4	0.60206	-1.15007
28	5	0.69897	-0.87695
29	5	0.69897	-0.87695
30	5	0.69897	-0.87695
31	5	0.69897	-0.87695
32	5	0.69897	-0.87695
33	5	0.69897	-0.87695
34	5	0.69897	-0.87695
35	5	0.69897	-0.87695
36	5	0.69897	-0.87695
37	5	0.69897	-0.87695
38	5	0.69897	-0.87695
39	5	0.69897	-0.87695
40	5	0.69897	-0.87695
41	6	0.77815	-0.65800
42	6	0.77815	-0.65800
43	6	0.77815	-0.65800
44	6	0.77815	-0.65800
45	6	0.77815	-0.65800
46	6	0.77815	-0.65800
47	6	0.77815	-0.65800
48	6	0.77815	-0.65800
49	6	0.77815	-0.65800
50	6	0.77815	-0.65800
51	7	0.84510	-0.45953
52	7	0.84510	-0.45953
53	7	0.84510	-0.45953
54	7	0.84510	-0.45953
55	7	0.84510	-0.45953

Table 8.21 (see Figure 8.25).

56	7	0.84510	-0.45953
57	7	0.84510	-0.45953
58	7	0.84510	-0.45953
59	7	0.84510	-0.45953
60	7	0.84510	-0.45953
61	7	0.84510	-0.45953
62	7	0.84510	-0.45953
63	7	0.84510	-0.45953
64	7	0.84510	-0.45953
65	8	0.90309	-0.27816
66	8	0.90309	-0.27816
67	8	0.90309	-0.27816
68	8	0.90309	-0.27816
69	8	0.90309	-0.27816
70	8	0.90309	-0.27816
71	8	0.90309	-0.27816
72	8	0.90309	-0.27816
73	8	0.90309	-0.27816
74	8	0.90309	-0.27816
75	9	0.95424	-0.17692
76	9	0.95424	-0.17692
77	9	0.95424	-0.17692
78	9	0.95424	-0.17692
79	10	1.00000	-0.08457
80	10	1.00000	-0.08457
81	10	1.00000	-0.08457
82	10	1.00000	-0.08457
83	10	1.00000	-0.08457
84	10	1.00000	-0.08457
85	10	1.00000	-0.08457
86	10	1.00000	-0.08457
87	10	1.00000	-0.08457
88	11	1.04139	0.00704
89	11	1.04139	0.00704
90	11	1.04139	0.00704
91	11	1.04139	0.00704
92	12	1.07918	0.07751
93	12	1.07918	0.07751
94	12	1.07918	0.07751
95	12	1.07918	0.07751
96	12	1.07918	0.07751
97	12	1.07918	0.07751
98	13	1.11394	0.15550
99	13	1.11394	0.15550
100	13	1.11394	0.15550

Table 8.21 cont'd (see Figure 8.25).

101	13	1.11394	0.15550
102	13	1.11394	0.15550
103	14	1.14613	0.24898
104	14	1.14613	0.24898
105	14	1.14613	0.24898
106	14	1.14613	0.24898
107	14	1.14613	0.24898
108	14	1.14613	0.24898
109	14	1.14613	0.24898
110	14	1.14613	0.24898
111	15	1.17609	0.32240
112	15	1.17609	0.32240
113	16	1.20412	0.36729
114	16	1.20412	0.36729
115	16	1.20412	0.36729
116	16	1.20412	0.36729
117	17	1.23045	0.41296
118	17	1.23045	0.41296
119	18	1.25527	0.43613
120	19	1.27875	0.45953
121	19	1.27875	0.45953
122	20	1.30103	0.53139
123	20	1.30103	0.53139
124	20	1.30103	0.53139
125	20	1.30103	0.53139
126	20	1.30103	0.53139
127	20	1.30103	0.53139
128	20	1.30103	0.53139
129	21	1.32222	0.61469
130	21	1.32222	0.61469
131	21	1.32222	0.61469
132	23	1.36173	0.68459
133	23	1.36173	0.68459
134	23	1.36173	0.68459
135	23	1.36173	0.68459
136	23	1.36173	0.68459
137	24	1.38021	0.74868
138	24	1.38021	0.74868
139	25	1.39794	0.79643
140	25	1.39794	0.79643
141	25	1.39794	0.79643
142	26	1.41497	0.86657
143	26	1.41497	0.86657
144	26	1.41497	0.86657
145	26	1.41497	0.86657
146	29	1.46240	0.91945
147	30	1.47712	0.98655
148	30	1.47712	0.98655
149	30	1.47712	0.98655
150	30	1.47712	0.98655

Table 8.21 cont'd (see Figure 8.25).

151	30	1.47712	0.98655
152	35	1.54407	1.07101
153	35	1.54407	1.07101
154	38	1.57978	1.20707
155	38	1.57978	1.20707
156	38	1.57978	1.20707
157	38	1.57978	1.20707
158	38	1.57978	1.20707
159	38	1.57978	1.20707
160	38	1.57978	1.20707
161	38	1.57978	1.20707
162	40	1.60206	1.40754
163	40	1.60206	1.40754
164	40	1.60206	1.40754
165	40	1.60206	1.40754
166	44	1.64345	1.51058
167	47	1.67210	1.60623
168	47	1.67210	1.60623
169	47	1.67210	1.60623
170	50	1.69897	1.71910
171	51	1.70757	1.78471
172	52	1.71600	1.85890
173	59	1.77085	1.99357
174	59	1.77085	1.99357
175	63	1.79934	2.17732
176	64	1.80618	2.35802
177	67	1.82607	2.68066

Table 8.21 cont'd (see Figure 8.25).

Table to Show All SS Outflow Data Collected in the Research Programme.

No.	SS	LOG SS	NSCORE
1	1	0.00000	-2.71242
2	1	0.00000	-2.71242
3	2	0.30103	-2.22508
4	2	0.30103	-2.22508
5	2	0.30103	-2.22508
6	2	0.30103	-2.22508
7	2	0.30103	-2.22508
8	3	0.47712	-1.97322
9	3	0.47712	-1.97322
10	3	0.47712	-1.97322
11	4	0.60206	-1.70589
12	4	0.60206	-1.70589
13	4	0.60206	-1.70589
14	4	0.60206	-1.70589
15	4	0.60206	-1.70589
16	4	0.60206	-1.70589
17	4	0.60206	-1.70589
18	4	0.60206	-1.70589
19	4	0.60206	-1.70589
20	4	0.60206	-1.70589
21	4	0.60206	-1.70589
22	5	0.69897	-1.45785
23	5	0.69897	-1.45785
24	5	0.69897	-1.45785
25	5	0.69897	-1.45785
26	5	0.69897	-1.45785
27	5	0.69897	-1.45785
28	5	0.69897	-1.45785
29	5	0.69897	-1.45785
30	5	0.69897	-1.45785
31	6	0.77815	-1.30085
32	6	0.77815	-1.30085
33	6	0.77815	-1.30085
34	6	0.77815	-1.30085
35	6	0.77815	-1.30085
36	6	0.77815	-1.30085
37	6	0.77815	-1.30085
38	6	0.77815	-1.30085
39	7	0.84510	-1.18492
40	7	0.84510	-1.18492
41	7	0.84510	-1.18492
42	7	0.84510	-1.18492
43	7	0.84510	-1.18492
44	7	0.84510	-1.18492
45	7	0.84510	-1.18492
46	8	0.90309	-1.07035
47	8	0.90309	-1.07035
48	8	0.90309	-1.07035
49	8	0.90309	-1.07035
50	8	0.90309	-1.07035

Table 8.22 (see Figure 8.26).

51	8	0.90309	-1.07035
52	8	0.90309	-1.07035
53	8	0.90309	-1.07035
54	8	0.90309	-1.07035
55	8	0.90309	-1.07035
56	9	0.95424	-0.95148
57	9	0.95424	-0.95148
58	9	0.95424	-0.95148
59	9	0.95424	-0.95148
60	9	0.95424	-0.95148
61	9	0.95424	-0.95148
62	9	0.95424	-0.95148
63	9	0.95424	-0.95148
64	9	0.95424	-0.95148
65	9	0.95424	-0.95148
66	10	1.00000	-0.85507
67	10	1.00000	-0.85507
68	10	1.00000	-0.85507
69	10	1.00000	-0.85507
70	10	1.00000	-0.85507
71	10	1.00000	-0.85507
72	10	1.00000	-0.85507
73	10	1.00000	-0.85507
74	11	1.04139	-0.77570
75	11	1.04139	-0.77570
76	11	1.04139	-0.77570
77	11	1.04139	-0.77570
78	11	1.04139	-0.77570
79	11	1.04139	-0.77570
80	11	1.04139	-0.77570
81	11	1.04139	-0.77570
82	12	1.07918	-0.69647
83	12	1.07918	-0.69647
84	12	1.07918	-0.69647
85	12	1.07918	-0.69647
86	12	1.07918	-0.69647
87	12	1.07918	-0.69647
88	12	1.07918	-0.69647
89	12	1.07918	-0.69647
90	12	1.07918	-0.69647
91	13	1.11394	-0.63010
92	13	1.11394	-0.63010
93	13	1.11394	-0.63010
94	13	1.11394	-0.63010
95	13	1.11394	-0.63010
96	13	1.11394	-0.63010
97	14	1.14613	-0.58740
98	14	1.14613	-0.58740
99	14	1.14613	-0.58740
100	14	1.14613	-0.58740

Table 8.22 cont'd (see Figure 8.26).

101	15	1.17609	-0.54166
102	15	1.17609	-0.54166
103	15	1.17609	-0.54166
104	15	1.17609	-0.54166
105	15	1.17609	-0.54166
106	15	1.17609	-0.54166
107	15	1.17609	-0.54166
108	16	1.20412	-0.49704
109	16	1.20412	-0.49704
110	16	1.20412	-0.49704
111	16	1.20412	-0.49704
112	17	1.23045	-0.46128
113	17	1.23045	-0.46128
114	17	1.23045	-0.46128
115	17	1.23045	-0.46128
116	17	1.23045	-0.46128
117	18	1.25527	-0.42224
118	18	1.25527	-0.42224
119	18	1.25527	-0.42224
120	18	1.25527	-0.42224
121	18	1.25527	-0.42224
122	19	1.27875	-0.37624
123	19	1.27875	-0.37624
124	19	1.27875	-0.37624
125	19	1.27875	-0.37624
126	19	1.27875	-0.37624
127	19	1.27875	-0.37624
128	19	1.27875	-0.37624
129	20	1.30103	-0.33104
130	20	1.30103	-0.33104
131	20	1.30103	-0.33104
132	20	1.30103	-0.33104
133	20	1.30103	-0.33104
134	21	1.32222	-0.29760
135	21	1.32222	-0.29760
136	21	1.32222	-0.29760
137	21	1.32222	-0.29760
138	22	1.34242	-0.26816
139	22	1.34242	-0.26816
140	22	1.34242	-0.26816
141	22	1.34242	-0.26816
142	23	1.36173	-0.23532
143	23	1.36173	-0.23532
144	23	1.36173	-0.23532
145	23	1.36173	-0.23532
146	23	1.36173	-0.23532
147	24	1.38021	-0.20635
148	24	1.38021	-0.20635
149	24	1.38021	-0.20635
150	25	1.39794	-0.16679

Table 8.22 cont'd (see Figure 8.26).

151	25	1.39794	-0.16679
152	25	1.39794	-0.16679
153	25	1.39794	-0.16679
154	25	1.39794	-0.16679
155	25	1.39794	-0.16679
156	25	1.39794	-0.16679
157	25	1.39794	-0.16679
158	26	1.41497	-0.12750
159	26	1.41497	-0.12750
160	26	1.41497	-0.12750
161	27	1.43136	-0.10261
162	27	1.43136	-0.10261
163	27	1.43136	-0.10261
164	27	1.43136	-0.10261
165	28	1.44716	-0.07070
166	28	1.44716	-0.07070
167	28	1.44716	-0.07070
168	28	1.44716	-0.07070
169	28	1.44716	-0.07070
170	29	1.46240	-0.04593
171	29	1.46240	-0.04593
172	30	1.47712	-0.00706
173	30	1.47712	-0.00706
174	30	1.47712	-0.00706
175	30	1.47712	-0.00706
176	30	1.47712	-0.00706
177	30	1.47712	-0.00706
178	30	1.47712	-0.00706
179	30	1.47712	-0.00706
180	30	1.47712	-0.00706
181	31	1.49136	0.03886
182	31	1.49136	0.03886
183	31	1.49136	0.03886
184	31	1.49136	0.03886
185	32	1.50515	0.07070
186	32	1.50515	0.07070
187	32	1.50515	0.07070
188	32	1.50515	0.07070
189	32	1.50515	0.07070
190	33	1.51851	0.09551
191	33	1.51851	0.09551
192	34	1.53148	0.12038
193	34	1.53148	0.12038
194	34	1.53148	0.12038
195	34	1.53148	0.12038
196	34	1.53148	0.12038
197	35	1.54407	0.15605
198	35	1.54407	0.15605
199	35	1.54407	0.15605
200	35	1.54407	0.15605

Table 8.22 cont'd (see Figure 8.26).

201	35	1.54407	0.15605
202	36	1.55630	0.18473
203	36	1.55630	0.18473
204	36	1.55630	0.18473
205	37	1.56820	0.20635
206	37	1.56820	0.20635
207	37	1.56820	0.20635
208	38	1.57978	0.22081
209	39	1.59106	0.24259
210	39	1.59106	0.24259
211	39	1.59106	0.24259
212	39	1.59106	0.24259
213	39	1.59106	0.24259
214	40	1.60206	0.26816
215	40	1.60206	0.26816
216	41	1.61278	0.27917
217	42	1.62325	0.29760
218	42	1.62325	0.29760
219	42	1.62325	0.29760
220	42	1.62325	0.29760
221	43	1.63347	0.31986
222	43	1.63347	0.31986
223	44	1.64345	0.33478
224	44	1.64345	0.33478
225	45	1.65321	0.34603
226	46	1.66276	0.36109
227	46	1.66276	0.36109
228	46	1.66276	0.36109
229	47	1.67210	0.38766
230	47	1.67210	0.38766
231	47	1.67210	0.38766
232	47	1.67210	0.38766
233	48	1.68124	0.40681
234	50	1.69897	0.42611
235	50	1.69897	0.42611
236	50	1.69897	0.42611
237	50	1.69897	0.42611
238	51	1.70757	0.44558
239	52	1.71600	0.46128
240	52	1.71600	0.46128
241	52	1.71600	0.46128
242	53	1.72428	0.48505
243	53	1.72428	0.48505
244	53	1.72428	0.48505
245	54	1.73239	0.50507
246	54	1.73239	0.50507
247	55	1.74036	0.51719
248	56	1.74819	0.52531
249	57	1.75587	0.53756
250	57	1.75587	0.53756

Table 8.22 cont'd (see Figure 8.26).

251	59	1.77085	0.54988
252	60	1.77815	0.55815
253	61	1.78533	0.56646
254	62	1.79239	0.57480
255	63	1.79934	0.58319
256	64	1.80618	0.59585
257	64	1.80618	0.59585
258	65	1.81291	0.61289
259	65	1.81291	0.61289
260	66	1.81954	0.62578
261	67	1.82607	0.63444
262	69	1.83885	0.64752
263	69	1.83885	0.64752
264	70	1.84510	0.66071
265	71	1.85126	0.66957
266	72	1.85733	0.69195
267	72	1.85733	0.69195
268	72	1.85733	0.69195
269	72	1.85733	0.69195
270	74	1.86923	0.71470
271	76	1.88081	0.72390
272	77	1.88649	0.74250
273	77	1.88649	0.74250
274	77	1.88649	0.74250
275	78	1.89209	0.76612
276	78	1.89209	0.76612
277	79	1.89763	0.78051
278	80	1.90309	0.80486
279	80	1.90309	0.80486
280	80	1.90309	0.80486
281	80	1.90309	0.80486
282	81	1.90849	0.84995
283	81	1.90849	0.84995
284	81	1.90849	0.84995
285	81	1.90849	0.84995
286	81	1.90849	0.84995
287	83	1.91908	0.88101
288	84	1.92428	0.89687
289	84	1.92428	0.89687
290	85	1.92942	0.91838
291	85	1.92942	0.91838
292	86	1.93450	0.95710
293	86	1.93450	0.95710
294	86	1.93450	0.95710
295	86	1.93450	0.95710
296	86	1.93450	0.95710
297	87	1.93952	0.99732
298	87	1.93952	0.99732
299	88	1.94448	1.01506
300	89	1.94939	1.04538

Table 8.22 cont'd (see Figure 8.26).

301	89	1.94939	1.04538
302	89	1.94939	1.04538
303	89	1.94939	1.04538
304	90	1.95424	1.08309
305	90	1.95424	1.08309
306	91	1.95904	1.10912
307	91	1.95904	1.10912
308	93	1.96848	1.12915
309	94	1.97313	1.15658
310	94	1.97313	1.15658
311	94	1.97313	1.15658
312	98	1.99123	1.18492
313	100	2.00000	1.20682
314	100	2.00000	1.20682
315	101	2.00432	1.22931
316	102	2.00860	1.24466
317	103	2.01284	1.26031
318	104	2.01703	1.27627
319	106	2.02531	1.29257
320	110	2.04139	1.34364
321	110	2.04139	1.34364
322	110	2.04139	1.34364
323	110	2.04139	1.34364
324	110	2.04139	1.34364
325	111	2.04532	1.39848
326	117	2.06819	1.41772
327	118	2.07188	1.43749
328	120	2.07918	1.45785
329	122	2.08636	1.47882
330	123	2.08991	1.51155
331	123	2.08991	1.51155
332	124	2.09342	1.54596
333	129	2.11059	1.56995
334	132	2.12057	1.60771
335	132	2.12057	1.60771
336	134	2.12710	1.67619
337	134	2.12710	1.67619
338	134	2.12710	1.67619
339	135	2.13033	1.73716
340	140	2.14613	1.77019
341	141	2.14922	1.82362
342	141	2.14922	1.82362
343	147	2.16732	1.90394
344	147	2.16732	1.90394
345	149	2.17319	1.97322
346	151	2.17898	2.02514
347	152	2.18184	2.08306
348	175	2.24304	2.18536
349	175	2.24304	2.18536
350	201	2.30320	2.31677
351	217	2.33646	2.43299
352	220	2.34242	2.59546
353	231	2.36361	2.88682

Table 8.22 cont'd (see Figure 8.26).

STATISTICAL ANALYSIS OF GULLY OUTFLOW PARAMETER DATA

BOD, mg/ℓ

Churnet Close, (C2)	Log BOD	NSCORE
No. of samples, N	28	28
Mean	0.924	0.001
St. Deviation	0.290	0.965
95% Confidence Intervale	±0.112	
Correlation of outflow log BOD and NSCORE = 0.953		
Regression Equation: log BOD = 0.924 + 0.287 NSCORE		
Tame Close, (T2)	**Log BOD**	**NSCORE**
No. of samples	69	69
Mean	1.019	-0.002
St. Deviation	0.375	0.969
95% Confidence Interval	±0.089	
Correlation of outflow log BOD and NSCORE = 0.990		
Regression Equation: log BOD = 1.02 + 0.383 NSCORE		
Twyford Gardens, (TW2)	**Log BOD**	**NSCORE**
No. of samples, N	80	80
Mean	1.103	0.002
St. Deviation	0.458	0.980
95% Confidence Interval	±0.101	
Correlation of outflow log BOD and NSCORE = 0.983		
Regression Equation: log BOD = 1.10 + 0.460 NSCORE		

Table 8.23.

STATISTICAL ANALYSIS OF GULLY OUTFLOW PARAMETER DATA

Suspended Solids Concentration, mg/ℓ

Churnet Close, (C2)	Log SS	N SCORE
No. of samples, N	79	79
Mean	1.250	0.002
St. Deviation	0.421	0.979
95% Confidence Interval	±0.094	
Correlation of outflow log SS and NSCORE = 0.989		
Regression Equation: log SS = 1.25 + 0.426 N SCORE		

Tame Close, (T2)	Log SS	NSCORE
No. of samples, N	156	156
Mean	1.525	0.001
St. Deviation	0.444	0.989
95% Confidence Interval	±0.070	
Correlation of outflow log SS and NSCORE = 0986		
Regression Equation: Log SS = 1.52 + 0.442 NSCORE		

Twyford Gardens, (TW2)	Log SS	NSCORE
No. of samples, N	118	118
Mean	1.455	0.001
St. Deviation	0.510	0.987
95% Confidence Interval	±0.093	
Correlation of outflow log SS and NSCORE = 0.985		
Regression Equation: Log SS = 1.45 + 0.508 NSCORE		

Table 8.24.

STATISTICAL ANALYSIS OF GULLY OUTFLOW PARAMETER DATA

Combined Data from Gully Pots C2, T2 and TW2	Log SS	NSCORE
Suspended Solids Concentration, mg/ℓ		
No. of samples, N	353	353
Mean	1.440	0.001
St. Deviation	0.473	0.993
95% Confidence Interval	±0.049	
Correlation of total outflow log SS and NSCORE = 0.990		
Regression Equation: log SS = 1.44 + 0.471 NSCORE		
BOD, mg/ℓ	Log BOD	NSCORE
No. of samples, N	177	177
Mean	1.042	0.002
St. Deviation	0.407	0.985
95% Confidence Interval	±0.060	
Correlation of total outflow log BOD and NSCORE = 0.993		
Regression Equation: log BOD = 1.04 + 0.410 NSCORE		

Table 8.25.

8.26 Conclusions.

Very few studies have been conducted which have measured the quality of water discharging from a gully pot. The 'Storm Event Sampling Programme' has been one of the few attempts to collect, analyse and model the quality of gully pot outflow waters. A series of deterministic models have been presented (see Table 8.12) together with a series of probabilistic models (see Figures 8.19 to 8.26 and Tables 8.23 to 8.25) based on a log-normal distribution. These models are valuable in providing a means of prediction of the quality of a gully pot outflow water, given certain hydrological factors or inflow quality/hydrological factors, or a given level of probability of occurrence. They may also be incorporated into larger stormwater quality models which take into account the above-ground and the below-ground phases in stormwater runoff, since they provide a means of identifying the role of the gully pot in determining the quality of the stormwater runoff.

Chapter 9: The Urban Sediments Sampling Programme.

9.1 Introduction.

A number of previous studies have concluded that sediments found within the urban catchment areas can influence the quality of stormwater runoff (Fletcher 1981; Adams 1983; Ellis (in Hollis) 1979, Ellis, Revitt and Gavens 1985; Forstner and Salomons 1980 (parts I and II)). Sediments found within the urban catchments can come from a variety of sources but their nature, size and composition reflect the nature of the urban fabric and the processes operating within it. The state of the building fabric and the nature of the road, roof and paved surfaces are likely to be translated into the type of sediments found within the urban areas. The size and nature of the vegetated or pervious areas will influence the degree to which organics are found as sediments or are associated with the non-volatile sediments within the urban catchments. The climatic regime may also affect the nature and the distribution of sediments within an urban catchment area. The fluvial and aeolian processes within the catchment will influence the transport mechanisms responsible for moving the sediments from their sources to the paved and roof surfaces, thereby enabling them to be susceptible to mobilisation and subsequent transport by the overland flow regime of a runoff event. The amount of traffic using the roads will also affect the quantity and the distribution of sediments within the catchment areas and the role of vehicular movement should not be underestimated in this regard. The quantification of the amount of sediment collected in a gully pot chamber and the role that the pot plays in transporting sediment-associated pollutants, such as heavy metals,

pesticides and hydrocarbons, was seen as an important process which should be included in any analysis of the changes in stormwater quality in the pot during the quiescent periods as well as under storm conditions.

An urban sediment sampling programme was set up to investigate the amount of sediment going into a single gully pot; the size fractionation of the sediments involved; and an analysis of the heavy metals associated with the sediment and its respective fractions. The aim of the sediment analysis programme was to establish sediment discharge rates into the gully pot and to investigate whether the sediments were likely to exert any influence over the quality of the standing pot liquor and the quality of the gully pot outflow waters under dynamic conditions.

9.2 Sediment Delivery Rates to the Gully Pots.

A sampling procedure was set up whereby the amount of sediment going into a gully pot would be measured over a given time period. This was achieved by performing a complete sediment clearance operation on an individual gully pot. This was done by removing the gully pot liquor with a bucket and then removing all the sediments with a long-handled scoop. The scoop was specifically designed for this task and its use enabled a relatively easy collection of all the gully pot basal sediments, plus any remaining pot liquor. A considerable amount of time had to be spent on the gully pot clearance programme so as to ensure that all the sediments had been removed. The sediments were collected in plastic boxes and the sediment collected from each pot was air dried at room temperature for several days. All twelve gully

pots under study in the 'Gully Liquor Monitoring Programme' were cleared during the month of July 1984 so that the pots were devoid of all basal sediments. The gully pots were left for a full one year period and on the corresponding day in 1985, all twelve pots were again cleared and the sediments were collected for analysis. All the sediments were fully dried before analysis and this included air drying plus some oven drying at 105 'C to ensure that all the water had been evaporated. The total mass of sediment delivered to each gully pot was then calculated. The results can be seen in Table 9.1. The area of urban surface surrounding each gully pot had been previously measured (see Chapter 4) and so the sediment delivery rate could be calculated and expressed in units of mass of sediment per unit area per day, which transcribed to $mgm^{-2}\ day^{-1}$. The rates for the twelve gully pots over the one year period can be seen in Table 9.1. It was found that the roadstone chippings found on the Clifton Grove Estate tended to dominate the sediments found in the pots and with this in mind, it was decided to sieve the sediments collected into five size fractions so that a better understanding of the sizes and nature of the basal deposits could be ascertained. The size fractions were:

a) < 0.15 mm.

b) $0.15 \leqslant X > 1.00$ mm.

c) $1.00 \leqslant X > 4.00$ mm.

d) $4.00 \leqslant X > 10.00$ mm.

e) > 10.00 mm. (see Figures 9.1 to 9.4).

The percentage of each of the five size fractions for the sediments

SIZE FRACTIONATION AND SUPPLY RATE FOR BASAL SEDIMENTS ACCUMULATED IN GULLY POTS OVER THE PERIOD JULY 1984 - JULY 1985 (365 DAYS) ON THE CLIFTON GROVE ESTATE, NOTTINGHAM

Gully Pot	Total Mass of Basal sediment g	Size Fractionation (mm. sieve size)					Total Mean Supply Rate mg/^{2}/day
		<0.15 % mg/m^2/day	0.15≤x<1.00 % mg/m^2/day	1.00≤x<4.00 % mg/m^2/day	4.00≤x<10.00 % mg/m^2/day	≥10.00 % mg/m^2/day	
C1	3372	8 4.2	9 4.9	43 22.8	22 11.4	17 9.1	52.5
C2	5366	2 1.4	20 11.9	21 12.6	41 25.4	16 9.6	61.0
C3	17013	2 6.5	2 7.4	14 42.9	56 172.0	26 79.8	308.7
C4	3234	7 3.3	9 4.4	48 24.5	6 2.4	32 16.0	50.6
Churnet Average		**3 3.9**	**7 7.2**	**22 25.7**	**44 52.8**	**24 28.6**	**106.8**
T1	7125	6 4.9	12 9.2	45 35.8	18 14.6	19 15.0	79.6
T2	11164	3 3.8	9 11.9	30 40.6	41 55.1	17 22.7	134.2
T3	17929	3 9.9	6 24.3	16 60.0	16 61.2	59 219.5	374.9
T4	6020	3 4.2	5 7.2	26 35.9	13 17.6	53 72.6	137.4
Tame Average		**3 5.7**	**8 13.2**	**26 43.1**	**23 37.1**	**40 82.5**	**159.8**
TW1	609	4 0.6	15 2.3	16 2.4	13 1.9	53 8.1	15.3
TW2	1857	1 0.2	3 0.4	16 2.1	54 7.2	26 3.4	13.3
TW3	1667	- 0.3	6 6.5	30 35.3	38 44.8	26 30.1	117.1
TW4	2049	8 2.8	12 4.3	30 11.1	16 5.9	35 13.2	37.4
Twyford Average		**3 0.9**	**8 3.4**	**24 12.7**	**33 14.9**	**32 13.7**	**24.9**
12 No. Gully Average	**(Range)**	**3 (0-8)**	**8 (2-20)**	**25 (14-48)**	**31 (5-56)**	**33 (16-59)**	

Table 9.1

Photograph of the ≤0.15 mm Sediment Fraction from the Tame Close Gully Pot 1.

Figure 9.1

Photograph of the 4-10 mm Sediment Fraction from the Churnet Close Gully Pot 2.

Figure 9.2

Photograph of the >10 mm Sediment Fraction from the Tame Close Gully Pot 1.

Figure 9.3

Photograph of the Large Debris found in the Tame Close Gully Pot 1.

Figure 9.4

collected from all twelve gully pots were calculated. The sediment supply rates for each size fraction to the pots were then determined. The results are presented in Table 9.1.

Once the sediment supply rates and the sediment loadings to the twelve pots had been established over the one year period from July 1984 to July 1985, it was decided to continue this part of the 'Sediment Sampling Programme over a second one year period, but on a limited number of gully pots. The "number 2" gully pots on each of the three sub-catchments (ie. those which were used in the 'Storm Event Sampling Programme') were selected for further study and they were left for a further one year period with the gully pot clearance on the corresponding date in 1986. The "number 1" gully pots in the three sub-catchments were to be analysed more frequently and they were cleared approximately every three months from July 1985 to May 1986. The aim of this exercise was to attempt to establish if there was a seasonality factor in the sediment supply rates to the pots. The "number 1" gully pots were left for a period of 91 days between July 1985 and October 1985; for a period of 124 days between October 1985 and February 1986; and for 91 days between February and May 1986. The 124 day period was longer than scheduled because the heavy snowfalls in January and February 1986 meant that gully pot clearance was difficult to achieve, since frost intrusion under the gully pot grating, meant that it was impossible to lift the grating and to obtain access to the pot. A total mass loading and average sediment supply rates were calculated for all the sediments collected during the period July 1985 to July 1986. The fractionation analysis was also conducted on these sediments and the results can be seen in Tables 9.2 to 9.3.

SIZE FRACTIONATION AND SUPPLY RATE FOR BASAL SEDIMENTS ACCUMULATED IN GULLY POTS OVER THE PERIOD JULY 1985 - JULY 1986 (365 DAYS) ON THE CLIFTON GROVE ESTATE, NOTTINGHAM

Gully Pot	Total Mass of Basal sediment g	Size Fractionation (mm, sieve size)					Total Mean Supply Rate $mg/^2/day$
		<0.15 % $mg/m^2/day$	0.15≤x<1.00 % $mg/m^2/day$	1.00≤x<4.00 % $mg/m^2/day$	4.00≤x<10.00 % $mg/m^2/day$	≥10.00 % $mg/m^2/day$	
C2	8463	7 6.1	8 8.2	49 47.1	14 13.8	22 21.1	96.2
T2	10164	3 3.8	10 11.9	48 58.2	19 23.9	20 24.3	122.1
TW2	1973	5 0.6	8 1.2	43 6.1	22 3.2	22 3.2	14.1
3 No. Gully Average		5	9	47 (SUMMER 1985 - SUMMER 1986)	18	21	

Table 9.2

SIZE FRACTIONATION AND SUPPLY RATE FOR BASAL SEDIMENTS ACCUMULATED IN GULLY POTS OVER THE PERIOD JULY 1985 - MAY 1986 (306 DAYS) ON THE CLIFTON GROVE ESTATE, NOTTINGHAM

Gully Pot	Total Mass of Basal sediment g	Size Fractionation (mm, sieve size)					Total Mean Supply Rate $mg/m^2/day$
		<0.15 % $mg/m^2/day$	0.15≤x<1.00 % $mg/m^2/day$	1.00≤x<4.00 % $mg/m^2/day$	4.00≤x<10.00 % $mg/m^2/day$	>10.00 % $mg/m^2/day$	
		JULY - OCTOBER, 1985: 91 DAYS					
C1	1247	10 8.0	33 25.7	18 14.1	14 10.6	21 19.4	77.8
T1	1316	10 5.9	44 26.2	29 17.1	9 5.4	8 4.4	59.0
TW1	197	6 1.1	20 4.0	30 5.9	21 4.2	23 4.7	19.9
3 No. Gully Average		10	30	24	12	16	
		(SUMMER - AUTUMN)					
		OCTOBER - FEBRUARY, 1985/86: 124 DAYS					
C1	1390	2 1.3	10 6.6	4 2.5	12 7.8	71 45.5	63.7
T1	449	3 0.5	16 2.3	9 1.3	32 4.7	40 6.0	14.8
TW1	158		5 0.6	4 0.5	14 1.6	77 9.0	11.7
3 No. Gully Average		2	11	5	17	65	
		(AUTUMN - WINTER)					
		FEBRUARY - MAY, 1986: 91 DAYS					
C1	1249	4 3.1	23 18.0	26 20.4	32 25.0	15 11.4	77.4
T1	83	5 3.9	22 18.3	29 24.2	34 27.9	10 8.2	82.5
TW1	525	2 1.1	22 11.7	37 19.7	25 13.0	14 7.3	
3 No. Gully Average		4	23	29	32	12	
		(WINTER - SPRING)					

Table 9.3

Gully Pot	Average Sediment Supply Rate to the Gully Pot (all values are in $mgm^{-2}.day^{-1}$.)	
	July 84 to July 85	July 85 to July 86
Tame 2	159.8	122.1
Churnet 2	106.8	96.2
Twyford 2	24.9	14.1

Table: 9.4

The sediment supply rates to the "number 2" gully pots showed very similar values for the two one year periods. The supply rates for the "number 1" gully pots were a little more varied and a seasonal influence could be detected in the data. The investigation of seasonal effects prompted the decision to analyse the gully sediments more frequently in the "number 1" pots during the second one year period (ie. from July 1985 to July 1986). The supply rates were noticeably lower during the period October 1985 to February 1986 and this was probably due to a lack of organic and vegetal matter, since there was unlikely to be much plant and grass material within the urban catchment areas. The lower supply rates for the second one year period were also reflected in the data for the "number 2" gully pots, but the difference was not as marked (see Tables 9.1 to 9.4). The low supply rates obtained for the Twyford "number 2" gully pot were indicative of its location and this was also observed in the 'Gully

Liquor Monitoring Programme' and in the 'Storm Event Sampling Programme'. The analysis of the supply of sediment to the gully pots on the sub-catchments provided very useful background information to the research programme and the results emphasised the significance of the sediments in terms of mass transport within a urban micro-catchment. The gully pots act as sedimentation chambers and the sediment loadings to the pots could be quantified using the derived data. The role of the pots in preventing the passage of sediments into the storm sewer pipe network and subsequently to the stormwater outfall could be ascertained and their role in reducing the sediment loadings to the receiving waters could be appreciated. The SS within the quiescent gully pot liquor were also of interest to the sediment sampling programme. The results of the SS analysis carried out were used to determine the amount of volatile matter in the SS found in the pot liquors. The method of analysis to determine the volatile fraction has been presented in Chapter 5. It was important, therefore, to retain a sufficient quantity of SS on the filter papers (after the determination for SS) to enable the volatile fraction to be accurately determined. The volatile fraction analysis was performed on a number of SS samples obtained from the standing gully pot liquors which were collected duing October and November' 1984 and during February and March 1985. The results of these analyses can be seen in Table 9.5. The results were fairly consistent except for that determined for a group of SS samples collected on the 27th. February 1985, which had an extremely high content of volatile matter. If this sample was excluded, an overall mean value of 21.9% volatile matter was obtained for the SS found in the standing pot liquor. The mean volatile fraction in the SS in the quiescent liquor was found to be of the same order of magnitude as those found in the gully pot basal

sediments. The dominance of the large (ie. > 10.00 mm dia.) road stone chipping meant that a larger than average size fractionation was found on the Clifton Grove Estate sub-catchment surfaces. The sediment supply rates were, therefore, similarly high, since the mass of sediments collected from an individual pot often exceeded 10 kilograms over the one year period (see Figures 9.1 to 9.4 inclusive).

An analysis of the volatile fraction in the SS in the stormwater samples was also carried out. The SS collected from both the inflow and the outflow waters for the first five storm events analysed as part of the 'Storm Event Sampling Programme' were used in this analysis. The volatile fraction was measured in the SS for both the inflow and outflow waters and the results are presented in Table 9.6. The results are presented as mean values and the volatile fraction in the outflow waters was at all times higher than those in the inflow waters. The average % volatile fraction in the SS in the outflow waters was 27.4%, whilst it was only 15.1% in the SS found in the inflow waters. There was therefore an enhancement of the volatile matter from within the pot liquor itself and this was achieved by the discharging of floating organic debris, suspended organic particles within the pot liquor and from the resuspension of the finer, organic basal sediments. The larger, inert roadstones were most likely to fall within the liquor once they had entered the gully pot during a storm event and would form part of the basal sediments. The net effect of these processes would be that the percentage volatile matter in the SS in the outflow waters would be increased. A similar exercise was also carried out on composite sediment samples from the Gully Pot Storm Field Trials (see Table 9.7 and see Chapter 10).

DETERMINATION OF THE VOLATILE FRACTION IN THE SUSPENDED SOLIDS IN URBAN STORMWATER ON THE CLIFTON GROVE ESTATE, NOTTINGHAM.

Standing Liquor in gully pots (quiescent conditions)

Table 9.5

DATE	NO. OF GULLIES SAMPLED	VOLATILE SUSPENDED SOLIDS % (MEANS)
31.10.84	12	23.4
7.11.84	12	19.4
14.11.84	12	21.9
21.11.84	6	18.7
28.11.84	6	24.6
	OVERALL MEAN =	**21.6 %**
20.2.85	6	19.2
27.2.85	6	87.6
6.3.85	6	22.4
13.3.85	6	24.2
20.3.85	6	21.7
	OVERALL MEAN :	**35.0 %**
	EXCLUDING SAMPLE 27.2.85, MEAN :	**21.9 %**

DETERMINATION OF THE VOLATILE FRACTION IN THE SUSPENDED SOLIDS IN URBAN STORMWATER ON THE CLIFTON GROVE ESTATE, NOTTINGHAM

Stormwater flows into and discharged from gully pots

DATE (STORM NUMBER)	GULLY POT	VOLATILE SUSPENDED SOLIDS % INFLOW MEAN VALUE (NUMBER OF SAMPLES IN BRACKETS)	OUTFLOW MEAN VALUE (NUMBER OF SAMPLES IN BRACKETS)
2.6.84 (I)	T2	15.0 (7)	27.0 (10)
	TW2	14.2 (10)	22.1 (12)
12.7.84 (II)	T2	20.2 (10)	34.7 (12)
	TW2	7.1 (8)	38.7 (12)
2.8.84 (III)	T2	14.6 (15)	19.0 (12)
	TW2	21.8 (5)	25.3 (12)
13.9.84 (IV)	C2	13.4 (24)	27.1 (24)
	T2	-	21.1 (12)
	TW2	19.7 (8)	31.2 (12)
8.10.84 (V)	C2	16.7 (5)	24.8 (12)
	T2	8.3 (1)	23.4 (12)
	TW2	-	34.2 (12)
	OVERALL MEAN	**= 15.1% (93)**	**= 27.4% (154)**

Table 9.6

Stormwater discharged from gully pots During artificial storms with no runoff from the highway surface into the gullies

TEST	VOLATILE SUSPENDED SOLIDS, % OUTFLOW MEAN VALUE (NUMBER OF SAMPLES IN BRACKETS)
1	32 (12)
2	30 (12)
3	43 (12)
4	29 (12)

Table 9.7 (see Chapter 10).

9.3 Sediment Characterisation.

The previous section has described the methods used to calculate the supply rate of sediment into an individual gully pot and the estimated supply rates are presented in Tables 9.1 to 9.4. The second part of the sediment sampling programme involved an investigation to determine the sediment characteristics associated with road surface sediments, those sediments washed into the gully pot and the gully pot basal sediments. The aim of this monitoring exercise was to describe the three different categories of sediment in terms of their size fraction characteristics, their volatile fraction and the sediment-associated metal concentrations. The programme was conducted over a six month period from October 1984 to March 1985. All twelve gully pots on the three sub-catchments under study were used in the sediment monitoring programme. The sediments were sampled once per month and the samples were collected on the following dates:

841001	1st. October 1984
841031	31st. October 1984
841205	5th. December 1984
850109	9th. January 1985
850227	27th. February 1985
850313	13th. March 1985

On the dates as given above, basal sediments were collected from all twelve gully pots. This was done using a long-handled scoop which was

specifically designed and made for the job. About 20 grams of sediment was removed from each pot. This grab sample was considered to be representative of the basal sediments. These sediments were then air dried for several days and they were then put into an oven at 105 'C for a couple of hours to ensure that all the water had been removed. The sample was then divided into two so as to leave a sub-sample totally representative of that taken from the gully pot, and a second sub-sample was used for the fractionation analysis. The sample was sieved into three size fractions, which were:

i) < 0.15 mm.

ii) $0.15 \leq X < 1.00$ mm.

iii) ≥ 1.00 mm.

In the results presented, the fractions are stated as perentages. The results can be seen in Tables 9.8 to 9.13. The samples were then arranged such that two fractions were used in the analysis for the volatile fraction and the metals analysis in addition to the sub-sample which was kept and described as a 'Total Sample'. The samples were arranged into two size fractions which were:

i) ≤ 1.00 mm.

ii) > 1.00 mm.

The volatile fraction for each of the two size fractions, as well as for the total sample, was then derived using the method as outlined in Chapter 5. The three sample categories, ie) Fraction < 1.00 mm., Fraction > 1.00 mm. and the Total Sample were also used in the metals

analysis. The aim of the programme was to look primarily at the volatile matter and the metals associated with the total sample, but the analysis of the two fractions enabled trends to be established with either the smaller or the larger size fraction, or both. The results of the basal sediments volatile fraction analysis can be seen in Tables 9.14 to 9.19.

The same experimental procedures were applied to the sediments collected from the road surface and those sediments which had recently entered the gully pot system. These sediment samples were collected at three locations which were at, or adjacent to, the "number 2" gully pots in each of the three sub-catchments (ie. those gully pots used in the 'Storm Event Sampling Programme'). The sediments collected from the road and channel surfaces were called 'Road Sediments'. These were collected at random by a grab sample using a small hand scoop. They were collected from the road surface adjacent to the kerb within a few metres of the entrance to the gully pot. All the road sediment samples collected were considered to be representative of those lying on the road surface and a mass of about 10 to 20 grams of sediment was collected on each of the monthly sampling runs. The sediments, which had recently been washed into the gully pot system, were those which had collected on the mesh which was hung over the top of the receiving box, installed as part of the 'Storm Event Sampling Programme'. The mesh was installed in order to prevent any blockage to the receiving box, but it provided a useful and convenient means of collecting sediments which were known to have been washed into the gully pot. Sediments were collected from the mesh and also from the ledge just inside the upstream side of each of the gully pots. These sediments were known as the 'Box Sediments'. These samples were again

considered to be representative of the sediments mobilised and transported by the overland fluvial processes during a storm runoff event. A size fractionation analysis was carried out in the same manner as for the gully pot basal sediments, as described above. The determination of the volatile fraction and the metals concentrations were conducted on the Fraction ≤ 1.00 mm., Fraction > 1.00 mm. and the total sample, as above. The results are presented in Tables 9.20 to 9.25, Tables 9.26 to 9.31, Tables 9.32 to 9.37 and Tables 9.38 to 9.43.

The metals analysis was conducted on all the sediment samples collected and the twelve metals as measured in the 'Gully Liquor Monitoring Programme' were analysed in the sediment analysis programme. The sediments were digested using the following 'Standard Method'. The sediment samples were air dried and then oven dried at 105 'C to remove all the excess water. The sample was placed in a beaker (previously washed in an acid bath) and 30.0 ml. of distilled water was added. The solution was then stirred and 10.0 ml of 10M Hydrochloric acid and 10.0 ml of 10M Nitric acid were added, to bring the solution to a volume of 50.0 ml. The beaker was then stirred thoroughly and put on a hot plate and was brought to the boil for a period of about fifteen minutes. The solutions were then covered and left to cool. The method used was that as outlined in Chapter 5 under the American Standard Methods. The solutions were filtered and diluted (if necessary) and they were then ready for the metals analysis using the AAS and Spectrophotometer methods as outlined in Chapter 5. The metal concentrations were expressed as a mass of the metal per unit mass of the sediment from which it was derived and so all the metals are expressed in the units of mgg-1. It was essential

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.8

Sediments Survey Programme
CODE : 841ØØ1
DATE SAMPLES COLLECTED : 841ØØ1
DATE SAMPLES ANALYSED : 841ØØ1

SEDIMENT FRACTIONATION ANALYSIS

****

PERCENTAGE FRACTIONATION
All values are expressed as percentages

****

	Fraction <Ø.15 mm.	Fraction Ø.15<X<1.ØØ mm.	Fraction >1.ØØ mm.
LOCATION :			
T1	7.Ø	32.Ø	61.Ø
T2	3.Ø	12.Ø	85.Ø
T3	3.Ø	21.Ø	76.Ø
T4	3.Ø	35.Ø	62.Ø
C1	3.Ø	32.Ø	65.Ø
C2	1.Ø	4.Ø	95.Ø
C3	2.Ø	13.Ø	85.Ø
C4	11.Ø	58.Ø	31.Ø
TW1	3.Ø	13.Ø	84.Ø
TW2	Ø.4	Ø.6	99.Ø
TW3	1.Ø	5.Ø	94.Ø
TW4	2.Ø	1Ø.Ø	88.Ø

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.9

Sediments Survey Programme
CODE : 841Ø31
DATE SAMPLES COLLECTED : 841Ø31
DATE SAMPLES ANALYSED : 841Ø31

SEDIMENT FRACTIONATION ANALYSIS

PERCENTAGE FRACTIONATION
All values are expressed as percentages

LOCATION	Fraction <Ø.15 mm.	Fraction Ø.15<X<1.ØØ mm.	Fraction >1.ØØ mm.
T1	1.3	34.Ø	64.7
T2	Ø.5	3.8	95.7
T3	Ø.4	16.4	83.2
T4	Ø.9	12.6	86.5
C1	2.4	13.4	84.2
C2	Ø.9	5.6	93.5
C3	Ø.3	3.Ø	96.7
C4	5.1	36.9	58.Ø
TW1	Ø.Ø	7.1	92.9
TW2	1.5	Ø.3	98.2
TW3	Ø.Ø	Ø.Ø	1ØØ.Ø
TW4	Ø.Ø	Ø.4	99.6

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.10

Sediments Survey Programme
CODE : 8412Ø5
DATE SAMPLES COLLECTED : 8412Ø5
DATE SAMPLES ANALYSED : 8412Ø5

SEDIMENT FRACTIONATION ANALYSIS

PERCENTAGE FRACTIONATION
All values are expressed as percentages

	Fraction <Ø.15 mm.	Fraction Ø.15<X<1.ØØ mm.	Fraction >1.ØØ mm.
LOCATION :			
T1	5.6	57.9	36.5
T2	Ø.5	3.6	95.9
T3	Ø.9	14.8	84.3
T4	1.Ø	19.8	79.2
C1	1.6	8.Ø	9Ø.4
C2	1.3	7.2	91.5
C3	Ø.1	1.2	98.7
C4	4.1	3Ø.9	65.Ø
TW1	Ø.8	7.9	91.3
TW2	Ø.2	4Ø.9	58.9
TW3	Ø.5	5.1	94.4
TW4	3.6	26.5	69.9

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.11

Sediments Survey Programme
CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø1Ø9

SEDIMENT FRACTIONATION ANALYSIS

PERCENTAGE FRACTIONATION
All values are expressed as percentages

LOCATION	Fraction <Ø.15 mm.	Fraction Ø.15<X<1.ØØ mm.	Fraction >1.ØØ mm.
T1	2.1	23.1	74.8
T2	Ø.4	4.1	95.5
T3	Ø.7	12.1	87.2
T4	Ø.Ø	5.5	94.5
C1	Ø.2	2.Ø	97.8
C2	Ø.2	1.1	98.7
C3	Ø.Ø	Ø.1	99.9
C4	4.8	53.1	42.1
TW1	Ø.Ø	Ø.9	99.1
TW2	Ø.Ø	Ø.1	99.9
TW3	Ø.7	7.5	91.8
TW4	Ø.9	11.9	87.2

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.12

Sediments Survey Programme
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850227

SEDIMENT FRACTIONATION ANALYSIS

PERCENTAGE FRACTIONATION
All values are expressed as percentages

LOCATION	Fraction <Ø.15 mm.	Fraction Ø.15<X<1.ØØ mm.	Fraction >1.ØØ mm.
T1	2.8	23.7	73.5
T2	Ø.7	4.8	94.5
T3	Ø.8	9.1	9Ø.1
T4	Ø.1	3.6	96.3
C1	Ø.3	4.8	94.9
C2	Ø.6	3.9	95.5
C3	Ø.1	Ø.2	99.7
C4	4.Ø	36.5	59.5
TW1	Ø.3	2.4	97.3
TW2	Ø.5	2.4	97.1
TW3	Ø.5	3.2	96.3
TW4	1.7	12.8	85.5

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS

Table 9.13

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø313

SEDIMENT FRACTIONATION ANALYSIS

PERCENTAGE FRACTIONATION
All values are expressed as percentages

LOCATION	Fraction <Ø.15 mm.	Fraction Ø.15<X<1.ØØ mm.	Fraction >1.ØØ mm.
T1	3.1	17.6	79.2
T2	1.3	1Ø.7	87.9
T3	Ø.Ø	Ø.4	99.6
T4	Ø.2	Ø.5	99.3
C1	Ø.7	6.5	92.8
C2	Ø.3	2.2	97.5
C3	Ø.Ø	Ø.1	99.9
C4	Ø.6	6.9	92.5
TW1	-1.Ø	-1.Ø	-1.Ø
TW2	Ø.3	1.2	98.5
TW3	Ø.2	1.Ø	98.8
TW4	1.8	1Ø.7	87.5

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme

Table 9.14

CODE : 841001
DATE SAMPLES COLLECTED : 841001
DATE SAMPLES ANALYSED : 841001

SEDIMENT FRACTIONATION: VOLATILE ANALYSIS

****

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

****

LOCATION	Fraction <1.00 mm.	Fraction >1.00 mm.	Fraction TOTAL
T1	43.9	2.2	7.8
T2	6.8	28.9	33.7
T3	1.8	4.5	14.3
T4	6.3	7.5	22.8
C1	2.1	10.4	20.7
C2	1.3	29.7	40.0
C3	0.8	18.2	18.9
C4	13.9	5.5	29.3
TW1	4.7	30.2	40.3
TW2	1.8	42.3	66.6
TW3	0.9	10.6	18.7
TW4	2.0	12.1	8.1

NOTE: The figure 0.00 means a non-detectable level
NOTE: The figure -1.0 or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme

Table 9.15

CODE : 841031
DATE SAMPLES COLLECTED : 841031
DATE SAMPLES ANALYSED : 841031

SEDIMENT FRACTIONATION: VOLATILE ANALYSIS

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

	Fraction <1.00 mm.	Fraction >1.00 mm.	Fraction TOTAL
LOCATION :			
T1	11.3	1.9	2.5
T2	24.0	18.8	3.3
T3	9.2	3.7	1.9
T4	23.2	7.4	3.3
C1	20.6	11.6	13.1
C2	23.8	21.5	7.5
C3	0.0	9.6	1.5
C4	0.0	16.1	5.4
TW1	0.0	0.0	49.6
TW2	40.2	18.1	0.8
TW3	0.0	42.7	42.5
TW4	0.0	11.6	9.7

NOTE: The figure 0.00 means a non-detectable level
NOTE: The figure -1.0 or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841205

Table 9.16

SEDIMENT FRACTIONATION: VOLATILE ANALYSIS

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

LOCATION	Fraction <1.00 mm.	Fraction >1.00 mm.	Fraction TOTAL
T1	3.4	6.0	0.9
T2	17.0	4.6	3.6
T3	6.8	2.1	4.5
T4	10.8	7.2	18.5
C1	14.1	1.8	8.4
C2	22.6	4.8	3.8
C3	12.5	1.1	32.1
C4	11.1	14.9	15.9
TW1	21.0	17.1	5.1
TW2	29.5	3.5	0.1
TW3	14.9	1.3	8.6
TW4	19.8	36.0	6.0

NOTE: The figure 0.00 means a non-detectable level
NOTE: The figure -1.0 or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø1Ø9

Table 9.17

SEDIMENT FRACTIONATION: VOLATILE - ANALYSIS

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

LOCATION	Fraction <1.ØØ mm.	Fraction >1.ØØ mm.	Fraction TOTAL
T1	8.5	2.4	3.6
T2	11.6	3.5	5.3
T3	4.9	1.4	3.5
T4	6.9	1.8	11.6
C1	5.Ø	Ø.8	2.4
C2	19.5	2.Ø	2.Ø
C3	11.1	Ø.7	2.7
C4	3.3	2.4	1.6
TW1	13.2	3.3	5.1
TW2	36.8	Ø.6	3.5
TW3	1Ø.1	Ø.8	3.9
TW4	6.9	2.1	3.7

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
CODE : 85Ø227
DATE SAMPLES COLLECTED : 85Ø227
DATE SAMPLES ANALYSED : 85Ø227

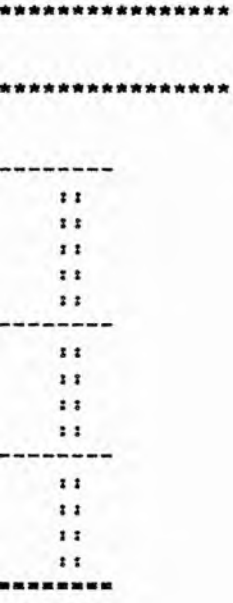
SEDIMENT FRACTIONATION: VOLATILE ANALYSIS

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

LOCATION	Fraction <1.ØØ mm.	Fraction >1.ØØ mm.	Fraction TOTAL
T1	7.5	4.2	4.Ø
T2	19.9	7.9	5.3
T3	9.3	1.6	3.Ø
T4	8.9	1.Ø	2.9
C1	3.8	1.Ø	1.7
C2	19.1	1.9	3.7
C3	Ø.Ø	Ø.1	2.3
C4	7.5	4.8	1.4
TW1	9.2	5.4	4.5
TW2	22.5	3.4	3.5
TW3	13.Ø	Ø.1	1.7
TW4	18.6	4.Ø	2.4

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample

Table 9.18



Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø313

Table 9.19

SEDIMENT FRACTIONATION: VOLATILE ANALYSIS

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

LOCATION	Fraction <1.ØØ mm.	Fraction >1.ØØ mm.	Fraction TOTAL
T1	66.Ø	27.6	4.6
T2	81.8	23.Ø	8.9
T3	-1.Ø	8.3	3.Ø
T4	-1.Ø	-1.Ø	1.1
C1	8.Ø	1.1	5.9
C2	15.2	1.3	2.Ø
C3	-1.Ø	1.5	Ø.1
C4	9.2	13.5	36.Ø
TW1	-1.Ø	-1.Ø	-1.Ø
TW2	Ø.Ø	1.2	2.Ø
TW3	Ø.Ø	8.4	4.Ø
TW4	9.4	17.2	6.7

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.20

Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 841ØØ1
DATE SAMPLES COLLECTED : 841ØØ1
DATE SAMPLES ANALYSED : 841ØØ1

ROAD SEDIMENTS
Sediment Fractionation Analysis

****

PERCENTAGE FRACTIONATION
All values are expressed as percentages

****

LOCATION :	Fraction <Ø.15 mm.	Fraction Ø.15<X<1.ØØ mm.	Fraction >1.ØØ mm.
Tam	14.3	24.6	6Ø.7
Chu	1Ø.9	29.1	6Ø.Ø
Twy	13.2	19.3	67.5

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: Ta=Tame Close; Ch=Churnet close and Tw=Twyford Gardens

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 841031
DATE SAMPLES COLLECTED : 841031
DATE SAMPLES ANALYSED : 841031

Table 9.21

ROAD SEDIMENTS
Sediment Fractionation Analysis

PERCENTAGE FRACTIONATION
All values are expressed as percentages

LOCATION :	Fraction <Ø.15 mm.	Fraction Ø.15<X<1.ØØ mm.	Fraction >1.ØØ mm.
Tam	2.5	33.7	63.8
Chu	3.6	29.1	67.3
Twy	6.6	34.1	59.3

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -I stands for NO ANALYSIS
NOTE: Ta=Tame Close; Ch=Churnet close and Tw=Twyford Gardens

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841205

Table 9.22

ROAD SEDIMENTS
Sediment Fractionation Analysis

****

PERCENTAGE FRACTIONATION
All values are expressed as percentages

****

LOCATION :	Fraction <Ø.15 mm.	Fraction Ø.15<X<1.ØØ mm.	Fraction >1.ØØ mm.
Tam	7.8	15.2	77.Ø
Chu	4.7	14.1	81.2
Twy	7.9	11.Ø	81.1

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: Ta=Tame Close; Ch=Churnet close and Tw=Twyford Gardens

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø1Ø9

Table 9.23

ROAD SEDIMENTS
Sediment Fractionation Analysis

****

PERCENTAGE FRACTIONATION
All values are expressed as percentages

****

LOCATION	Fraction <Ø.15 mm.	Fraction Ø.15<X<1.ØØ mm.	Fraction >1.ØØ mm.
Tam	Ø.5	6.9	92.6
Chu	Ø.1	Ø.8	99.1
Twy	Ø.Ø	Ø.9	99.1

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: Ta=Tame Close; Ch=Churnet close and Tw=Twyford Gardens

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850227

Table 9.24

ROAD SEDIMENTS
Sediment Fractionation Analysis

PERCENTAGE FRACTIONATION
All values are expressed as percentages

LOCATION :	Fraction <Ø.15 mm. :	Fraction Ø.15<X<1.ØØ mm. :	Fraction >1.ØØ mm. :
Tam	Ø.7	14.3	85.Ø
Chu	1.6	22.8	75.6
Twy	2.5	18.7	78.8

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: Ta=Tame Close; Ch=Churnet close and Tw=Twyford Gardens

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø313

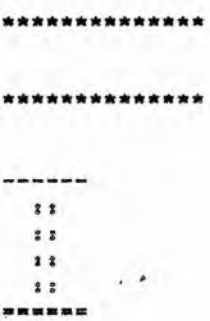
ROAD SEDIMENTS
Sediment Fractionation Analysis

PERCENTAGE FRACTIONATION
All values are expressed as percentages

	Fraction <Ø.15 mm.	Fraction Ø.15<X<1.ØØ mm.	Fraction >1.ØØ mm.
LOCATION :			
Tam :	1.7	13.5	84.8
Chu :	1.2	17.9	8Ø.9
Twy :	4.5	23.7	71.8

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: Ta=Tame Close; Ch=Churnet close and Tw=Twyford Gardens

Table 9.25



Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 841001
DATE SAMPLES COLLECTED : 841001
DATE SAMPLES ANALYSED : 841001

Table 9.26

ROAD SEDIMENTS
Sediment Fractionation : Volatile Analysis

****

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

****

	Fraction <1.00 mm.	Fraction >1.00 mm.	Fraction TOTAL
LOCATION :	:	:	: :
Ta :	15.1 :	31.9 :	10.1 : :
Ch :	12.6 :	21.5 :	39.2 : :
Tw :	3.8 :	19.3 :	26.4 : :

NOTE: The figure 0.00 means a non-detectable level
NOTE: The figure -1.0 or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample
NOTE: Ta=Tame Close;Ch=Churnet Close and Tw= Twyford Gardens

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 841Ø31
DATE SAMPLES COLLECTED : 841Ø31
DATE SAMPLES ANALYSED : 841Ø31

Table 9.27

ROAD SEDIMENTS
Sediment Fractionation : Volatile Analysis

****

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

****

LOCATION :	Fraction <1.ØØ mm.	Fraction >1.ØØ mm.	Fraction TOTAL
Ta	2.Ø	5.Ø	4.Ø
Ch	2.Ø	4.Ø	11.Ø
Tw	3.Ø	7.Ø	11.Ø

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample
NOTE: Ta=Tame Close;Ch=Churnet Close and Tw= Twyford Gardens

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 8412Ø5
DATE SAMPLES COLLECTED : 8412Ø5
DATE SAMPLES ANALYSED : 8412Ø5

Table 9.28

ROAD SEDIMENTS
Sediment Fractionation : Volatile Analysis

****

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

****

LOCATION :	Fraction <1.ØØ mm.	Fraction >1.ØØ mm.	Fraction TOTAL
Ta	29.9	44.2	15.1
Ch	28.4	13.6	14.Ø
Tw	5.4	41.3	5.1

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample
NOTE: Ta=Tame Close;Ch=Churnet Close and Tw= Twyford Gardens

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø1Ø9

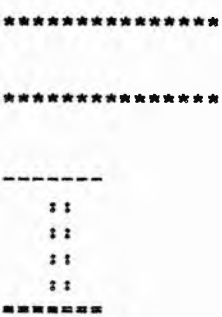
ROAD SEDIMENTS
Sediment Fractionation : Volatile Analysis

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

	Fraction <1.ØØ mm.	Fraction >1.ØØ mm.	Fraction TOTAL
LOCATION :			
Ta	12.4	1.9	1.9
Ch	18.Ø	2.2	1.6
Tw	2Ø.3	5.Ø	4.3

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample
NOTE: Ta=Tame Close;Ch=Churnet Close and Tw= Twyford Gardens

Table 9.29



Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850227

Table 9.30

ROAD SEDIMENTS
Sediment Fractionation : Volatile Analysis

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

LOCATION :	Fraction <1.00 mm. :	Fraction >1.00 mm. :	Fraction TOTAL :
Ta	11.3	2.2	4.3
Ch	10.3	7.3	4.7
Tw	8.0	4.8	4.0

NOTE: The figure 0.00 means a non-detectable level
NOTE: The figure -1.0 or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample
NOTE: Ta=Tame Close;Ch=Churnet Close and Tw= Twyford Gardens

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø313

ROAD SEDIMENTS
Sediment Fractionation : Volatile Analysis

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

LOCATION	Fraction <1.ØØ mm.	Fraction >1.ØØ mm.	Fraction TOTAL
Ta	29.2	Ø.1	3.4
Ch	29.2	2.Ø	6.7
Tw	11.6	2.5	6.Ø

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample
NOTE: Ta=Tame Close;Ch=Churnet Close and Tw= Twyford Gardens

Table 9.31

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Urban Stormwater Analysis : CLIFTON GROVE

Table 9.32

Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 841001
DATE SAMPLES COLLECTED : 841001
DATE SAMPLES ANALYSED : 841001

BOX SEDIMENTS
Sediment Fractionation Analysis

****

PERCENTAGE FRACTIONATION
All values are expressed as percentages

****

LOCATION :	Fraction <0.15 mm.	Fraction 0.15<X<1.00 mm.	Fraction >1.00 mm.
Tam :	1.0	11.0	88.0
Chu :	2.0	31.0	67.0
Twy :	2.0	19.0	79.0

NOTE: The figure 0.00 means a non-detectable level
NOTE: The figure -1.0 or -1 stands for NO ANALYSIS
NOTE: Ta=Tame Close; Ch=Churnet close and Tw=Twyford Gardens

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 841Ø31
DATE SAMPLES COLLECTED : 841Ø31
DATE SAMPLES ANALYSED : 841Ø31

Table 9.33

BOX SEDIMENTS
Sediment Fractionation Analysis

****

PERCENTAGE FRACTIONATION
All values are expressed as percentages

****

LOCATION	Fraction <Ø.15 mm.	Fraction Ø.15<X<1.ØØ mm.	Fraction >1.ØØ mm.
Tam	8.9	19.7	71.4
Chu	1Ø.9	34.3	54.8
Twy	8.3	21.7	7Ø.Ø

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: Ta=Tame Close; Ch=Churnet close and Tw=Twyford Gardens

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 8412Ø5
DATE SAMPLES COLLECTED : 8412Ø5
DATE SAMPLES ANALYSED : 8412Ø5

Table 9.34

BOX SEDIMENTS
Sediment Fractionation Analysis

PERCENTAGE FRACTIONATION
All values are expressed as percentages

LOCATION :	Fraction <Ø.15 mm.	Fraction Ø.15<X<1.ØØ mm.	Fraction >1.ØØ mm.
Tam	Ø.2	31.1	68.7
Chu	1.2	1Ø.3	88.5
Twy	Ø.9	5.5	93.6

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: Ta=Tame Close; Ch=Churnet close and Tw=Twyford Gardens

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø1Ø9

Table 9.35

BOX SEDIMENTS
Sediment Fractionation Analysis

PERCENTAGE FRACTIONATION
All values are expressed as percentages

LOCATION :	Fraction <Ø.15 mm.	Fraction Ø.15<X<1.ØØ mm.	Fraction >1.ØØ mm.
Tam	Ø.Ø	Ø.3	99.7
Chu	1.2	13.7	85.1
Twy	Ø.6	2.9	96.5

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE:. Ta=Tame Close; Ch=Churnet close and Tw=Twyford Gardens

733a (extra)

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 85Ø227
DATE SAMPLES COLLECTED : 85Ø227
DATE SAMPLES ANALYSED : 85Ø227

BOX SEDIMENTS
Sediment Fractionation Analysis

PERCENTAGE FRACTIONATION
All values are expressed as percentages

	Fraction <Ø.15 mm.	Fraction Ø.15<X<1.ØØ mm.	Fraction >1.ØØ mm.
LOCATION :			
Tam :	Ø.4	7.2	92.4
Chu :	1.4	9.7	88.9
Twy :	Ø.7	7.Ø	92.3

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: Ta=Tame Close; Ch=Churnet close and Tw=Twyford Gardens

Table 9.36

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Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø313

BOX SEDIMENTS
Sediment Fractionation Analysis

PERCENTAGE FRACTIONATION
All values are expressed as percentages

	Fraction <Ø.15 mm.	Fraction Ø.15<X<1.ØØ mm.	Fraction >1.ØØ mm.
LOCATION :			
Tam	1.7	12.4	85.9
Chu	Ø.4	3.4	96.2
Twy	1.3	8.5	9Ø.2

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: Ta=Tame Close; Ch=Churnet close and Tw=Twyford Gardens

Table 9.37

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Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 841Ø31
DATE SAMPLES COLLECTED : 841Ø31
DATE SAMPLES ANALYSED : 841Ø31

Table 9.38

BOX SEDIMENTS
Sediment Fractionation : Volatile Analysis

****

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

****

LOCATION :	Fraction <1.ØØ mm.	Fraction >1.ØØ mm.	Fraction TOTAL
Ta	3.6	6.2	1.6
Ch	4.9	4.8	23.6
Tw	3.7	5.1	12.9

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample
NOTE: Ta=Tame Close;Ch=Churnet Close and Tw= Twyford Gardens

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 841ØØ1
DATE SAMPLES COLLECTED : 841ØØ1
DATE SAMPLES ANALYSED : 841ØØ1

Table 9.39

BOX SEDIMENTS
Sediment Fractionation : Volatile Analysis

****

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

****

LOCATION	Fraction <1.ØØ mm.	Fraction >1.ØØ mm.	Fraction TOTAL
Ta	32.7	24.8	46.Ø
Ch	18.7	4.2	2Ø.4
Tw	11.8	3Ø.3	47.Ø

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample
NOTE: Ta=Tame Close;Ch=Churnet Close and Tw= Twyford Gardens

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841205

Table 9.40

BOX SEDIMENTS
Sediment Fractionation : Volatile Analysis

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

LOCATION	Fraction <1.00 mm.	Fraction >1.00 mm.	Fraction TOTAL
Ta	13.0	1.7	7.8
Ch	9.7	1.2	38.1
Tw	17.2	4.9	9.1

NOTE: The figure 0.00 means a non-detectable level
NOTE: The figure -1.0 or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample
NOTE: Ta=Tame Close;Ch=Churnet Close and Tw= Twyford Gardens

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø1Ø9

Table 9.41

BOX SEDIMENTS
Sediment Fractionation : Volatile Analysis

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

LOCATION	Fraction <1.ØØ mm.	Fraction >1.ØØ mm.	Fraction TOTAL
Ta	-1.Ø	1.5	2.1
Ch	8.4	3.7	3.6
Tw	-1.Ø	2.1	Ø.5

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample
NOTE: Ta=Tame Close;Ch=Churnet Close and Tw= Twyford Gardens

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850227

Table 9.42

BOX SEDIMENTS
Sediment Fractionation : Volatile Analysis

****

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

****

LOCATION :	Fraction <1.00 mm. :	Fraction >1.00 mm. :	Fraction TOTAL :
Ta	22.4	3.6	7.6
Ch	15.3	15.3	2.9
Tw	18.5	1.8	4.7

NOTE: The figure 0.00 means a non-detectable level
NOTE: The figure -1.0 or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample
NOTE: Ta=Tame Close;Ch=Churnet Close and Tw= Twyford Gardens

Urban Stormwater Analysis : CLIFTON GROVE
Sediments Survey Programme
G. A. Fulcher : Dept. of Civil Engineering
CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø313

Table 9.43

BOX SEDIMENTS
Sediment Fractionation : Volatile Analysis

PERCENTAGE VOLATILE FRACTION
All values are expressed as percentages

LOCATION :	Fraction <1.ØØ mm.	Fraction >1.ØØ mm.	Fraction TOTAL
Ta	15.7	4.9	2.6
Ch	22.8	3.9	3.1
Tw	13.2	2.5	5.8

NOTE: The figure Ø.ØØ means a non-detectable level
NOTE: The figure -1.Ø or -1 stands for NO ANALYSIS
NOTE: TOTAL stands for a collected, non-fractionated sample
NOTE: Ta=Tame Close;Ch=Churnet Close and Tw= Twyford Gardens

to know the mass of the original sediment sample before it was digested. The results of the metals analysis can be seen in Tables 9.44 to 9.79, Tables 9.80 to 9.115 and Tables 9.116 to 9.151.

A summary of the results found in the Tables as referenced above can be seen below in Table 9.152.

Average Metal Concentrations on the Total Sample (Non-fractionated) Sediments.

(All values are in mgg-1)

	Na	K	Fe	Pb	Ca	Mg
Road	0.568	0.320	4.396	0.062	15.760	3.085
Box	0.357	0.177	5.040	0.028	22.280	2.331
Basal	4.320	4.380	6.770	0.104	31.110	6.280
	Zn	Mn	Cu	Cd	Ni	Cr
Road	0.095	0.204	0.014	0.003	0.011	0.026
Box	0.117	0.200	0.013	0.002	0.012	0.022
Basal	0.138	0.303	0.019	0.003	0.020	0.057

Table: 9.152

The results showed that the sediment metal concentrations were very similar for the Box and the Road sediments. The average figures for the sediment metal concentrations in the Basal sediments were found to be noticeably higher than both the Road and the Box sediments (see Table 9.152). This trend was particularly marked for the sodium and potassium values. The lead concentrations in the Basal sediments were

found to be twice those found on the road surface. The concentrations of the heavy metals zinc, manganese, copper, cadmium, nickel and chromium in the Basal sediments were all well above those found in the Road and Box sediments. These results suggested that the gully pot basal sediments acted as a sink for metals (and in particular the heavy metals). This trend was also observed in the metals data collected for certain storm events in the 'Storm Event Sampling Programme' (see Chapter 8). The Road and Box sediments showed very similar metal concentrations for all twelve metals and it seemed unlikely that the sediments had undergone any physiochemical change during their passage into the gully pot under storm conditions. The sediment metal concentrations in the basal deposits had been enhanced from the gully pot liquor itself and metals had been precipitated out into the soild form, under varying conditions of pH and Redox Potential within the pot liquor. The six month sediment sampling programme was not exhaustive but it provided enough data to clearly illustrate the differences in size fractionation, volatile fraction and the sediment-associated metal concentrations between those sediments found on the road surfaces (Road), those washed into the gully pot during a storm runoff event (Box) and the Basal deposits found within the gully pot liquor itself.

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841ØØ1
DATE SAMPLES COLLECTED : 841ØØ1
DATE SAMPLES ANALYSED : 841ØØ2
ROAD SEDIMENTS

Table 9.44

METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	Ø.147	Ø.18Ø	2.616	Ø.ØØ46	8.698	2.319
Ch	Ø.195	Ø.4Ø1	1Ø.263	Ø.2Ø2	5.274	5.274
Tw	Ø.164	Ø.262	7.268	Ø.ØØ82	11.77Ø	5.75Ø

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841001
DATE SAMPLES COLLECTED : 841001
DATE SAMPLES ANALYSED : 841002
ROAD SEDIMENTS

Table 9.45

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	0.050	0.212	0.008	0.011	0.007	0.035
Ch	0.161	0.301	0.033	0.017	0.021	0.122
Tw	0.083	0.305	0.030	0.009	0.012	0.079

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841ØØ1
DATE SAMPLES COLLECTED : 841ØØ1
DATE SAMPLES ANALYSED : 841ØØ2
ROAD SEDIMENTS

Table 9.46

METALS ANALYSIS : Na K Fe Pb Ca Mg
LARGER FRACTION (> 1.ØØ MM.)

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	Ø.594	Ø.629	Ø.ØØ98	Ø.1Ø5	17.828	3.67Ø
Ch	Ø.2Ø7	Ø.239	Ø.ØØ87	Ø.1Ø6	13.918	6.959
Tw	1.248	1.731	Ø.ØØ93	Ø.181	41.952	9.489

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841ØØ1
DATE SAMPLES COLLECTED : 841ØØ1
DATE SAMPLES ANALYSED : 841ØØ2
ROAD SEDIMENTS

Table 9.47

****
METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
LARGER FRACTION (> 1.ØØ MM.)
****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta :	Ø.162	Ø.594	Ø.ØØ24	Ø.ØØ28	Ø.ØØ31	Ø.Ø93
Ch :	Ø.116	Ø.375	Ø.ØØ23	Ø.ØØ15	Ø.ØØ18	Ø.1Ø6
Tw :	Ø.241	1.198	Ø.ØØ28	Ø.ØØ24	Ø.ØØ22	Ø.135

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841001
DATE SAMPLES COLLECTED : 841001
DATE SAMPLES ANALYSED : 841002
ROAD SEDIMENTS

Table 9.48

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
SMALLER FRACTION (< 1.00 MM.)

****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	0.724	0.483	17.711	0.060	47.498	8.453
Ch	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
Tw	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841001
DATE SAMPLES COLLECTED : 841001
DATE SAMPLES ANALYSED : 841002
ROAD SEDIMENTS

Table 9.49

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
SMALLER FRACTION (< 1.00 MM.)

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	0.211	1.328	0.050	0.028	0.031	0.093
Ch	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
Tw	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841Ø31
DATE SAMPLES COLLECTED : 841Ø31
DATE SAMPLES ANALYSED : 8411Ø1
ROAD SEDIMENTS

Table 9.50

****
METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE
****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	Ø.315	Ø.265	6.856	Ø.Ø47	21.Ø21	5.323
Ch	Ø.172	Ø.14Ø	5.Ø76	Ø.Ø5Ø	18.739	2.646
Tw	1.Ø59	1.35Ø	11.627	Ø.131	34.881	7.126

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.51

G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841031
DATE SAMPLES COLLECTED : 841031
DATE SAMPLES ANALYSED : 841102
ROAD SEDIMENTS

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE

****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	Ø.342	Ø.44Ø	Ø.Ø23	Ø.ØØ3	Ø.ØØ7	Ø.Ø14
Ch	Ø.Ø52	Ø.168	Ø.Ø15	Ø.ØØ3	Ø.ØØ8	Ø.Ø1Ø
Tw	Ø.176	1.2ØØ	Ø.Ø21	Ø.ØØ5	Ø.Ø17	Ø.Ø28

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841031
DATE SAMPLES COLLECTED : 841031
DATE SAMPLES ANALYSED : 841101
ROAD SEDIMENTS

Table 9.52

METALS ANALYSIS : Na K Fe Pb Ca Mg
LARGER FRACTION (> 1.00 MM.)

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	0.380	0.206	6.203	0.051	12.007	2.782
Ch	0.350	0.119	4.848	0.046	8.932	1.684
Tw	0.458	0.159	10.354	0.091	9.458	2.260

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.53

CODE : 841031
DATE SAMPLES COLLECTED : 841031
DATE SAMPLES ANALYSED : 841102
ROAD SEDIMENTS

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
LARGER FRACTION (> 1.00 MM.)

****

LOCATION :	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
Ta	0.180	0.288	0.013	0.002	0.003	0.012
Ch	0.097	0.166	0.007	0.000	0.000	0.000
Tw	0.131	0.350	0.016	0.000	0.002	0.000

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841Ø31
DATE SAMPLES COLLECTED : 841Ø31
DATE SAMPLES ANALYSED : 8411Ø1
ROAD SEDIMENTS

Table 9.54

****
METALS ANALYSIS : Na K Fe Pb Ca Mg
SMALLER FRACTION (< 1.ØØ MM.)
****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta :	Ø.465	Ø.21Ø	11.423	Ø.1Ø6	25.9Ø2	4.118
Ch :	Ø.345	Ø.162	7.583	Ø.ØØ77	14.279	3.614
Tw :	Ø.856	Ø.249	14.631	Ø.149	38.913	5.526

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841Ø31
DATE SAMPLES COLLECTED : 841Ø31
DATE SAMPLES ANALYSED : 8411Ø2
ROAD SEDIMENTS

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
SMALLER FRACTION (< 1.ØØ MM.)

****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1
LOCATION :				
Ta	Ø.393	Ø.531	Ø.Ø32	Ø.ØØ5
Ch	Ø.232	Ø.342	Ø.Ø2Ø	Ø.ØØ4
Tw	Ø.43Ø	Ø.573	Ø.Ø31	Ø.ØØØ

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Table 9.55

****

****

Ni mgg-1	Cr mgg-1
Ø.ØØ9	Ø.Ø24
Ø.ØØØ	Ø.Ø12
Ø.ØØØ	Ø.ØØØ

****

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841207
ROAD SEDIMENTS

Table 9.56

****
METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE
****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	Ø.17Ø	Ø.ØØ73	2.762	Ø.ØØ34	1Ø.624	1.898
Ch	Ø.272	Ø.ØØ59	6.Ø12	Ø.ØØ22	31.135	2.348
Tw	Ø.493	Ø.122	5.243	Ø.348	13.695	2.269

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841207
ROAD SEDIMENTS

Table 9.57

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta :	0.060	0.076	0.010	0.000	0.002	0.000
Ch :	0.072	0.046	0.011	0.002	0.005	0.009
Tw :	0.113	0.095	0.008	0.000	0.008	0.010

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841207
ROAD SEDIMENTS

Table 9.58

****
METALS ANALYSIS : Na K Fe Pb Ca Mg
LARGER FRACTION (> 1.00 MM.)
****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	0.395	0.087	3.126	0.034	17.010	2.069
Ch	0.594	0.020	3.480	0.035	26.614	3.357
Tw	0.716	0.022	4.565	0.046	14.770	2.685

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.59

CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841207
ROAD SEDIMENTS

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
LARGER FRACTION (> 1.00 MM.)

****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	0.160	0.013	0.000	0.006	0.000	0.000
Ch	0.194	0.020	0.017	0.004	0.008	0.018
Tw	0.129	0.015	0.017	0.000	0.007	0.021

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.60

G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841207
ROAD SEDIMENTS

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
SMALLER FRACTION (< 1.00 MM.)

****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	0.261	0.076	4.516	0.015	15.212	13.370
Ch	0.343	0.112	3.717	0.028	28.596	15.845
Tw	0.165	0.051	1.831	0.017	10.529	12.269

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841207
ROAD SEDIMENTS

Table 9.61

****
METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
SMALLER FRACTION (< 1.00 MM.)
****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	0.075	0.011	0.000	0.000	0.000	0.000
Ch	0.080	0.017	0.015	0.004	0.005	0.000
Tw	0.063	0.007	0.008	0.000	0.004	0.012

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø111
ROAD SEDIMENTS

METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1
LOCATION :				
Ta	Ø.Ø97	Ø.127	2.587	Ø.Ø2Ø
Ch	Ø.Ø94	Ø.Ø91	4.594	Ø.Ø21
Tw	Ø.228	Ø.293	Ø.977	Ø.Ø13

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Table 9.62

****

****

Ca mgg-1	Mg mgg-1	
8.Ø42	1.629	
5.341	2.35Ø	
5.2Ø8	1.12Ø	

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø111
ROAD SEDIMENTS

Table 9.63

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	Ø.Ø22	Ø.175	Ø.ØØ5	Ø.ØØ1	Ø.ØØ3	Ø.Ø63
Ch	Ø.Ø2Ø	Ø.146	Ø.Ø11	Ø.ØØ1	Ø.ØØ4	Ø.Ø53
Tw	Ø.Ø27	Ø.ØØ2	Ø.ØØ3	Ø.ØØ1	Ø.ØØ2	Ø.Ø16

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø111
ROAD SEDIMENTS

Table 9.64

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
LARGER FRACTION (> 1.ØØ MM.)

****

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
Ta	Ø.Ø66	Ø.Ø3Ø	Ø.926	Ø.ØØ6	7.484	2.58Ø
Ch	Ø.Ø35	Ø.Ø3Ø	Ø.735	Ø.ØØ7	5.324	Ø.456
Tw	Ø.183	Ø.167	Ø.Ø83	Ø.Ø15	28.351	1.Ø34

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 850109
DATE SAMPLES COLLECTED : 850109
DATE SAMPLES ANALYSED : 850111
ROAD SEDIMENTS

Table 9.65

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
LARGER FRACTION (> 1.00 MM.)

****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	0.010	0.200	0.004	0.001	0.001	0.007
Ch	0.009	0.021	0.006	0.001	0.002	0.000
Tw	0.018	0.153	0.007	0.004	0.003	0.000

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)

Table 9.66

Sediments Survey Programme
CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø111
ROAD SEDIMENTS

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
SMALLER FRACTION (< 1.ØØ MM.)

****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	Ø.615	Ø.538	6.293	Ø.12Ø	17.832	4.895
Ch	2.358	Ø.584	8.Ø19	Ø.264	15.Ø94	4.717
Tw	118.644	3.Ø51	2Ø.762	1.Ø59	57.2Ø3	42.372

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø1Ø9

Table 9.67

DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø111
ROAD SEDIMENTS

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
SMALLER FRACTION (< 1.ØØ MM.)

****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	Ø.Ø99	Ø.5Ø3	Ø.Ø31	Ø.ØØ6	Ø.Ø19	Ø.Ø7Ø
Ch	Ø.547	Ø.311	Ø.Ø56	Ø.Ø56	Ø.1Ø4	Ø.ØØØ
Tw	3.Ø51	1.568	Ø.5Ø8	3.771	Ø.169	Ø.ØØØ

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850227
ROAD SEDIMENTS

Table 9.68

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE

****

	Na mgg-I	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	0.709	0.174	3.180	0.022	21.041	2.446
Ch	1.788	0.339	4.630	0.021	21.078	2.697
Tw	2.950	0.743	5.310	0.050	50.440	5.162

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED . : 850227
ROAD SEDIMENTS

Table 9.69

****
METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE
****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	0.020	0.022	0.009	0.001	0.003	0.012
Ch	0.024	0.026	0.017	0.000	0.004	0.000
Tw	0.195	0.054	0.020	0.000	0.008	0.000

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø227
DATE SAMPLES COLLECTED : 85Ø227
DATE SAMPLES ANALYSED : 85Ø227
ROAD SEDIMENTS

Table 9.70

****
METALS ANALYSIS : Na K Fe Pb Ca Mg
LARGER FRACTION (> 1.ØØ MM.)
****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	Ø.288	Ø.125	1.897	Ø.ØØ25	11.718	1.6Ø9
Ch	1.513	Ø.121	4.167	Ø.121	17.764	1.842
Tw	1.188	Ø.532	4.3Ø4	Ø.ØØ45	21.517	3.791

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.71

CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850227
ROAD SEDIMENTS

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
LARGER FRACTION (> 1.00 MM.)

****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	0.025	0.222	0.008	0.001	0.003	0.013
Ch	0.068	0.156	0.013	0.001	0.010	0.027
Tw	0.070	0.615	0.008	0.002	0.007	0.033

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø227
DATE SAMPLES COLLECTED : 85Ø227
DATE SAMPLES ANALYSED : 85Ø227
ROAD SEDIMENTS

Table 9.72

****
METALS ANALYSIS : Na K Fe Pb Ca Mg
SMALLER FRACTION (< 1.ØØ MM.)
****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta :	Ø.863	Ø.257	12.134	Ø.131	14.173	4.611
Ch :	2.429	Ø.392	12.145	Ø.313	14.Ø26	5.Ø15
Tw :	3.262	1.218	16.314	Ø.239	37.524	8.7Ø1

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850227
ROAD SEDIMENTS

Table 9.73

/

****
METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
SMALLER FRACTION (< 1.00 MM.)
****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	0.180	0.398	0.036	0.003	0.016	0.049
Ch	0.208	0.513	0.036	0.005	0.023	0.063
Tw	0.348	0.978	0.045	0.014	0.041	0.054

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.74

G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø315
ROAD SEDIMENTS

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE

****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	Ø.113	Ø.11Ø	Ø.Ø35	Ø.ØØ4	12.11Ø	1.792
Ch	Ø.13Ø	Ø.1Ø8	Ø.Ø47	Ø.ØØ6	2.Ø93	1.2Ø9
Tw	1.125	Ø.924	Ø.Ø45	Ø.ØØ8	2.49Ø	2.169

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.75

CODE : 850313
DATE SAMPLES COLLECTED : 850313
DATE SAMPLES ANALYSED : 850315
ROAD SEDIMENTS

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE

****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta :	0.048	0.113	0.006	0.001	0.005	0.005
Ch :	0.063	0.032	0.008	0.001	0.006	0.004
Tw :	0.181	0.273	0.014	0.004	0.090	0.014

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø315
ROAD SEDIMENTS

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
LARGER FRACTION (> 1.ØØ MM.)

****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1
LOCATION :				
Ta :	Ø.Ø71	Ø.Ø51	Ø.Ø39	Ø.ØØ1
Ch :	Ø.Ø69	Ø.Ø5Ø	Ø.Ø53	Ø.Ø11
Tw :	Ø.579	1.Ø14	Ø.Ø64	Ø.ØØ3

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Table 9.76

****

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Ca mgg-1	Mg mgg-1
9.139	1.11Ø
3.591	Ø.793
24.627	6.Ø84

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø315
ROAD SEDIMENTS

Table 9.77

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
LARGER FRACTION (> 1.ØØ MM.)

LOCATION :	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
Ta	Ø.Ø23	Ø.Ø65	Ø.Ø13	Ø.ØØ1	Ø.ØØ2	Ø.ØØ2
Ch	Ø.Ø44	Ø.Ø45	Ø.Ø12	Ø.ØØ1	Ø.ØØ5	Ø.ØØ2
Tw	Ø.1Ø7	Ø.Ø78	Ø.Ø22	Ø.ØØ2	Ø.Ø12	Ø.Ø16

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)

Table 9.78

Sediments Survey Programme
CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø315
ROAD SEDIMENTS

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
SMALLER FRACTION (< 1.ØØ MM.)

****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	Ø.445	Ø.468	1.364	Ø.ØØ27	18.748	3.562
Ch	Ø.656	Ø.735	Ø.257	Ø.Ø41	18.9ØØ	6.825
Tw	1.Ø93	1.744	Ø.166	Ø.ØØ29	46.558	17.736

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø315
ROAD SEDIMENTS

Table 9.79

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
SMALLER FRACTION (< 1.ØØ MM.)

****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	Ø.234	Ø.152	Ø.Ø4Ø	Ø.ØØ5	Ø.Ø19	Ø.Ø19
Ch	Ø.46Ø	Ø.352	Ø.178	Ø.ØØ5	Ø.Ø41	Ø.Ø26
Tw	Ø.6Ø6	Ø.665	Ø.Ø67	Ø.ØØ5	Ø.Ø31	Ø.Ø35

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841ØØ1
DATE SAMPLES COLLECTED : 841ØØ1
DATE SAMPLES ANALYSED : 841ØØ2
BOX SEDIMENTS

Table 9.80

****
METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE
****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta :	Ø.422	Ø.2Ø1	5.956	Ø.ØØ32	34.563	6.274
Ch :	Ø.192	Ø.296	7.522	Ø.ØØ89	8.466	4.559
Tw :	Ø.2Ø6	Ø.299	3.ØØ36	Ø.ØØ33	6.182	1.627

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)

Table 9.81

Sediments Survey Programme
CODE : 841001
DATE SAMPLES COLLECTED : 841001
DATE SAMPLES ANALYSED : 841002
BOX SEDIMENTS

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	0.046	0.576	0.010	0.008	0.009	0.074
Ch	0.085	0.260	0.024	0.011	0.014	0.099
Tw	0.043	0.184	0.007	0.008	0.008	0.048

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841ØØ1
DATE SAMPLES COLLECTED : 841ØØ1
DATE SAMPLES ANALYSED : 841ØØ2
BOX SEDIMENTS

Table 9.82

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
LARGER FRACTION (> 1.ØØ MM.)

****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	Ø.6Ø4	Ø.345	7.985	Ø.ØØ28	45.1Ø8	7.769
Ch	Ø.Ø93	Ø.149	2.849	Ø.ØØ3Ø	8.Ø3Ø	1.295
Tw	-1.ØØØ	-1.ØØØ	-1.ØØØ	-1.ØØØ	-1.ØØØ	-1.ØØØ

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841001
DATE SAMPLES COLLECTED : 841001
DATE SAMPLES ANALYSED : 841002
BOX SEDIMENTS

Table 9.83

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
LARGER FRACTION (> 1.00 MM.)

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta :	0.026	0.147	0.017	0.008	0.010	0.000
Ch :	0.011	0.158	0.006	0.005	0.000	0.000
Tw :	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)

Table 9.84

Sediments Survey Programme
CODE : 841001
DATE SAMPLES COLLECTED : 841001
DATE SAMPLES ANALYSED : 841002
BOX SEDIMENTS

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
SMALLER FRACTION (< 1.00 MM.)

****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
Ch	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
Tw	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)

Table 9.85

Sediments Survey Programme
CODE : 841001
DATE SAMPLES COLLECTED : 841001
DATE SAMPLES ANALYSED : 841002
BOX SEDIMENTS

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
SMALLER FRACTION (< 1.00 MM.)

****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta :	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
Ch :	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
Tw :	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.86

CODE : 841Ø31
DATE SAMPLES COLLECTED : 841Ø31
DATE SAMPLES ANALYSED : 8411Ø1
BOX SEDIMENTS

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE

****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	Ø.1Ø5	Ø.1ØØ	5.59Ø	Ø.ØØ29	15.293	1.962
Ch	Ø.242	Ø.166	6.Ø93	Ø.ØØ56	15.925	2.631
Tw	Ø.743	Ø.593	27.374	Ø.ØØ84	36.499	7.Ø72

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841031
DATE SAMPLES COLLECTED : 841031
DATE SAMPLES ANALYSED : 841101
BOX SEDIMENTS

Table 9.87

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta :	0.149	0.221	0.010	0.002	0.008	0.006
Ch :	0.180	0.368	0.012	0.004	0.010	0.000
Tw :	0.447	0.985	0.034	0.000	0.039	0.000

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.88

CODE : 841Ø31
DATE SAMPLES COLLECTED : 841Ø31
DATE SAMPLES ANALYSED : 8411Ø1
BOX SEDIMENTS

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
LARGER FRACTION (> 1.ØØ MM.)

****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	Ø.412	Ø.165	6.836	Ø.ØØ28	13.553	1.932
Ch	Ø.474	Ø.199	7.591	Ø.ØØ62	21.823	3.558
Tw	-1.ØØØ	-1.ØØØ	-1.ØØØ	-1.ØØØ	-1.ØØØ	-1.ØØØ

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)

Table 9.89

Sediments Survey Programme
CODE : 841031
DATE SAMPLES COLLECTED : 841031
DATE SAMPLES ANALYSED : 841101
BOX SEDIMENTS

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
LARGER FRACTION (> 1.00 MM.)

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :	.					
Ta	0.156	0.130	0.007	0.000	0.009	0.000
Ch	0.132	0.323	0.000	0.000	0.000	0.000
Tw	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841031
DATE SAMPLES COLLECTED : 841031
DATE SAMPLES ANALYSED : 841102
BOX SEDIMENTS

Table 9.90

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
SMALLER FRACTION (< 1.00 MM.)

****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION						
Ta	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
Ch	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
Tw	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841031
DATE SAMPLES COLLECTED : 841031
DATE SAMPLES ANALYSED : 841101
BOX SEDIMENTS

Table 9.91

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
SMALLER FRACTION (< 1.00 MM.)

****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
Ch	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
Tw	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841207
BOX SEDIMENTS

Table 9.92

****
METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE
****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	Ø.292	Ø.ØØ34	3.488	Ø.Ø027	24.622	1.7Ø3
Ch	Ø.226	Ø.ØØ25	6.299	Ø.Ø031	46.352	1.6Ø5
Tw	Ø.6Ø7	Ø.ØØ2Ø	8.947	Ø.Ø018	47.928	1.598

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.93

CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841207
BOX SEDIMENTS

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE

****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	0.307	0.095	0.017	0.000	0.004	0.000
Ch	0.173	0.133	0.023	0.003	0.002	0.000
Tw	0.204	0.136	0.026	0.003	0.003	0.023

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841207
BOX SEDIMENTS

Table 9.94

****
METALS ANALYSIS : Na K Fe Pb Ca Mg
LARGER FRACTION (> 1.00 MM.)
****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	0.061	0.043	2.279	0.023	2.805	1.081
Ch	0.173	0.090	4.290	0.021	3.678	1.862
Tw	2.426	2.045	4.620	0.081	20.215	7.104

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.95

CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841207
BOX SEDIMENTS

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
LARGER FRACTION (> 1.00 MM.)

****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta :	0.018	0.161	0.013	0.001	0.005	0.040
Ch :	0.034	0.192	0.046	0.002	0.005	0.055
Tw :	0.254	2.021	0.035	0.127	0.023	0.127

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw=. Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841207
BOX SEDIMENTS

Table 9.96

****
METALS ANALYSIS : Na K Fe Pb Ca Mg
SMALLER FRACTION (< 1.00 MM.)
****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION						
Ta	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
Ch	1.230	0.825	24.745	0.270	56.239	10.648
Tw	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.97

G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841207
BOX SEDIMENTS

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
SMALLER FRACTION (< 1.00 MM.)

****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
Ch	0.300	0.570	0.102	0.030	0.045	0.330
Tw	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)

Table 9.98

Sediments Survey Programme
CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø111
BOX SEDIMENTS

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE

****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	Ø.ØØØ	Ø.Ø64	1.463	Ø.Ø19	3.55Ø	1.Ø65
Ch	Ø.Ø77	Ø.123	3.113	Ø.Ø29	4.7Ø3	1.66Ø
Tw	Ø.884	Ø.Ø54	1.55Ø	Ø.ØØ7	2.326	1.Ø85

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.99

CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø111
BOX SEDIMENTS

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
Ta	Ø.Ø17	Ø.Ø82	Ø.ØØ4	Ø.ØØ2	Ø.ØØ6	Ø.Ø36
Ch	Ø.Ø33	Ø.Ø95	Ø.ØØ7	Ø.ØØ1	Ø.ØØ4	Ø.Ø52
Tw	Ø.Ø15	Ø.Ø57	Ø.ØØ5	Ø.ØØ2	Ø.ØØ2	Ø.Ø39

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø111
BOX SEDIMENTS

Table 9.100

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
LARGER FRACTION (> 1.ØØ MM.)

****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	Ø.16Ø	Ø.Ø25	1.197	Ø.ØØ7	1.535	8.749
Ch	Ø.127	Ø.153	3.Ø59	Ø.Ø27	3.456	1.42Ø
Tw	1.117	Ø.Ø42	3.27Ø	Ø.Ø11	3.788	Ø.837

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø111
BOX SEDIMENTS

Table 9.101

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
LARGER FRACTION (> 1.ØØ MM.)

****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	Ø.Ø21	Ø.Ø54	Ø.ØØØ	Ø.ØØ2	Ø.ØØØ	Ø.ØØØ
Ch	Ø.Ø34	Ø.Ø72	Ø.ØØ8	Ø.ØØ2	Ø.ØØ6	Ø.Ø52
Tw	Ø.Ø29	Ø.Ø92	Ø.Ø1Ø	Ø.Ø18	Ø.ØØ8	Ø.ØØØ

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø111
BOX SEDIMENTS

Table 9.102

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
SMALLER FRACTION (< 1.ØØ MM.)

****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	18.113	2.Ø75	24.528	Ø.642	48.3Ø2	15.472
Ch	Ø.527	1.166	19.277	Ø.ØØ32	32.467	9.639
Tw	1Ø.247	1.486	38.288	Ø.315	26.463	21.396

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø111
BOX SEDIMENTS

Table 9.103

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
SMALLER FRACTION (< 1.ØØ MM.)

****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta :	1.811	1.245	Ø.264	Ø.Ø75	Ø.ØØØ	Ø.ØØØ
Ch :	Ø.223	Ø.487	Ø.Ø51	Ø.Ø12	Ø.Ø47	Ø.ØØØ
Tw :	Ø.7Ø9	1.182	Ø.ØØØ	Ø.281	Ø.Ø34	Ø.ØØØ

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850228
BOX SEDIMENTS

Table 9.104

METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	0.182	0.029	2.405	0.008	35.271	0.307
Ch	0.424	0.050	3.238	0.014	70.161	0.252
Tw	0.871	0.027	4.257	0.007	11.998	0.108

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)

Table 9.105

Sediments Survey Programme
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850227
BOX SEDIMENTS

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE

****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	0.013	0.010	0.003	0.002	0.000	0.000
Ch	0.038	0.010	0.007	0.000	0.009	0.000
Tw	0.018	0.035	0.002	0.000	0.004	0.000

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø227
DATE SAMPLES COLLECTED : 85Ø227
DATE SAMPLES ANALYSED : 85Ø228
BOX SEDIMENTS

Table 9.106

METALS ANALYSIS : Na K Fe Pb Ca Mg
LARGER FRACTION (> 1.ØØ MM.)

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	Ø.183	Ø.Ø2Ø	Ø.475	Ø.ØØ15	3.834	Ø.299
Ch	1.257	Ø.ØØ64	2.373	Ø.ØØ22	18.849	2.Ø94
Tw	Ø.862	Ø.419	3.697	Ø.ØØ25	16.84Ø	3.162

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850227
BOX SEDIMENTS

Table 9.107

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
LARGER FRACTION (> 1.00 MM.)

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta :	0.017	0.030	0.005	0.000	0.005	0.000
Ch :	0.020	0.102	0.011	0.001	0.005	0.000
Tw :	0.097	0.616	0.012	0.002	0.007	0.000

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø227
DATE SAMPLES COLLECTED : 85Ø227
DATE SAMPLES ANALYSED : 85Ø228
BOX SEDIMENTS

Table 9.108

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
SMALLER FRACTION (< 1.ØØ MM.)

****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	2.941	Ø.294	6.127	Ø.184	7.Ø47	2.45Ø
Ch	2Ø.375	Ø.64Ø	19.972	Ø.279	24.682	8.732
Tw	44.623	2.Ø53	29.ØØ5	Ø.4Ø2	31.682	13.833

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850227
BOX SEDIMENTS

Table 9.109

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
SMALLER FRACTION (< 1.00 MM.)

****

LOCATION :	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
Ta	0.263	0.282	0.080	0.000	0.080	0.000
Ch	0.235	0.489	0.059	0.006	0.044	0.000
Tw	1.205	1.272	0.062	0.022	0.056	0.000

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Table 9.110

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø315
BOX SEDIMENTS

METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	Ø.291	Ø.4Ø9	Ø.169	Ø.ØØ11	23.984	2.87Ø
Ch	Ø.338	Ø.13Ø	Ø.Ø68	Ø.ØØ4	5.853	2.667
Tw	Ø.245	Ø.575	Ø.Ø87	Ø.ØØ6	7.276	2.91Ø

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø313

Table 9.111

DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø315
BOX SEDIMENTS

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta :	Ø.136	Ø.Ø76	Ø.Ø15	Ø.ØØ2	Ø.Ø18	Ø.ØØ9
Ch :	Ø.Ø57	Ø.Ø46	Ø.Ø1Ø	Ø.ØØ1	Ø.ØØ7	Ø.ØØ5
Tw :	Ø.142	Ø.237	Ø.Ø21	Ø.ØØ2	Ø.Ø77	Ø.Ø15

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø315
BOX SEDIMENTS

Table 9.112

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
LARGER FRACTION (> 1.ØØ MM.)

****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	Ø.28Ø	Ø.168	Ø.769	Ø.ØØ4	31.8Ø9	1.923
Ch	Ø.178	Ø.134	Ø.517	Ø.ØØ9	4.64Ø	1.427
Tw	Ø.122	Ø.234	Ø.Ø92	Ø.ØØ2	5.931	1.937

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.113

CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø315
BOX SEDIMENTS

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
LARGER FRACTION (> 1.ØØ MM.)

****

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta	Ø.Ø86	Ø.Ø79	Ø.Ø14	Ø.ØØ2	Ø.Ø12	Ø.ØØ9
Ch	Ø.Ø55	Ø.Ø39	Ø.Ø13	Ø.ØØ1	Ø.ØØ6	Ø.ØØ4
Tw	Ø.Ø45	Ø.Ø59	Ø.Ø31	Ø.ØØ1	Ø.ØØ9	Ø.Ø1Ø

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.114

G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø313
DATE SAMPLES COLLECTED : 85Ø313
DATE SAMPLES ANALYSED : 85Ø315
BOX SEDIMENTS

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
SMALLER FRACTION (< 1.ØØ MM.)

****

	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
LOCATION :						
Ta	1.178	Ø.728	2.8Ø7	Ø.ØØ24	72.867	2.678
Ch	27.644	Ø.96Ø	4.798	Ø.ØØ69	35.412	7.265
Tw	1.93Ø	2.879	4.463	Ø.ØØ47	28.146	9.168

NOTE:The figure Ø.ØØØ stands for a non-detectable level
NOTE:The figure -1 or -1.Ø stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 850313
DATE SAMPLES COLLECTED : 850313
DATE SAMPLES ANALYSED : 850315
BOX SEDIMENTS

Table 9.115

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
SMALLER FRACTION (< 1.00 MM.)

	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
LOCATION :						
Ta :	0.439	0.235	0.066	0.015	0.060	0.043
Ch :	0.708	0.320	0.080	0.018	0.002	0.091
Tw :	0.924	0.499	0.086	0.011	0.060	0.064

NOTE:The figure 0.000 stands for a non-detectable level
NOTE:The figure -1 or -1.0 stands for NO ANALYSIS
NOTE:Ta=Tame Close; Ch=Churnet Close and Tw= Twyford Close

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.116

G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841ØØ1
DATE SAMPLES COLLECTED : 841ØØ1
DATE SAMPLES ANALYSED : 841ØØ1

METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
T1	Ø.235	Ø.3Ø7	4.135	Ø.ØØ56	81.Ø34	27.942
T2	Ø.ØØ96	Ø.272	5.131	Ø.1Ø1	5.968	2.242
T3	Ø.129	Ø.219	3.8Ø7	Ø.ØØ35	8.218	1.353
T4	1.561	1.642	1Ø.772	Ø.269	255.844	88.872
C1	Ø.323	Ø.367	8.ØØ2	Ø.153	87.372	39.317
C2	Ø.ØØ55	Ø.ØØ3	2.313	Ø.ØØ55	27.544	17.ØØ78
C3	Ø.242	Ø.247	4.984	Ø.ØØ94	4Ø.413	11.854
C4	Ø.566	Ø.7Ø4	13.922	Ø.321	145.337	32.127
TW1	1.186	2.174	24.716	Ø.682	42.Ø16	13.347
TW2	Ø.Ø72	Ø.Ø98	2.861	Ø.Ø11	1Ø.582	2.132
TW3	Ø.119	Ø.216	1.258	Ø.ØØ8	6.287	1.329
TW4	Ø.22Ø	Ø.266	6.2Ø8	Ø.Ø18	17.59Ø	2.716

The figure Ø.ØØØ stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.117

G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841001
DATE SAMPLES COLLECTED : 841001
DATE SAMPLES ANALYSED : 841001

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	0.056	0.159	0.018	0.000	0.011	0.067
T2	0.175	0.202	0.027	0.003	0.013	0.036
T3	0.086	0.208	0.012	0.000	0.010	0.027
T4	0.404	0.633	0.089	0.001	0.039	0.183
C1	0.218	0.209	0.029	0.000	0.024	0.150
C2	0.044	0.108	0.028	0.000	0.006	0.061
C3	0.086	0.167	0.027	0.000	0.016	0.094
C4	0.306	0.352	0.050	0.001	0.047	0.263
TW1	1.087	1.238	0.247	0.025	0.395	0.222
TW2	0.027	0.141	0.018	0.000	0.009	0.017
TW3	0.014	0.132	0.006	0.000	0.005	0.010
TW4	0.048	0.173	0.021	0.001	0.031	0.045

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841001
DATE SAMPLES COLLECTED : 841001
DATE SAMPLES ANALYSED : 841001

Table 9.118

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
Smaller Fraction (> 1.00 mm.).

****

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
T1	0.154	0.642	3.338	0.037	27.991	7.191
T2	1.216	0.709	27.353	0.122	91.176	36.470
T3	0.296	0.555	8.885	0.041	32.208	17.770
T4	1.279	1.105	6.978	0.058	26.748	25.004
C1	0.216	0.270	4.406	0.022	31.828	11.598
C2	0.772	0.309	13.907	0.077	91.168	33.222
C3	0.512	0.192	2.435	0.013	7.050	3.973
C4	0.510	0.807	3.822	0.026	36.951	9.768
TW1	0.000	0.000	0.000	0.000	0.000	0.000
TW2	0.765	0.319	1.912	0.013	10.622	4.886
TW3	0.144	0.126	0.540	0.011	10.445	6.483
TW4	0.000	0.000	0.000	0.000	0.000	0.000

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.119

G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841001
DATE SAMPLES COLLECTED : 841001
DATE SAMPLES ANALYSED : 841001

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
Smaller Fraction (> 1.00 mm.).

****

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	0.277	0.116	0.015	0.000	0.018	0.026
T2	0.436	0.203	0.065	0.001	0.050	0.050
T3	0.400	0.400	0.024	0.001	0.019	0.023
T4	0.628	0.500	0.041	0.000	0.000	0.000
C1	0.329	0.200	0.026	0.000	0.000	0.000
C2	0.556	0.417	0.049	0.000	0.000	0.048
C3	0.092	0.032	0.007	0.000	0.009	0.000
C4	0.348	0.123	0.013	0.000	0.000	0.000
TW1	0.000	0.000	0.000	0.000	0.000	0.000
TW2	0.142	0.047	0.012	0.000	0.000	0.000
TW3	0.120	0.045	0.007	0.000	0.009	0.000
TW4	0.000	0.000	0.000	0.000	0.000	0.000

****

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841ØØ1
DATE SAMPLES COLLECTED : 841ØØ1
DATE SAMPLES ANALYSED : 841ØØ1

Table 9.120

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
Larger Fraction (> 1.ØØ mm.).

****

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
T1	Ø.228	Ø.535	6.268	Ø.ØØ51	23.25Ø	4.1Ø3
T2	1.378	Ø.727	14.546	Ø.136	78.474	16.46Ø
T3	Ø.315	Ø.562	6.ØØ76	Ø.ØØ9Ø	53.112	16.653
T4	1.999	1.879	13.195	Ø.148	55.979	23.591
C1	Ø.543	Ø.645	13.586	Ø.Ø5Ø	21.738	11.718
C2	Ø.794	Ø.827	6.62Ø	Ø.ØØ51	43.364	9.269
C3	Ø.4Ø6	Ø.429	4.294	Ø.ØØ23	9.493	4.859
C4	Ø.547	Ø.866	8.889	Ø.ØØ67	46.724	1Ø.94Ø
TW1	19.ØØ5	9.532	114.395	1.22Ø	524.3Ø9	5Ø5.243
TW2	Ø.2Ø4	Ø.436	3.491	Ø.ØØ28	15.711	12.51Ø
TW3	Ø.262	Ø.262	1.787	Ø.ØØ16	17.352	6.671
TW4	Ø.381	Ø.333	9.Ø38	Ø.Ø4Ø	73.729	13.318

The figure Ø.ØØØ stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.121

CODE : 841001
DATE SAMPLES COLLECTED : 841001
DATE SAMPLES ANALYSED : 841001

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
Larger Fraction (> 1.00 mm.).

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	0.097	0.098	0.011	0.000	0.010	0.019
T2	0.256	0.364	0.045	0.001	0.039	0.036
T3	0.252	0.212	0.024	0.000	0.023	0.025
T4	0.448	0.312	0.042	0.000	0.000	0.000
C1	0.139	0.126	0.010	0.000	0.014	0.000
C2	0.179	0.182	0.024	0.000	0.034	0.060
C3	0.122	0.059	0.007	0.000	0.010	0.019
C4	0.255	0.223	0.015	0.000	0.000	0.000
TW1	4.099	8.866	0.638	0.000	0.000	0.000
TW2	0.097	0.140	0.012	0.000	0.000	0.000
TW3	0.080	0.113	0.000	0.000	0.000	0.000
TW4	0.204	0.095	0.013	0.000	0.031	0.000

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841Ø31
DATE SAMPLES COLLECTED : 841Ø31
DATE SAMPLES ANALYSED : 841Ø31

Table 9.122

METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
T1	Ø.195	Ø.116	1.462	Ø.ØØ6	7.555	1.326
T2	Ø.Ø43	Ø.Ø55	1.599	Ø.Ø13	2.451	Ø.938
T3	Ø.Ø85	Ø.Ø95	1.935	Ø.Ø11	5.592	Ø.731
T4	Ø.114	Ø.613	3.25Ø	Ø.Ø59	24.87Ø	2.232
C1	Ø.154	Ø.2Ø7	5.715	Ø.Ø55	13.693	2.572
C2	Ø.Ø78	Ø.Ø89	2.3Ø7	Ø.Ø3Ø	5.537	1.329
C3	Ø.Ø72	Ø.Ø65	3.578	Ø.Ø15	5.399	1.971
C4	Ø.436	Ø.782	13.379	Ø.322	43.359	4.162
TW1	4.167	5.556	177.778	Ø.167	2Ø1.389	21.945
TW2	Ø.Ø57	Ø.Ø54	1.642	Ø.ØØ9	5.694	1.357
TW3	1.Ø51	1.546	7.985	Ø.Ø36	56.736	3.838
TW4	Ø.119	Ø.536	2.Ø3Ø	Ø.Ø11	4.588	1.227

The figure Ø.ØØØ stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.123

CODE : 841031
DATE SAMPLES COLLECTED : 841031
DATE SAMPLES ANALYSED : 841031

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE

****

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	0.019	0.117	0.003	0.003	0.003	0.004
T2	0.029	0.049	0.004	0.002	0.004	0.003
T3	0.027	0.063	0.003	0.002	0.003	0.005
T4	0.069	0.289	0.008	0.003	0.008	0.013
C1	0.074	0.150	0.014	0.005	0.010	0.007
C2	0.038	0.044	0.007	0.002	0.004	0.000
C3	0.037	0.094	0.008	0.003	0.004	0.008
C4	0.213	0.262	0.035	0.010	0.019	0.025
TW1	0.445	4.028	0.222	0.028	0.222	0.528
TW2	0.027	0.065	0.009	0.001	0.002	0.005
TW3	0.084	1.157	0.011	0.008	0.011	0.028
TW4	0.019	0.060	0.005	0.009	0.004	0.005

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841031
DATE SAMPLES COLLECTED : 841031
DATE SAMPLES ANALYSED : 841031

Table 9.124

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
Smaller Fraction (< 1.00 mm.).

****

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
T1	0.113	0.272	0.941	0.033	21.648	4.941
T2	0.037	0.071	0.386	0.012	6.097	1.341
T3	0.029	0.122	0.408	0.021	15.151	1.894
T4	0.092	0.193	1.101	0.015	19.947	2.866
C1	0.299	0.155	0.463	0.047	12.885	2.835
C2	0.065	0.082	0.136	0.011	8.180	1.489
C3	0.032	0.099	0.187	0.010	7.588	1.133
C4	0.082	0.190	0.537	0.020	36.155	2.582
TW1	3.203	2.446	8.154	0.186	334.886	58.241
TW2	0.057	0.314	0.677	0.034	20.739	4.959
TW3	0.382	0.327	1.963	0.100	56.737	16.912
TW4	0.073	0.399	0.653	0.058	37.727	6.094

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.125

CODE : 841031
DATE SAMPLES COLLECTED : 841031
DATE SAMPLES ANALYSED : 841031

METALS ANALYSIS : Zn Mn Cu .Cd Ni Cr
Smaller Fraction (< 1.00 mm.).

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	0.029	0.049	0.006	0.001	0.002	0.000
T2	0.013	0.021	0.002	0.000	0.003	0.000
T3	0.011	0.028	0.004	0.000	0.000	0.000
T4	0.023	0.050	0.004	0.000	0.000	0.000
C1	0.018	0.040	0.000	0.003	0.000	0.000
C2	0.011	0.025	0.000	0.001	0.000	0.000
C3	0.009	0.017	0.002	0.001	0.000	0.000
C4	0.021	0.031	0.005	0.000	0.000	0.000
TW1	0.297	0.565	0.070	0.000	0.232	0.000
TW2	0.020	0.051	0.000	0.000	0.000	0.000
TW3	0.061	0.151	0.016	0.000	0.043	0.000
TW4	0.048	0.105	0.008	0.000	0.000	0.000

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841031
DATE SAMPLES COLLECTED : 841031
DATE SAMPLES ANALYSED : 841031

Table 9.126

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
Larger Fraction (> 1.00 mm.).

****

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
T1	0.146	0.138	0.778	0.015	6.275	1.782
T2	0.029	0.092	0.321	0.007	1.838	0.781
T3	0.073	0.204	0.450	0.007	8.395	1.402
T4	0.071	0.173	0.488	0.008	10.997	1.578
C1	0.167	0.195	0.130	0.013	13.537	1.367
C2	0.079	0.170	0.124	0.015	7.467	1.368
C3	0.065	0.181	0.172	0.022	3.872	0.817
C4	0.165	0.362	0.310	0.041	10.341	1.895
TW1	0.759	1.423	2.135	0.337	305.977	59.298
TW2	0.026	0.231	0.117	0.018	13.919	4.176
TW3	0.109	0.384	0.165	0.033	29.649	6.863
TW4	0.034	0.147	0.142	0.019	10.279	2.009

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.127

CODE : 841031
DATE SAMPLES COLLECTED : 841031
DATE SAMPLES ANALYSED : 841031

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
Larger Fraction (>1.00 mm.).

****

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	0.019	0.027	0.005	0.001	0.003	0.000
T2	0.007	0.003	0.002	0.001	0.003	0.000
T3	0.013	0.018	0.004	0.000	0.007	0.000
T4	0.013	0.025	0.004	0.000	0.000	0.006
C1	0.012	0.020	0.006	0.001	0.001	0.000
C2	0.011	0.000	0.003	0.005	0.004	0.000
C3	0.009	0.015	0.003	0.003	0.006	0.009
C4	0.014	0.023	0.005	0.004	0.000	0.041
TW1	0.365	0.536	0.081	0.000	0.389	0.071
TW2	0.023	0.046	0.004	0.000	0.010	0.015
TW3	0.035	0.096	0.010	0.000	0.011	0.000
TW4	0.015	0.032	0.003	0.004	0.008	0.000

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841205

Table 9.128

METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
T1	Ø.356	Ø.183	5.6Ø2	Ø.ØØ45	5.296	Ø.183
T2	Ø.147	Ø.176	2.672	Ø.ØØ15	1.817	Ø.1Ø2
T3	Ø.116	Ø.294	4.211	Ø.ØØ98	6.855	Ø.186
T4	Ø.443	Ø.127	7.768	Ø.144	4.971	Ø.171
C1	Ø.215	Ø.161	Ø.976	Ø.ØØ16	4.652	Ø.ØØ63
C2	Ø.587	Ø.385	5.ØØ3	Ø.ØØ23	5.548	Ø.117
C3	Ø.272	Ø.1Ø5	Ø.387	Ø.ØØ3Ø	1.376	Ø.ØØ49
C4	Ø.885	Ø.181	2.665	Ø.ØØ23	3.945	Ø.2Ø3
TW1	Ø.841	Ø.353	4.456	Ø.ØØ25	11.Ø97	Ø.235
TW2	Ø.5ØØ	Ø.225	3.519	Ø.ØØ25	6.545	Ø.134
TW3	Ø.473	Ø.ØØ33	4.Ø64	Ø.ØØ21	6.196	Ø.14Ø
TW4	1.123	Ø.168	8.259	Ø.ØØ84	6.71Ø	Ø.258

The figure Ø.ØØØ stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.129

CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841205

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	Ø.Ø74	Ø.163	Ø.ØØ9	Ø.ØØ5	Ø.ØØ7	Ø.ØØ8
T2	Ø.Ø11	Ø.139	Ø.ØØ8	Ø.ØØ2	Ø.ØØ7	Ø.ØØ9
T3	Ø.Ø17	Ø.186	Ø.ØØ8	Ø.ØØ5	Ø.ØØ4	Ø.Ø13
T4	Ø.Ø16	Ø.Ø93	Ø.ØØ6	Ø.ØØ4	Ø.Ø13	Ø.ØØ8
C1	Ø.Ø28	Ø.1Ø1	Ø.ØØ7	Ø.ØØ2	Ø.ØØ6	Ø.ØØ3
C2	Ø.Ø33	Ø.28Ø	Ø.Ø14	Ø.Ø13	Ø.Ø16	Ø.Ø29
C3	Ø.Ø12	Ø.Ø77	Ø.ØØ2	Ø.ØØ2	Ø.ØØ5	Ø.ØØ4
C4	Ø.Ø46	Ø.33Ø	Ø.Ø17	Ø.ØØ5	Ø.ØØ8	Ø.Ø17
TW1	Ø.316	Ø.193	Ø.Ø22	Ø.Ø11	Ø.Ø13	Ø.Ø49
TW2	Ø.Ø51	Ø.Ø15	Ø.ØØ5	Ø.ØØ7	Ø.ØØ7	Ø.Ø21
TW3	Ø.Ø29	Ø.133	Ø.ØØ3	Ø.ØØ4	Ø.ØØ6	Ø.Ø19
TW4	Ø.Ø3Ø	Ø.161	Ø.ØØ7	Ø.ØØ8	Ø.Ø15	Ø.Ø28

The figure Ø.ØØØ stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.130

CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841205

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
Smaller Fraction (< 1.00 mm.).

****

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
T1	0.162	0.346	11.697	0.108	1.733	1.332
T2	1.048	0.740	19.527	1.192	61.664	2.569
T3	0.755	0.472	13.692	0.661	35.410	2.125
T4	0.249	2.868	16.920	0.502	11.471	0.932
C1	0.439	0.746	17.258	0.483	27.613	6.903
C2	0.978	1.076	22.356	0.699	38.243	12.924
C3	2.223	1.067	22.229	0.415	111.144	36.010
C4	0.950	0.630	16.042	0.452	68.330	8.437
TW1	3.252	1.247	14.905	0.433	271.003	44.173
TW2	0.000	0.000	0.000	0.000	0.000	0.000
TW3	1.636	1.477	17.944	0.232	42.220	11.875
TW4	3.905	1.604	34.867	0.523	130.753	34.868

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841205

Table 9.131

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
Smaller Fraction (< 1.00 mm.).

****

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	0.102	0.390	0.039	0.004	0.019	0.182
T2	0.431	0.493	0.103	0.062	0.082	0.329
T3	0.227	0.547	0.038	0.009	0.047	0.264
T4	0.516	0.789	0.077	0.011	0.043	0.258
C1	0.794	0.297	0.089	0.020	0.041	0.276
C2	0.699	0.349	0.125	0.028	0.070	0.307
C3	0.504	0.533	0.089	0.030	0.089	0.474
C4	0.356	0.309	0.178	0.024	0.047	0.190
TW1	0.975	0.488	0.108	0.054	0.054	0.000
TW2	0.000	0.000	0.000	0.000	0.000	0.000
TW3	0.306	1.319	0.084	0.011	0.032	0.295
TW4	0.837	0.872	0.209	0.035	0.070	0.558

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)

Table 9.132

Sediments Survey Programme
CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841205

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
Larger Fraction (> 1.00 mm.).

****

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	0.098	1.389	0.020	0.009	0.020	0.225
T2	0.081	0.185	0.013	0.001	0.006	0.053
T3	0.098	0.492	0.020	0.004	0.013	0.096
T4	0.330	0.915	0.038	0.005	0.019	0.250
C1	0.181	0.151	0.025	0.002	0.009	0.067
C2	0.067	0.097	0.019	0.003	0.009	0.058
C3	0.011	0.060	0.012	0.001	0.002	0.019
C4	0.333	0.274	0.069	0.039	0.030	0.216
TW1	0.331	0.277	0.020	0.004	0.008	0.088
TW2	0.022	0.027	0.011	0.013	0.003	0.013
TW3	0.029	0.513	0.009	0.002	0.004	0.050
TW4	0.332	0.702	0.099	0.037	0.037	0.419

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 841205
DATE SAMPLES COLLECTED : 841205
DATE SAMPLES ANALYSED : 841205

Table 9.133

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
Larger Fraction (> 1.00 mm.).

****

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
T1	0.893	0.541	15.548	0.060	10.797	2.663
T2	0.174	0.115	3.475	0.009	2.514	1.268
T3	0.241	0.438	7.003	0.098	6.566	3.283
T4	1.286	0.161	16.968	0.447	3.349	1.183
C1	0.134	0.174	6.356	0.127	2.007	0.752
C2	0.188	0.159	3.760	0.099	4.700	2.077
C3	0.043	0.030	1.329	0.009	1.608	0.482
C4	1.146	0.734	12.736	0.421	39.188	34.290
TW1	1.023	2.666	5.715	0.086	7.519	5.013
TW2	0.146	0.027	0.702	0.008	10.799	5.670
TW3	0.472	0.638	2.565	0.021	3.120	1.259
TW4	1.774	1.417	22.175	0.259	36.959	13.860

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.134

CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø1Ø9

METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
T1	Ø.879	Ø.8Ø8	1Ø.696	Ø.115	83.192	7.725
T2	Ø.ØØ6	Ø.Ø49	3.689	Ø.Ø38	17.338	4.919
T3	Ø.143	Ø.111	3.9Ø5	Ø.Ø4Ø	13.731	2.31Ø
T4	Ø.811	Ø.344	9.826	Ø.1Ø3	213.7Ø7	3.267
C1	Ø.316	Ø.Ø73	2.8Ø8	Ø.Ø18	1Ø.18Ø	2.Ø71
C2	Ø.119	Ø.Ø73	4.57Ø	Ø.Ø38	9.596	12.186
C3	Ø.184	Ø.Ø39	2.626	Ø.Ø16	51.986	14.878
C4	Ø.539	Ø.44Ø	13.197	Ø.22Ø	95.679	7.698
TW1	Ø.1Ø2	Ø.Ø25	4.Ø77	Ø.Ø16	26.5Ø2	2.375
TW2	Ø.ØØ7	Ø.Ø29	3.744	Ø.ØØ4	2.496	Ø.849
TW3	Ø.537	Ø.728	3.7Ø1	Ø.Ø4Ø	53.Ø41	5.551
TW4	Ø.568	Ø.648	1.776	Ø.Ø66	3Ø.645	5.774

The figure Ø.ØØØ stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø1Ø9

Table 9.135

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	Ø.535	Ø.82Ø	Ø.Ø15	Ø.ØØ7	Ø.Ø22	Ø.149
T2	Ø.277	Ø.369	Ø.Ø1Ø	Ø.ØØ2	Ø.ØØ7	Ø.Ø61
T3	Ø.247	Ø.195	Ø.ØØ7	Ø.ØØ2	Ø.ØØ9	Ø.Ø65
T4	Ø.737	Ø.447	Ø.Ø22	Ø.Ø1Ø	Ø.Ø38	Ø.246
C1	Ø.211	Ø.Ø91	Ø.ØØ6	Ø.ØØ4	Ø.Ø1Ø	Ø.Ø7Ø
C2	Ø.Ø18	Ø.122	Ø.ØØ7	Ø.ØØ3	Ø.ØØ7	Ø.Ø76
C3	Ø.131	Ø.131	Ø.ØØ8	Ø.ØØ2	Ø.ØØ6	Ø.Ø55
C4	Ø.748	Ø.33Ø	Ø.Ø51	Ø.ØØ6	Ø.Ø23	Ø.165
TW1	Ø.3Ø6	Ø.ØØØ	Ø.ØØ6	Ø.ØØ3	Ø.ØØ9	Ø.Ø51
TW2	Ø.Ø46	Ø.Ø56	Ø.ØØ3	Ø.ØØ3	Ø.ØØ3	Ø.Ø31
TW3	Ø.358	Ø.8Ø2	Ø.ØØ9	Ø.ØØ3	Ø.ØØ9	Ø.Ø62
TW4	Ø.4ØØ	1.244	Ø.Ø15	Ø.ØØ4	Ø.Ø16	Ø.199

The figure Ø.ØØØ stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 850109
DATE SAMPLES COLLECTED : 850109
DATE SAMPLES ANALYSED : 850109

Table 9.136

METALS ANALYSIS : Na K Fe Pb Ca Mg
Smaller Fraction (< 1.00 mm.).

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
T1	0.558	0.080	1.994	0.064	8.974	1.296
T2	0.089	0.046	1.140	0.036	5.128	0.741
T3	0.234	0.253	5.062	0.078	19.616	1.772
T4	0.168	0.129	3.231	0.349	8.078	0.695
C1	0.000	0.000	0.000	0.000	0.000	0.000
C2	0.000	0.000	0.000	0.000	0.000	0.000
C3	0.000	0.000	0.000	0.000	0.000	0.000
C4	0.867	0.526	6.194	0.619	93.525	7.216
TW1	0.000	0.000	0.000	0.000	0.000	0.000
TW2	0.000	0.000	0.000	0.000	0.000	0.000
TW3	0.132	0.097	2.436	0.017	3.654	0.792
TW4	0.218	0.204	18.512	0.056	11.107	1.518

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)

Table 9.137

Sediments Survey Programme
CODE : 850109
DATE SAMPLES COLLECTED : 850109
DATE SAMPLES ANALYSED : 850109

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
Smaller Fraction (< 1.00 mm.).

****

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	0.267	0.140	0.016	0.007	0.014	0.099
T2	0.153	0.080	0.009	0.004	0.008	0.057
T3	0.569	0.228	0.012	0.004	0.011	0.127
T4	0.336	0.129	0.004	0.006	0.007	0.000
C1	0.000	0.000	0.000	0.000	0.000	0.000
C2	0.000	0.000	0.000	0.000	0.000	0.000
C3	0.000	0.000	0.000	0.000	0.000	0.000
C4	1.394	0.681	0.161	0.013	0.040	0.155
TW1	0.000	0.000	0.000	0.000	0.000	0.000
TW2	0.000	0.000	0.000	0.000	0.000	0.000
TW3	0.365	0.097	0.007	0.002	0.005	0.000
TW4	0.278	0.148	0.012	0.003	0.006	0.093

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.138

CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø1Ø9

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
Larger Fraction (> 1.ØØ mm.).

****

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
T1	Ø.413	Ø.426	5.Ø12	Ø.1Ø3	35.71Ø	2.832
T2	Ø.161	Ø.177	3.223	Ø.Ø6Ø	17.565	2.256
T3	Ø.335	Ø.274	5.Ø79	Ø.ØØ3	37.586	2.794
T4	Ø.357	Ø.233	1Ø.351	Ø.499	38.3ØØ	2.898
C1	Ø.252	Ø.Ø31	Ø.899	Ø.Ø11	35.Ø65	5.395
C2	Ø.1Ø1	Ø.Ø66	3.485	Ø.ØØ5	5.751	Ø.958
C3	Ø.193	Ø.Ø6Ø	2.299	Ø.Ø15	25.859	11.493
C4	Ø.42Ø	Ø.164	9.126	Ø.ØØ5	57.128	3.559
TW1	Ø.Ø76	Ø.Ø26	Ø.Ø57	Ø.ØØ4	1.317	Ø.437
TW2	Ø.Ø59	Ø.Ø26	1.36Ø	Ø.ØØ5	2.992	Ø.85Ø
TW3	Ø.27Ø	Ø.6Ø2	1.545	Ø.Ø15	2Ø.699	4.634
TW4	Ø.456	Ø.4Ø5	6.Ø74	Ø.Ø1Ø	23.Ø79	3.239

****

The figure Ø.ØØØ stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.139

CODE : 85Ø1Ø9
DATE SAMPLES COLLECTED : 85Ø1Ø9
DATE SAMPLES ANALYSED : 85Ø1Ø9

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
Larger Fraction (> 1.ØØ mm.).

****

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	Ø.564	Ø.251	Ø.Ø17	Ø.ØØ5	Ø.Ø17	Ø.125
T2	Ø.222	Ø.322	Ø.117	Ø.ØØ2	Ø.ØØ9	Ø.Ø81
T3	Ø.61Ø	Ø.4Ø6	Ø.Ø19	Ø.ØØ4	Ø.Ø12	Ø.1Ø2
T4	1.734	Ø.518	Ø.Ø2Ø	Ø.ØØ6	Ø.Ø17	Ø.129
C1	Ø.27Ø	Ø.153	Ø.ØØ7	Ø.ØØ3	Ø.ØØ7	Ø.Ø45
C2	Ø.145	Ø.Ø87	Ø.ØØ9	Ø.ØØ2	Ø.ØØ6	Ø.ØØØ
C3	Ø.1Ø1	Ø.2Ø7	Ø.Ø21	Ø.ØØ4	Ø.ØØ9	Ø.Ø86
C4	Ø.325	Ø.347	Ø.Ø14	Ø.ØØ6	Ø.Ø16	Ø.183
TW1	Ø.429	Ø.315	Ø.ØØ2	Ø.ØØ1	Ø.ØØ3	Ø.ØØØ
TW2	Ø.Ø41	Ø.Ø27	Ø.ØØ8	Ø.ØØ1	Ø.ØØ2	Ø.ØØØ
TW3	Ø.348	Ø.386	Ø.ØØ5	Ø.ØØ2	Ø.ØØ5	Ø.Ø39
TW4	Ø.456	Ø.3Ø4	Ø.ØØ8	Ø.ØØ2	Ø.ØØ9	Ø.1Ø1

The figure Ø.ØØØ stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 85Ø227
DATE SAMPLES COLLECTED : 85Ø227
DATE SAMPLES ANALYSED : 85Ø227

Table 9.140

METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
T1	8.276	Ø.3Ø1	4.815	Ø.82Ø	37.618	3.912
T2	1.196	Ø.ØØ7	4.572	Ø.812	18.Ø87	3.219
T3	Ø.431	Ø.174	1.687	Ø.288	16.281	2.482
T4	Ø.178	Ø.214	1.997	Ø.168	14.978	3.124
C1	3.435	Ø.Ø64	1.145	Ø.145	7Ø.626	8.971
C2	2.1Ø6	Ø.Ø56	1.797	Ø.286	13.759	1.8Ø8
C3	Ø.136	Ø.Ø58	1.2Ø1	Ø.ØØ3	2.4Ø2	Ø.635
C4	Ø.236	Ø.264	2.2Ø1	Ø.126	2.83Ø	2.453
TW1	Ø.836	Ø.Ø64	1.114	Ø.Ø13	8.497	1.142
TW2	1.824	Ø.229	Ø.915	Ø.ØØ3	9.731	4.Ø87
TW3	Ø.4Ø4	Ø.266	1.291	Ø.Ø18	8.173	1.9Ø7
TW4	27.ØØØ	1.456	11.Ø89	Ø.457	5.336	6.653

The figure Ø.ØØØ stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850227

Table 9.141

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	0.042	0.527	0.009	0.001	0.014	0.150
T2	0.043	0.241	0.011	0.002	0.005	0.092
T3	0.015	0.208	0.005	0.001	0.003	0.055
T4	0.017	0.118	0.001	0.001	0.003	0.044
C1	0.010	0.159	0.004	0.001	0.003	0.048
C2	0.015	0.080	0.006	0.000	0.001	0.028
C3	0.006	0.043	0.002	0.000	0.001	0.012
C4	0.019	0.189	0.021	0.003	0.004	0.094
TW1	0.024	0.086	0.001	0.001	0.010	0.033
TW2	0.038	0.096	0.001	0.001	0.035	0.037
TW3	0.034	0.187	0.002	0.000	0.007	0.048
TW4	0.541	0.471	0.014	0.017	0.069	0.139

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.142

CODE : 85Ø227
DATE SAMPLES COLLECTED : 85Ø227
DATE SAMPLES ANALYSED : 85Ø227

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
Smaller Fraction (< 1.ØØ mm.).

****

LOCATION :	Na mgg-1 :	K mgg-1 :	Fe mgg-1 :	Pb mgg-1 :	Ca mgg-1 :	Mg mgg-1 :
T1	16.394	Ø.315	1Ø.ØØ9	1.655	48.868	5.359
T2	7.Ø95	Ø.682	32.746	1.91Ø	21.148	6.139
T3	2.392	1.112	3.838	1.334	39.492	4.728
T4	5.5Ø1	2.115	52.898	4.ØØØ	15Ø.232	23.699
C1	3Ø.5Ø6	3.66Ø	34.167	1.342	78.Ø96	13.545
C2	33.316	Ø.666	35.981	3.797	14.925	7.995
C3	7.363	14.727	441.826	5.891	125.184	6.333
C4	2.168	Ø.5Ø6	5.Ø6Ø	Ø.556	44.822	4.626
TW1	8.943	1.228	16.216	Ø.Ø98	8.845	18.575
TW2	24.541	2.454	2Ø.942	Ø.Ø98	19.96Ø	7.526
TW3	4.9Ø1	1.633	15.Ø32	Ø.Ø98	27.287	9.967
TW4	15.398	2.3Ø9	2Ø.634	Ø.154	24.946	9.Ø85

The figure Ø.ØØØ stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.143

CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850227

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
Smaller Fraction (< 1.00 mm.).

****

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	0.088	0.397	0.003	0.001	0.000	0.042
T2	0.259	0.382	0.034	0.204	0.041	0.422
T3	0.139	0.451	0.025	0.014	0.017	0.211
T4	0.381	1.100	0.000	0.004	0.034	0.634
C1	0.244	0.366	0.011	0.007	0.031	0.342
C2	0.320	0.253	0.080	0.011	0.007	0.506
C3	0.913	0.294	0.000	0.235	0.117	1.620
C4	0.046	0.462	0.072	0.008	0.001	0.203
TW1	0.452	0.393	0.015	0.059	0.147	0.442
TW2	0.605	0.491	0.010	0.000	0.098	0.294
TW3	0.506	0.621	0.029	0.026	0.147	0.653
TW4	0.579	0.616	0.010	0.025	0.077	0.277

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850227

Table 9.144

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
Larger Fraction (> 1.00 mm.).

****

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
T1	1.479	0.105	3.147	0.115	20.459	1.700
T2	0.861	0.150	1.926	0.328	7.526	2.120
T3	0.118	0.084	1.261	0.059	11.771	1.345
T4	0.441	0.509	2.716	0.412	28.859	6.960
C1	2.096	0.049	1.657	0.078	23.396	1.780
C2	2.007	0.040	1.285	0.341	5.822	1.686
C3	0.146	0.025	0.908	0.038	10.722	0.492
C4	0.614	0.058	3.935	0.544	21.995	2.084
TW1	0.962	0.103	1.022	0.002	9.798	2.008
TW2	2.168	0.336	3.007	0.010	3.688	7.516
TW3	0.538	0.629	0.802	0.003	1.855	3.321
TW4	6.032	0.916	4.578	0.081	33.394	4.874

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 850227
DATE SAMPLES COLLECTED : 850227
DATE SAMPLES ANALYSED : 850227

Table 9.145

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
Larger Fraction (> 1.00 mm.).

****

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	0.017	0.272	0.003	0.001	0.000	0.042
T2	0.017	0.163	0.007	0.001	0.001	0.048
T3	0.009	0.095	0.001	0.000	0.001	0.016
T4	0.020	0.174	0.006	0.001	0.000	0.068
C1	0.012	0.100	0.004	0.001	0.002	0.034
C2	0.012	0.069	0.008	0.001	0.000	0.024
C3	0.008	0.030	0.003	0.000	0.000	0.010
C4	0.030	0.013	0.018	0.001	0.002	0.071
TW1	0.023	0.099	0.000	0.001	0.010	0.011
TW2	0.061	0.220	0.003	0.001	0.016	0.031
TW3	0.023	0.105	0.001	0.000	0.006	0.000
TW4	0.164	0.576	0.004	0.006	0.024	0.000

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.146

G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 850313
DATE SAMPLES COLLECTED : 850313
DATE SAMPLES ANALYSED : 850313

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
TOTAL SAMPLE

****

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
T1	24.800	45.925	4.409	0.086	25.718	4.005
T2	14.279	16.189	1.931	0.058	6.536	2.715
T3	20.320	28.146	2.059	0.026	35.011	5.011
T4	6.778	11.605	0.585	0.024	35.109	1.176
C1	23.230	32.049	3.043	0.075	28.571	5.528
C2	11.548	25.359	1.038	0.027	7.264	2.173
C3	5.966	7.631	0.590	0.004	3.607	1.301
C4	113.473	122.091	8.044	0.128	37.346	25.136
TW1	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
TW2	2.377	0.137	1.189	0.002	2.674	1.248
TW3	1.720	0.555	3.596	0.016	30.490	3.205
TW4	18.642	0.694	2.010	0.022	41.123	4.752

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 850313
DATE SAMPLES COLLECTED : 850313
DATE SAMPLES ANALYSED : 850313

Table 9.147

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
TOTAL SAMPLE

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	0.055	0.309	0.015	0.001	0.021	0.017
T2	0.033	0.163	0.010	0.001	0.008	0.005
T3	0.025	0.796	0.008	0.001	0.009	0.003
T4	0.020	0.171	0.004	0.001	0.016	0.011
C1	0.043	0.205	0.023	0.001	0.015	0.006
C2	0.016	0.143	0.006	0.000	0.004	0.003
C3	0.006	0.068	0.003	0.000	0.001	0.000
C4	0.108	0.405	0.013	0.000	0.030	0.014
TW1	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
TW2	0.090	0.039	0.010	0.002	0.008	0.007
TW3	0.188	0.172	0.020	0.004	0.021	0.020
TW4	0.303	0.405	0.073	0.006	0.040	0.026

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.148

G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 850313
DATE SAMPLES COLLECTED : 850313
DATE SAMPLES ANALYSED : 850313

****

METALS ANALYSIS : Na K Fe Pb Ca Mg
Smaller Fraction (< 1.00 mm.).

****

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
T1	37.517	51.434	9.803	0.172	51.434	8.047
T2	135.689	88.832	7.321	0.209	22.647	3.484
T3	1689.189	3265.765	7.657	0.113	63.063	4.054
T4	1932.367	2053.140	8.937	0.121	84.541	14.010
C1	116.824	154.881	13.276	0.214	46.907	23.011
C2	1039.794	1123.235	25.673	0.372	73.813	13.479
C3	3204.420	3259.669	16.574	0.828	262.431	12.431
C4	634.417	1149.881	11.895	0.333	99.127	6.186
TW1	0.000	0.000	0.000	0.000	0.000	0.000
TW2	408.163	11.774	26.688	0.078	125.589	42.386
TW3	0.000	0.000	0.000	0.000	0.000	0.000
TW4	1.779	1.259	5.187	0.074	48.170	7.707

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.149

G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 850313
DATE SAMPLES COLLECTED : 850313
DATE SAMPLES ANALYSED : 850313

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
Smaller Fraction (< 1.00 mm.).

****

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	0.151	0.436	0.048	0.001	0.045	0.024
T2	0.215	0.273	0.041	0.000	0.041	0.010
T3	1.126	0.450	0.000	0.000	0.202	0.000
T4	1.208	0.483	0.000	0.000	0.217	0.242
C1	0.212	0.310	0.075	0.000	0.044	0.044
C2	0.706	0.321	0.180	0.000	0.128	0.064
C3	2.486	0.276	0.414	0.000	0.552	0.000
C4	0.634	0.317	0.119	0.000	0.159	0.079
TW1	0.000	0.000	0.000	0.000	0.000	0.000
TW2	1.491	0.314	0.243	0.055	0.196	0.157
TW3	0.000	0.000	0.000	0.000	0.000	0.000
TW4	0.711	0.385	0.136	0.018	0.074	0.074

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE
G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme

Table 9.150

CODE : 850313
DATE SAMPLES COLLECTED : 850313
DATE SAMPLES ANALYSED : 850313

METALS ANALYSIS : Na K Fe Pb Ca Mg
Larger Fraction (> 1.00 mm.).

LOCATION	Na mgg-1	K mgg-1	Fe mgg-1	Pb mgg-1	Ca mgg-1	Mg mgg-1
T1	10.582	16.009	2.306	0.035	37.309	2.496
T2	17.595	8.613	1.353	0.050	5.299	0.726
T3	16.837	20.388	0.157	0.004	2.104	0.500
T4	27.169	32.703	0.805	0.004	3.656	5.115
C1	24.016	24.165	3.430	0.042	31.325	3.952
C2	8.281	16.916	0.974	0.014	4.649	1.372
C3	8.696	7.407	0.483	0.004	6.871	0.848
C4	54.294	82.922	0.542	0.091	335.637	2.665
TW1	0.000	0.000	0.000	0.000	0.000	0.000
TW2	1.903	0.113	0.485	0.004	2.678	2.996
TW3	1.261	0.171	0.570	0.009	62.676	12.413
TW4	2.352	0.367	2.352	0.164	24.158	1.533

The figure 0.000 stands for a non-detectable level

Urban Stormwater Analysis : CLIFTON GROVE

Table 9.151

G. A. Fulcher (Dept. of Civil Engineering)
Sediments Survey Programme
CODE : 850313
DATE SAMPLES COLLECTED : 850313
DATE SAMPLES ANALYSED : 850313

****

METALS ANALYSIS : Zn Mn Cu Cd Ni Cr
Larger Fraction (> 1.00 mm.).

****

LOCATION	Zn mgg-1	Mn mgg-1	Cu mgg-1	Cd mgg-1	Ni mgg-1	Cr mgg-1
T1	0.049	0.214	0.008	0.001	0.011	0.007
T2	0.041	0.096	0.010	0.000	0.005	0.002
T3	0.010	0.036	0.002	0.000	0.001	0.000
T4	0.012	0.028	0.004	0.000	0.006	0.002
C1	0.042	0.254	0.013	0.000	0.012	0.009
C2	0.011	0.083	0.008	0.000	0.003	0.002
C3	0.007	0.015	0.006	0.000	0.000	0.001
C4	0.089	0.182	0.021	0.000	0.021	0.010
TW1	0.000	0.000	0.000	0.000	0.000	0.000
TW2	0.059	0.043	0.012	0.001	0.007	0.005
TW3	0.130	0.114	0.013	0.005	0.020	0.016
TW4	0.172	0.032	0.074	0.003	0.029	0.023

The figure 0.000 stands for a non-detectable level

9.4 Laboratory Experiments on Collected Sediment Samples.

An additional series of experiments were conducted in the laboratory in order to investigate the behaviour of the gully pot basal sediments standing in liquor over time, with respect to their sediment-associated metal concentrations. The experiments were carried out to show the different metal adsorption and release mechanisms for different size sediment fractions under different pH conditions. The experiments were conducted in a 500 ml bottle which had been thoroughly washed and rinsed in an acid bath, at least twice before use. Each sediment fraction was put into an individual bottle. A quantity of each sediment fraction was added to the bottle so that the proportion of sediment to standing liquor was commensurate by volume with the conditions found in the gully pots in the field. About 10 grams of sediment was added to the 500 ml. of liquor in each bottle. All sediments used in the experiments had been previously collected from gully pots on the Clifton Grove Estate (but not necessarily from the twelve gully pots under study), and the sediments were all dried thoroughly and fractionated before use. No other analysis had been performed on these sediments. The aim of the experiments was to look at five different size fractions which were:

i) > 10.00 mm.

ii) $4.00 \geqslant X > 10.00$ mm.

iii) $1.00 \geqslant X > 4.00$ mm.

iv) $0.15 \geqslant X > 1.00$ mm.

v) < 0.15 mm.

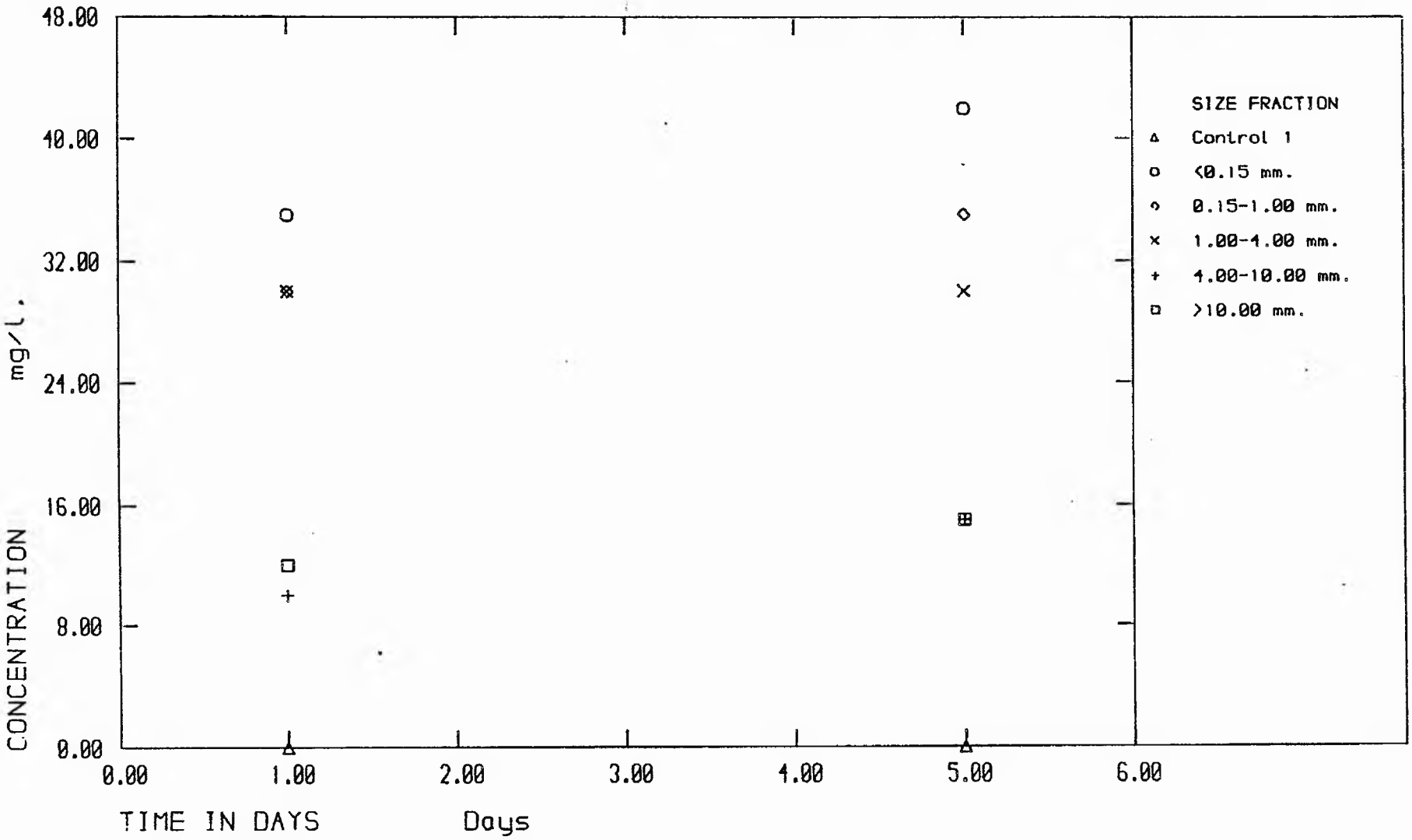
The aim was to investigate whether any adsorption/release mechanisms for metals were seen to operate under four different pH regimes. The analysis was conducted for three of the metals namely copper, lead and zinc, and also for TOC. The procedure involved leaving the size fraction undisturbed in the bottle containing a pH buffer solution which had previously been dosed with a known concentration of the metal. The sample was left for a five-day duration, and each day a small sample of the liquor was taken and analysed for its total soluble metal concentration. If the liquor metal concentration was enhanced, then the sediments could be seen to be releasing the metal: a reduction in the liquor metal concentration would imply that the sediments were adsorbing the metals out of solution and the metals were being precipitated onto the basal sediments. The five-day duration was chosen as an arbitrary time period of analysis, because it was felt that in the field situation the gully pot liquors (whose conditions were being simulated) were likely to be disturbed by inflowing storm runoff waters after this time period. The influence of evaporation would also be evident if the liquors were left for a greater time period. Each sediment size fraction was left in a pH buffer solution of pH 5, 6, 7 and 8 in the laboratory at a room temperature of approximately 20 'C. pH values less than pH 5 and greater than pH 8 were unlikely to be found in gully pot liquors in the field. An initial metal concentration of either 2.0 mgl-1 or 3.0 mgl-1 was dosed into the liquor and the metal concentrations were measured each day over the five-day period. A TOC measurement was made at the beginning and at the end of the experimental period. The results can be seen in Tables 9.153 to 9.168 and in Figures 9.5 to 9.20.

A duplicate control experiment was set up for each metal and this involved the liquor of an initially known metal concentration being left in the bottle with no sediment added. It was assumed that the metal concentration would not vary over the five-day period.

The Variation in TOC Concentration for pH Buffer 5.0.

SIZE FRACTION	DAY	CONCENTRATION IN LIQUOR 'mgl-1
Control 1		
	1	0.0
	5	0.0
<0.15 mm.		
	1	35.0
	5	42.0
0.15-1.00 mm.		
	1	30.0
	5	35.0
1.00-4.00 mm.		
	1	30.0
	5	30.0
4.00-10.00 mm.		
	1	10.0
	5	15.0
>10.00 mm.		
	1	12.0
	5	15.0

Table: 9.153 (see Figure 9.5)



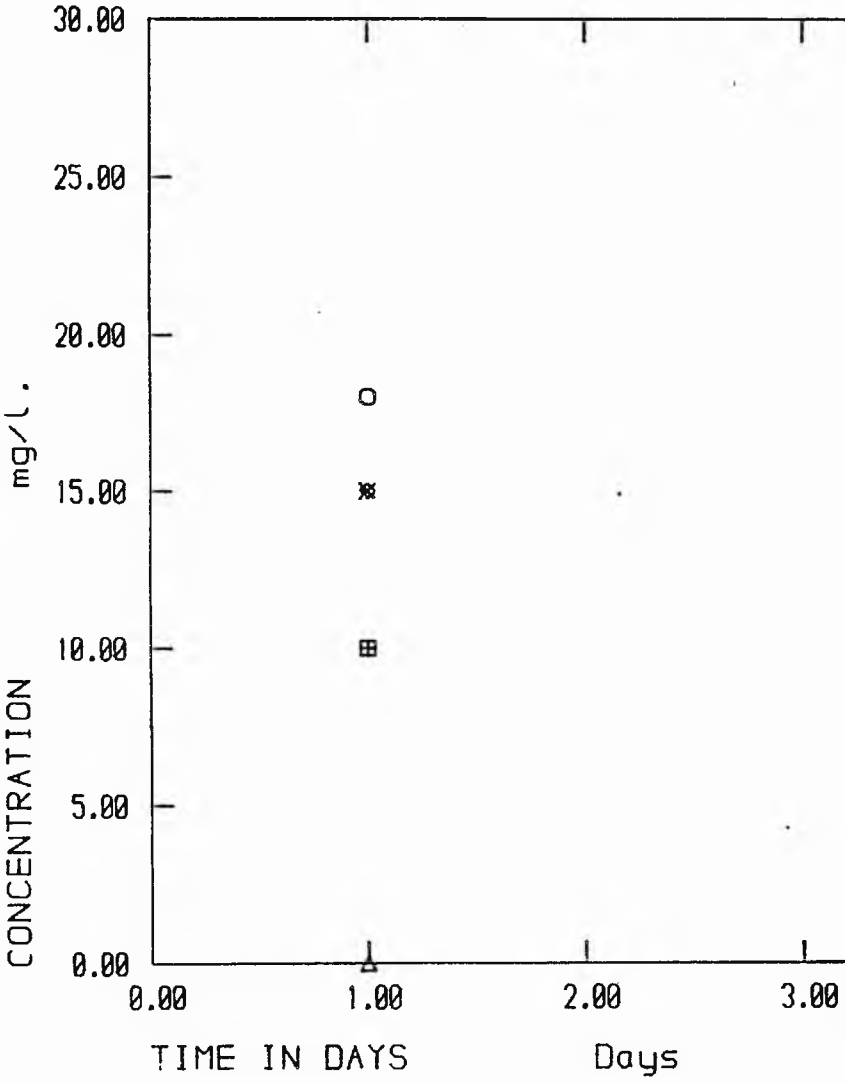
The Variation in TOC Concentration for pH Buffer 5.0.

Figure 9.5

The Variation in TOC Concentration for pH Buffer 6.0.

SIZE FRACTION	DAY	CONCENTRATION IN LIQUOR mgl-1
Control 1		
	1	0.0
	5	0.0
<0.15 mm.		
	1	18.0
	5	28.0
0.15-1.00 mm.		
	1	15.0
	5	22.0
1.00-4.00 mm.		
	1	15.0
	5	17.0
4.00-10.00 mm.		
	1	10.0
	5	10.0
>10.00 mm.		
	1	10.0
	5	10.0

Table: 9.154 (see Figure 9.6).



The Variation in TOC Concentration for pH Buffer 6.0.

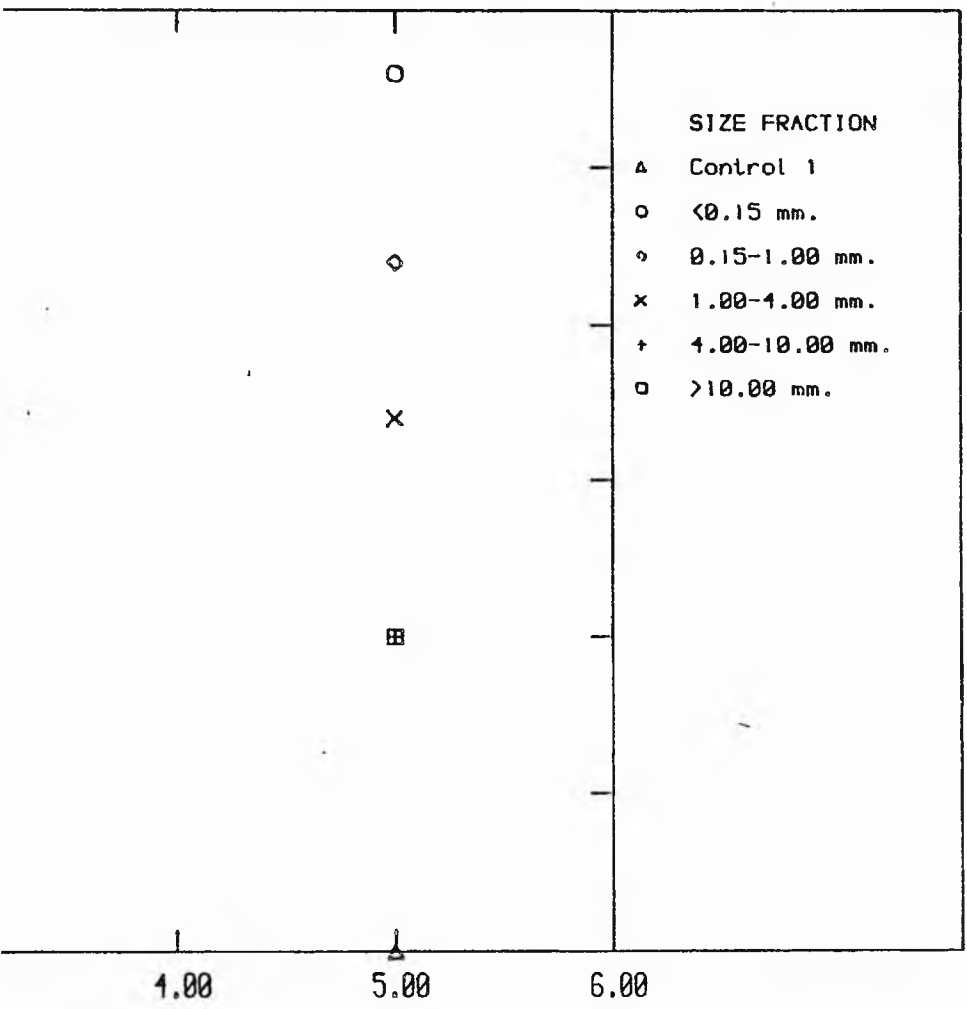
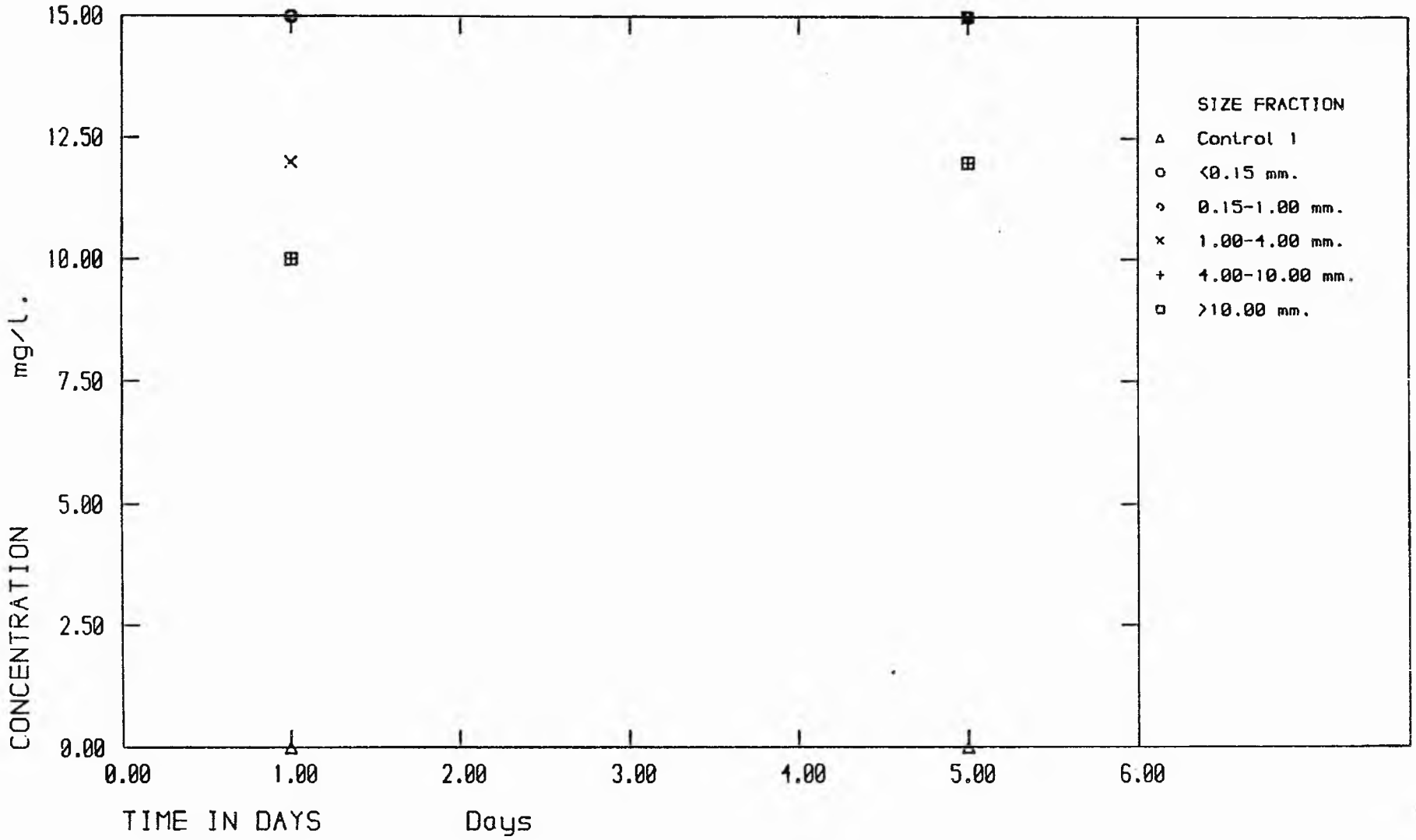

SIZE FRACTION
Control 1
<0.15 mm.
0.15-1.00 mm.
1.00-4.00 mm.
4.00-10.00 mm.
>10.00 mm.
4.00
5.00
6.00

Figure 9.6

The Variation in TOC Concentration for pH Buffer 7.0.

SIZE FRACTION	DAY	CONCENTRATION IN LIQUOR mgl-1
Control 1		
	1	0.0
	5	0.0
<0.15 mm.		
	1	15.0
	5	15.0
0.15-1.00 mm.		
	1	15.0
	5	15.0
1.00-4.00 mm.		
	1	12.0
	5	15.0
4.00-10.00 mm.		
	1	10.0
	5	12.0
>10.00 mm.		
	1	10.0
	5	12.0

Table: 9.155 (see Figure 9.7).



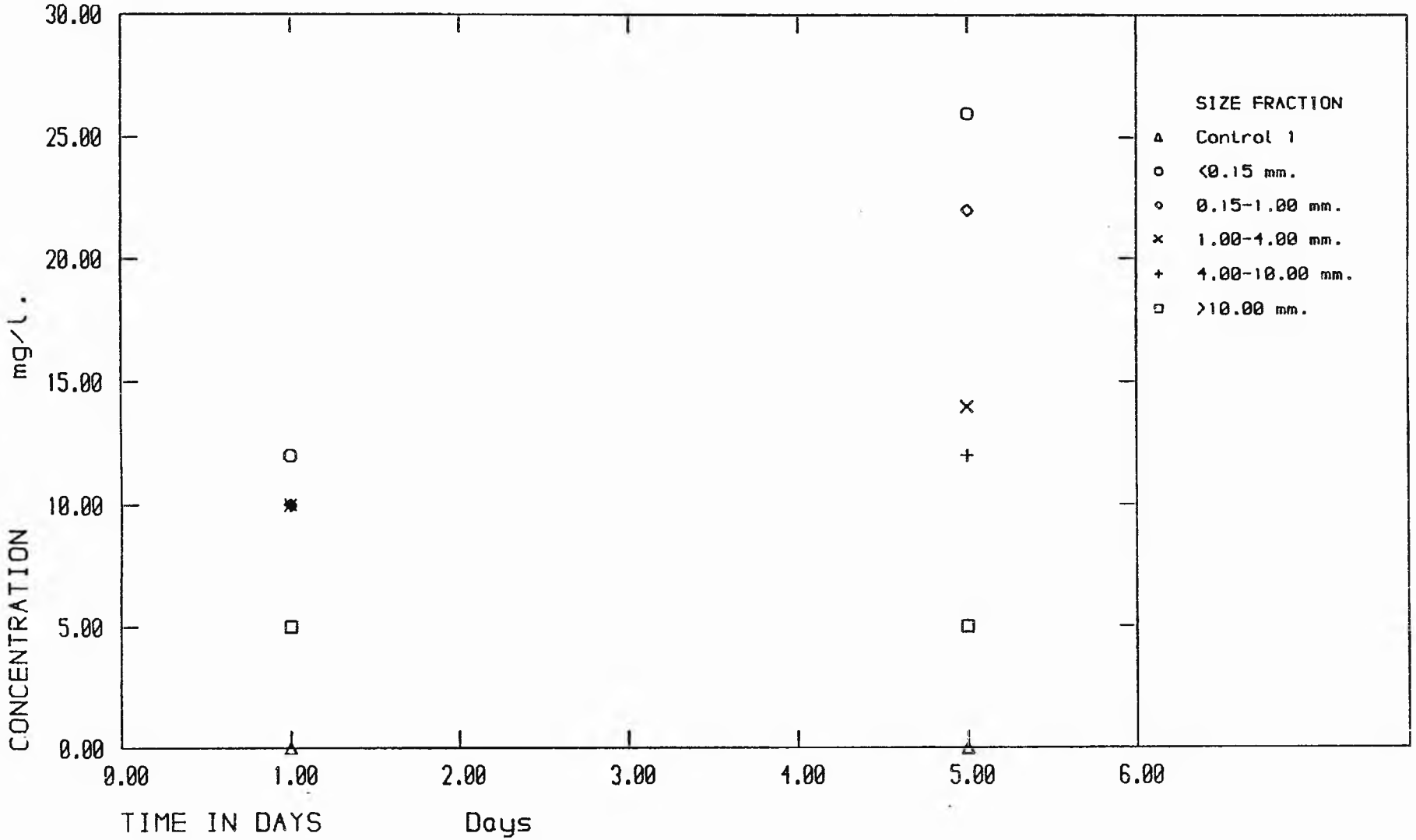
The Variation in TOC Concentration For pH Buffer 7.0.

Figure 9.7

The Variation in TOC Concentration for pH Buffer 8.0.

SIZE FRACTION	DAY	CONCENTRATION IN LIQUOR mgl-1.
Control 1		
	1	0.0
	5	0.0
<0.15 mm.		
	1	12.0
	5	26.0
0.15-1.00 mm.		
	1	10.0
	5	22.0
1.00-4.00 mm.		
	1	10.0
	5	14.0
4.00-10.00 mm.		
	1	10.0
	5	12.0
>10.00 mm.		
	1	5.0
	5	5.0

Table: 9.156 (see Figure 9.8).



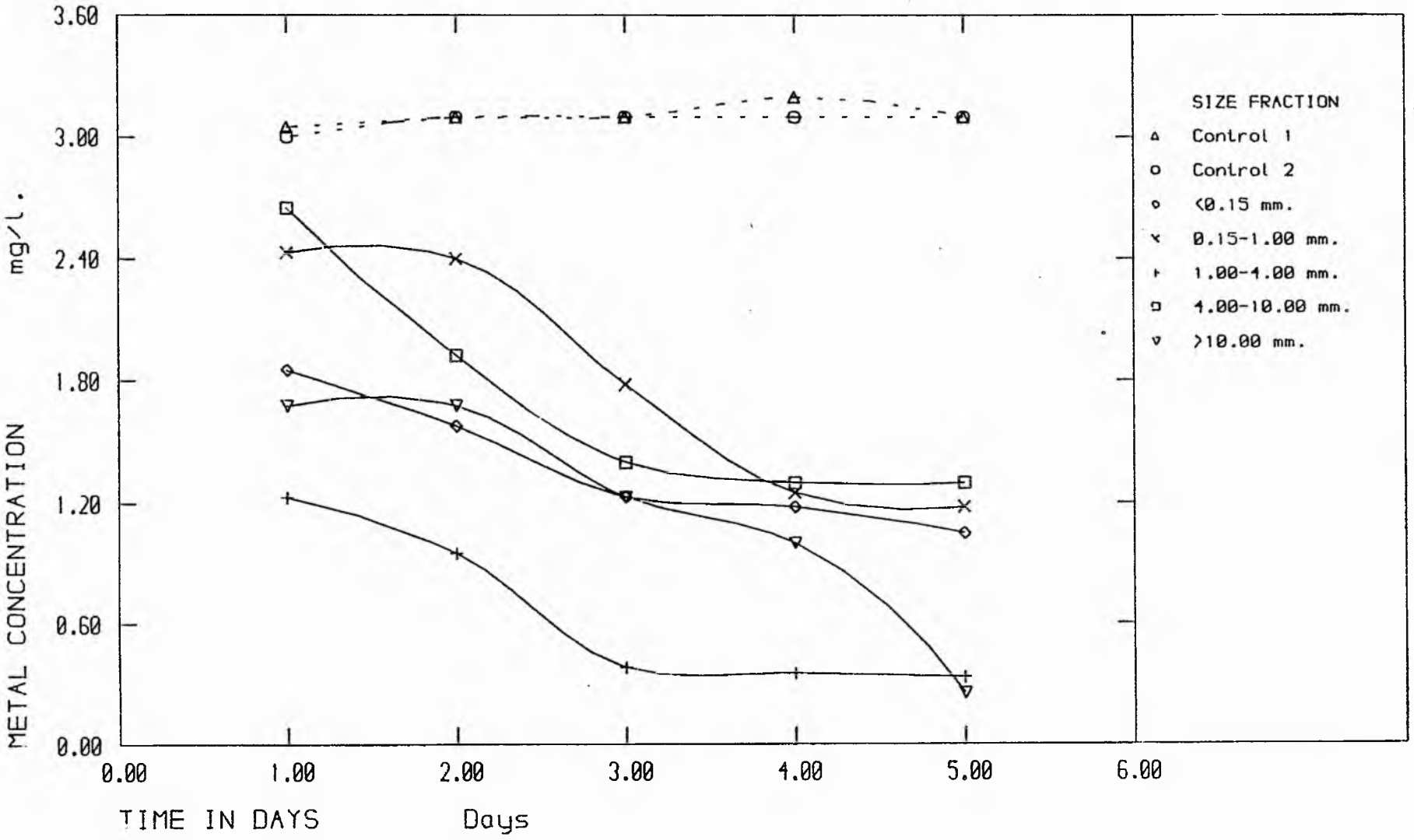
The Variation in TOC Concentration For pH Buffer 8.0.

Figure 9.8

The Variation in Soluble Copper Concentration for pH Buffer 5.0.

SIZE FRACTION	DAY	CONCENTRATION IN LIQUOR mgl-1
Control 1		
	1	3.05
	2	3.10
	3	3.10
	4	3.20
	5	3.10
Control 2		
	1	3.00
	2	3.10
	3	3.10
	4	3.10
	5	3.10
<0.15 mm.		
	1	1.85
	2	1.58
	3	1.23
	4	1.18
	5	1.05
0.15-1.00 mm.		
	1	2.43
	2	2.40
	3	1.78
	4	1.25
	5	1.18
1.00-4.00 mm.		
	1	1.23
	2	0.95
	3	0.38
	4	0.35
	5	0.33
4.00-10.00 mm.		
	1	2.65
	2	1.92
	3	1.40
	4	1.30
	5	1.30
>10.00 mm.		
	1	1.68
	2	1.68
	3	1.23
	4	1.00
	5	0.25

Table: 9.157 (see Figure 9.9).



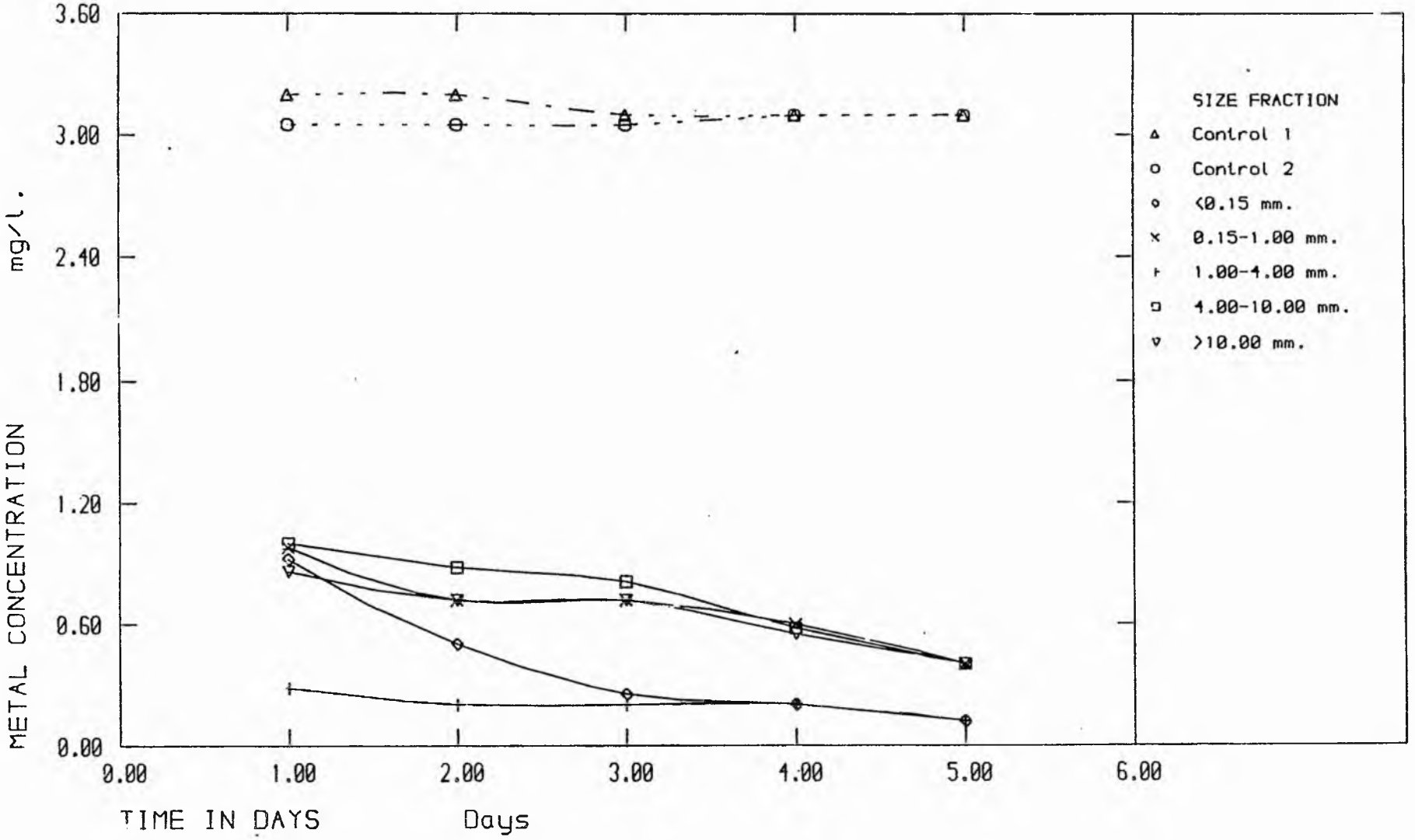
The Variation in Soluble Copper Concentration for pH Buffer 5.0.

Figure 9.9

The Variation in Soluble Copper Concentration for pH Buffer 6.0.

SIZE FRACTION	DAY	CONCENTRATION IN LIQUOR mgl-1.
Control 1		
	1	3.20
	2	3.20
	3	3.10
	4	3.10
	5	3.10
Control 2		
	1	3.05
	2	3.05
	3	3.05
	4	3.10
	5	3.10
<0.15 mm.		
	1	0.92
	2	0.50
	3	0.25
	4	0.20
	5	0.12
0.15-1.00 mm.		
	1	0.98
	2	0.72
	3	0.72
	4	0.60
	5	0.40
1.00-4.00 mm.		
	1	0.28
	2	0.20
	3	0.20
	4	0.20
	5	0.12
4.00-10.00 mm.		
	1	1.00
	2	0.88
	3	0.81
	4	0.58
	5	0.40
>10.00 mm.		
	1	0.86
	2	0.72
	3	0.72
	4	0.55
	5	0.40

Table: 9.158 (see Figure 9.10).



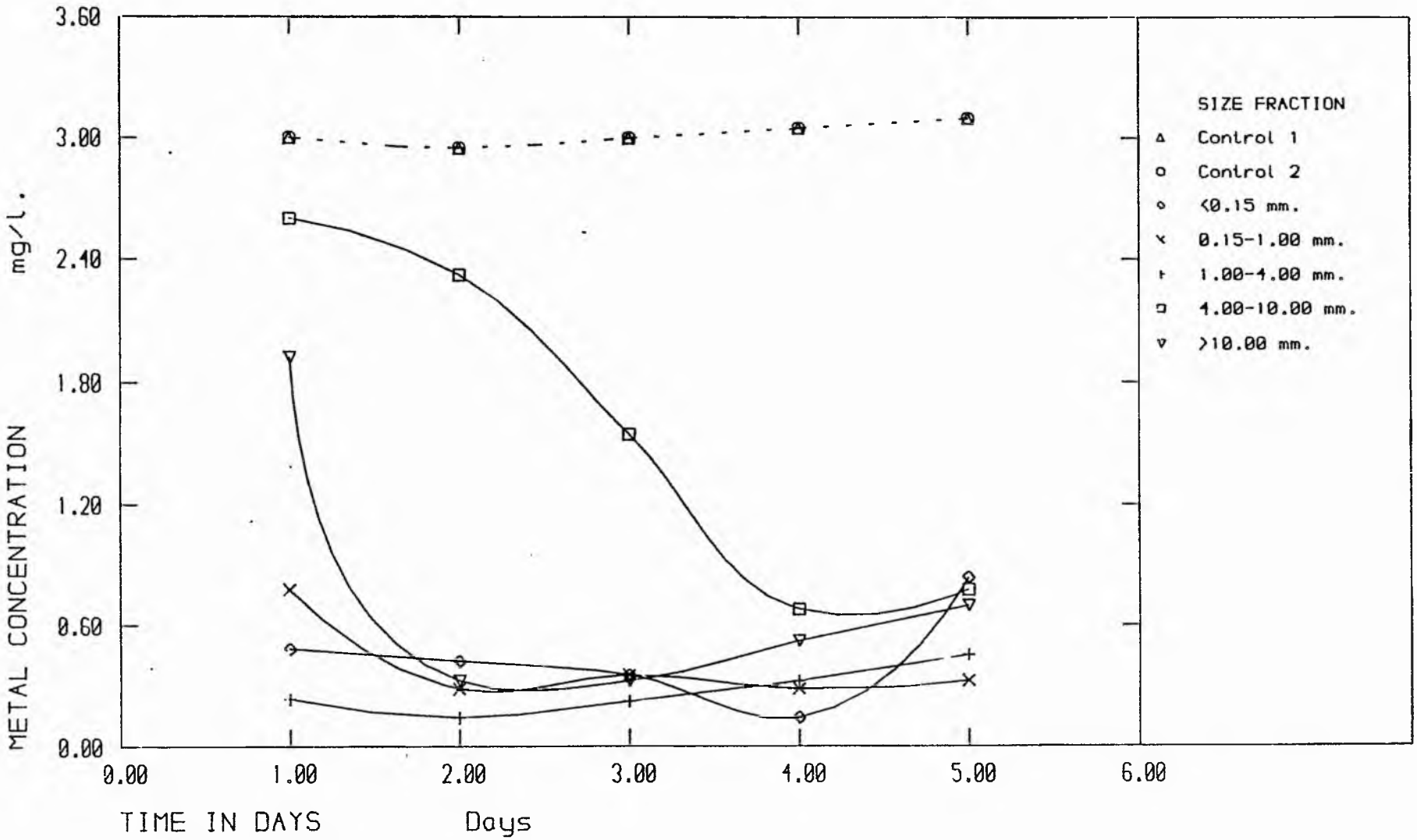
The Variation in Soluble Copper Concentration for pH Buffer 6.0.

Figure 9.10

The Variation in Soluble Copper Concentration for pH Buffer 7.0.

SIZE FRACTION	DAY	CONCENTRATION IN LIQUOR mgl-1.
Control 1		
	1	3.00
	2	2.95
	3	3.00
	4	3.05
	5	3.10
Control 2		
	1	3.00
	2	2.95
	3	3.00
	4	3.05
	5	3.10
<0.15 mm.		
	1	0.48
	2	0.42
	3	0.35
	4	0.14
	5	0.84
0.15-1.00 mm.		
	1	0.78
	2	0.28
	3	0.35
	4	0.28
	5	0.32
1.00-4.00 mm.		
	1	0.23
	2	0.14
	3	0.22
	4	0.32
	5	0.45
4.00-10.00 mm.		
	1	2.60
	2	2.32
	3	1.55
	4	0.68
	5	0.78
>10.00 mm.		
	1	1.92
	2	0.32
	3	0.32
	4	0.52
	5	0.70

Table: 9.159 (see Figure 9.11).



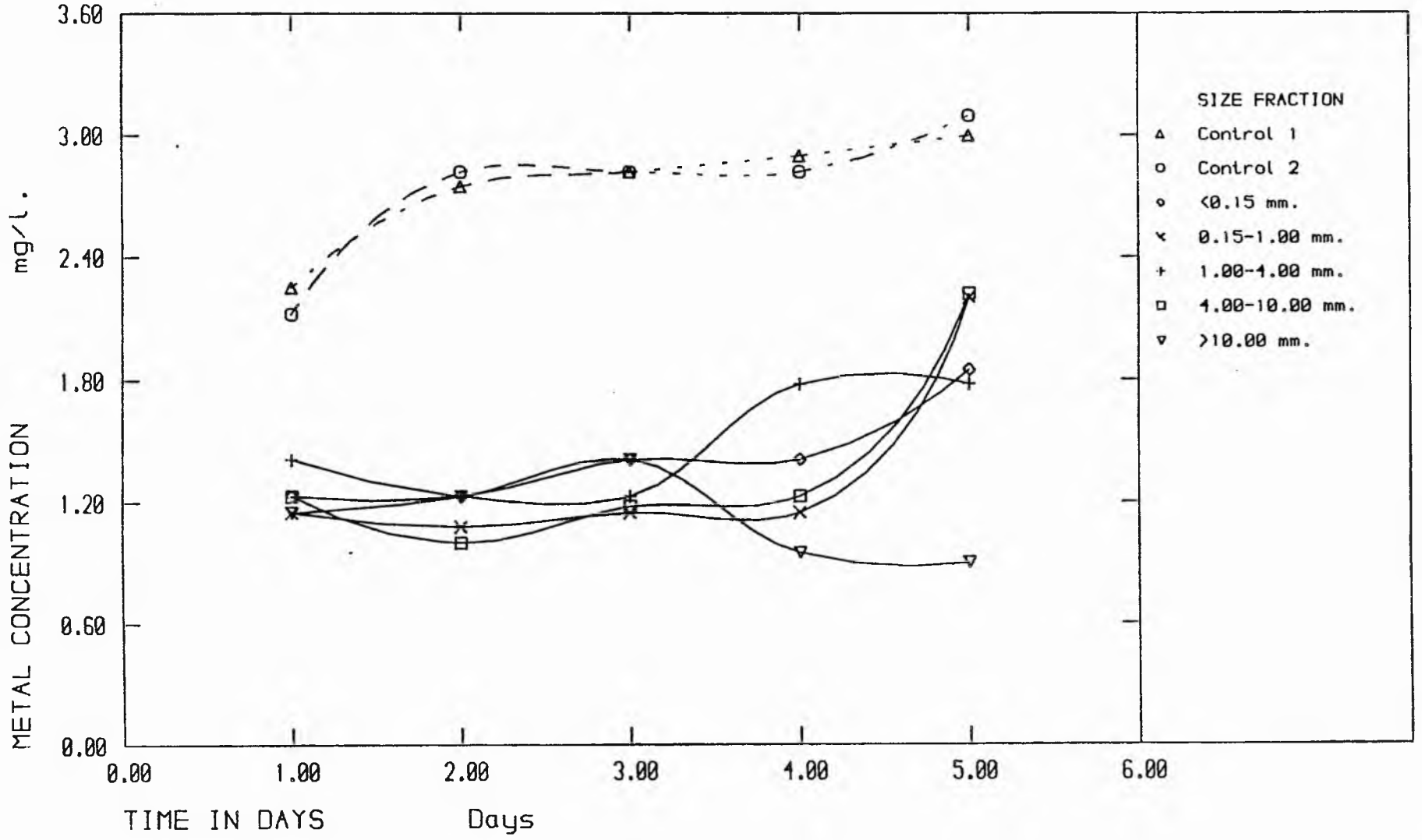
The Variation in Soluble Copper Concentration For pH Buffer 7.0.

Figure 9.11

The Variation in Soluble Copper Concentration for pH Buffer 8.0.

SIZE FRACTION	DAY	CONCENTRATION IN LIQUOR mgl-1.
Control 1		
	1	2.25
	2	2.75
	3	2.82
	4	2.90
	5	3.00
Control 2		
	1	2.12
	2	2.82
	3	2.82
	4	2.82
	5	3.10
<0.15 mm.		
	1	1.23
	2	1.23
	3	1.41
	4	1.41
	5	1.85
0.15-1.00 mm.		
	1	1.15
	2	1.08
	3	1.15
	4	1.15
	5	2.20
1.00-4.00 mm.		
	1	1.41
	2	1.23
	3	1.23
	4	1.78
	5	1.78
4.00-10.00 mm.		
	1	1.23
	2	1.00
	3	1.18
	4	1.23
	5	2.22
>10.00 mm.		
	1	1.15
	2	1.23
	3	1.41
	4	0.95
	5	0.90

Table: 9.160 (see Figure 9.12).



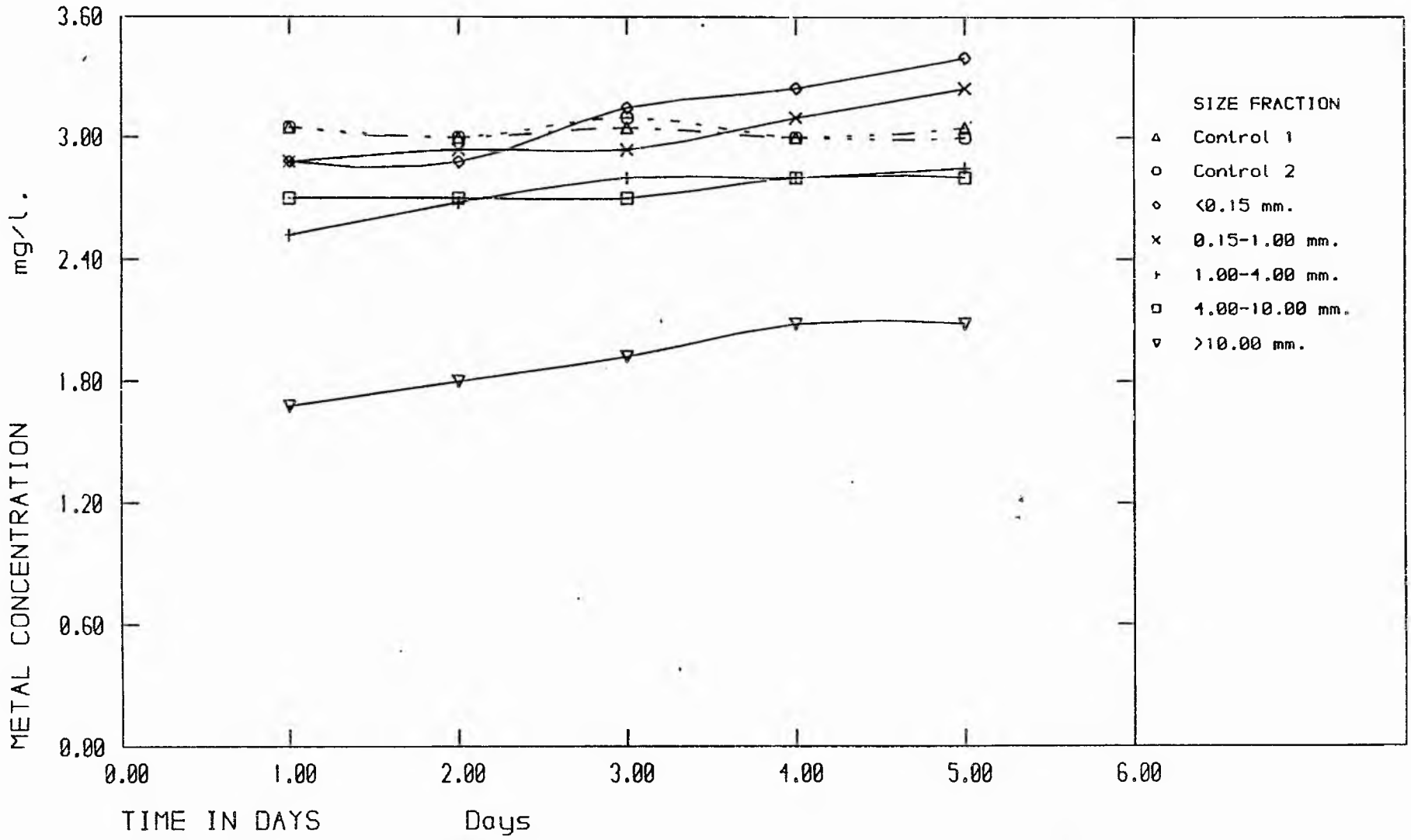
The Variation in Soluble Copper Concentration For pH Buffer 8.0.

Figure 9.12

The Variation in Soluble Lead Concentration for pH Buffer 5.0.

SIZE FRACTION	DAY	CONCENTRATION IN LIQUOR mgl-1.
Control 1		
	1	3.05
	2	3.00
	3	3.05
	4	3.00
	5	3.05
Control 2		
	1	3.05
	2	3.00
	3	3.10
	4	3.00
	5	3.00
<0.15 mm.		
	1	2.88
	2	2.88
	3	3.15
	4	3.25
	5	3.40
0.15-1.00 mm.		
	1	2.88
	2	2.94
	3	2.94
	4	3.10
	5	3.25
1.00-4.00 mm.		
	1	2.52
	2	2.68
	3	2.80
	4	2.80
	5	2.85
4.00-10.00 mm.		
	1	2.70
	2	2.70
	3	2.70
	4	2.80
	5	2.90
>10.00 mm.		
	1	1.68
	2	1.80
	3	1.92
	4	2.08
	5	2.08

Table: 9.161 (see Figure 9.13).



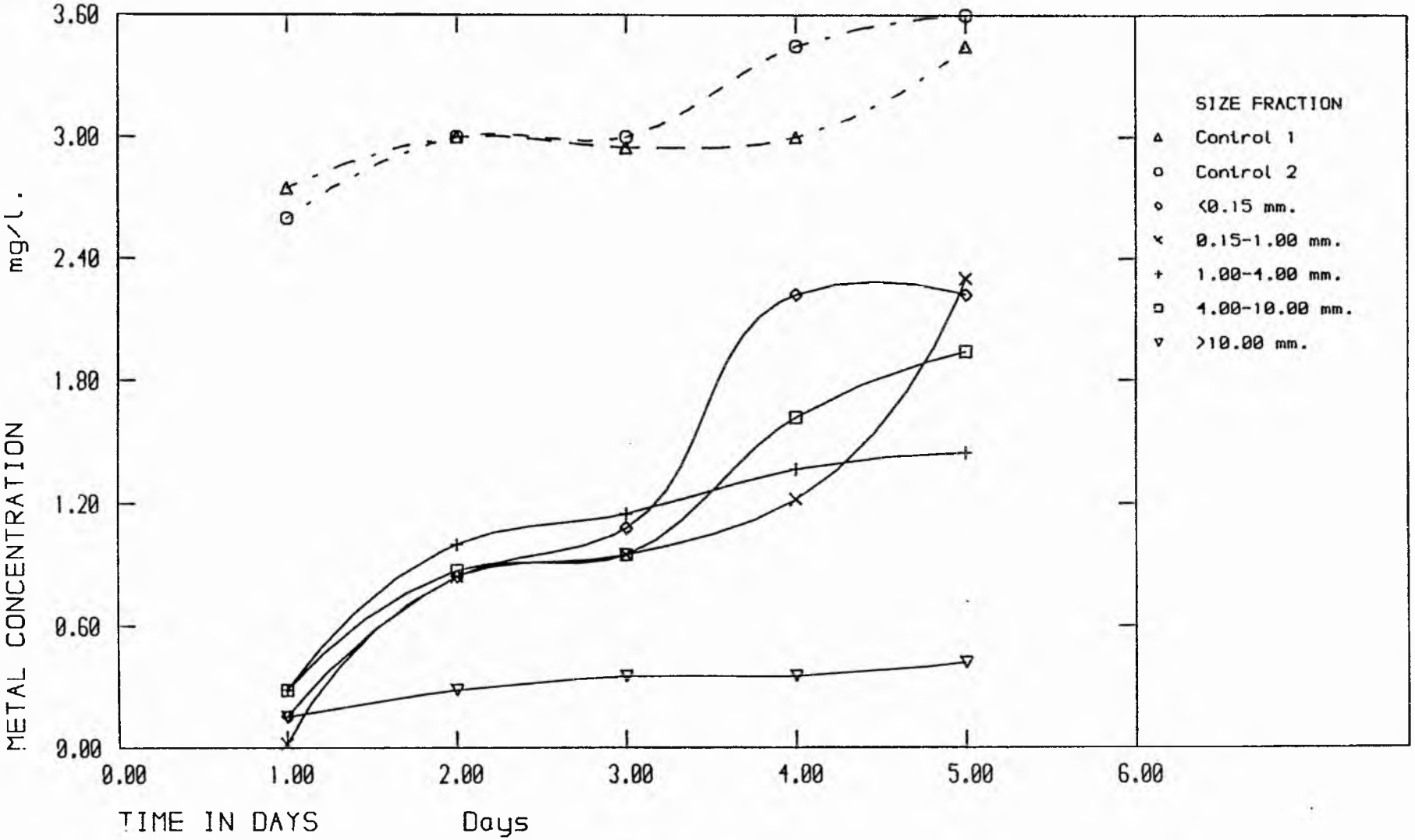
The Variation in Soluble Lead Concentration For pH Buffer 5.0.

Figure 9.13

The Variation in Soluble Lead Concentration for pH Buffer 6.0.

SIZE FRACTION	DAY	CONCENTRATION IN LIQUOR mgl-1.
Control 1		
	1	2.75
	2	3.00
	3	2.95
	4	3.00
	5	3.45
Control 2		
	1	2.60
	2	3.00
	3	3.00
	4	3.45
	5	3.60
<0.15 mm.		
	1	0.15
	2	0.84
	3	1.08
	4	2.22
	5	2.22
0.15-1.00 mm.		
	1	0.02
	2	0.84
	3	0.95
	4	1.22
	5	2.30
1.00-4.00 mm.		
	1	0.28
	2	1.00
	3	1.15
	4	1.37
	5	1.45
4.00-10.00 mm.		
	1	0.28
	2	0.87
	3	0.95
	4	1.62
	5	1.94
>10.00 mm.		
	1	0.15
	2	0.28
	3	0.35
	4	0.35
	5	0.42

Table: 9.162 (see Figure 9.14).



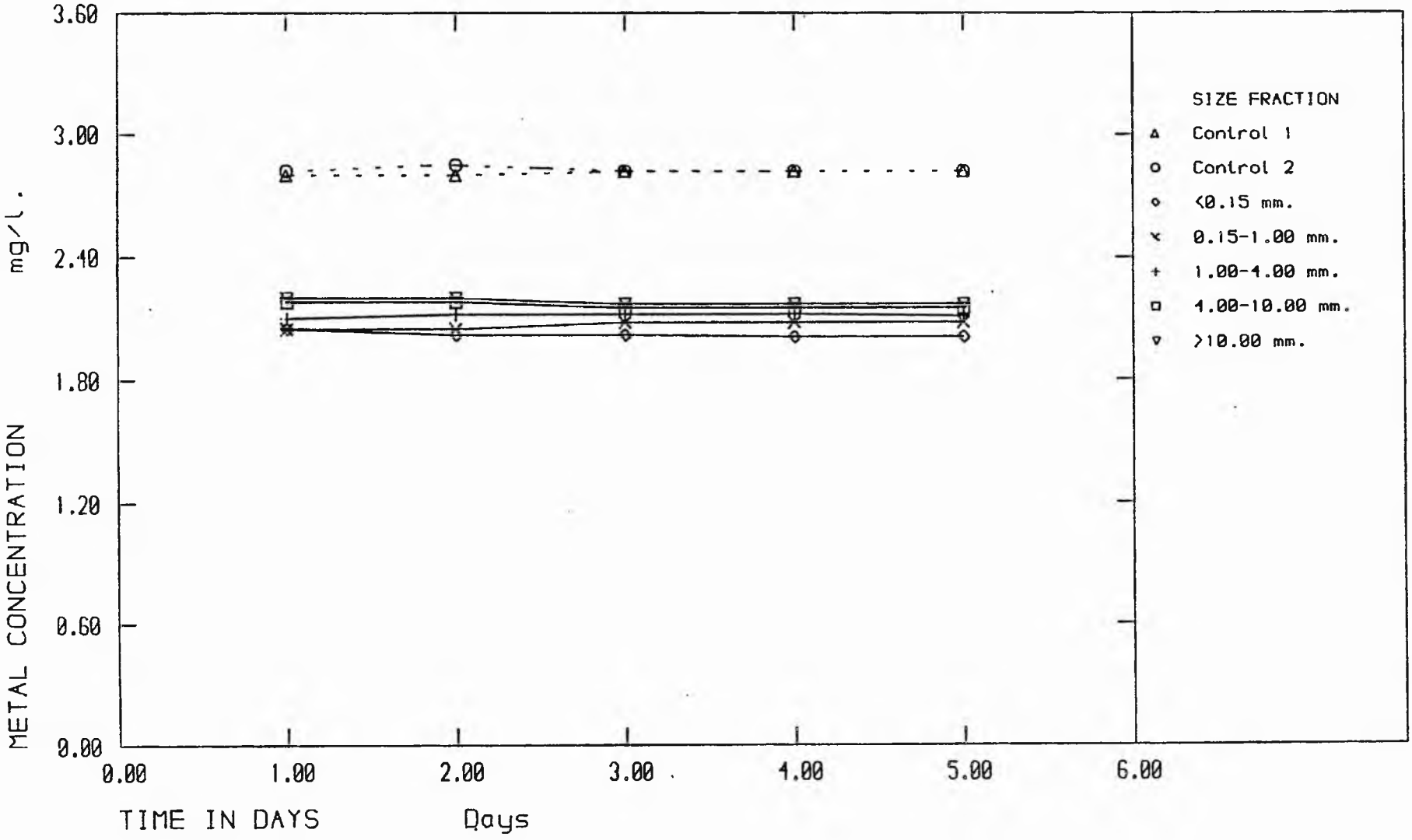
The Variation in Soluble Lead Concentration For pH Buffer 6.0.

Figure 9.14

The Variation in Soluble Lead Concentration for pH Buffer 7.0.

SIZE FRACTION	DAY	CONCENTRATION IN LIQUOR mgl-1.
Control 1		
	1	2.80
	2	2.80
	3	2.82
	4	2.82
	5	2.82
Control 2		
	1	2.82
	2	2.85
	3	2.82
	4	2.82
	5	2.82
<0.15 mm.		
	1	2.05
	2	2.02
	3	2.02
	4	2.01
	5	2.01
0.15-1.00 mm.		
	1	2.05
	2	2.05
	3	2.08
	4	2.08
	5	2.08
1.00-4.00 mm.		
	1	2.10
	2	2.12
	3	2.12
	4	2.12
	5	2.11
4.00-10.00 mm.		
	1	2.18
	2	2.18
	3	2.15
	4	2.15
	5	2.15
>10.00 mm.		
	1	2.20
	2	2.20
	3	2.17
	4	2.17
	5	2.17

Table: 9.163 (see Figure 9.15).



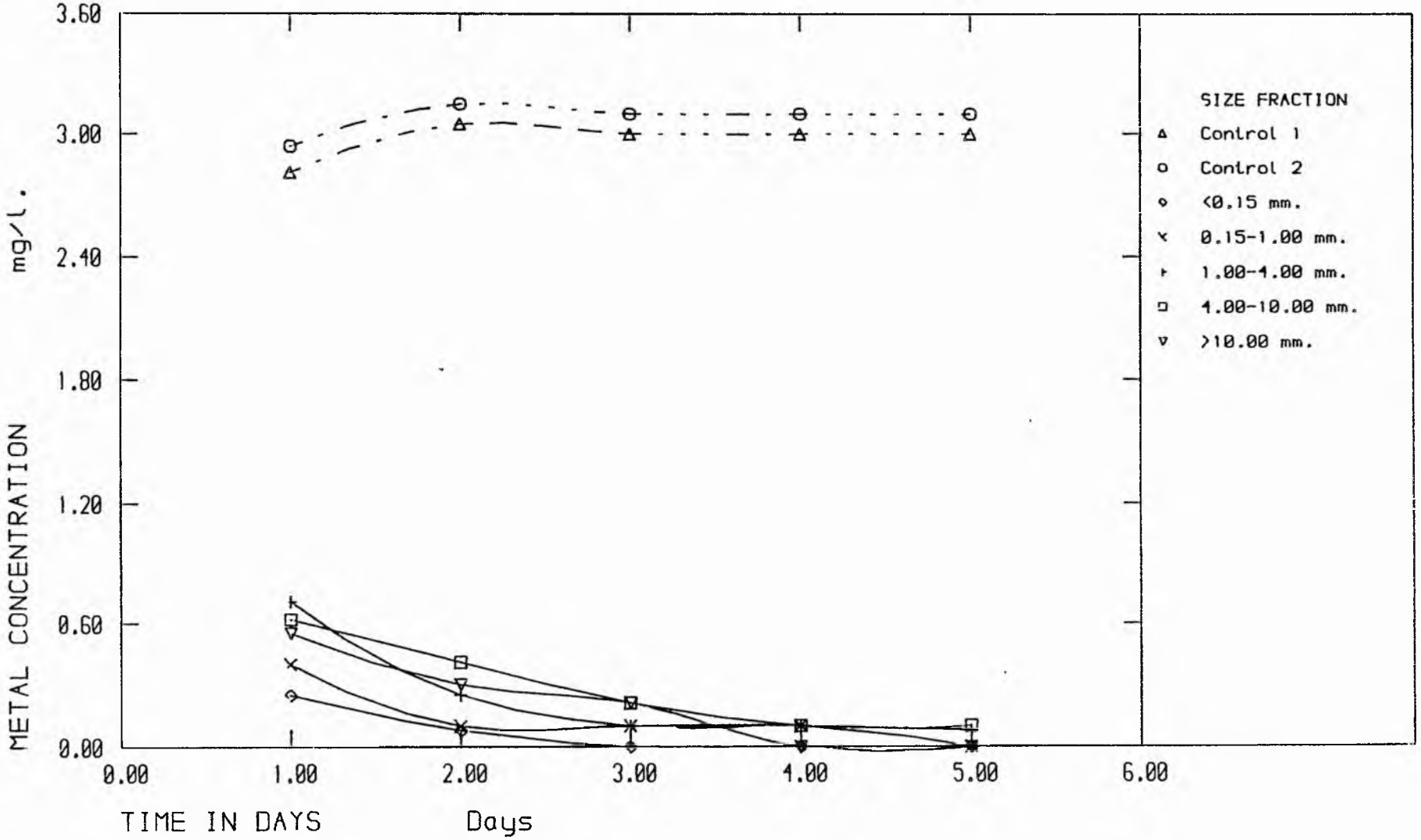
The Variation in Soluble Lead Concentration For pH Buffer 7.0.

Figure 9.15

The Variation in Soluble Lead Concentration for pH Buffer 8.0.

SIZE FRACTION	DAY	CONCENTRATION IN LIQUOR mgl-1.
Control 1		
	1	2.81
	2	3.05
	3	3.00
	4	3.00
	5	3.00
Control 2		
	1	2.94
	2	3.15
	3	3.10
	4	3.10
	5	3.10
<0.15 mm.		
	1	0.25
	2	0.08
	3	0.00
	4	0.00
	5	0.00
0.15-1.00 mm.		
	1	0.40
	2	0.10
	3	0.10
	4	0.10
	5	0.00
1.00-4.00 mm.		
	1	0.71
	2	0.25
	3	0.10
	4	0.10
	5	0.08
4.00-10.00 mm.		
	1	0.62
	2	0.41
	3	0.21
	4	0.10
	5	0.10
>10.00 mm.		
	1	0.55
	2	0.30
	3	0.21
	4	0.00
	5	0.00

Table: 9.164 (see Figure 9.16).



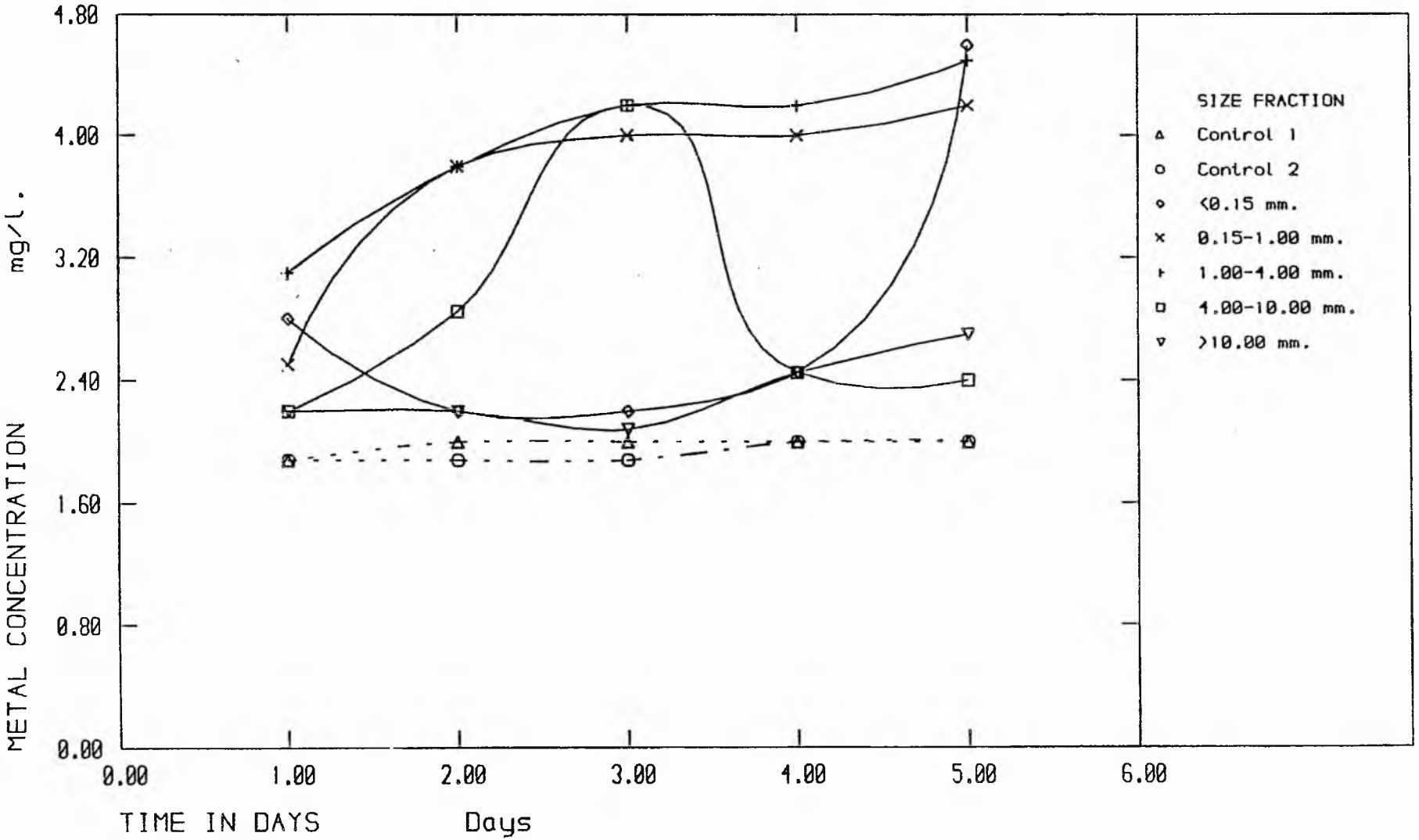
The Variation in Soluble Lead Concentration for pH Buffer 8.0.

Figure 9.16

The Variation in Soluble Zinc Concentration for pH Buffer 5.0.

SIZE FRACTION	DAY	CONCENTRATION IN LIQUOR mgl-1.
Control 1		
	1	1.88
	2	2.00
	3	2.00
	4	2.00
	5	2.00
Control 2		
	1	1.88
	2	1.88
	3	1.88
	4	2.00
	5	2.00
<0.15 mm.		
	1	2.80
	2	2.20
	3	2.20
	4	2.45
	5	4.60
0.15-1.00 mm.		
	1	2.50
	2	3.80
	3	4.00
	4	4.00
	5	4.20
1.00-4.00 mm.		
	1	3.10
	2	3.80
	3	4.20
	4	4.20
	5	4.50
4.00-10.00 mm.		
	1	2.20
	2	2.85
	3	4.20
	4	2.45
	5	2.40
>10.00 mm.		
	1	2.20
	2	2.20
	3	2.08
	4	2.45
	5	2.70

Table: 9.165 (see Figure 9.17).



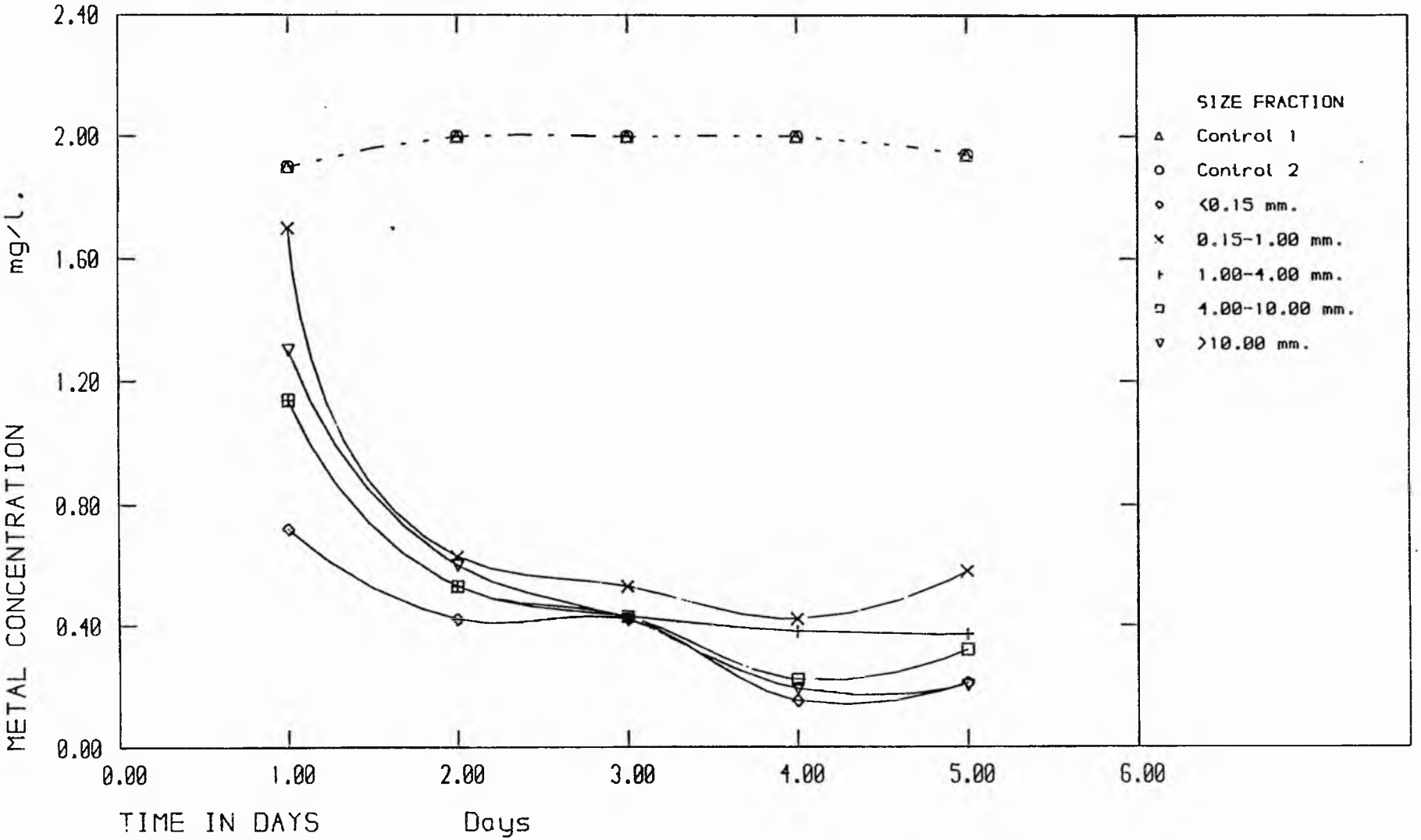
The Variation in Soluble Zinc Concentration For pH Buffer 5.0.

Figure 9.17

The Variation in Soluble Zinc Concentration for pH Buffer 6.0.

SIZE FRACTION	DAY	CONCENTRATION IN LIQUOR mgl-1.
Control 1		
	1	1.90
	2	2.00
	3	2.00
	4	2.00
	5	1.94
Control 2		
	1	1.90
	2	2.00
	3	2.00
	4	2.00
	5	1.94
<0.15 mm.		
	1	0.72
	2	0.42
	3	0.42
	4	0.15
	5	0.21
0.15-1.00 mm.		
	1	1.70
	2	0.63
	3	0.53
	4	0.42
	5	0.58
1.00-4.00 mm.		
	1	1.14
	2	0.53
	3	0.43
	4	0.38
	5	0.37
4.00-10.00 mm.		
	1	1.14
	2	0.53
	3	0.43
	4	0.22
	5	0.32
>10.00 mm.		
	1	1.30
	2	0.60
	3	0.42
	4	0.19
	5	0.20

Table: 9.166 (see Figure 9.18).



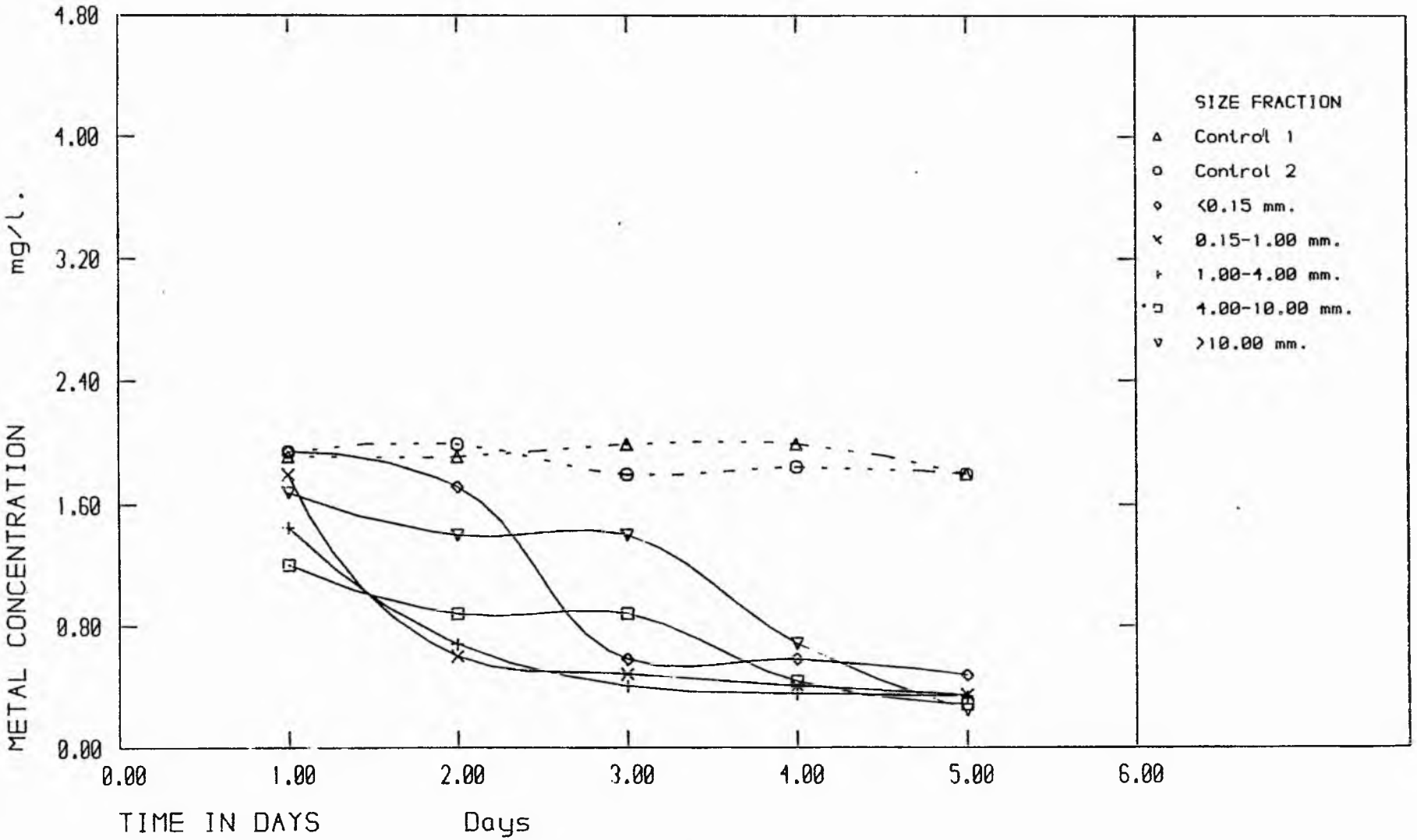
The Variation in Soluble Zinc Concentration for pH Buffer 6.0.

Figure 9.18

The Variation in Soluble Zinc Concentration for pH Buffer 7.0.

SIZE FRACTION	DAY	CONCENTRATION IN LIQUOR mgl-1.
Control 1		
	1	1.92
	2	1.92
	3	2.00
	4	2.00
	5	1.80
Control 2		
	1	1.95
	2	2.00
	3	1.80
	4	1.85
	5	1.80
<0.15 mm.		
	1	1.95
	2	1.72
	3	0.58
	4	0.58
	5	0.47
0.15-1.00 mm.		
	1	1.80
	2	0.60
	3	0.48
	4	0.40
	5	0.34
1.00-4.00 mm.		
	1	1.45
	2	0.68
	3	0.40
	4	0.35
	5	0.33
4.00-10.00 mm.		
	1	1.20
	2	0.88
	3	0.88
	4	0.43
	5	0.28
>10.00 mm.		
	1	1.68
	2	1.40
	3	1.40
	4	0.68
	5	0.24

Table: 9.167 (see Figure 9.19).



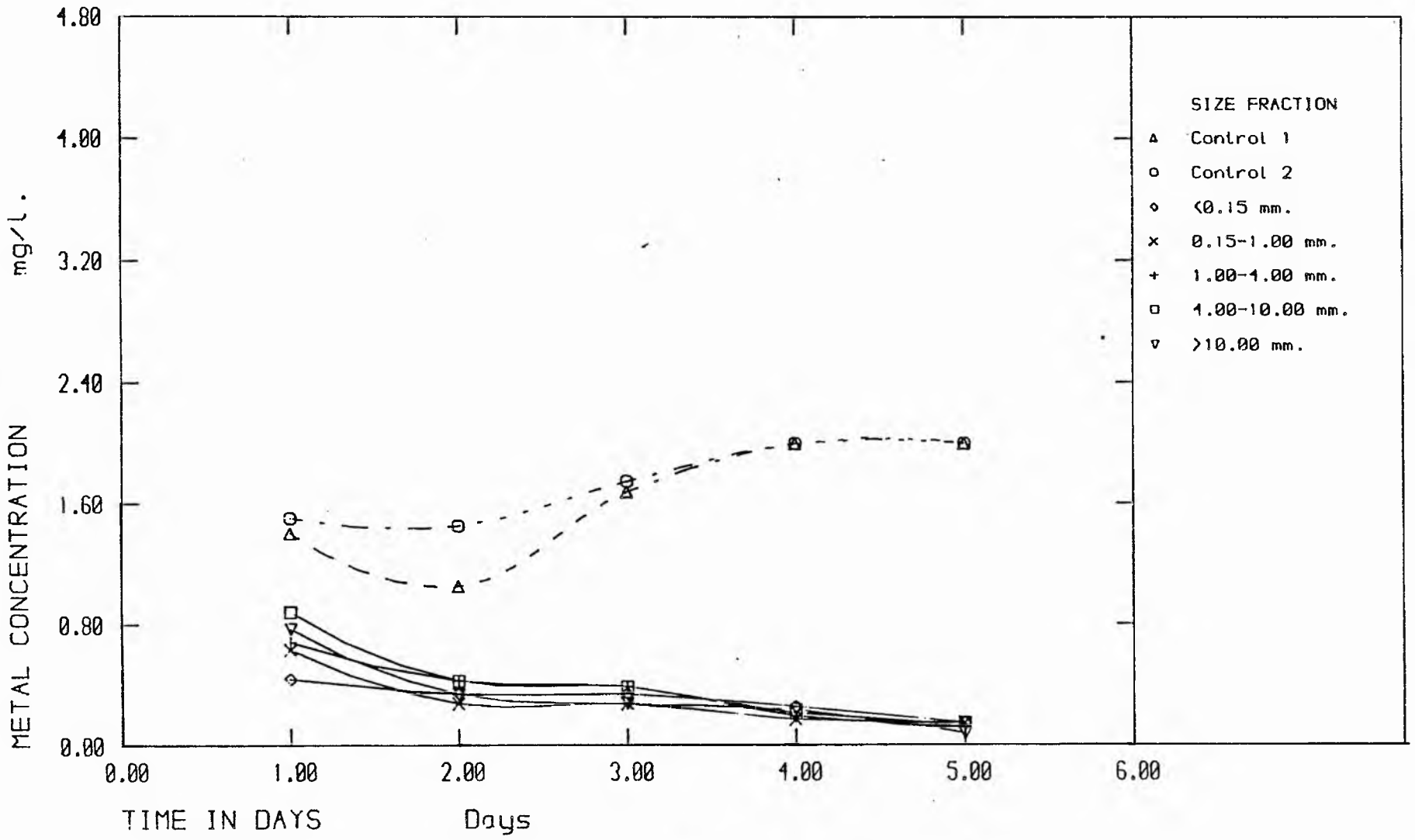
The Variation in Soluble Zinc Concentration For pH Buffer 7.0.

Figure 9.19

The Variation in Soluble Zinc Concentration for pH Buffer 8.0.

SIZE FRACTION	DAY	CONCENTRATION IN LIQUOR mgl-1.
Control 1		
	1	1.40
	2	1.05
	3	1.68
	4	2.00
	5	2.00
Control 2		
	1	1.50
	2	1.45
	3	1.75
	4	2.00
	5	2.00
<0.15 mm.		
	1	0.43
	2	0.33
	3	0.33
	4	0.25
	5	0.15
0.15-1.00 mm.		
	1	0.63
	2	0.27
	3	0.27
	4	0.17
	5	0.15
1.00-4.00 mm.		
	1	0.68
	2	0.42
	3	0.38
	4	0.19
	5	0.12
4.00-10.00 mm.		
	1	0.88
	2	0.42
	3	0.38
	4	0.21
	5	0.15
>10.00 mm.		
	1	0.77
	2	0.33
	3	0.27
	4	0.23
	5	0.08

Table: 9.168 (see Figure 9.20).



The Variation in Soluble Zinc Concentration For pH Buffer 8.0.

Figure 9.20

9.5 An Analysis of the Results of the Bottle Experiments.

9.6 Copper:

The initial copper concentration in the liquor was 3.0 mgl-1. The 'Control Experiments' remained very stable at around the 3.0 mgl-1. level for all the experiments within this category except for those conducted at a pH level of 8, whereby concentrations less than 3.0 mgl-1. were measured on the first day of analysis, but were then seen to reach an equilibrium on the second day, after which they remained stable. The results showed that under pH conditions 5 and 6, there was a net adsorption of copper from solution, whereas a reverse effect was observed at pH values 7 and 8. Even at pH 8, the copper concentrations in the liquor for each size fraction were fairly consistent and the adsorption/release mechanisms were not that well illustrated. An equilibrium copper concentration in the liquor was reached during the first day and this was why the liquor copper concentrations were well below 3.0 mgl-1 level after the first day (ie. at the start of the measurement period). These effects were more pronounced for the larger sized sediment fractions (see Tables 9.157 to 9.160 and Figures 9.9 to 9.12).

9.7 Zinc:

The initial zinc concentration in the liquor was set to 2.0 mgl-1. The 'Control Experiments' were seen to operate well and concentrations of about 2.0 mgl-1 were maintained for all the pH buffer solutions over the five-day period. The zinc analysis showed a very profound

effect for the pH 5 buffer solution. The zinc concentrations in the liquor rose dramatically over the five-day period and this was particularly marked for the smaller sized sediment fractions. The zinc concentrations were in excess of 2.0 mgl-1 level (initial) at all times and the basal sediments in the bottle were obviously contributing to the soluble zinc metal concentrations. The reverse effect was observed for the zinc in the pH 6, 7 and 8 solutions. The zinc concentrations in the liquor decreased gradually over the five-day period and the soluble zinc had been adsorbed by the basal sediments. This process was more obvious and more rapid, the higher (ie. the more alkaline) the pH of the buffer solution used. (see Tables 9.165 to 9.168 and Figures 9.17 to 9.20).

9.8 Lead:

The initial lead concentration in the liquor was 3.0 mgl-1. The 'Control Experiments' were again seen to have performed well and the Controls had lead concentrations of about 3.0 mgl-1 for each of the four pH buffer solutions used, over the five-day period. For the pH 5 solution, the lead concentrations in the liquor were seen to rise above the initial concentration of 3.0 mgl-1, except for the largest sized sediment fraction. For those size fractions less than 10.00 mm., the sediments had released lead in the standing liquor so as to enhance its soluble lead concentrations. The lead concentration in the liquor for the > 10.00 mm. size fractions remained fairly constant over the full five-day period and this reflected the view that lead was most often associated with the smaller sized sediment fractions. For the pH 6 solutions, very low lead concentrations were

found in the liquors after the first day but they rose gradually over the five-day period. These sediments had released lead into solution, but the process was far less marked than that observed in the pH 5 buffer solutions. The lead concentrations in the liquor reached an equilibrium point at pH 7 whereby the soluble lead concentrations were consistent for all the size fractions under study throughout the five-day period. The pH 8 buffer solutions exhibited the adsorption of soluble lead by the basal sediments. This was most marked for the smaller sized sediment fractions and there was a gradual reduction in the soluble lead concentrations in the standing liquor over the five-day period to a non-detectable level for certain sediment fractions. (see Tables 9.161 to 9.164 and Figures 9.13 to 9.16).

9.9 TOC (Total Organic Carbon):

The final part of the bottle experiments series involved the analysis of TOC in the standing liquor at the beginning and at the end of the five-day sampling period. A single control experiment was set up for each pH buffer solution used and the initial TOC concentration was zero. The TOC remained zero at all times for each of the four pH solutions under study and this was due to the fact that the standard solutions were made up from de-ionised water and the buffer solutions were made up from double distilled water, so there was no source of organic carbon in the control experiments. For each of the four pH solutions, the TOC was seen to rise steadily over the five-day period for the smaller size sediment fractions. It seemed that the smaller sediment fractions had a higher volatile fraction and this provided the source of organics which were dissolved into the standing liquor

and were detected in the TOC determination. This effect was most pronounced for the pH 5 and 8 solutions where relatively high TOC values (ie. above 30.0 mgl-1) were observed in the standing liquor. The smaller size sediment fractions were made up of soil and vegetal matter and this was why they had a higher volatile fraction than the larger sediments, which were dominated by the road gritstones dislodged from the road surfaces. These experiments showed that the smaller fractions could contribute organic carbon to the pot liquor through the solution of organics from soil and vegetal particles. The larger sediment fractions were coated in tar and oil (in some cases) but it was unlikely that this would be dislodged from the particle even though the particles were exposed to a wide range of pH values. (see Tables 9.153 to 9.156 and Figures 9.5 to 9.8).

9.10 Conclusions:

The series of bottle experiments carried out in the laboratory set out to investigate the relationships between the adsorption/release mechanisms for copper, zinc and lead for different gully pot basal sediment size fractions under different pH regimes. The results showed that under acidic conditions (ie. under conditions of pH 5), metals were released from the sediments into solution, whereas metals were adsorbed onto the basal sediments under alkaline conditions (ie. under conditions of pH 8). The smaller size sediment fractions (ie. particularly those less than 0.15 mm.) showed a greater ability to adsorb the soluble metals in solution and this was particularly true for lead. The release of organics into solution from all size fractions, but particularly from the smaller fractions, produced detectable levels of TOC in the standing liquors and this in turn would have produced an oxygen demand within the liquor. The 'Control Experiments' were found to operate well (with the notable exception of one control used in the copper analysis) and this added some credibility to the results obtained and the conclusions drawn. The trends established in this series of laboratory experiments helped to clarify and support some previously stated observations and inferences made about the data collected in the field (see Chapters 7 and 8). The importance of pH variation and sediment size fractionation in determining the exchange of heavy metals and the release of soluble organics from the pot liquor to the basal sediments, and in some case vice versa, has been clearly demonstrated by the results of the experiments (see Tables 9.153 to 9.168 and Figures 9.5 to 9.20).

Chapter 10: Simulated Storm Runoff Experiments on Gully Pots.

10.1 Introduction.

A series of experiments was carried out to investigate the effect upon outflow water quality of different inflow rates of water into the gully pot. The outflow water quality was measured in terms of COD and SS and the aim of the experiments was to simulate different rates of discharge into the pot and to measure any corresponding changes in the outflow water quality. The field trials were conducted at a series of gully pots situated on the Clifton Grove Estate in Nottingham and these gully pot locations were chosen at random. The experiments were devised to complement the field observations of water quality changes during the real storm events as outlined in Chapter 8. The experiments were conducted such that a constant volume of water would inflow into the pot and this fixed volume would be achieved by a combination of a variable inflow intensity (between experiments and not within) and a variable flow duration. The simulated storm runoff was provided from a mains water supply and the runoff water was obtained from a fire hydrant through a set of calibrated rotameters, which provided a discharge at the required rate of discharge. The aim of the experiments was to investigate the relationships between the outflow water quality and the rate of discharge of the runoff waters into the pot. In order to overcome the effects of dilution, it was decided to run a fixed volume of water into the pot and therefore each experiment had the same volume of water passing through the pot. The flow duration was modified such that the changes in the flow intensity could be made. The runoff discharge was from a 75 mm. hose which was fixed to the rotameters and the discharge pipe was placed adjacent to

the kerbside at a distance of about ten metres from the gully pot. The storm runoff water flow was simulated in this way (see Figure 10.1). It was assumed that there were no losses during the passage of the water over the channel and road surfaces. It was assumed that the volume of water discharged onto the urban surfaces was equal to that which flowed into the gully pot. This assumption had to be made to provide consistency between the results obtained from the different gully pots used in the series of experiments, but it is known that there will always be some loss of water through ponding and infiltration. The inflow waters entering the gully pot and the waters discharging from the pot as outflow waters were sampled using one of the automatic sampling machines, as out outlined in Chapter 8. The inflow waters were collected and sampled in a receiving box placed against the inlet to the gully pot in exactly the same way as the inflow waters were sampled in the 'Storm Event Sampling Programme' (see Chapter 8). One sampler head was positioned in the receiving box whilst the second head was positioned adjacent to the discharge pipe from the pot to the storm sewer pipe. The outflow waters were assumed to be those waters within the pot liquor which were adjacent to the discharge pipe, in much the same way as the outflow waters were sampled in the 'Storm Event Sampling Programme'.

10.2 The Field Experiments.

The series of experiments consisted of eight separate field tests which were conducted in four groups of paired experiments. Each pair of experiments (ie Tests 1A and 1B) consisted of a common inflow intensity, but in each case, Test A used a flow volume of 500 litres and Test B used a flow volume of 1000 litres. The flow volumes of 500

Photograph of the Gully Pot Field Trial Experiment 1A.

Figure 10.1

litres and 1000 litres were selected since the average storm runoff event produced a flow volume of this order of magnitude. The selection of two different fixed flow volumes also enabled a comparison between a high and a low flow volume to be drawn from the experimental results data. The four groups of experiments each used a different inflow intensity, which were 0.5, 1.0, 1.5 and 2.0 litres per second, respectively. The experiments were conducted at eight different gully pots where no previous analysis had been carried out within the research programme. The experiments were conducted over a two day period in May 1986 when the weather was dry and sunny with average temperatures. The experiments were set up as follows:

TEST NAME	SAMPLING INTERVAL (Seconds)	INFLOW RATE (litres/sec)	FLOW DURATION (Seconds)	FLOW VOLUME (litres)
1A	20	2.0	250	500
1B	40	2.0	500	1000
2A	30	1.5	333	500
2B	60	1.5	666	1000
3A	40	1.0	500	500
3B	80	1.0	1000	1000
4A	90	0.5	1000	500
4B	180	0.5	2000	1000

Table: 10.1

The sampling interval was set so that about 12 samples could be taken during the flow duration and so the sampling interval was calculated

in accordance with the flow duration (see Table 10.1).

It was important to stress that the water used to simulate the storm runoff waters was from a mains water supply and should therefore have zero COD and SS at the discharge point. The SS and COD concentrations in the inflow waters would be attributable to the change in quality as the waters passed over the urban surfaces (ie. the kerb channel and the road surfaces). About 12 samples of both inflow and outflow waters were taken and were analysed in the laboratory for SS and COD. The results can be seen in Tables 10.2 to 10.9 and in Figures 10.2 to 10.9.

10.3 The Results of the Field Trials.

The results of the field tests can be summarised as follows:

10.4 TEST 1A:

The COD and SS concentrations decreased gradually throughout the duration of the simulated storm flow and the data showed a distinctive dilution curve when plotted against time (see Figure 10.2). Relatively high COD and SS volumes were recorded at the start of the inflow event and this was indicative of the washoff of accumulated sediments and soluble pollutants (especially organics) from the road surface. The outflow waters exhibited a characteristic bell-shaped pollutograph (see Figure 10.2) throughout the duration of the event with a steadily rising limb of the pollutograph followed by a more gradual recession limb. This was particularly marked for the SS concentrations in the outflow waters. The higher concentrations of

Gully Pot Field Test Experiment: TEST 1A

Flow volume = 500 l
Flow Intensity = 2.0 ls-1
Sampling Interval = 20 secs
Flow Duration = 250 secs

INFLOW WATERS:

Sample Number	SS mgl-1	COD mgl-1 as COD
1	473	325
2	383	220
3	297	145
4	184	115
5	130	95
6	96	60
7	72	20
8	45	20
9	49	70
10	50	40
11	57	35
12	*	*

OUTFLOW WATERS:

Sample Number	SS mgl-1	COD mgl-1 as COD
1	129	65
2	58	5
3	48	5
4	89	25
5	165	75
6	268	95
7	252	110
8	213	85
9	149	180
10	189	*
11	150	80
12	137	45

* = No Analysis

Table: 10.2

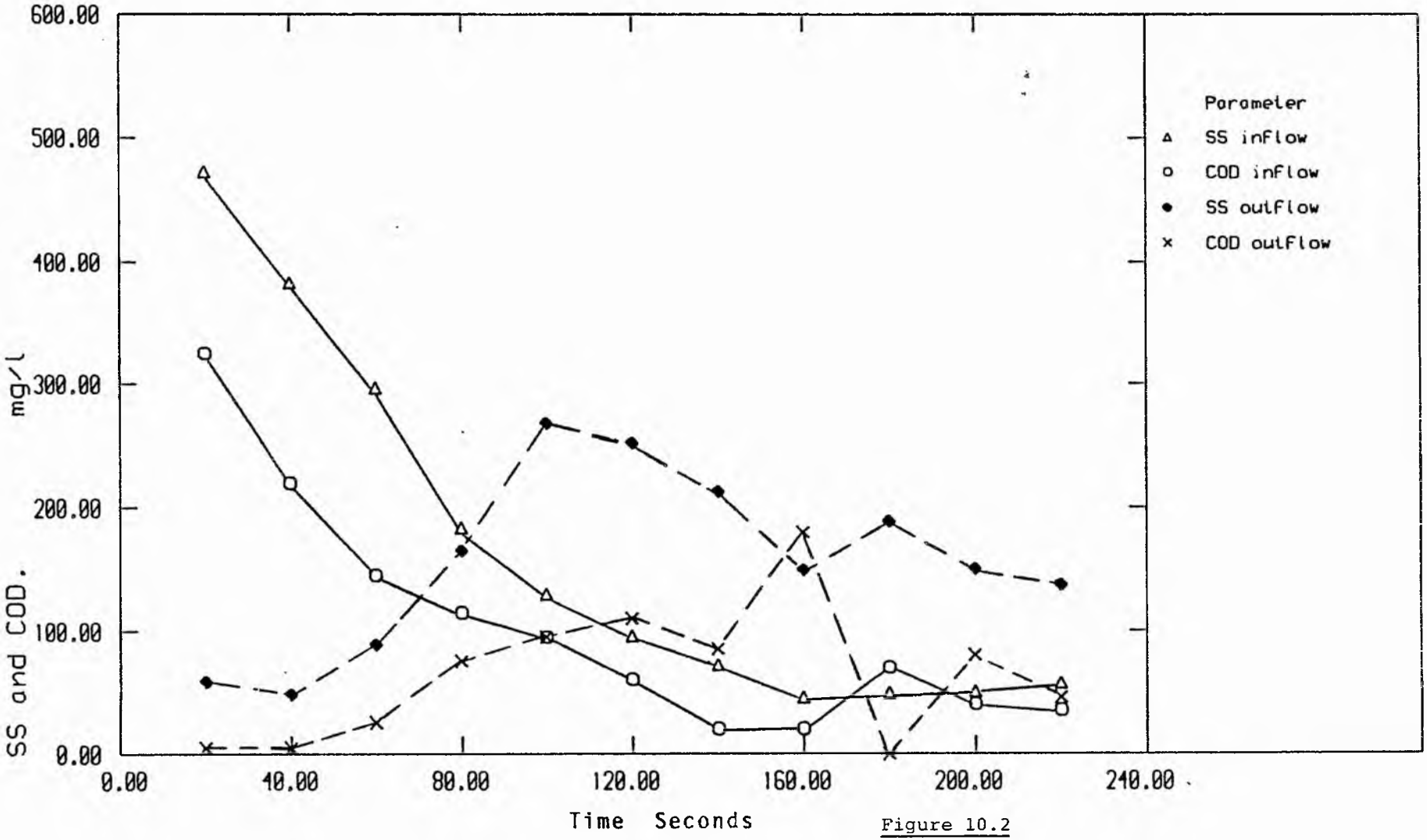


Figure 10.2

Graph of SS and COD for Test 1A.
Flow = 2.0 ls-1 for 250 secs. Volume of water through the gully pot = 500 l.

both COD and SS in the outflow waters suggested that the gully pot liquor and possibly the gully pot basal sediments were contributing to the COD and SS concentrations in the outflow waters (see Table 10.2 and Figure 10.2).

10.5 TEST 1B:

The concentrations of COD and SS in both the inflow and the outflow waters showed less consistent trends than those exhibited in Test 1A. The SS concentrations in the inflow waters rose at the beginning and then showed a gradual decrease in concentration, only to rise again sharply halfway through the flow duration. This secondary peak was due to a secondary source of sediment flowing into the pot from a previously non-contributable surface area. The SS concentrations were then seen to decrease again due to the effects of dilution and source depletion. The COD concentrations in the inflow waters increased at the beginning due to the washing in of urban surface pollutants by the simulated storm runoff flow. They were then observed to decrease to a consistent level towards the end of the flow duration. The SS concentrations in the outflow waters increased rapidly at the beginning only to decrease gradually towards the end of the sampling period. The maximum SS concentration observed in the outflow waters preceded that observed in the inflow waters. The responses found in the SS concentrations for the inflow and the outflow waters suggested that a secondary pulse of solids into the pot was dampened by the pot liquor, since the response in the outflow SS concentrations was not apparent. A similar response was also observed in the COD data, although the COD values in the outflow waters were generally above

Gully Pot Field Test Experiment: TEST 1B

Flow volume = 1000 l
Flow Intensity = 2.0 ls-1
Sampling Interval = 40 secs
Flow Duration = 500 secs

INFLOW WATERS:

Sample Number	SS mgl-1	COD mgl-1 as COD
1	32	65
2	161	105
3	92	135
4	69	55
5	46	55
6	214	12
7	102	55
8	64	32
9	47	65
10	86	55
11	42	*
12		

OUTFLOW WATERS:

Sample Number	SS mgl-1	COD mgl-1 as COD
1	70	125
2	83	65
3	82	0
4	27	0
5	87	120
6	212	60
7	117	120
8	*	*
9	106	65
10	80	45
11	71	40
12	100	40

* = No Analysis

Table: 10.3

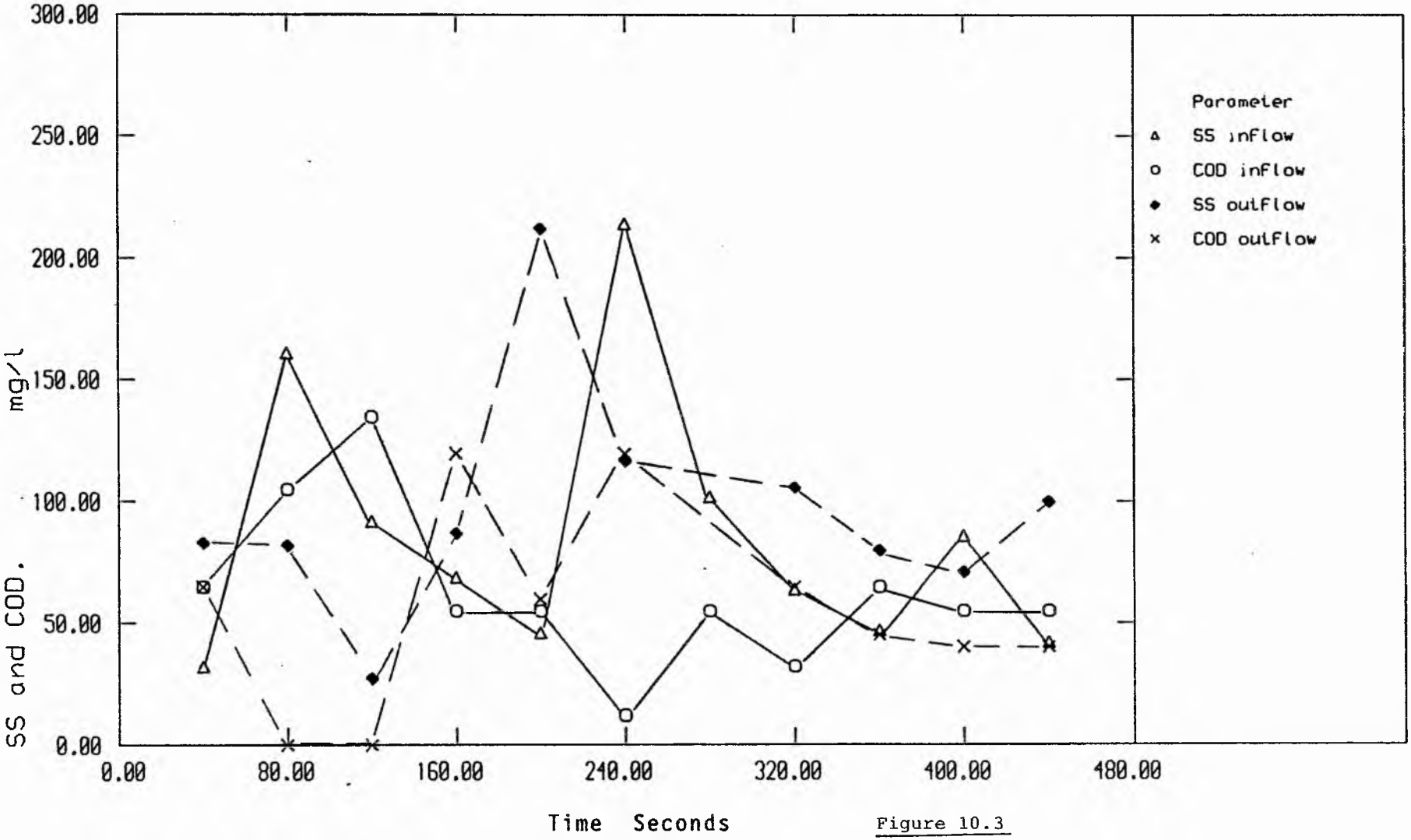


Figure 10.3

Graph of SS and COD For Test 1B.
Flow = 2.0 ls-1 For 500 secs. Volume of water through the gully pot = 1000 l.

Gully Pot Field Test Experiment: TEST 2A

Flow volume = 500 l
Flow Intensity = 1.5
Sampling Interval = 30 secs
Flow Duration = 333 secs

INFLOW WATERS:

Sample Number	SS mgl-1	COD mgl-1 as COD
1	468	319
2	261	211
3	63	211
4	306	201
5	62	39
6	16	34
7	4	9
8	0	0
9	3	0
10	7	9
11	0	0
12	*	*

OUTFLOW WATERS:

Sample Number	SS mgl-1	COD mgl-1 as COD
1	698	848
2	468	691
3	327	441
4	382	39
5	171	240
6	135	240
7	89	373
8	111	142
9	69	123
10	48	88
11	48	74
12	41	54

* = No Analysis

Table: 10.4

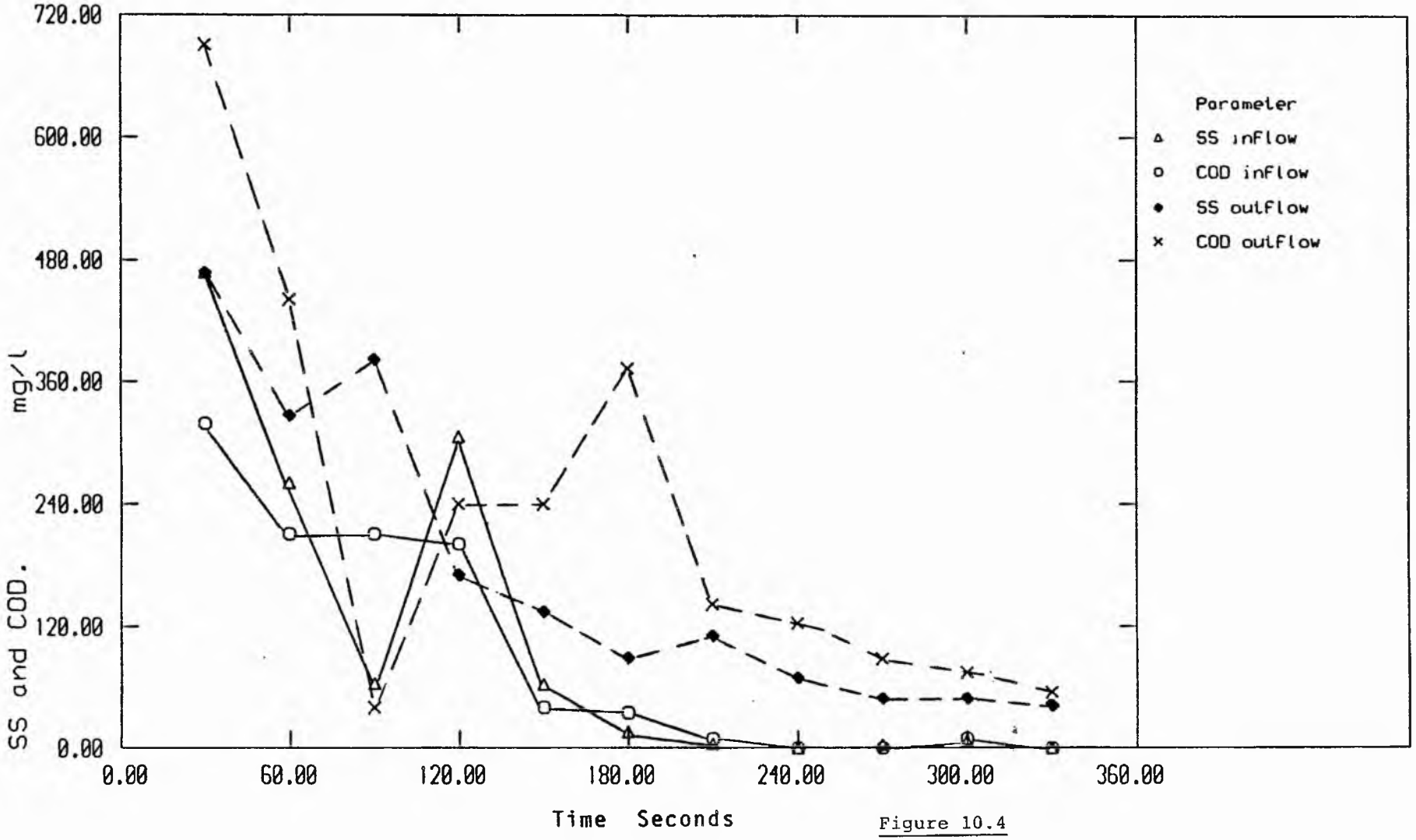


Figure 10.4

Graph of SS and COD For Test 2A.
Flow = 1.5 ls-1 for 333 secs. Volume of water through the gully pot = 500 l.

those in the inflow waters, which suggested that the pot liquor and the gully pot basal sediments were acting as a source of COD to the waters discharged from the pot (see Table 10.3 and Figure 10.3).

10.6 TEST 2A:

The SS concentrations in the inflow waters decreased sharply at the beginning of the simulated storm event, only to rise to a secondary peak before gradually falling again. The SS concentrations in the outflow waters showed a gradual decrease throughout the duration of the runoff event and this was due to a dilution effect and source depletion. The COD concentrations in the inflow and the outflow waters decreased throughout the sampling period, but it was significant to note that the COD concentrations in the outflow waters were higher than those in the inflow waters in nearly all the samples taken (see Table 10.4 and Figure 10.4).

10.7 TEST 2B:

The maximum SS concentration in the inflow waters occurred in the first sample collected at the beginning of the simulated storm event and the concentrations were then seen to fall sharply due to supply depletion of SS in the road channel. The trend in the SS concentrations in the outflow waters closely followed that for the inflow SS values, which again provided evidence of a dilution effect due to the larger flow volume (1000 litres) used in the series B field tests. The COD concentrations in the inflow waters showed a less characteristic trend, in that the values were observed to fall

Gully Pot Field Test Experiment: TEST 2B

Flow volume = 1000 l
Flow Intensity = 1.5 ls-1
Sampling Interval = 60 secs
Flow Duration = 666 secs

INFLOW WATERS:

Sample Number	SS mgl-1	COD mgl-1 as COD
1	644	345
2	337	310
3	198	210
4	73	255
5	84	300
6	105	235
7	51	80
8	93	175
9	168	420
10	117	470
11	124	415
12	*	*

OUTFLOW WATERS:

Sample Number	SS mgl-1	COD mgl-1 as COD
1	211	230
2	617	320
3	549	275
4	165	155
5	163	180
6	104	110
7	56	135
8	56	0
9	25	150
10	0	135
11	18	105
12	5	100

* = No Analysis

Table: 10.5

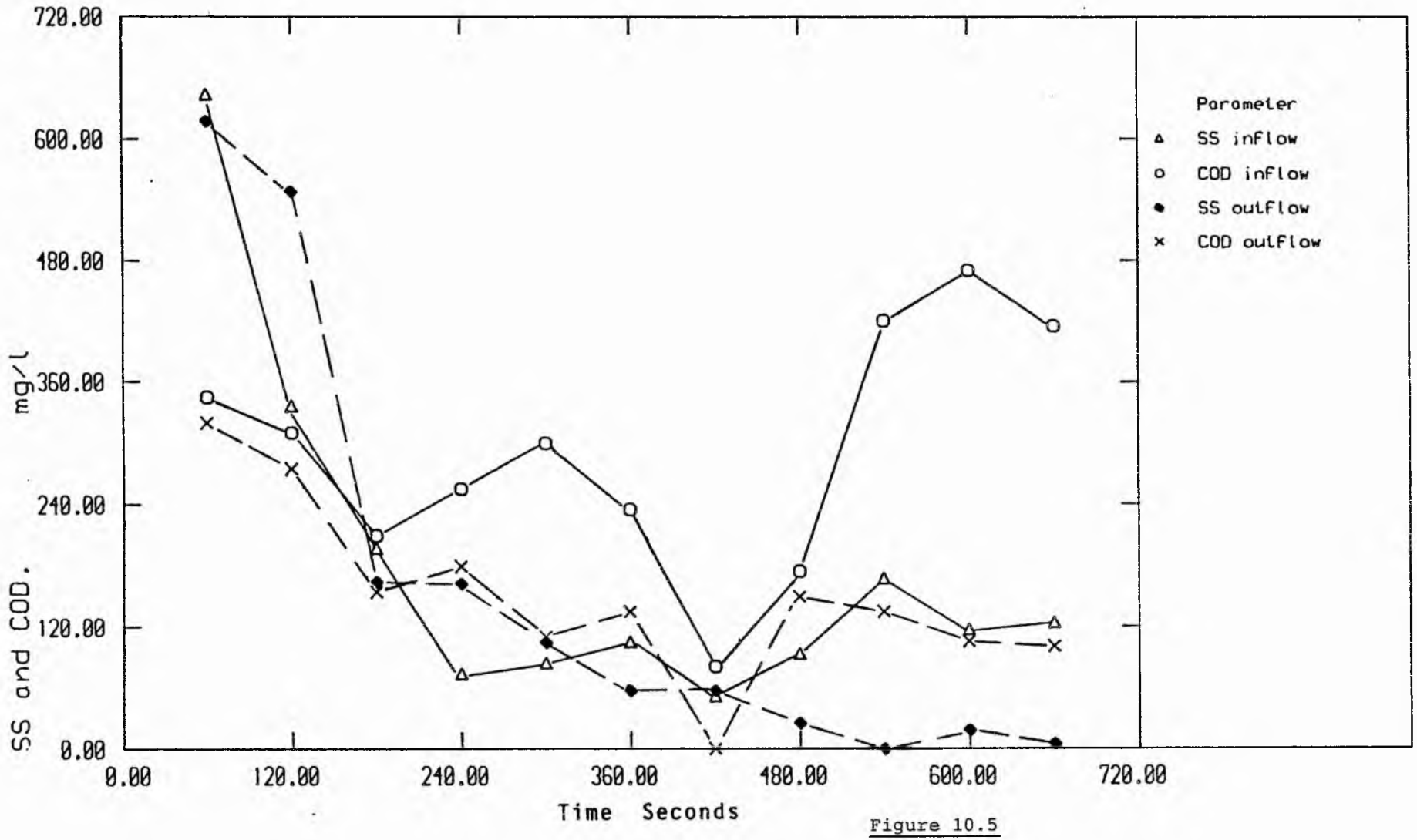


Figure 10.5

Graph of SS and COD for Test 2B.
Flow = 1.5 ls-1 for 666 secs. Volume of water through the gully pot = 1000 l.

gradually at the beginning of the event only to rise sharply towards the end of the runoff duration, to levels above those found at the beginning of the sampling period. This trend reflected an input of COD from a source on the road channel which was washed into the gully pot. The COD concentrations in the outflow waters reflected those established in the inflow waters. The COD concentrations in the outflow waters decreased gradually due to dilution only to rise slightly towards the end of the flow duration period due to a pulse of material entering the pot, which enhanced the COD values in the outflow waters. It should be noted that the COD concentrations in the inflow waters were at all times greater than those in the outflow waters, which suggested that the gully pot liquor and its asociated basal sediments acted as a sink for the COD in the inflow waters (see Table 10.5 and Figure 10.5).

10.8 TEST 3A:

The SS and COD concentrations in the inflow waters had their maxima at the beginning of the sampling period and the concentrations decreased gradually throughout the duration of the runoff event. The SS and COD concentrations in the outflow waters showed a gradual reduction in their values and they were always less than their respective concentrations (ie. those taken at the same time) in the inflow waters. There was no evidence that the gully pot liquor made any contribution to the SS and the COD values in the outflow waters since a dilution effect was observed for both the SS and COD concentrations. In fact, the gully pot liquor acted as a sink for both SS and COD on this occasion (see Table 10.6 and Figure 10.6).

Gully Pot Field Test Experiment: TEST 3A

Flow volume = 500 l
Flow Intensity = 1.0 ls-1
Sampling Interval = 40 secs
Flow Duration = 500 secs

INFLOW WATERS: Sample Number	SS mgl-1	COD mgl-1 as COD
1	525	268
2	378	182
3	213	91
4	180	86
5	129	30
6	127	51
7	72	5
8	89	25
9	112	0
10	87	0
11	70	0
12	*	*

OUTFLOW WATERS: Sample Number	SS mgl-1	COD mgl-1 as COD
1	338	45
2	219	15
3	119	172
4	100	40
5	68	51
6	75	71
7	37	10
8	65	0
9	41	15
10	44	56
11	48	61
12	40	30

* = No Analysis

Table: 10.6

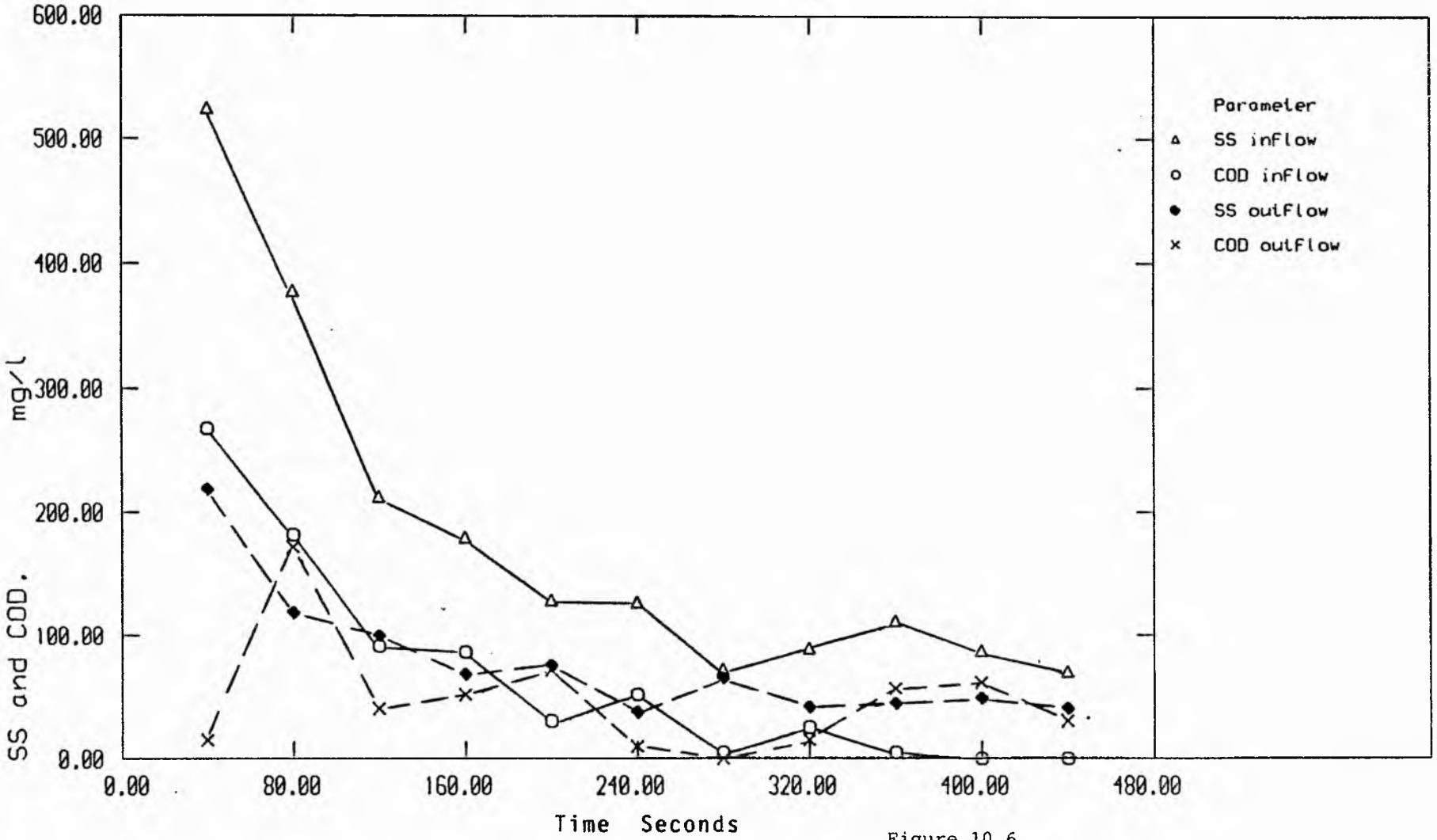


Figure 10.6

Graph of SS and COD For Test 3A.

Flow = 1.0 ls-1 For 500 secs. Volume of water through the gully pot = 500 l.

10.9 TEST 3B:

The trends in the data from samples collected in Test 3B were very similar to those observed in Test 3A, except that the SS concentrations in the outflow waters were much higher than those in the inflow waters. The liquor in the gully pot used for field Test 3B was obviously high in SS and these values were seen to decrease during the passage of the runoff event. This effect was quite dramatic since the initial SS concentration of over 750.0 mgl-1 at the start of the event was seen to decrease to less than 100.0 mgl-1 at the end of the sampling period. The COD concentrations were quite low by comparison in both the inflow and the outflow waters for this event. This was indicative of the pollutants found within and adjacent to the particular gully pot used in this field test analysis (see Table 10.7 and Figure 10.7).

10.10 TEST 4A:

The analysis of the inflow waters showed that there was a pulse of both SS and COD roughly halfway through the flow duration, since the SS and the COD concentrations reached their maxima in the inflow waters before gradually decreasing due to a dilution effect. The COD concentrations in the inflow waters were found to be very low towards the end of the sampling period. It was not possible to analyse the first two inflow water samples collected for Test 4A due to a loss of sample in transit to the laboratory. The SS and COD concentrations in the outflow waters were at a maximum at the beginning of the flow duration and the values were then seen to decrease rapidly. The SS

Gully Pot Field Test Experiment: TEST 3B

Flow volume = 1000 l
Flow Intensity = 1.0 ls-1
Sampling Interval = 80 secs
Flow Duration = 1000 secs

INFLOW WATERS:

Sample Number	SS mgl-1	COD mgl-1 as COD
1	21	218
2	36	73
3	174	78
4	131	73
5	110	44
6	67	68
7	48	58
8	62	63
9	40	34
10	29	49
11	40	102
12		

OUTFLOW WATERS:

Sample Number	SS mgl-1	COD mgl-1 as COD
1	157	44
2	796	121
3	581	78
4	326	63
5	179	83
6	114	68
7	87	39
8	*	*
9	66	19
10	45	39
11	40	56
12	35	10

* = No Analysis

Table: 10.7

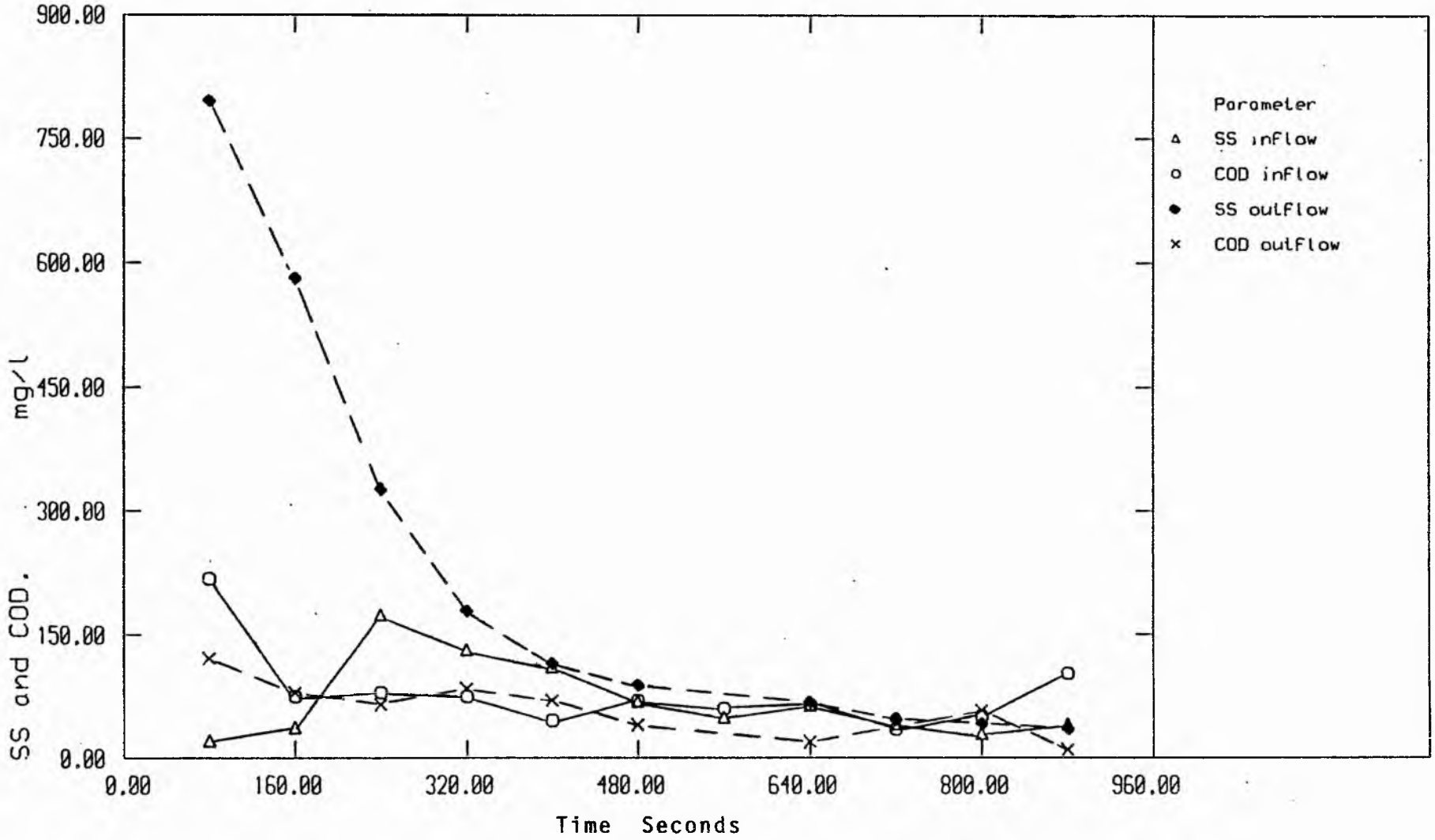


Figure 10.7

Graph of SS and COD For Test 3B.

Flow = 1.0 ls-1 for 1000 secs. Volume of water through the gully pot = 1000 l.

and COD concentrations in the outflow waters were found to be below those of the inflow waters during most of the runoff event. The gully pot was acting as a sink for such pollutants associated with the SS and COD measurement in the sampled waters, through the gully pot liquor and the associated basal sediments (see Table 10.8 and Figure 10.8).

10.11 TEST 4B:

The effects of dilution were very marked in the trends shown by the SS and COD concentrations found in the outflow waters. Both chemical determinands showed their maxima in the first sample taken and the concentrations gradually decreased throughout the duration of the event. The COD concentrations in the inflow waters were quite low and they did not vary greatly throughout the sampling period. Non-detectable COD levels were found in some samples. The SS concentrations in the inflow waters were generally higher than those in the outflow waters during the simulated runoff event, but they were seen to decrease gradually over the sampling period. A very high SS concentration (SS=196mgl-1) was observed in an inflow water sample taken towards the end of the sampling period. This exceptionally high value could be attributed to a pulse of SS finding its way into the gully pot, or otherwise, it could only be put down to an analytical error or a 'freak result'. It was considered that the latter case was more likely due to the trend observed in the remainder of the dataset obtained from Test 4B (see Table 10.9 and Figure 10.9).

Gully Pot Field Test Experiment: TEST 4A

Flow volume = 500 l
Flow Intensity = 0.5 ls-1
Sampling Interval = 90 secs
Flow Duration = 1000 secs

INFLOW WATERS:

Sample Number	SS mgl-1	COD mgl-1 as COD
1	*	*
2	*	*
3	82	45
4	60	0
5	125	104
6	186	104
7	70	10
8	86	0
9	42	5
10	33	0
11	30	0
12	*	*

OUTFLOW WATERS:

Sample Number	SS mgl-1	COD mgl-1 as COD
1	72	20
2	118	25
3	237	193
4	173	99
5	95	94
6	45	0
7	46	15
8	18	20
9	20	5
10	23	5
11	27	0
12	13	0

* = No Analysis

Table: 10.8

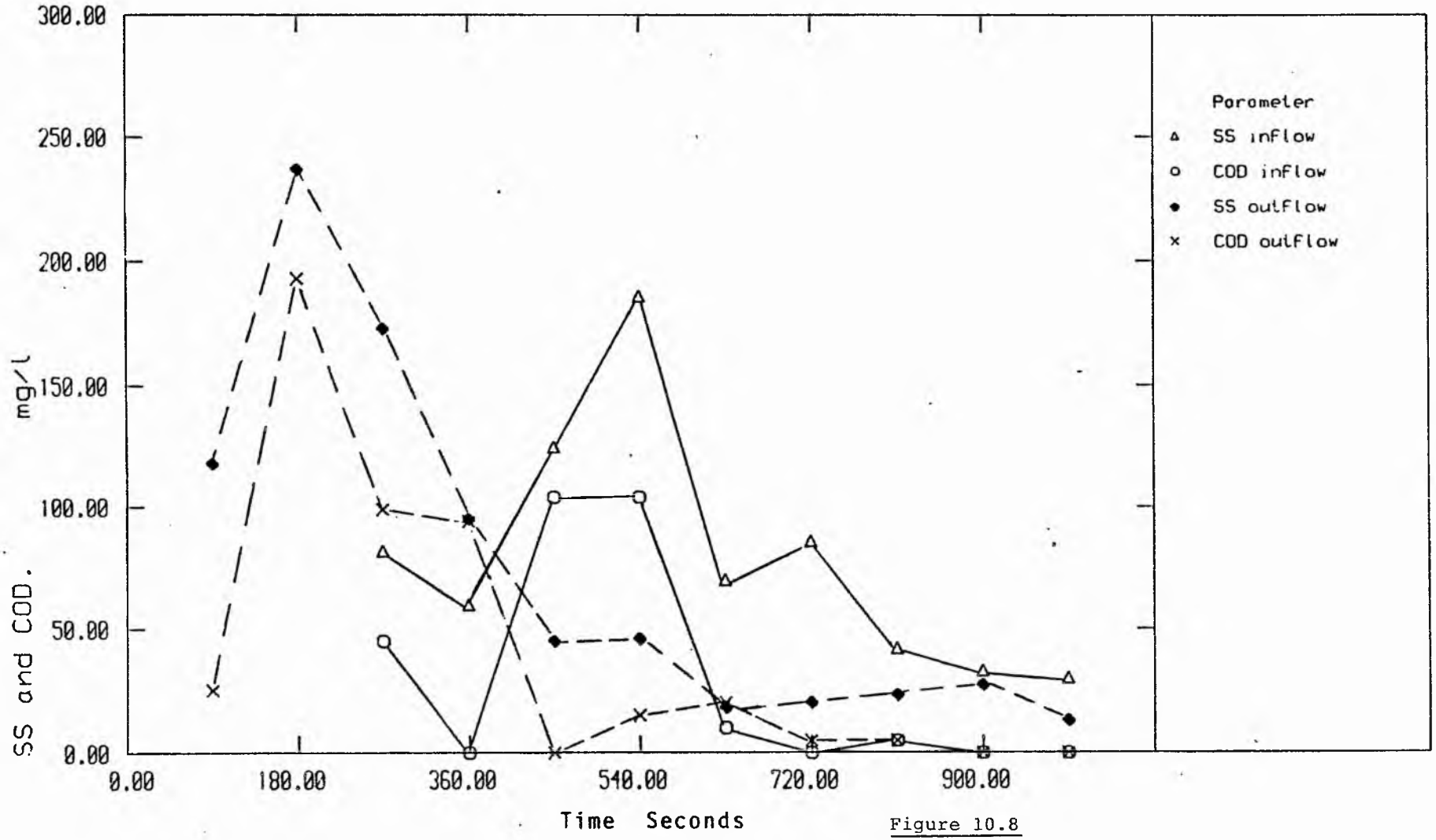


Figure 10.8

Graph of SS and COD For Test 4A.
Flow = 0.5 ls-1 For 1000 secs. Volume of water through the gully pot = 500 l.

Gully Pot Field Test Experiment: TEST 4B

Flow volume = 1000 l
Flow Intensity = 0.5 ls-1
Sampling Interval = 180 secs
Flow Duration = 2000 secs

INFLOW WATERS:

Sample Number	SS mgl-1	COD mgl-1 as COD
1	132	40
2	56	40
3	52	10
4	68	15
5	33	0
6	36	10
7	40	0
8	60	25
9	*	*
10	196	15
11	28	0
12		

OUTFLOW WATERS:

Sample Number	SS mgl-1	COD mgl-1 as COD
1	37	64
2	139	84
3	79	25
4	39	25
5	30	5
6	11	55
7	14	25
8	26	5
9	25	0
10	5	0
11	7	10
12	8	0

* = No Analysis

Table: 10.9

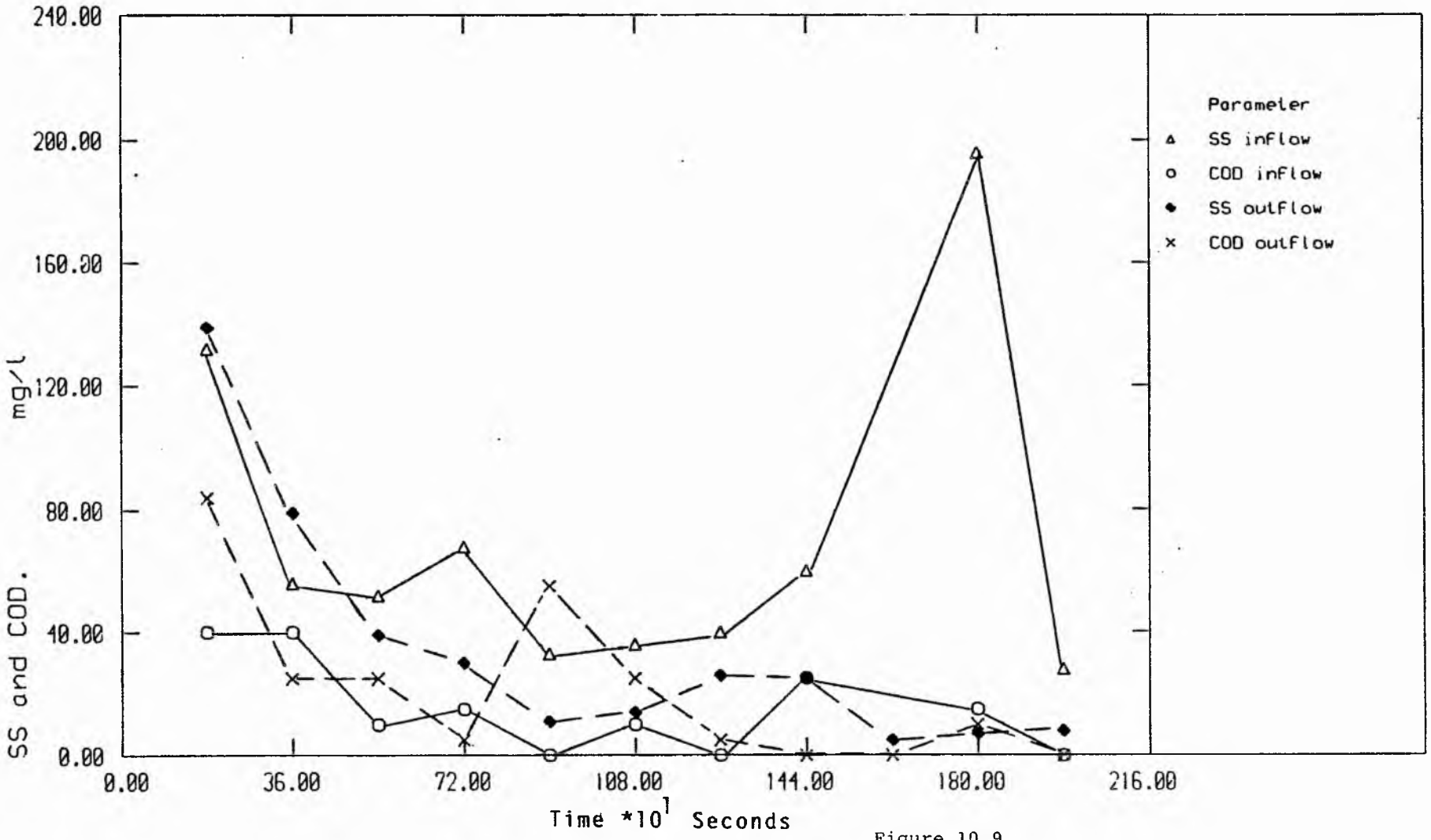


Figure 10.9

Graph of SS and COD For Test 4B.
Flow = 0.5 ls-1 For 2000 secs. Volume of water through the gully pot = 1000 l.

Photograph of the Inflow Water and Sampling Arrangements in Field Trial 1A.

Figure 10.10

Photograph of the Gully Pot Field Trial Experiment 2B.

Figure 10.11

Photograph of the Inflow Water and Sampling Arrangements in Field Trial 2B.

Figure 10.12

10.12 Conclusions.

The series of eight field tests carried out on gully pots selected at random on the Clifton Grove Estate provided an opportunity to study the behaviour of the gully pot under semi-controlled conditions in response to different inflow rates of discharge. The tests were controlled in the sense that the volume of runoff water passing through the gully pot was fixed and the decision to use two fixed volumes of 500 litres (Series A) and 1000 litres (Series B) in the tests enabled a comparison to be drawn between the responses to the two flow volumes in terms of the dilution effects on the SS and COD concentrations being discharged from the pots. The two volumes selected were indicative of the range of volume of runoff that an individual gully pot might be expected to receive from its contributing micro-catchment area during an average storm event in a temperate climate. The quality of the inflow water at the point of discharge (ie. from the mains supply) was also controlled since supply water should be of a consistent quality. The final controlling factor in the field tests was that the inflow rate of discharge was fixed on each test using a flow measuring device. The runoff duration was fixed accordingly so that the given runoff volume could be satisfied. The fact that these trials were conducted in the field and not in the laboratory meant that the environmental conditions could not be controlled. The state of the gully pot liquor, the mass and constitution of the gully pot basal sediments and the sources of pollutants available for mobilisation from the road and channel surfaces and in the transportation to the gully pot, were all unknown factors. The gully pots used in the tests were selected at random and it was assumed that the gully pots selected were representative of

those found on the Clifton Grove Estate. It was hoped that the different responses shown in the outflow quality from each gully pot caused by the different flow regimes would illustrate a general trend, or set of trends, which could describe the behaviour of the gully pot to different inflow water hydrological conditions. These conditions could be measured in terms of the outflow water quality expressed as SS and COD. The decision to measure COD in the field tests was taken because the results could be obtained quicker than those for BOD. The important conclusions drawn from the series of field tests were as follows:

i)
All the road and kerbside gutter surfaces provided some sources of SS and COD since they were measured in nearly all inflow waters.

ii)
The Tests conducted using the 1000 litre runoff volume all exhibited a greater degree of sediment supply depletion of the SS and the COD concentrations than those using the 500 litre runoff volume, for a given inflow rate of discharge. The dilution effect was most marked for the higher inflow rates of discharge tests.

iii)
For the lower flow intensity events (ie. Tests 3 and 4), the gully pot acted as a sink for the SS and COD and the pot liquor was not seen to make a contribution to the SS and the COD concentrations found in the outflow waters. The SS and COD concentrations in the inflow waters were generally found to be higher than their respective concentrations in the outflow waters.

iv)
There was some evidence provided by the higher inflow discharge rate events (ie. Tests 1 and 2), that the gully pot was acting as a source of both SS and COD during the runoff event. This was particularly noticeable when the SS concentrations in the outflow waters were observed to be higher than those found in the corresponding inflow waters. The resuspension of some basal deposits could have provided the enhancement to the SS and the COD levels and this was particularly evident for the Tests when the inflow discharge rate was fixed at 2.0 litres per second (ie. for Tests 1A and 1B). These observations provided further evidence of the importance of the inflow discharge rate into the pot in determining the quality of the discharge from a gully pot and the findings were in agreement with those made by Fletcher and Pratt (1981) who also conducted a series of field and laboratory experiments to investigate the possible resuspension of pot basal deposits under varying flow conditions (see Chapter 3).

Chapter 11: CONCLUSIONS.

The principal aim of the research project was to investigate the role of the gully pot in determining urban stormwater quality. A considerable amount of fieldwork, sample collection, laboratory analysis, data collection, validation and data analysis was carried out to obtain a comprehensive dataset of chemical and hydrological data from gully pot systems on the Clifton Grove Housing Estate in Nottingham. An extensive survey was made of the quality of the gully pot liquor during quiescent conditions and during storm conditions where surface runoff had occurred, in order to assess the influence of the gully pot on the resultant stormwater quality.

The hydrometric data collection programme was an integral part of the research project since the storm sequences could be recorded and quantified and the rainfall values could be translated into the runoff components using the Linear Reservoir Rainfall-Runoff Models developed. The collection of rainfall data in real-time and the ability to simulate the storm runoff flow volumes and the peak inflow intensities of the stormwater runoff into the the gully pot (through the derivation of an inlet storm hydrograph) added an essential dimension to the collection of the water quality data. The modelling of the relationships between the hydrological conditions (expressed by a number of hydrological variables such as rainfall depth, rainstorm duration, antecedent dry period, peak inflow intensity and the runoff volume) and the associated water quality was an important element in the research programme.

The results of the analysis of the quality of the precipitation waters

(Chapter 6) showed a number of consistencies with previous studies. The importance of the low pH values in rainwater was highlighted and the importance of the rainwater as a source of nitrogen (in the form of nitrates) was also clearly illustrated. The results were consistent with those measured in similar urban areas and provided an insight into the factors which control and determine the quality of the urban stormwater runoff.

The 'Gully Pot Liquor Monitoring Programme' set out to investigate the spatial and temporal variability in the chemical quality of the standing gully pot liquors. For some chemical parameters, spatial variability was observed and this was due entirely to the variations in the sources of some pollutants within the micro-catchment areas serving the individual gully pots. The heavy metals were mainly detected during the winter months and the impact of road salting was also observed through the changes in concentration of sodium, chloride and conductivity during the winter months. The influence of seasonality upon the BOD and SS concentrations was found to be slight and it was difficult to apply general trends to the data owing to its variability both spatially and temporally. The large ranges and standard deviations in some of the quality data confirm this point. A number of deterministic models were derived to predict the quality of the gully pot standing liquor in terms of a number of common chemical determinands. These models were calibrated on the Clifton Grove data. The quality models were established so that a prediction of the quality of the standing gully pot liquor could be made from a knowledge of its previous quality condition at a given time and the hydrological conditions prevalent since that time, and/or the hydrological conditions across a given time period. The variability

within the datasets compounded the problem of deriving quality models but it was found that the BOD and the SS concentrations both conformed to log-normal distributions and so probabilistic models were established using a relatively large number of observations to predict the pot liquor quality from a given level of probability of occurrence.

The 'Storm Event Sampling Programme' analysed fifteen storm events on the three gully pot systems under study over an eighteen month period. The storms captured varied a great deal in magnitude, duration and storm characteristics and each storm triggered a different response within the gully pot systems in terms of the changes in the water quality within the pot and in the gully pot outflow waters (ie. the waters discharging from the gully pot chamber into the separate storm sewer pipe network). The quality of the outflow waters (in terms of the BOD and the SS) was modelled both deterministically and probabilistically. The deterministic models were established so that the outflow quality could be predicted from the hydrological conditions experienced during the storm event. A number of such models relating the outflow water quality to the quality of the inflow storm runoff waters were also derived. The BOD and SS concentrations within the gully pot outflow waters were also found to conform to a log-normal distribution and so the probabilistic models relating the quality of the outflow waters (in terms of BOD and SS) to a given level of probability of occurrence were established. The derivation of the quality models (both deterministic and probabilistic) to predict the quality of the outflow waters discharging from the gully pot chamber during a storm event where surface runoff had occurred, were considered to be the most important findings of the whole of the

research programme.

The important relationships between the gully pot liquor and the basal sediments within the pot chamber were studied using a series of laboratory experiments in addition to the field data collected. The road surface sediments and the gully pot basal sediments were characterised according to their fractionation, volatile matter content and their sediment-associated metal concentrations. The release and/or adsorption of metals between the standing pot liquor and the basal sediments were analysed in a series of laboratory experiments and the paramount influence of the pH of the pot liquor on this whole process was confirmed. The sediment supply rates to the pot from the contributing surface areas (both road and paved areas) were of the same order of magnitude as those found in some previous studies carried out on the Clifton Grove Estate (Fletcher 1981; Pratt and Adams 1981; Adams 1983).

The research programme produced an extensive dataset of physio-chemical and hydrological data which was used to investigate the role of gully pots in determining stormwater quality. The results of the research programme have provided a number of important conclusions within the field of urban stormwater quality studies. The complexity of studying processes within a dynamic, environmental system has been confirmed but a series of established trends within the data collected has enabled the derivation of a series of deterministic and probabilistic models to predict the quality of both the standing gully pot liquor and the outflow waters discharging from the pot under storm conditions. These models can be incorporated into

more 'General Stormwater Quality Models' which encompass both the above-ground and the below-ground phases, which are currently under development within a number of studies and national research programmes throughout the world. The results of the research programme have provided an important focus of understanding between the above-ground and below-ground phases of stormwater runoff and the changes within the associated water quality.

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A P P E N D I C E S.

Appendix A: Reference Chapter 4: Computer Programme Listings.

Appendix B: Reference Chapters 4 and 8:

Storm Hyetographs and Inlet Storm Hydrographs.

Appendix C: Reference Chapter 7:

Gully Pot Liquor Monitoring Programme Data Tables.

Appendix D: Reference Chapter 8:

Storm Event Sampling Programme Data Tables and Graphs.

Appendix E: Published Papers.

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THE ROLE OF GULLY POTS IN DETERMINING URBAN STORMWATER QUALITY.

Gareth Andrew Fulcher.

Thesis submitted to the Council for National Academic Awards (CNAA) in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

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February 1989.

APPENDIX D.

Reference: Chapter 8.

Complete set of Data Tables and Figures for all Chemical Analysis carried out for the fifteen storm events in the "Storm Event Sampling Programme". The Tables and the Figures are listed in ascending 'Storm Number' order in the sequence of Tame, Churnet and Twyford Micro-catchments, as sampled.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. June 1984 (840602)
STORM NUMBER : 1

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
1648	19	9	72
1654	22	10	72
1700	34	10	68
1706	37	11	64
1712	41	13	80
1718	27	10	92
1736	35	7	112

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. June 1984 (840602)
STORM NUMBER : 1

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
1648	80	10	49
1700	104	8	45
1712	111	12	69
1724	122	12	87
1736	87	9	87
1748	123	6	87
1800	*	0	*
1812	129	4	114
1824	134	5	114
1836	140	8	87
1848	147	10	92
1900	*	0	92

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close

DATE OF THE STORM EVENT : 2nd. June 1984 (840602)

STORM NUMBER : I

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Cond uscm-1 (X1000)	DO mgl-1	pH pH units
1648	0.19	4.4	7.2
1654	0.21	3.8	7.1
1700	0.23	3.8	6.8
1706	0.29	3.8	6.8
1712	0.29	3.8	6.8
1718	0.21	3.5	6.9
1736	0.23	4.0	6.7

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. June 1984 (840602)
STORM NUMBER : 1

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
1648	0.32	4.1	6.9
1700	0.44	5.8	6.9
1712	0.45	5.8	6.9
1724	0.44	5.9	6.8
1736	0.49	6.1	6.7
1748	0.87	6.1	6.7
1800	0.69	6.1	6.7
1812	0.72	6.1	6.7
1824	0.49	5.8	6.7
1836	0.49	5.8	6.8
1848	0.44	5.8	6.8
1900	0.44	5.9	6.8

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close

DATE OF THE STORM EVENT : 2nd. June 1984 (840602)

STORM NUMBER : 1

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
1648	510.0	180.0	712	28.4
1654	490.0	180.0	596	28.4
1700	550.0	210.0	587	35.5
1706	450.0	250.0	596	35.5
1712	480.0	260.0	512	28.4
1718	510.0	320.0	552	28.4
1736	500.0	280.0	512	24.8

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close

DATE OF THE STORM EVENT : 2nd. June 1984 (840602)

STORM NUMBER : I

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
1648	480.0	180.0	1312	24.8
1700	440.0	210.0	584	24.8
1712	460.0	210.0	910	24.8
1724	460.0	210.0	1032	35.5
1736	460.0	210.0	1079	35.5
1748	460.0	240.0	1082	35.5
1800	480.0	210.0	1014	35.5
1812	520.0	210.0	1712	28.4
1824	510.0	210.0	1782	28.4
1836	480.0	210.0	1484	*
1848	460.0	240.0	1089	*
1900	460.0	240.0	1060	*

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. June 1984 (840602)
STORM NUMBER : 1

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Temperature 'C
1648	1.2	2.7	17.0
1654	1.2	3.4	17.0
1700	1.4	3.4	17.0
1706	1.8	3.4	17.5
1712	2.4	3.7	17.5
1718	2.9	3.8	17.5
1736	1.9	3.4	17.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close

DATE OF THE STORM EVENT : 2nd. June 1984 (840602)

STORM NUMBER : 1

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Temperature 'C
1648	1.4	2.7	17.5
1700	1.7	2.9	17.5
1712	1.7	2.9	17.0
1724	1.2	3.3	18.0
1736	1.1	2.9	18.0
1748	1.2	2.9	18.0
1800	1.1	3.7	18.0
1812	1.2	3.4	18.0
1824	1.4	3.7	17.5
1836	1.2	4.1	17.5
1848	1.1	3.3	17.5
1900	0.9	3.3	17.5

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. June 1984 (840602)
STORM NUMBER : 1

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
1648	7.7	1.6	670.0	19.0
1654	6.8	1.9	650.0	19.0
1700	7.2	2.2	820.0	19.5
1706	7.2	1.9	870.0	20.0
1712	6.8	1.9	870.0	20.0
1718	7.2	1.9	870.0	20.0
1736	7.7	1.9	750.0	21.2

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. June 1984 (840602)
STORM NUMBER : I

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
1648	11.2	3.0	270.0	14.5
1700	10.0	2.9	270.0	14.0
1712	10.8	2.9	270.0	14.0
1724	11.2	2.9	230.0	11.8
1736	12.5	2.8	420.0	11.8
1748	13.5	2.9	460.0	11.8
1800	14.0	3.0	460.0	15.7
1812	14.0	2.8	480.0	15.7
1824	14.0	2.9	480.0	16.0
1836	12.5	2.9	480.0	16.0
1848	12.5	2.9	380.0	16.0
1900	12.5	2.9	380.0	16.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. June 1984 (840602)
STORM NUMBER : I

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Zn mgl-1	Pb mgl-1
1648	0.7	0.3
1654	0.6	0.3
1700	0.9	0.3
1706	1.0	0.3
1712	1.0	0.4
1718	1.1	0.3
1736	1.1	0.0

****

* RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM *

*

* CATCHMENT : Tame Close *

* DATE OF THE STORM EVENT : 2nd. June 1984 (840602) *

* STORM NUMBER : I *

*

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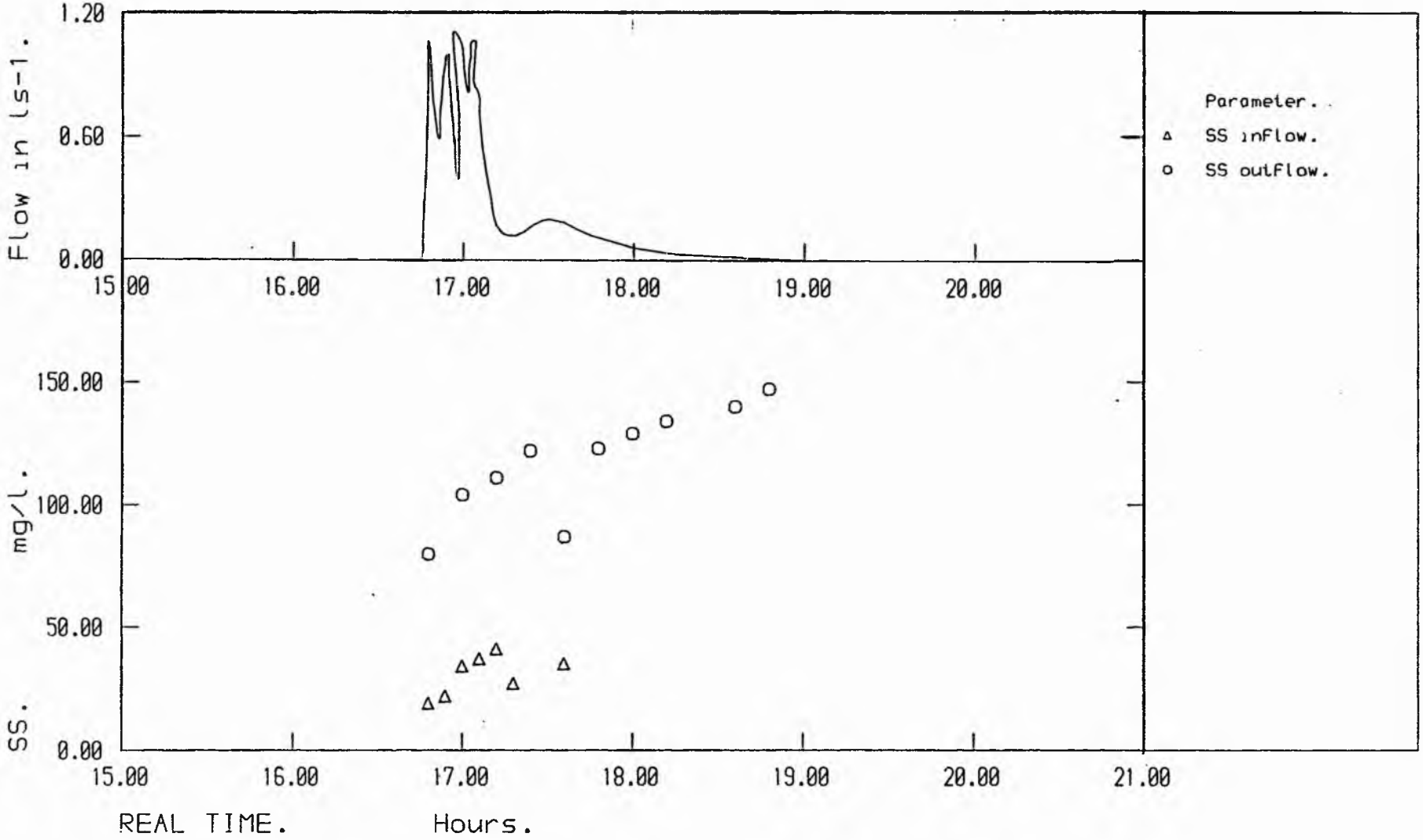
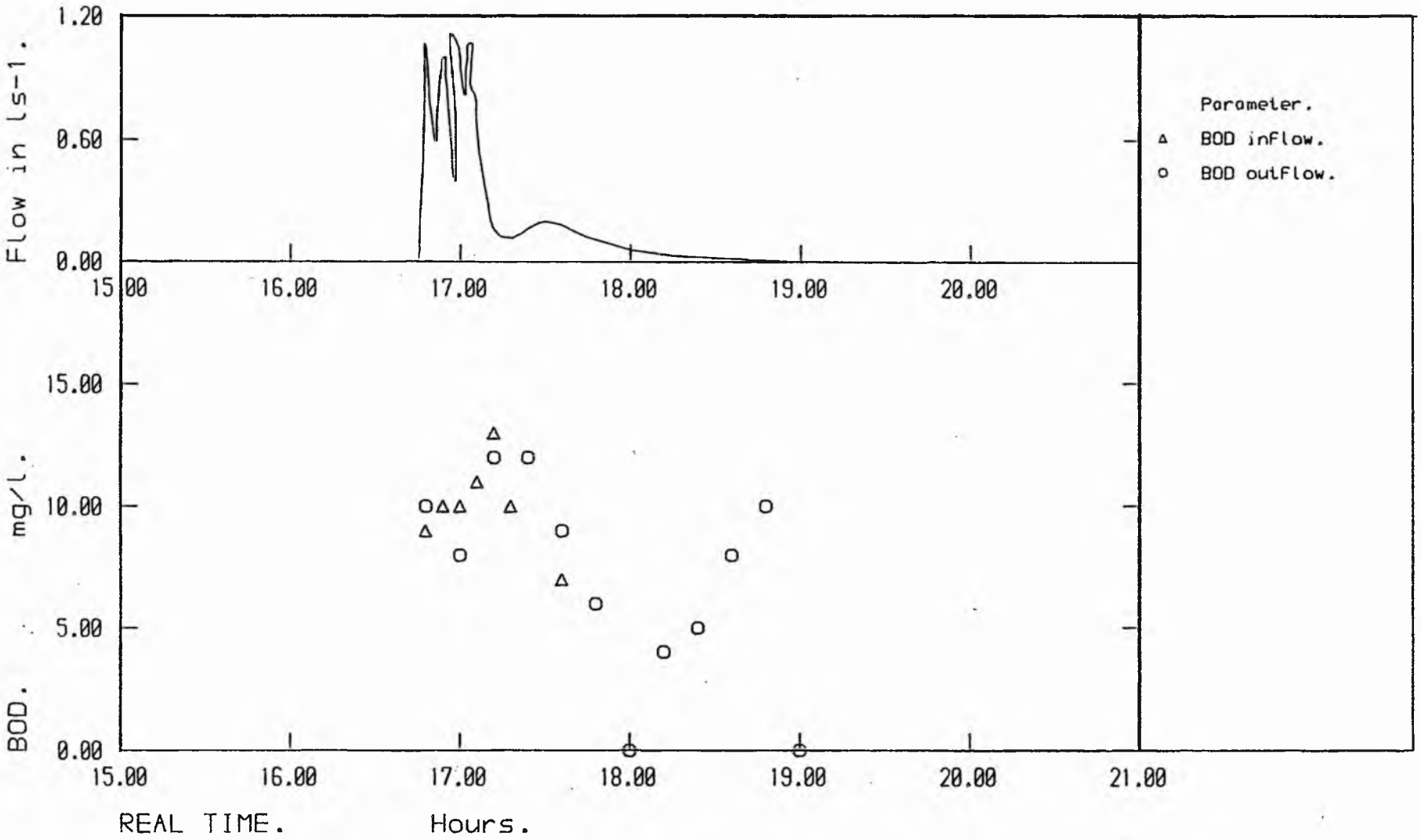
* ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT *

****

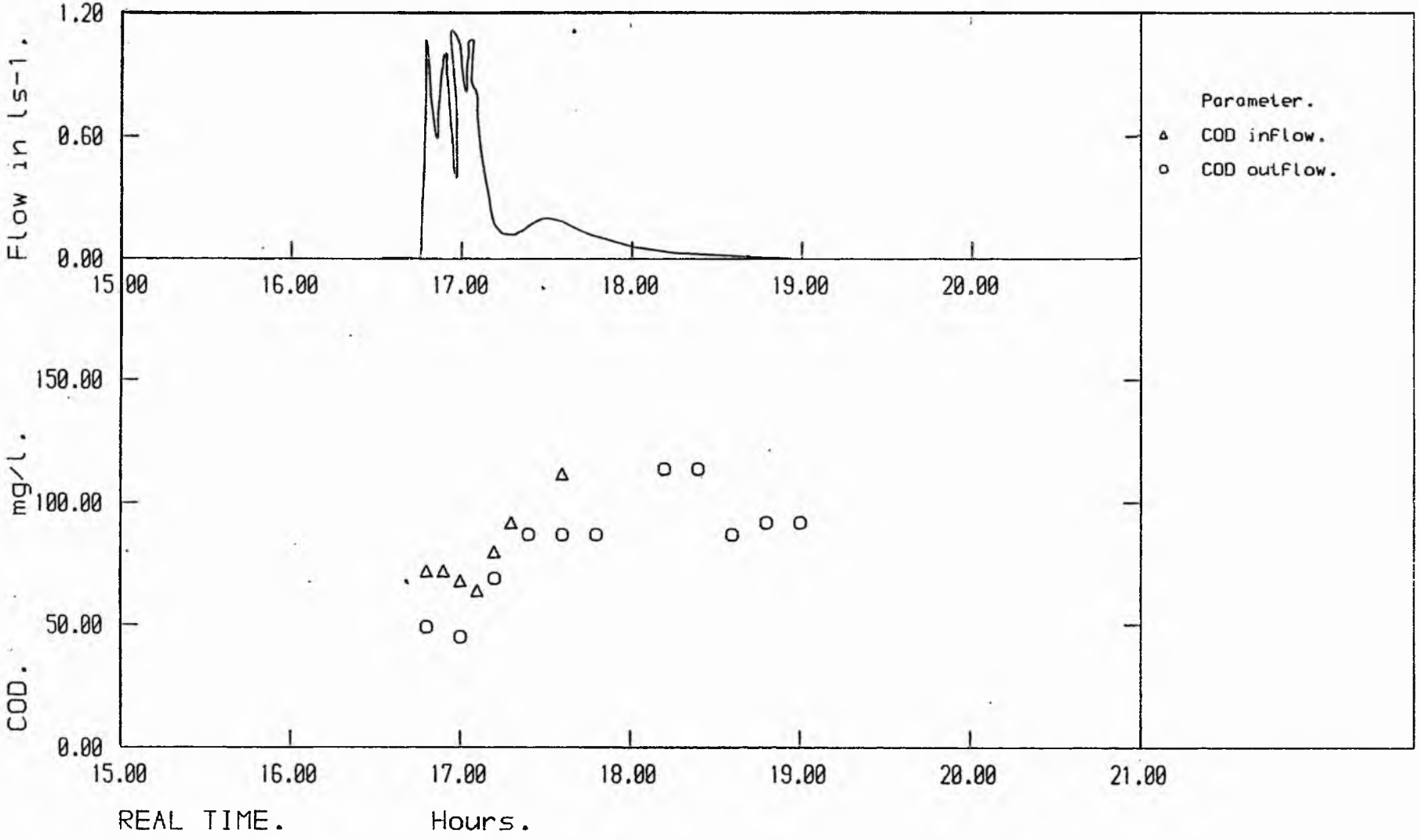
REAL TIME Hours	Zn mg l-1	Pb mg l-1	Fe mg l-1
1648	1.2	0.1	0.0
1700	0.9	0.2	0.0
1712	0.9	0.2	0.0
1724	0.9	0.0	0.0
1736	1.0	0.0	0.0
1748	1.0	0.0	0.0
1800	1.0	0.2	0.0
1812	1.4	0.2	0.9
1824	1.6	0.2	1.1
1836	1.6	0.0	1.1
1848	1.2	0.0	0.0
1900	1.2	0.0	0.0



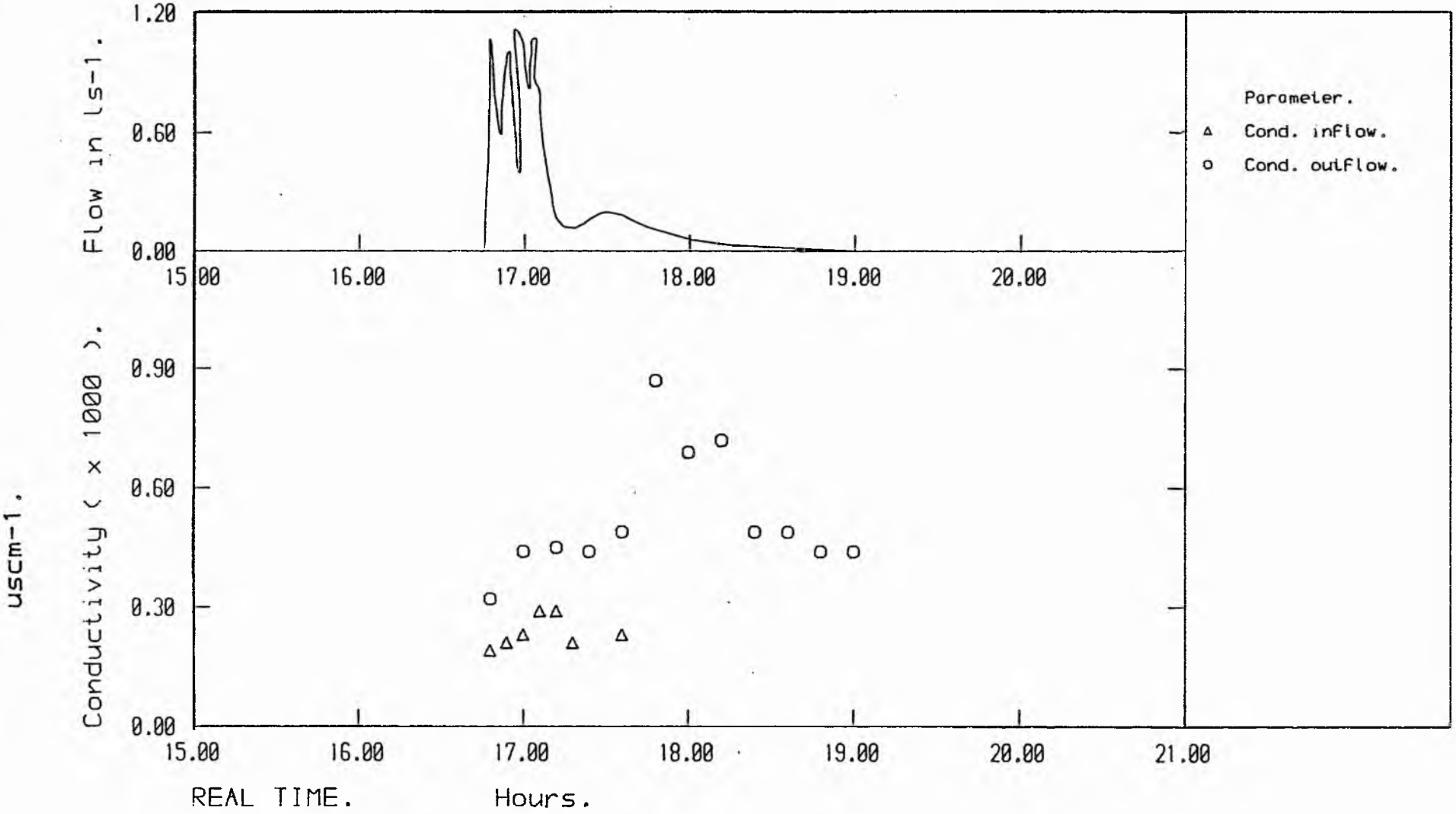
Graph of Suspended Solids for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



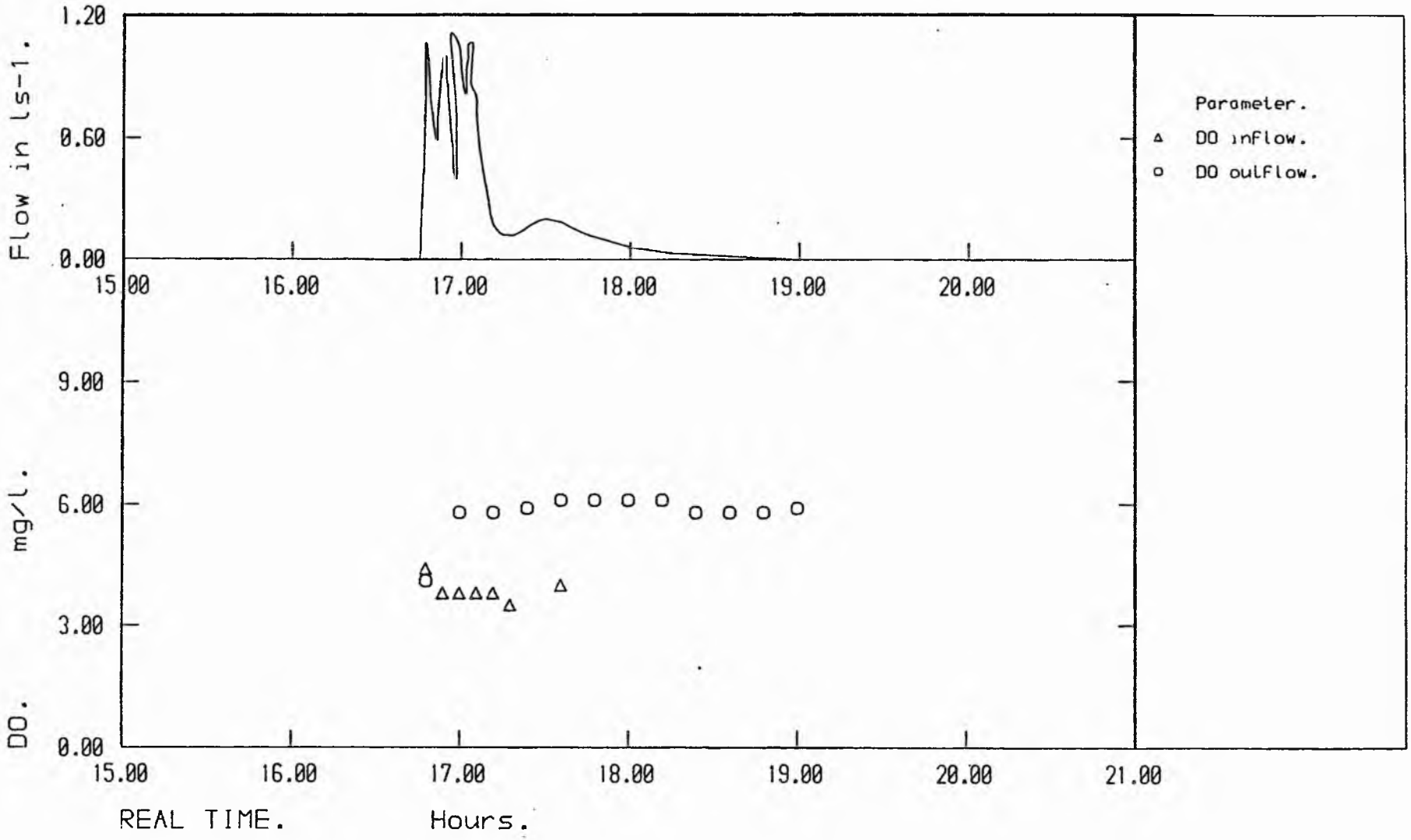
Graph of Biochemical Oxygen Demand For Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



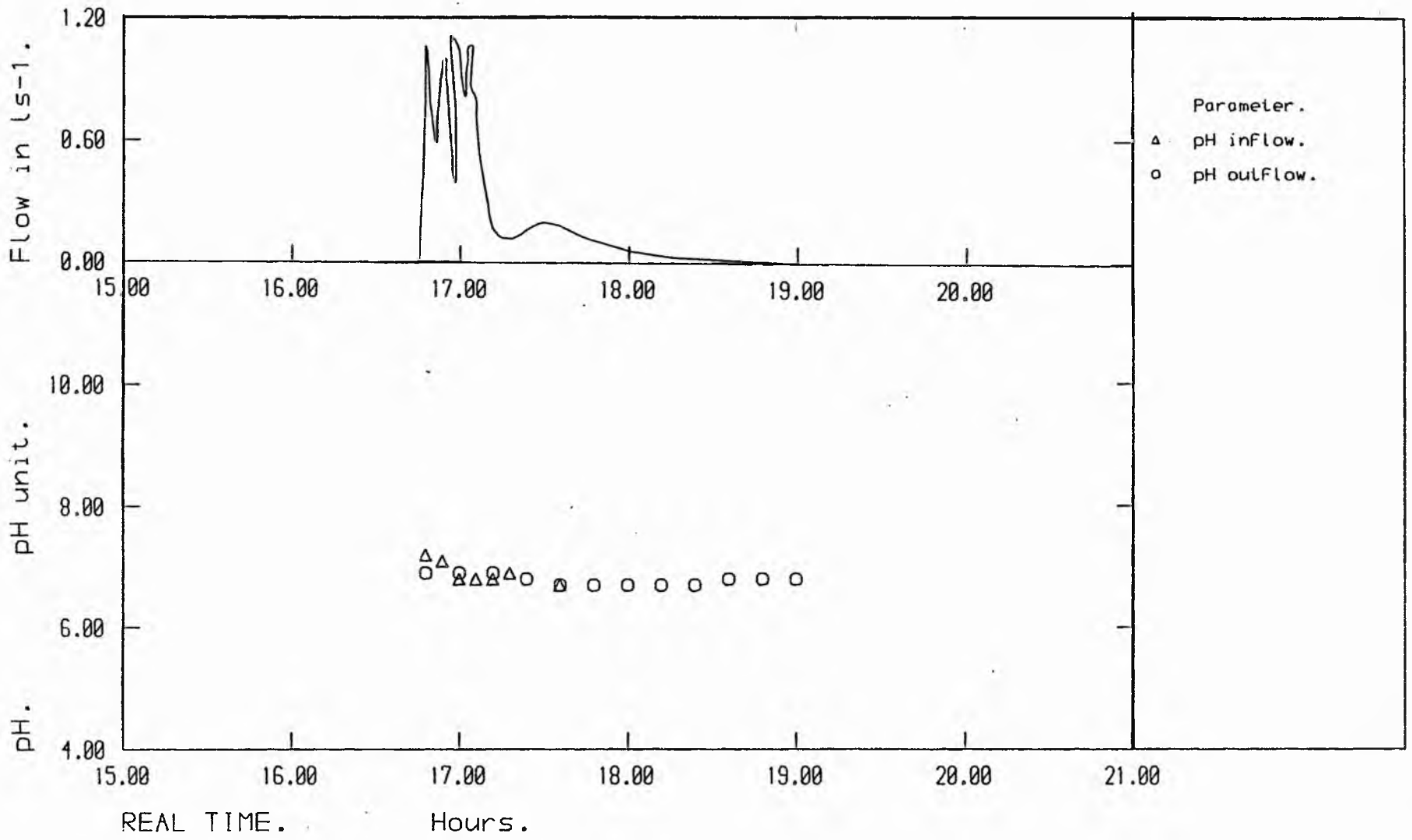
Graph of Chemical Oxygen Demand for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



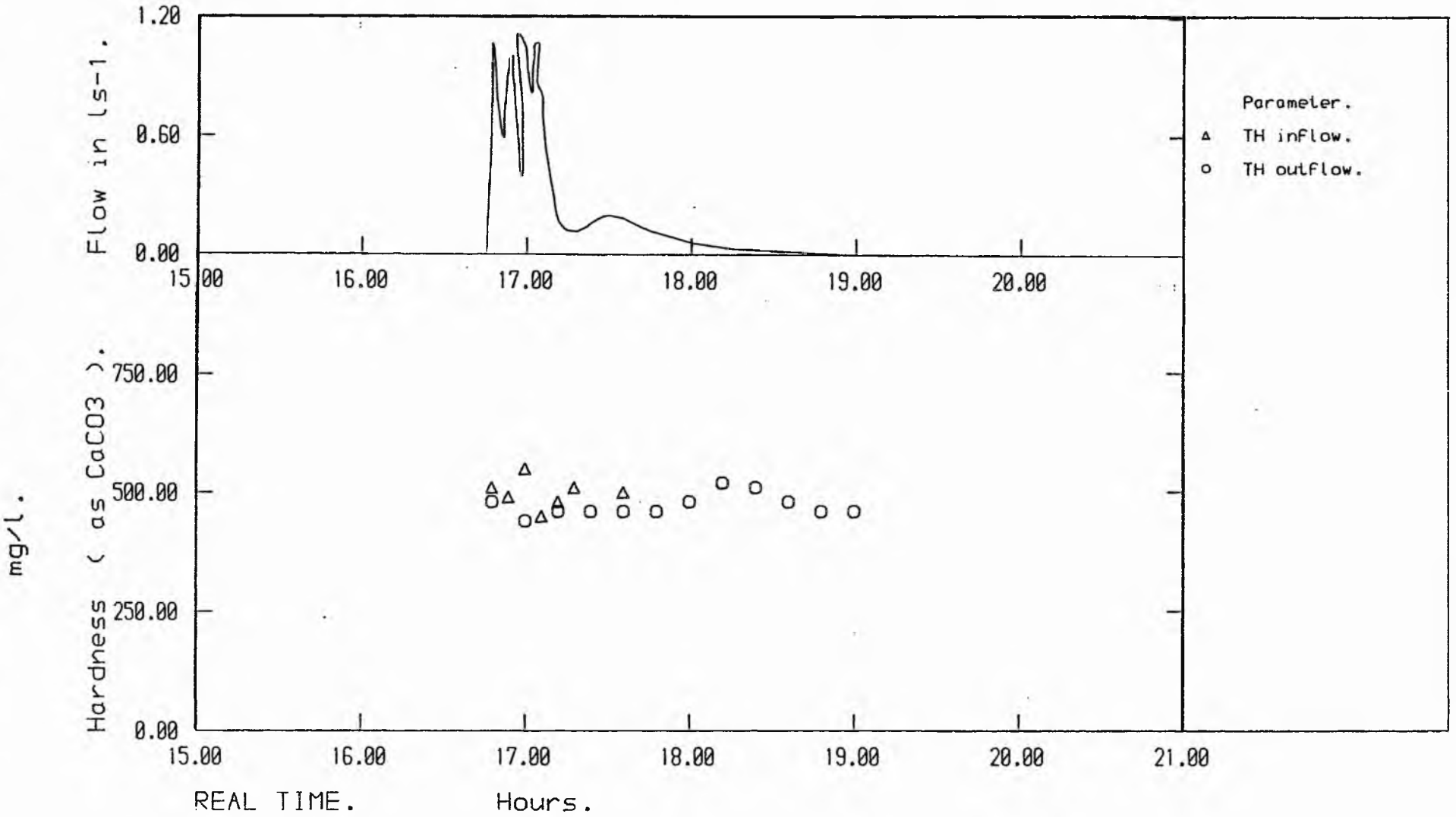
Graph of Conductivity for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



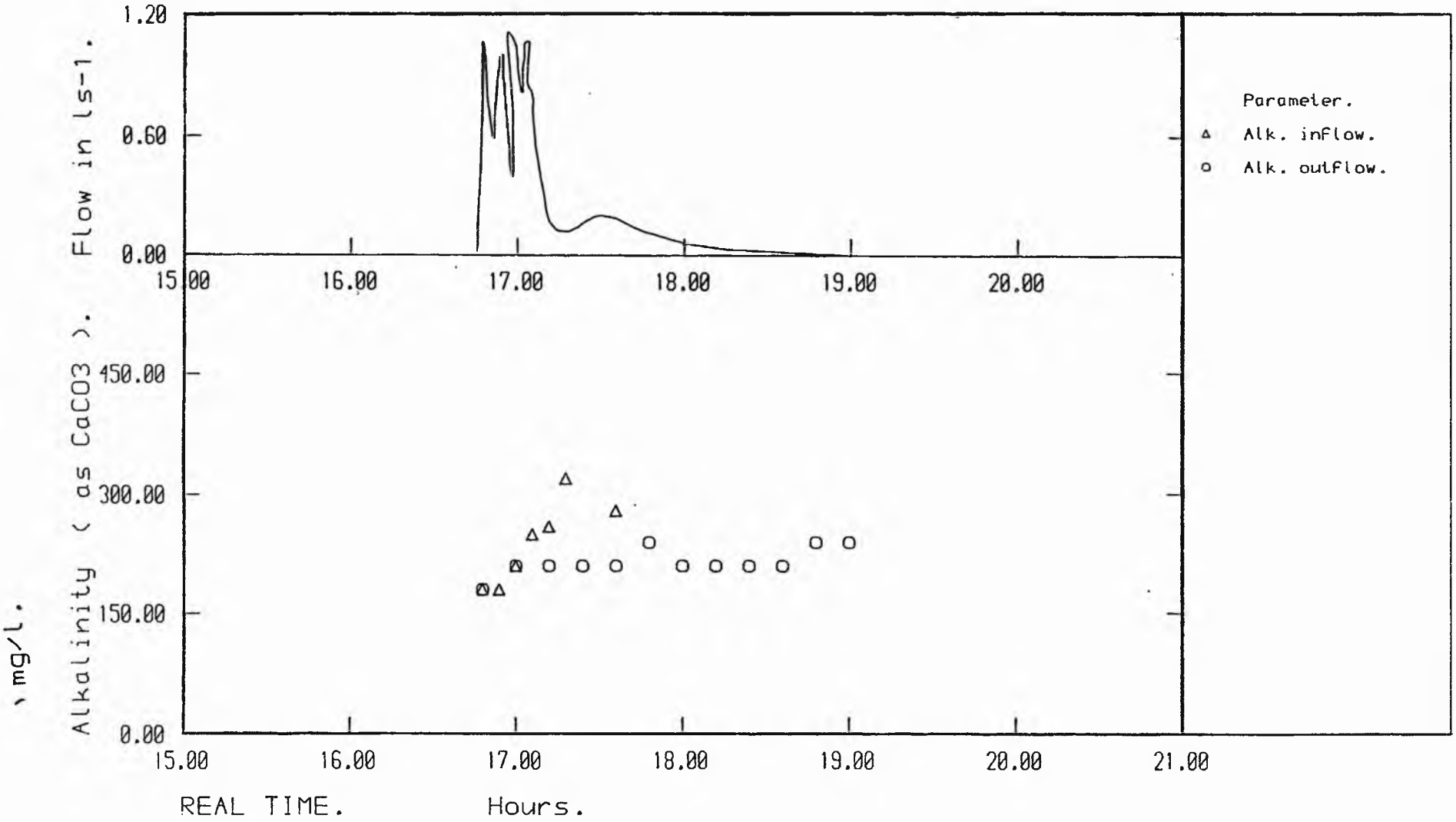
Graph of Dissolved Oxygen for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



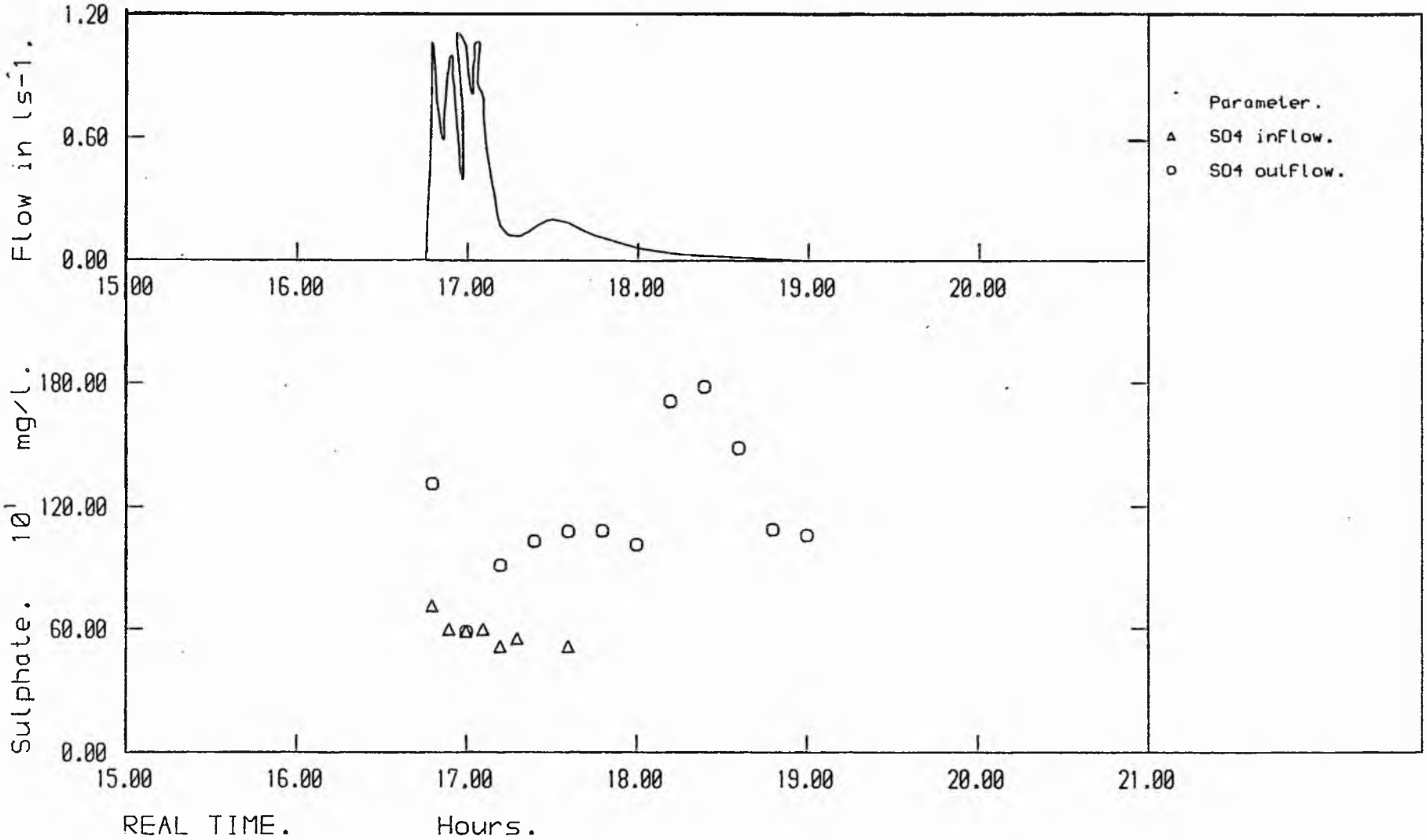
Graph of pH for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



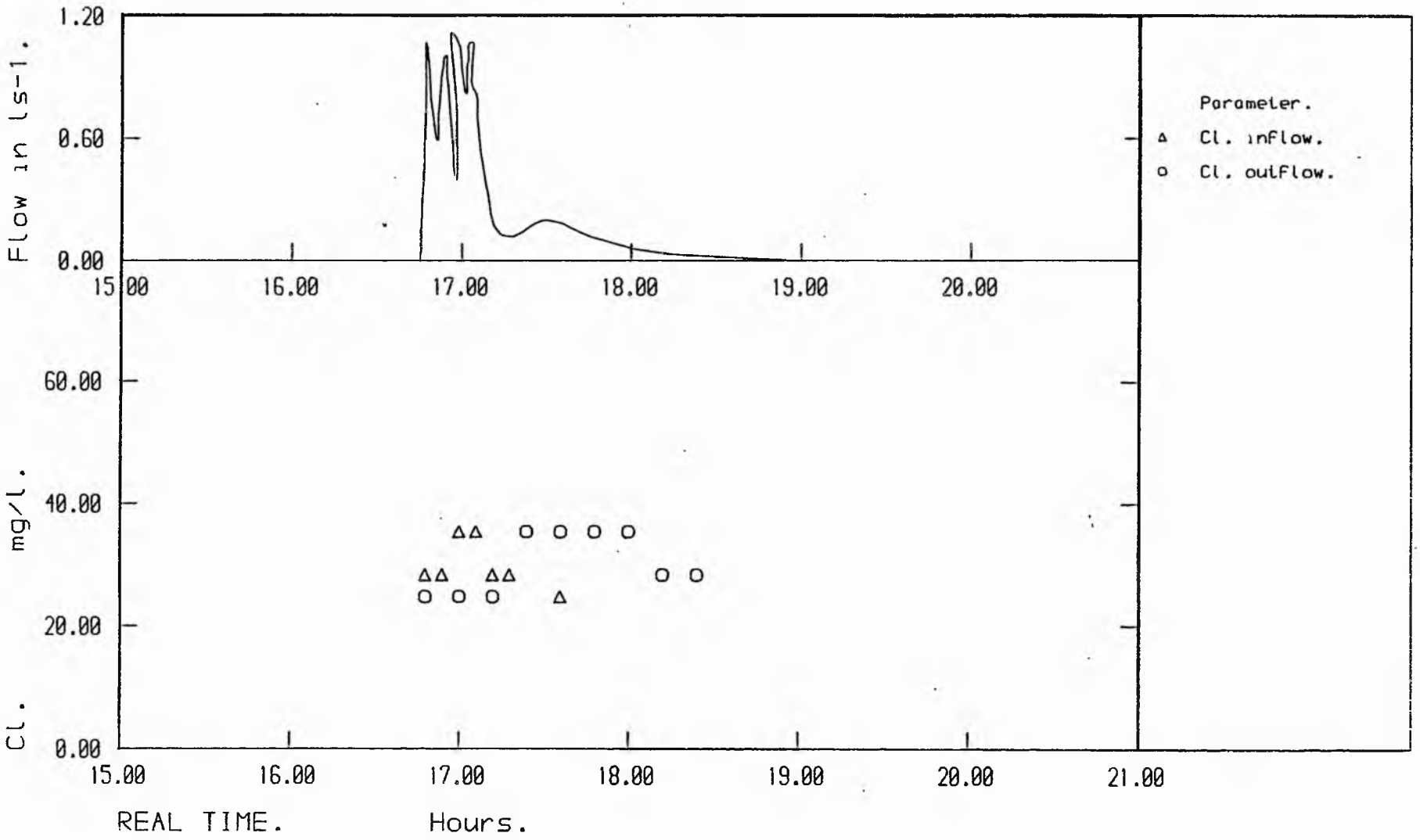
Graph of Total Hardness for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



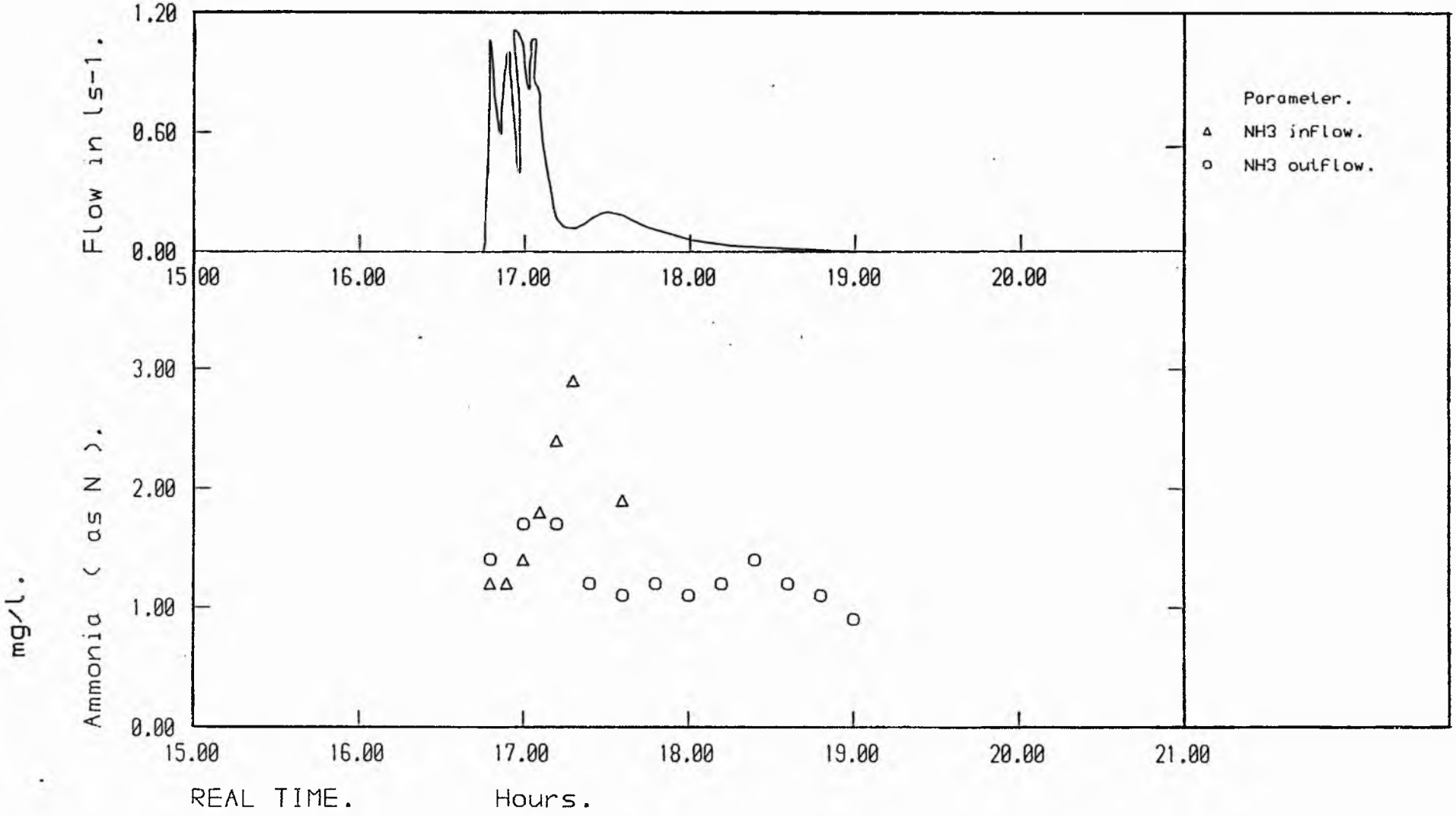
Graph of Total Alkalinity for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



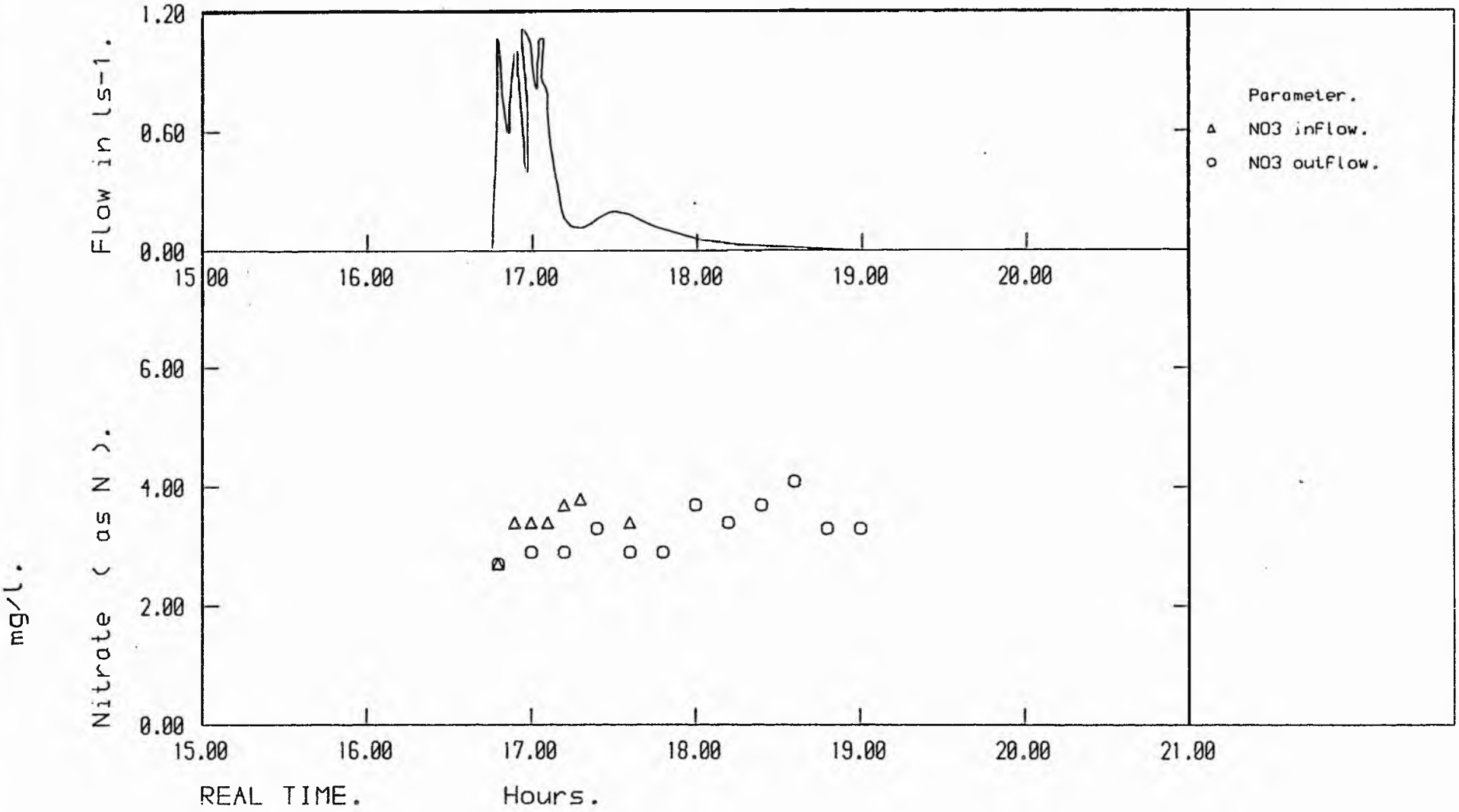
Graph of Sulphate for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



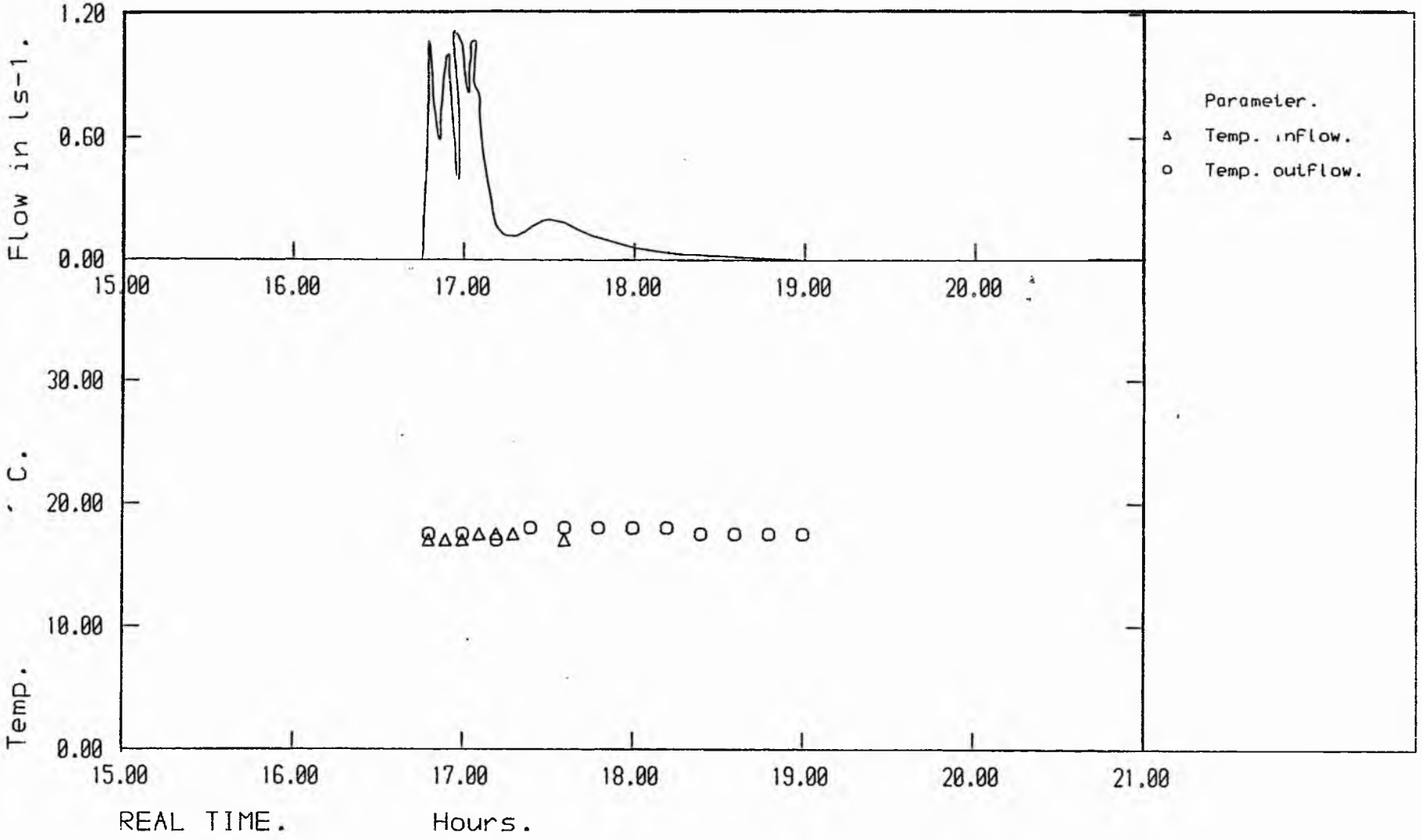
Graph of Chloride for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



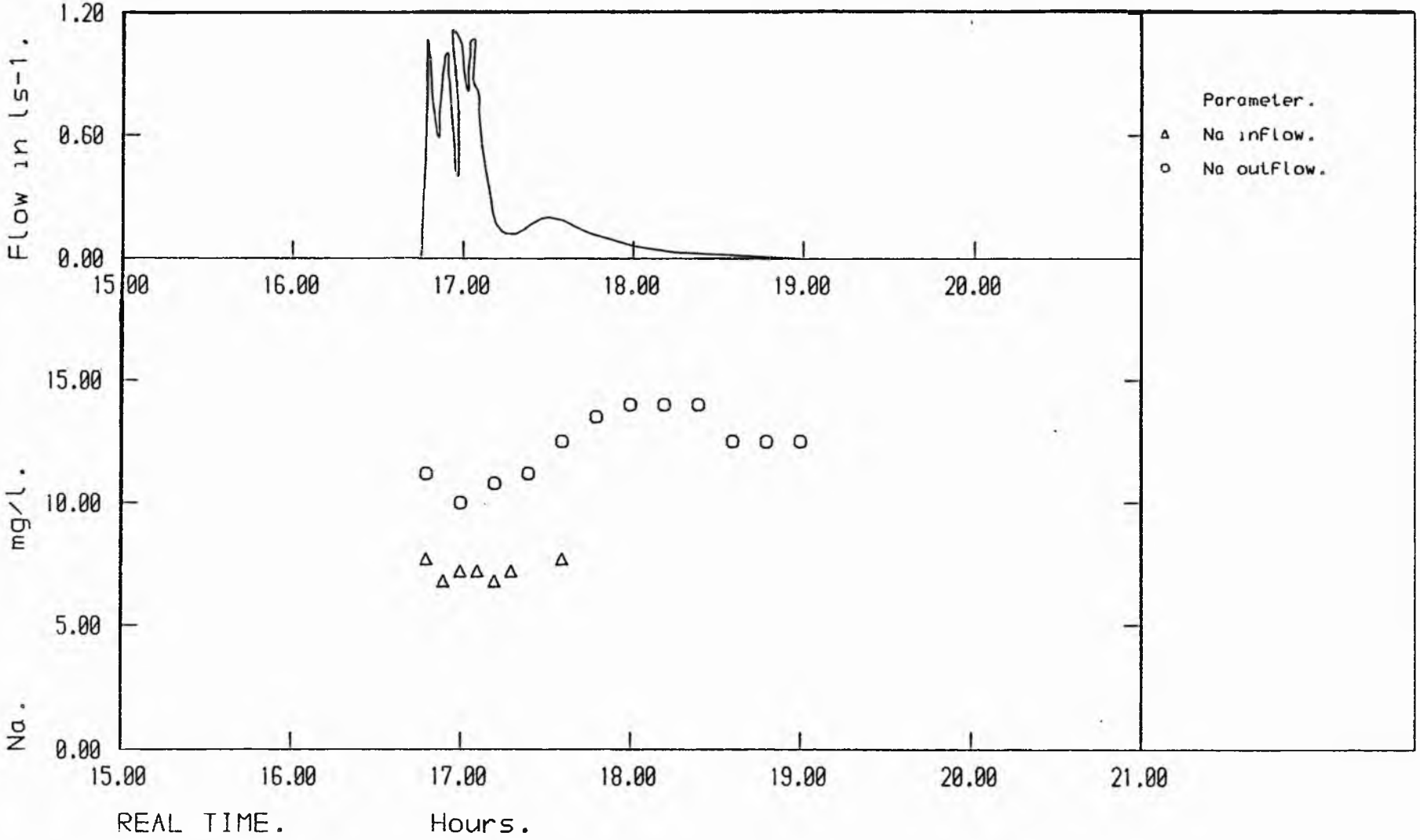
Graph of Ammonia for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



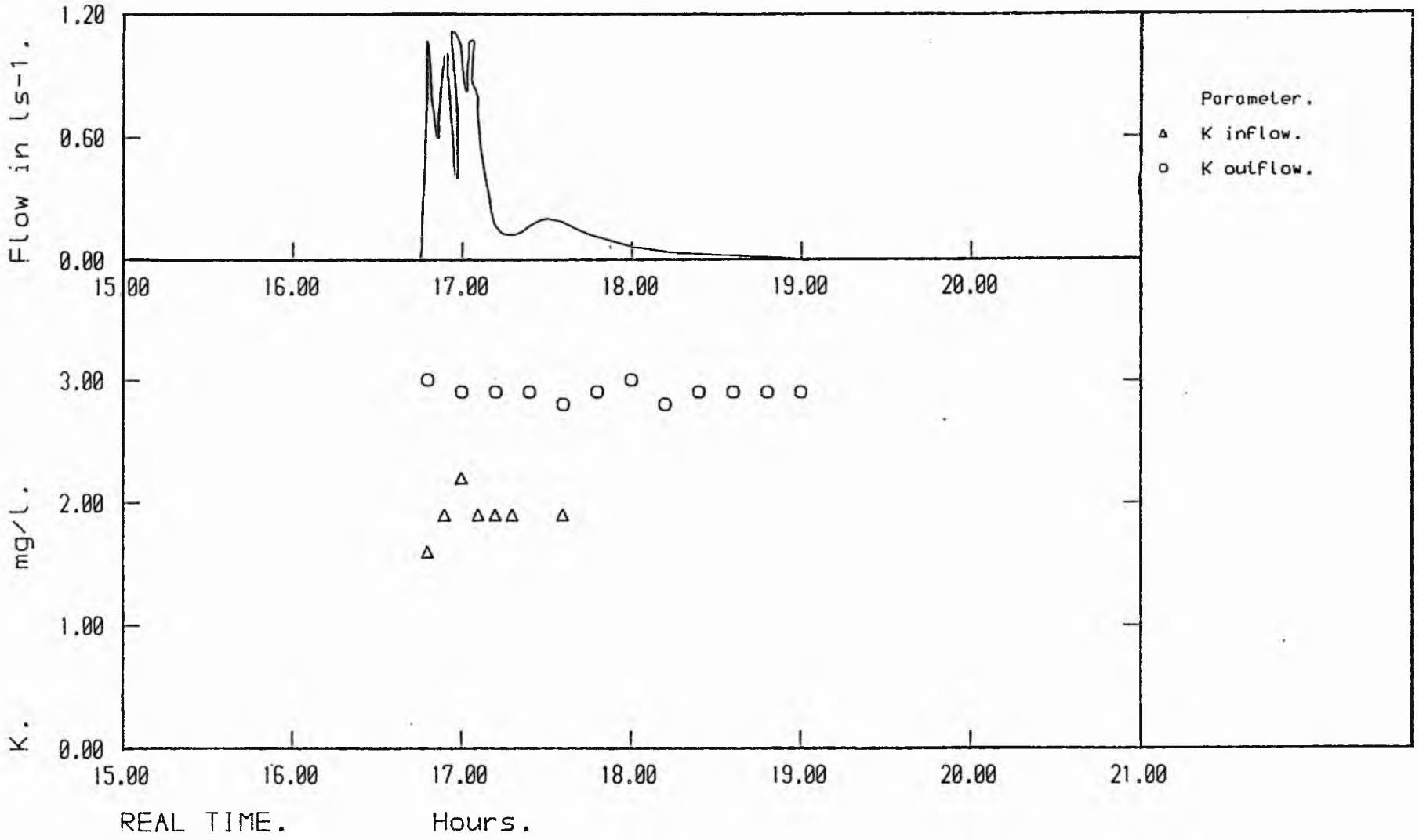
Graph of Nitrate for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



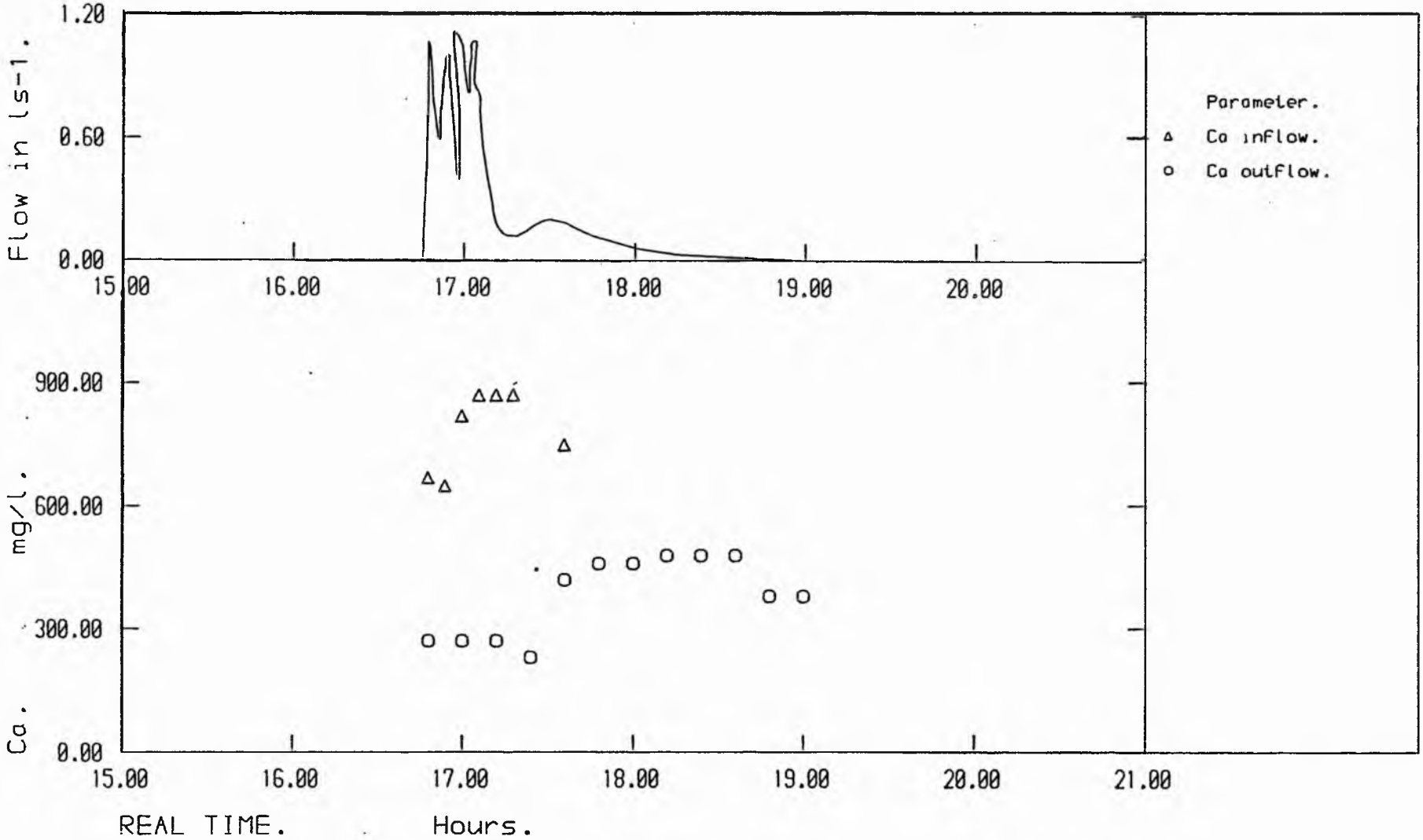
Graph of Liquor Temperature For Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



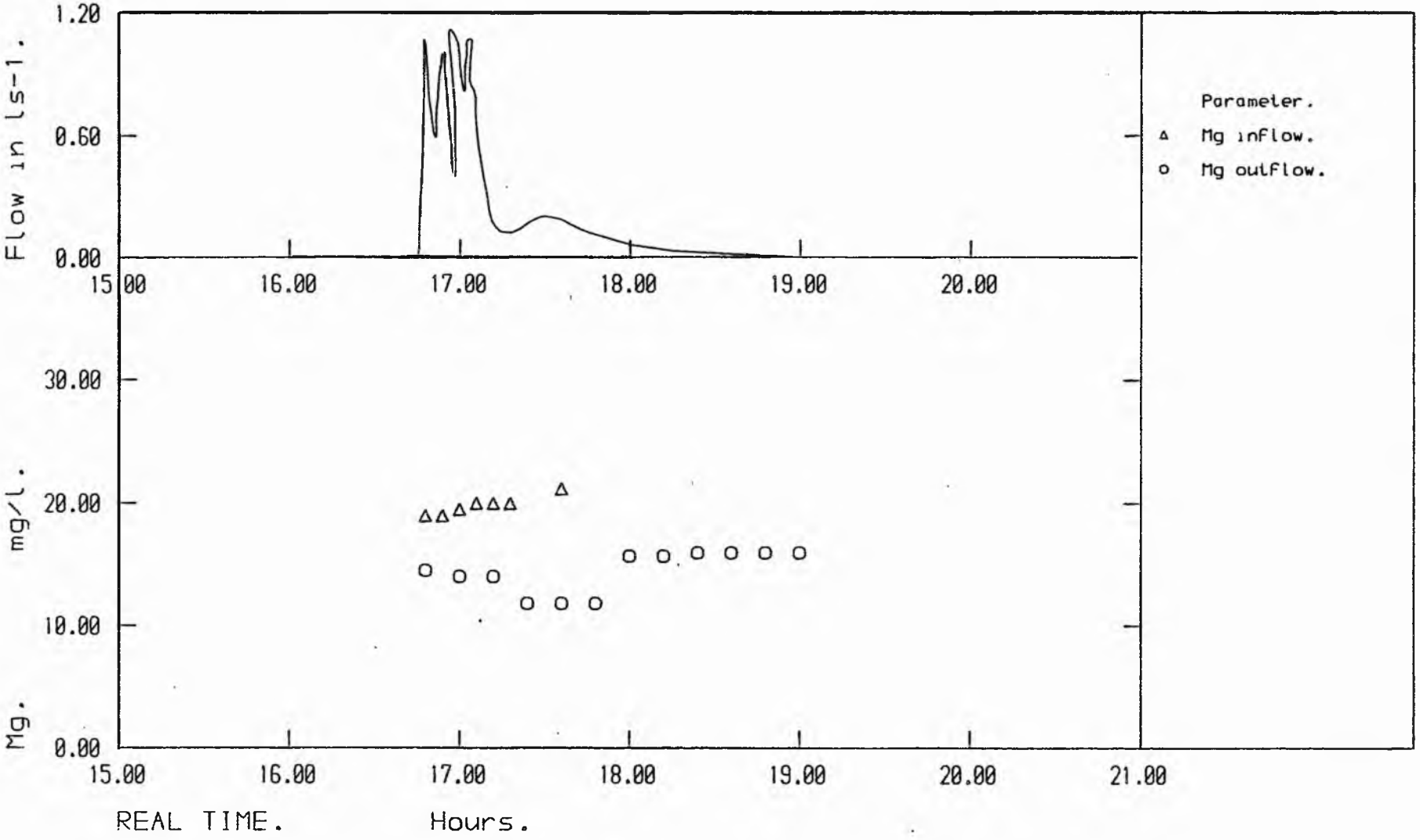
Graph of Sodium for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



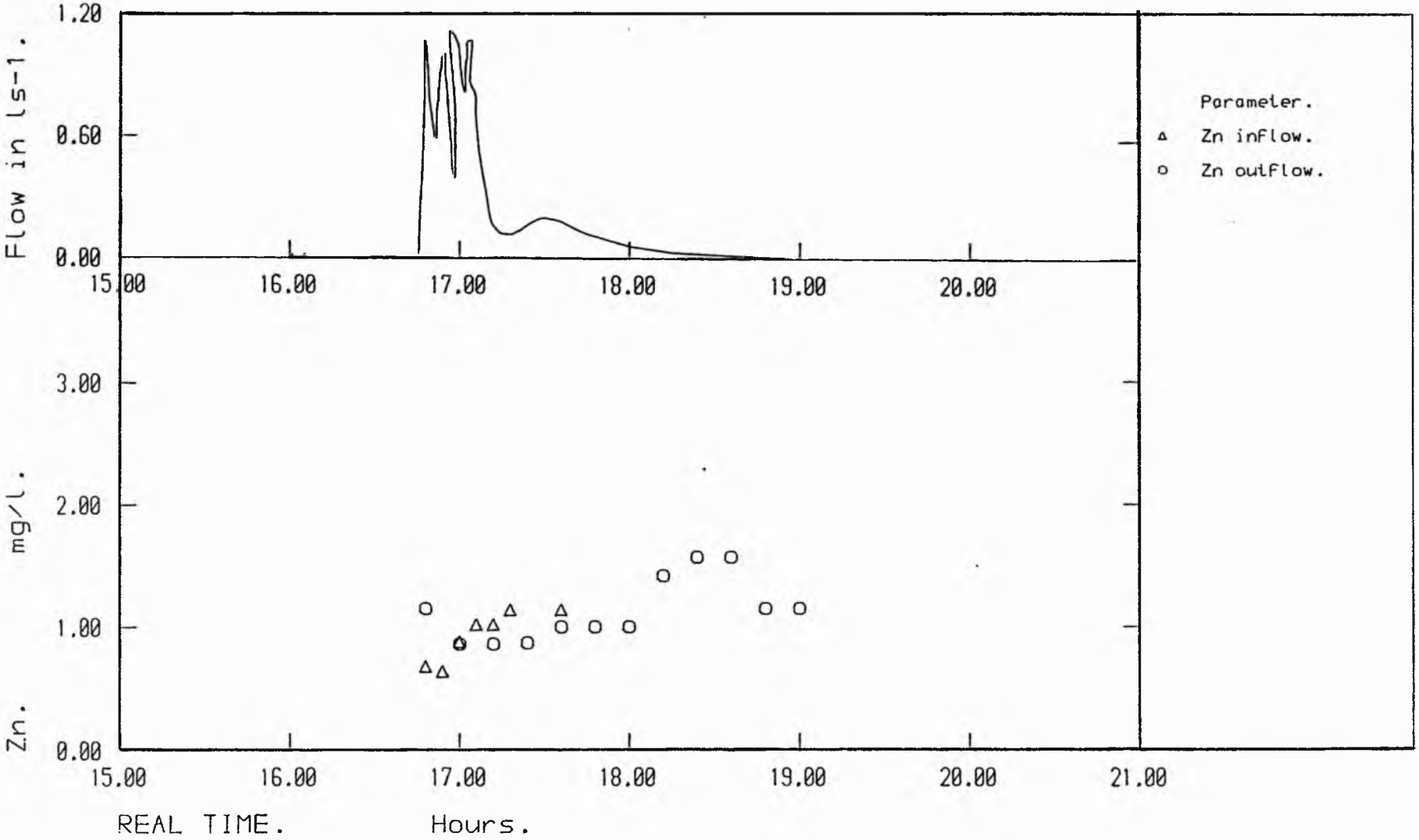
Graph of Potassium for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



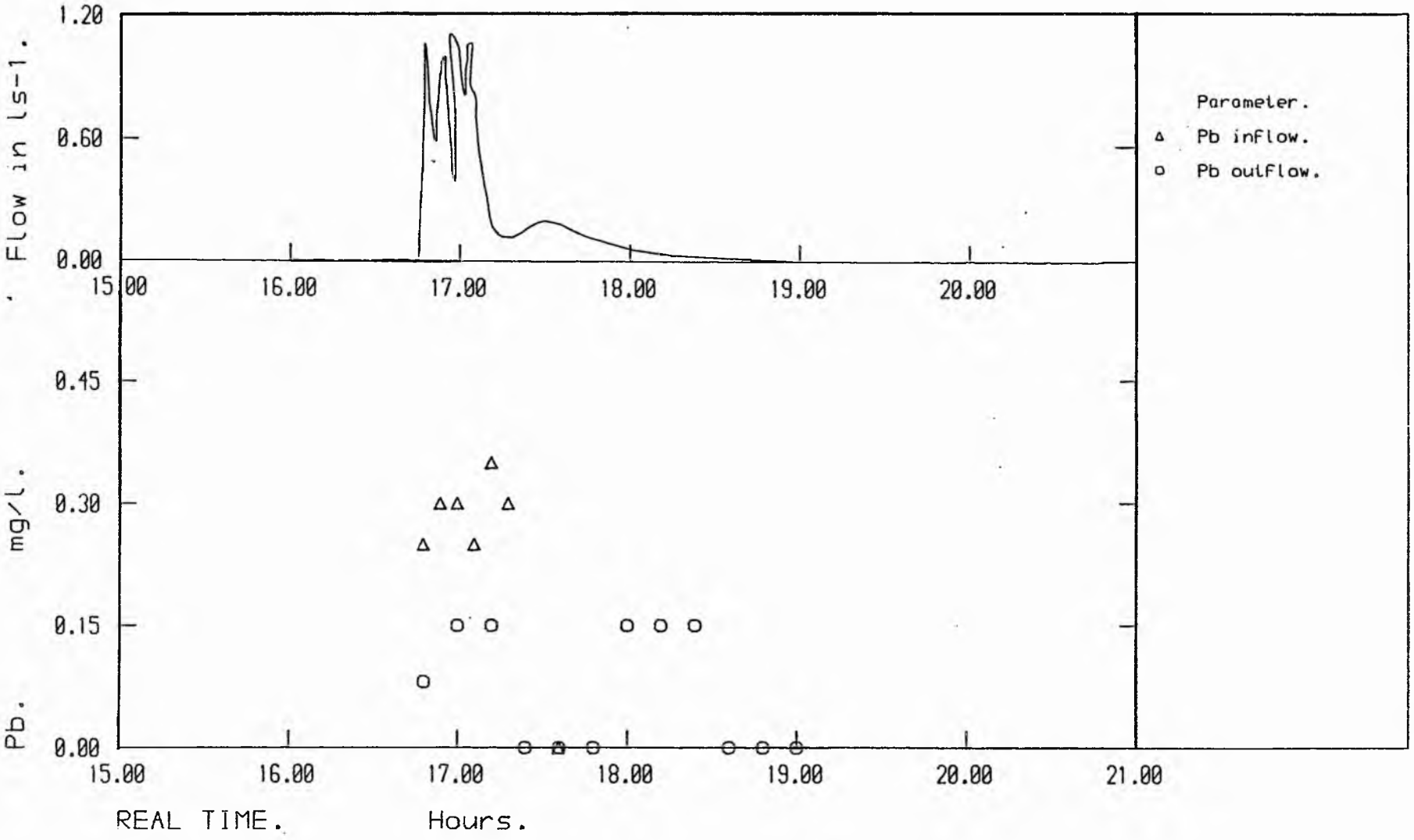
Graph of Calcium for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



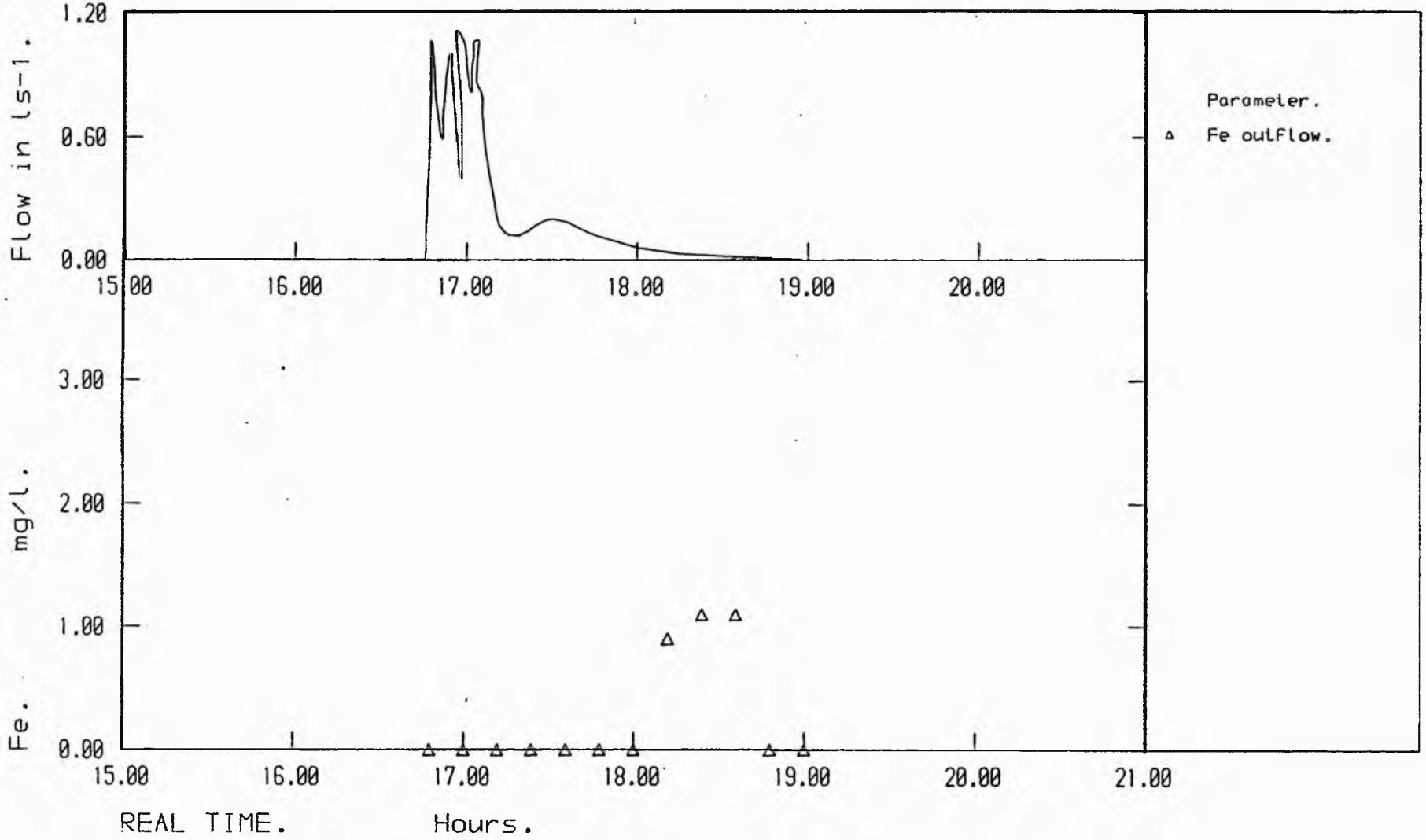
Graph of Magnesium for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Lead for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Iron for Storm I on Tame Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. June 1984 (840602)
STORM NUMBER : 1

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	SS mg]-1	BOD mg]-1	COD mg]-1
1648	59	20	87
1654	111	18	90
1700	89	22	112
1706	94	21	231
1712	98	24	147
1718	105	23	122
1736	90	26	108
1812	77	22	103
1830	71	22	109
1906	82	26	103

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. June 1984 (840602)
STORM NUMBER : 1

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
1648	59	20	74
1700	61	19	54
1712	69	19	83
1724	79	20	112
1736	135	23	135
1748	152	26	172
1800	231	26	155
1812	201	24	173
1824	175	23	173
1836	175	25	83
1848	110	26	74
1900	110	26	74

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. June 1984 (840602)
STORM NUMBER : I

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
1648	0.64	4.4	6.9
1654	0.53	4.0	6.9
1700	0.51	3.8	6.7
1706	0.54	3.7	6.8
1712	0.53	4.7	6.8
1718	0.64	4.8	6.9
1736	0.82	5.0	7.0
1812	0.80	4.8	7.3
1830	0.62	4.8	7.2
1906	0.64	4.8	7.1

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. June 1984 (840602)
STORM NUMBER : 1

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
1648	0.82	4.9	6.8
1700	0.82	5.2	7.0
1712	0.90	5.7	7.2
1724	0.88	5.7	7.2
1736	0.87	5.8	7.2
1748	1.23	5.8	7.1
1800	2.57	5.9	7.1
1812	2.64	5.9	6.8
1824	1.84	6.7	6.6
1836	1.84	6.7	6.6
1848	1.72	6.0	6.6
1900	1.71	6.2	6.6

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. June 1984 (840602)
STORM NUMBER : 1

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
1648	400.0	230.0	760.3	25.5
1654	400.0	410.0	728.4	33.4
1700	510.0	430.0	810.1	37.2
1706	530.0	470.0	836.1	31.2
1712	520.0	410.0	928.3	25.5
1718	530.0	380.0	887.7	25.5
1736	500.0	370.0	1013.4	24.8
1812	480.0	350.0	1063.0	24.8
1830	400.0	350.0	874.1	28.4
1906	400.0	310.0	831.5	28.4

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. June 1984 (840602)
STORM NUMBER : I

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
1648	270.0	110.0	474.2	24.8
1700	310.0	110.0	518.7	24.8
1712	330.0	120.0	534.7	24.8
1724	430.0	120.0	512.9	28.4
1736	490.0	110.0	515.7	28.4
1748	490.0	140.0	512.9	28.4
1800	550.0	170.0	714.7	35.5
1812	310.0	210.0	791.5	35.5
1824	390.0	110.0	*	51.2
1836	390.0	110.0	*	51.2
1848	390.0	140.0	*	35.5
1900	390.0	150.0	*	35.5

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. June 1984 (840602)
STORM NUMBER : 1

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Temperature 'C
1648	0.8	2.7	15.5
1654	0.8	2.9	15.5
1700	0.6	2.9	15.5
1706	0.7	3.3	16.0
1712	0.7	6.4	16.0
1718	0.6	6.1	16.0
1736	1.1	6.4	15.5
1812	1.3	6.1	15.5
1830	0.8	6.1	16.0
1906	0.6	0.5	15.5

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. June 1984 (840602)
STORM NUMBER : 1

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Fe mgl-1
1648	1.1	4.1	0.0
1700	1.2	2.3	0.0
1712	1.2	2.1	0.0
1724	1.2	2.3	0.1
1736	1.1	2.3	0.3
1748	1.1	2.4	0.0
1800	0.9	2.4	0.0
1812	1.4	2.3	0.0
1824	0.9	3.0	0.0
1836	0.9	2.4	0.0
1848	1.2	2.4	0.0
1900	1.1	2.4	0.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. June 1984 (840602)
STORM NUMBER : 1

ANALYSIS OF INFLOW WATER TO THE GULLY POT

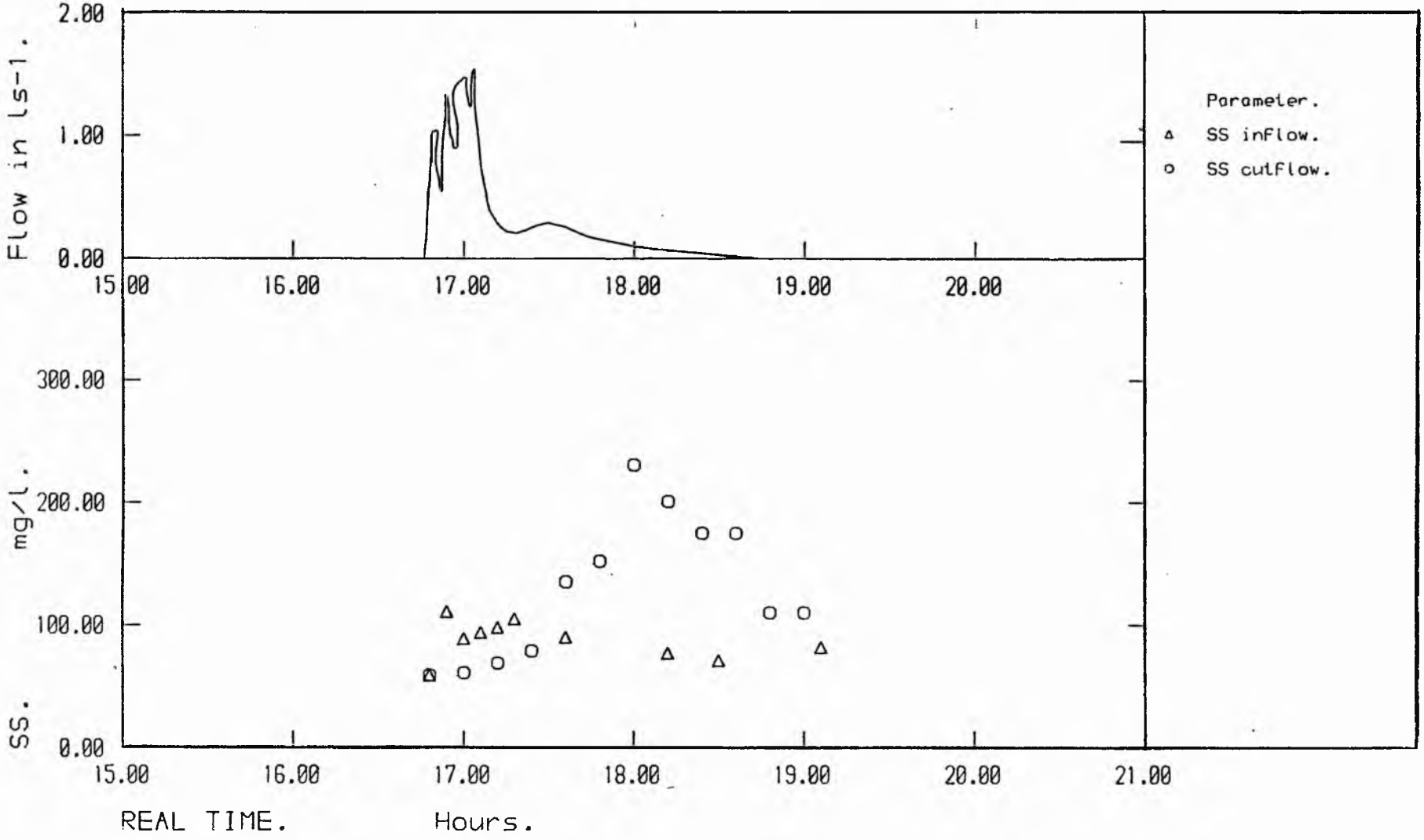
REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
1648	12.1	1.6	200.0	16.5
1654	12.5	1.8	220.0	16.5
1700	12.5	1.6	330.0	16.5
1706	12.1	1.6	330.0	17.5
1712	13.0	1.6	290.0	18.0
1718	13.7	1.6	280.0	18.0
1736	14.2	2.0	440.0	19.5
1812	14.2	1.9	400.0	22.0
1830	14.5	1.9	380.0	22.0
1906	14.2	1.9	380.0	22.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

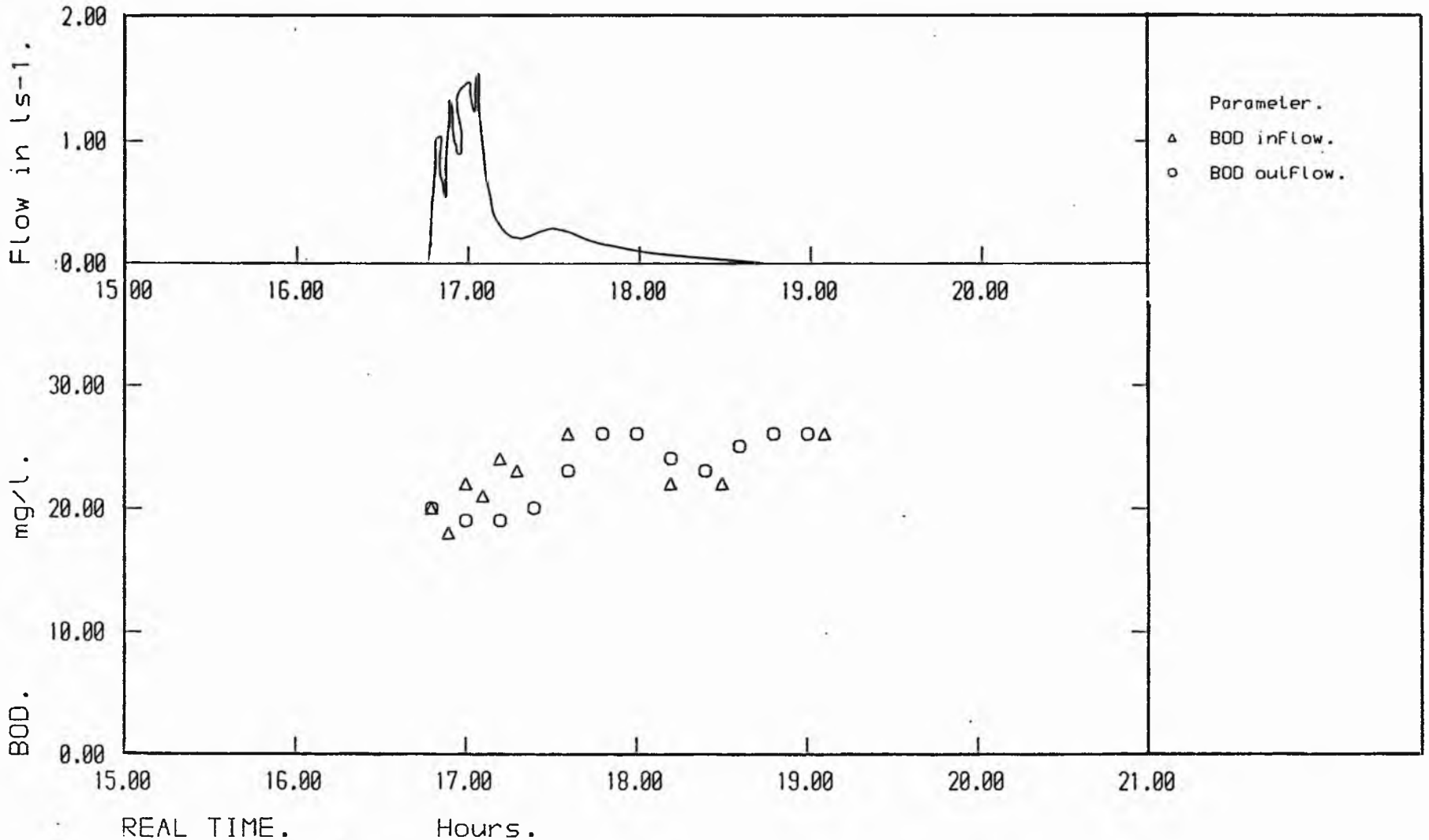
CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. June 1984 (840602)
STORM NUMBER : I

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

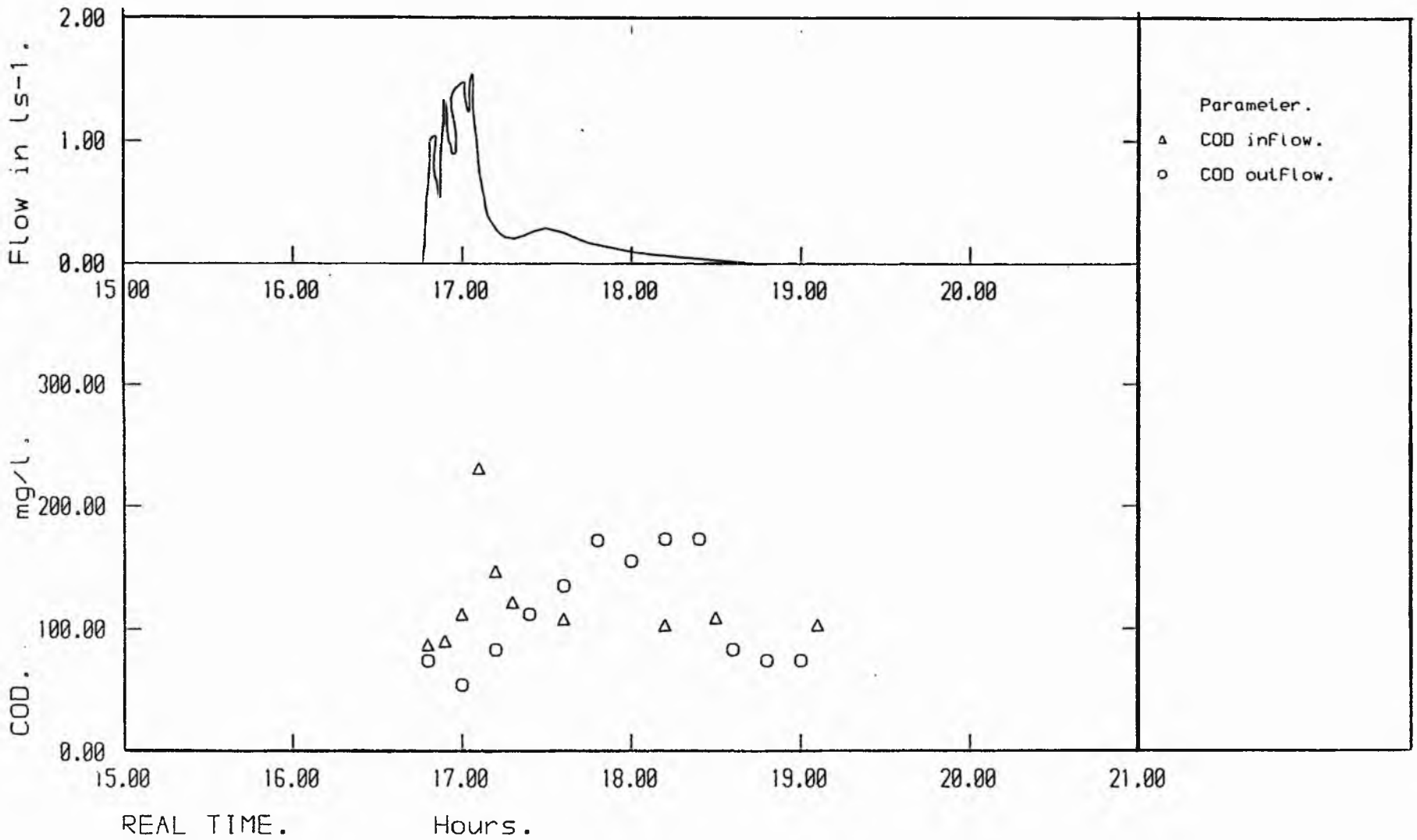
REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
1648	8.1	1.6	140.0	18.0
1700	8.5	1.6	120.0	15.7
1712	8.7	1.7	120.0	15.7
1724	8.7	1.8	100.0	18.0
1736	9.0	1.8	120.0	24.0
1748	12.0	1.9	100.0	24.1
1800	13.5	1.9	100.0	22.0
1812	14.0	1.9	80.0	22.0
1824	14.0	1.7	80.0	19.5
1836	14.0	1.7	170.0	18.0
1848	14.0	1.7	200.0	18.0
1900	13.5	1.6	200.0	18.0



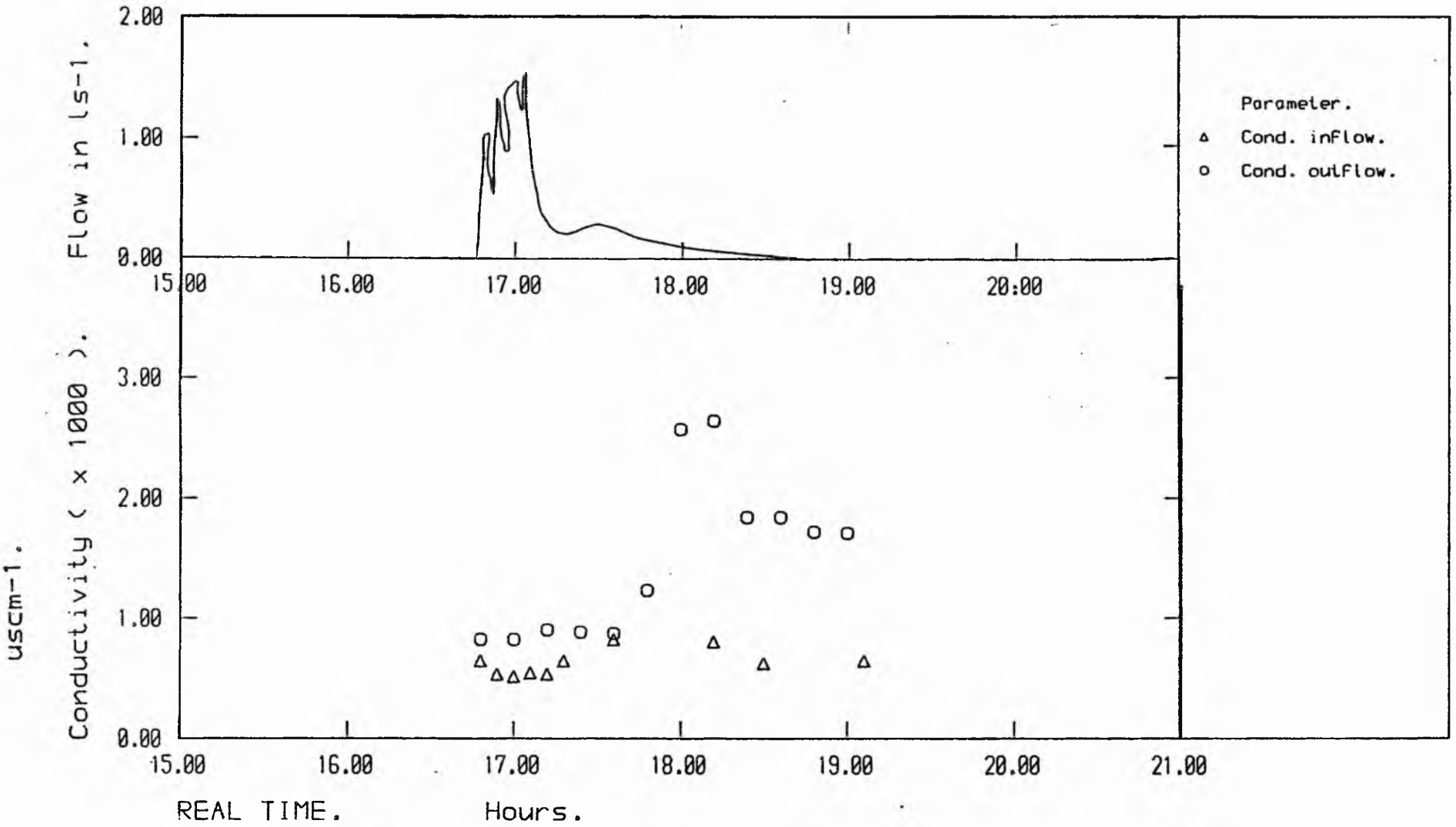
Graph of Suspended Solids for Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



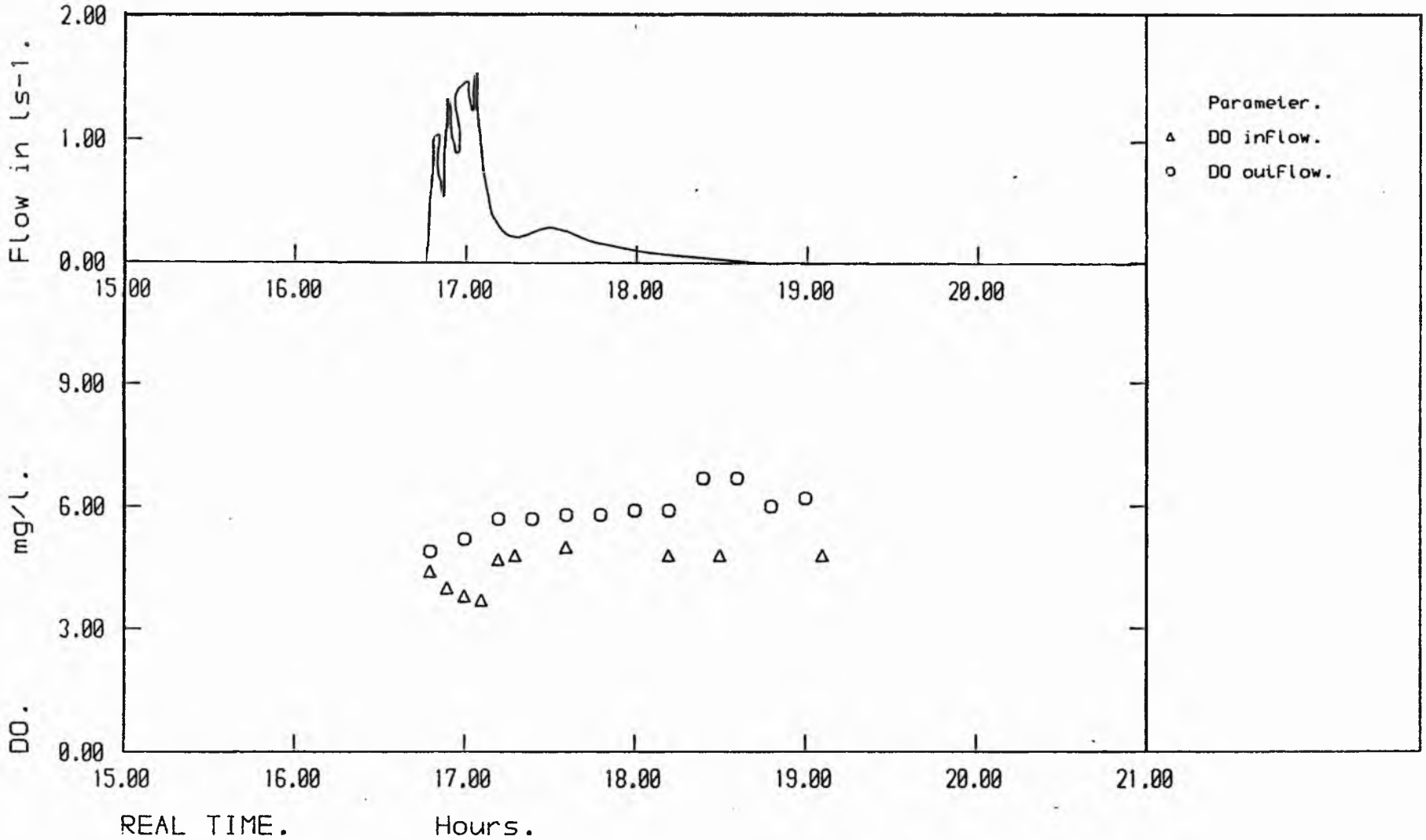
Graph of Biochemical Oxygen Demand for Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



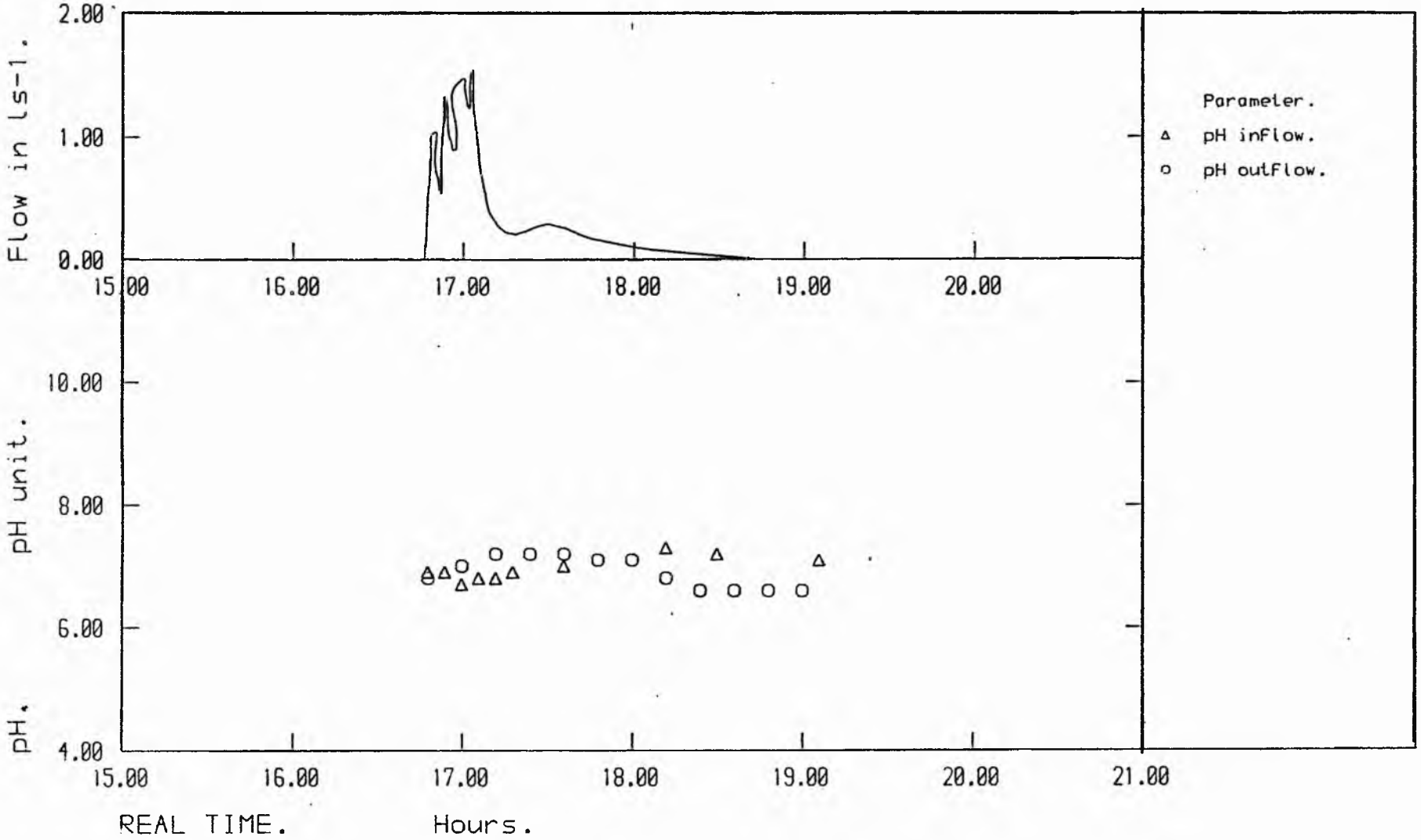
Graph of Chemical Oxygen Demand for Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



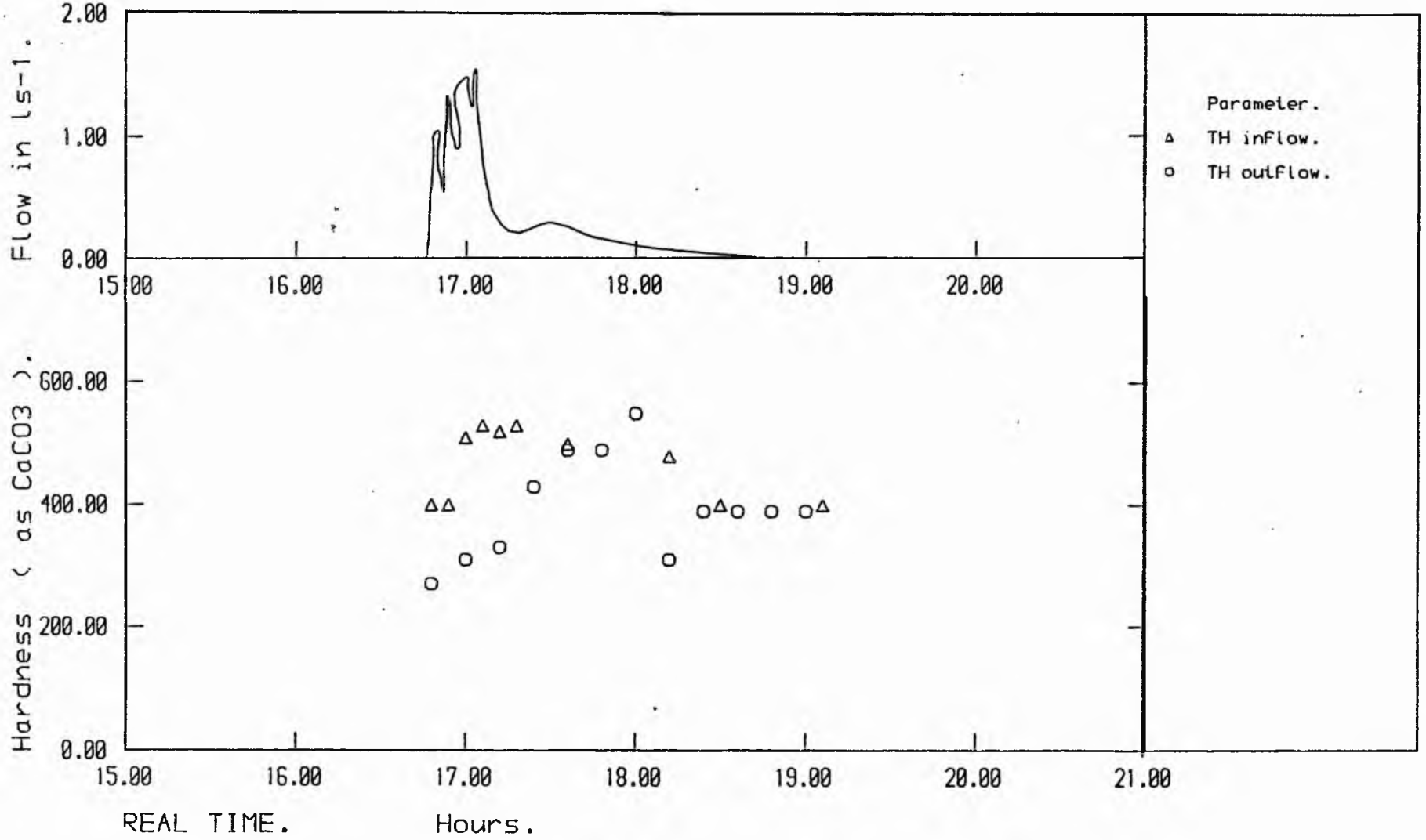
Graph of Conductivity for Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



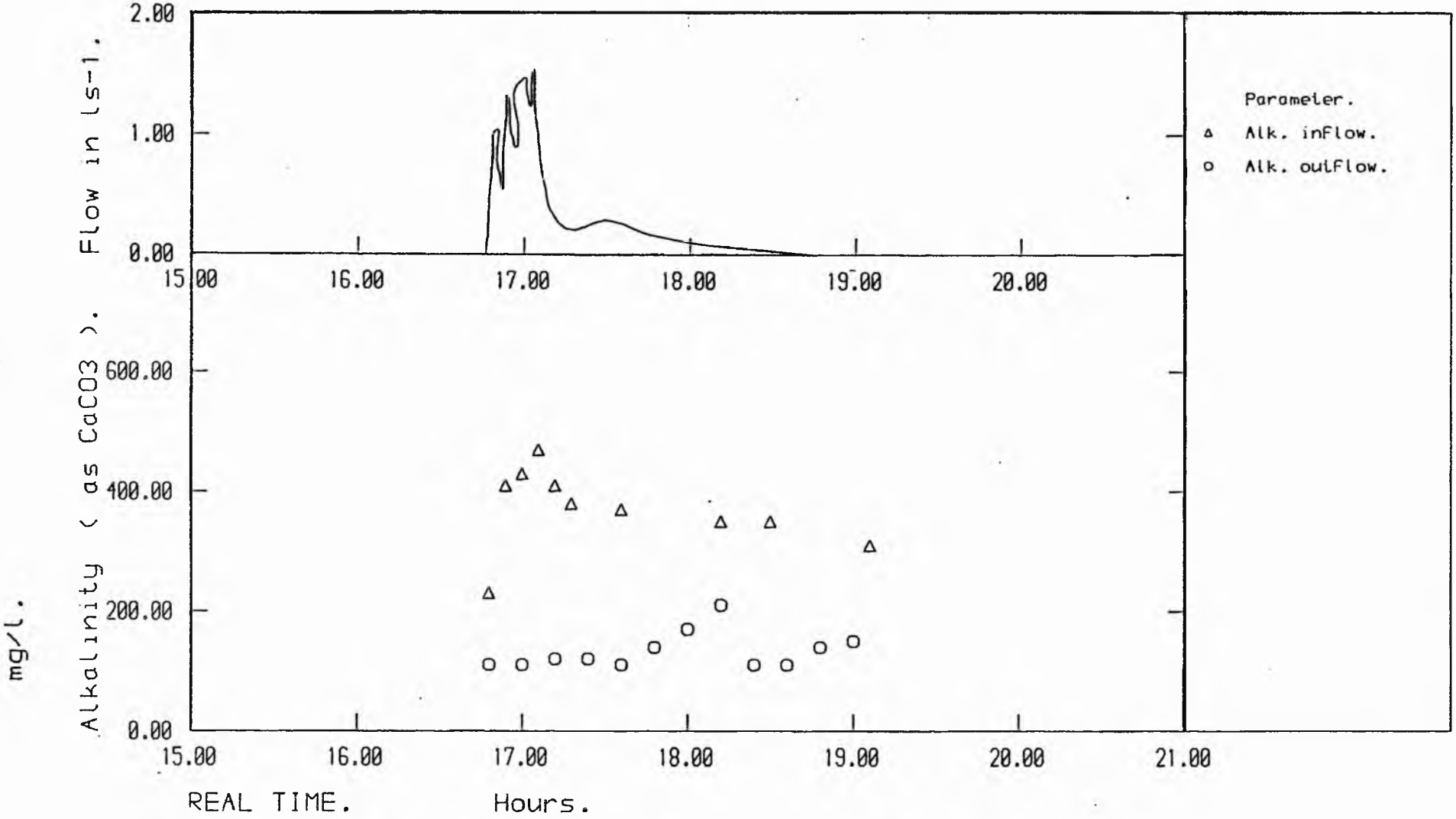
Graph of Dissolved Oxygen for Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



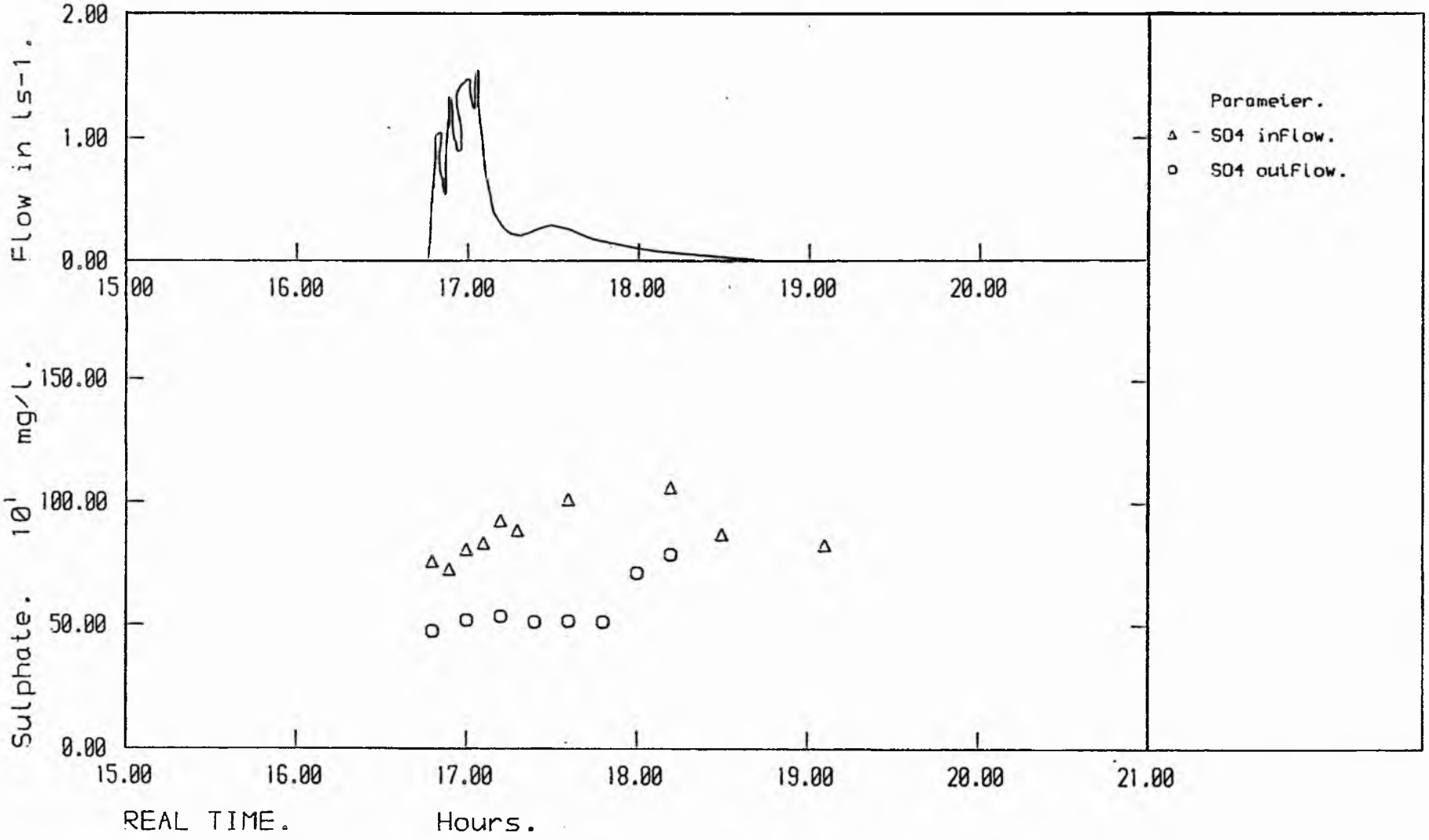
Graph of pH for Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



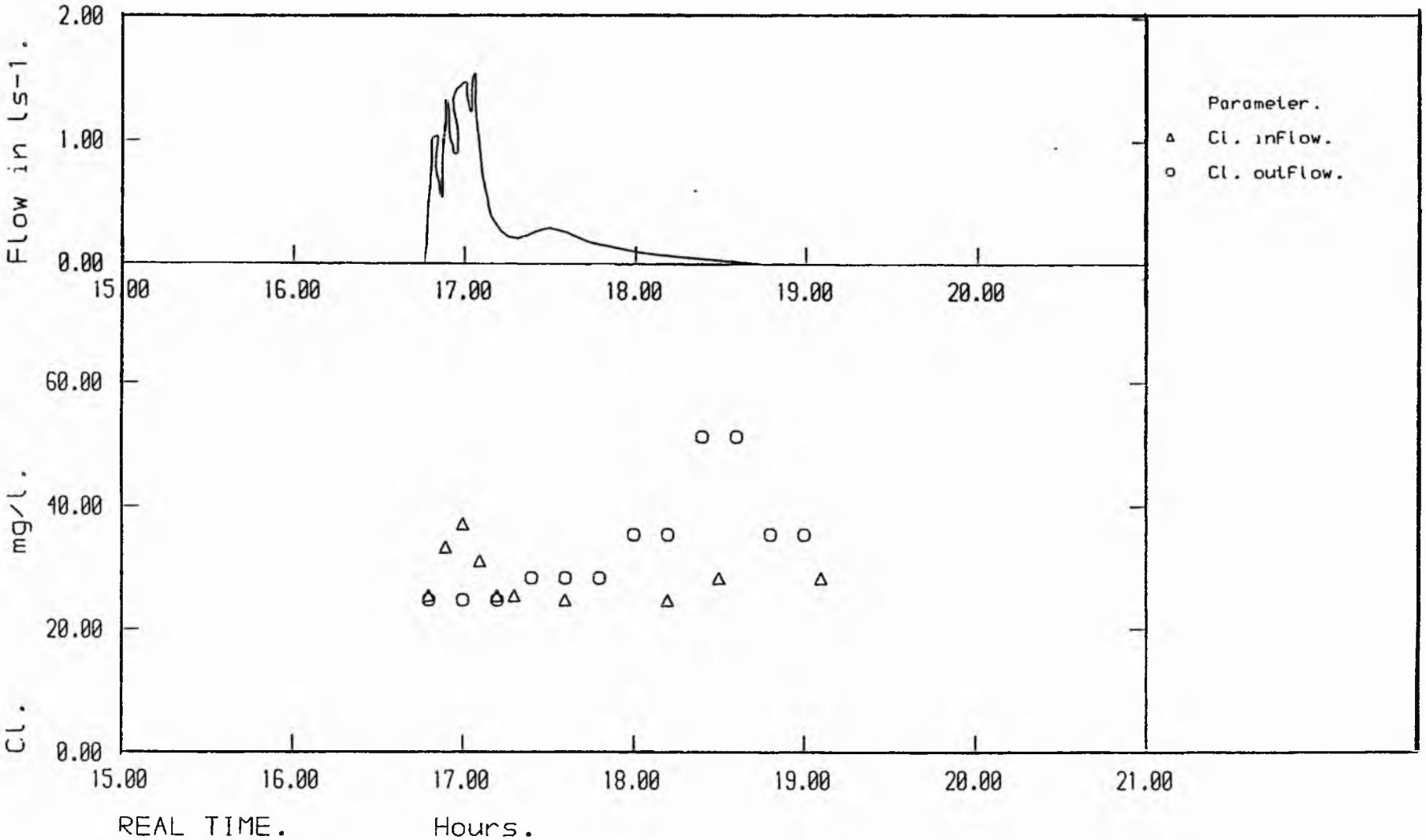
Graph of Total Hardness for Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



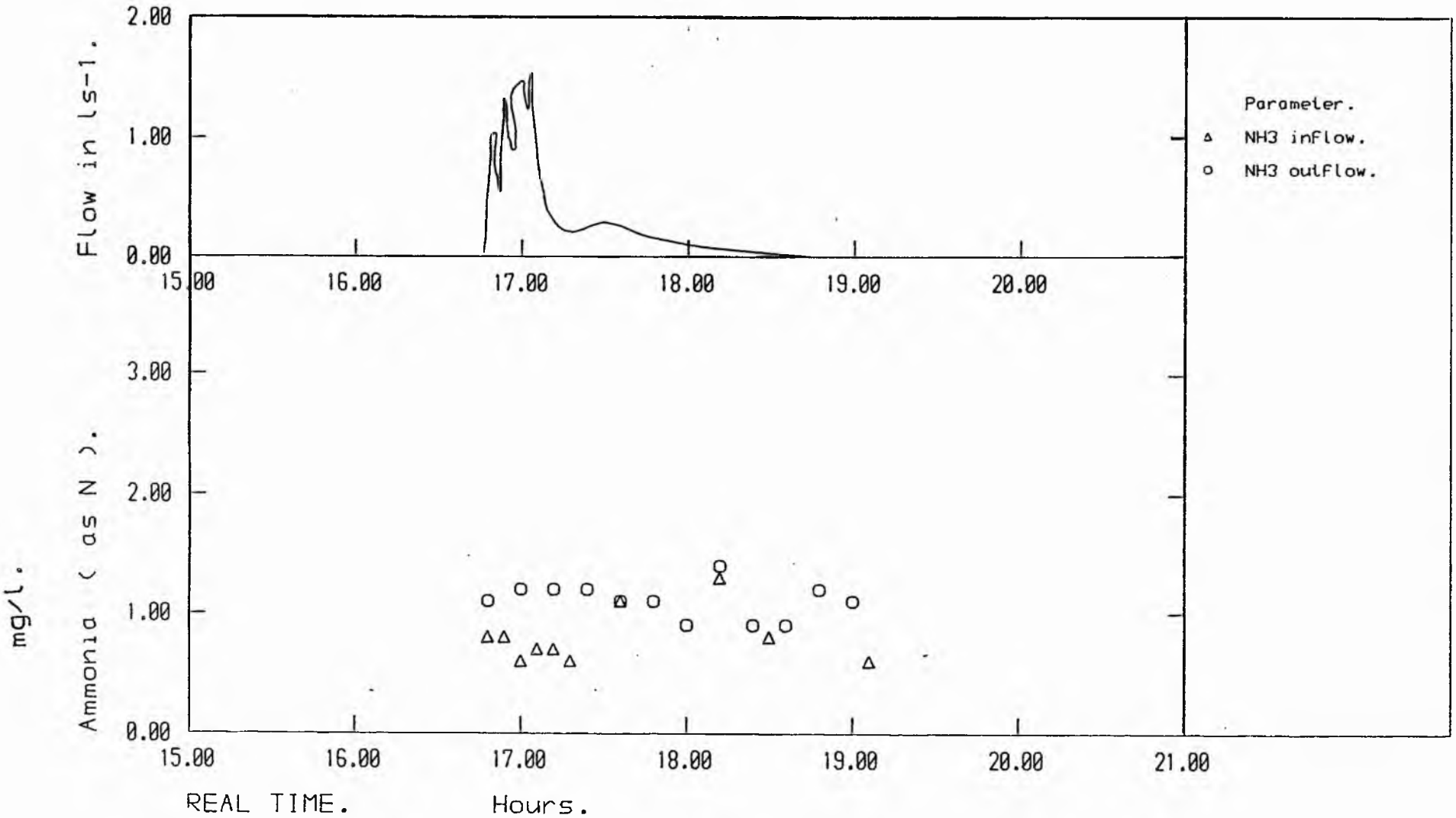
Graph of Total Alkalinity for Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



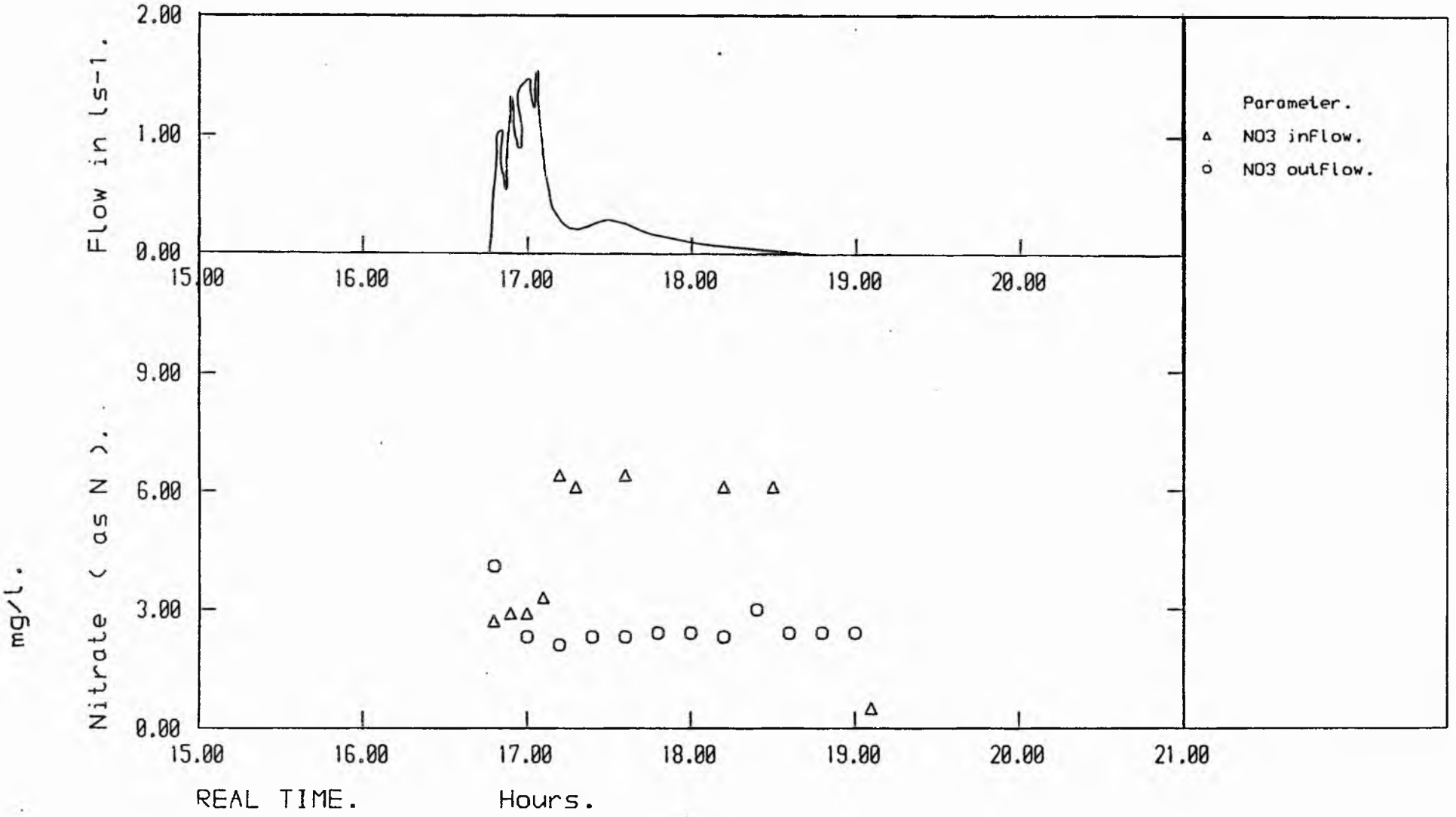
Graph of Sulphate for Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



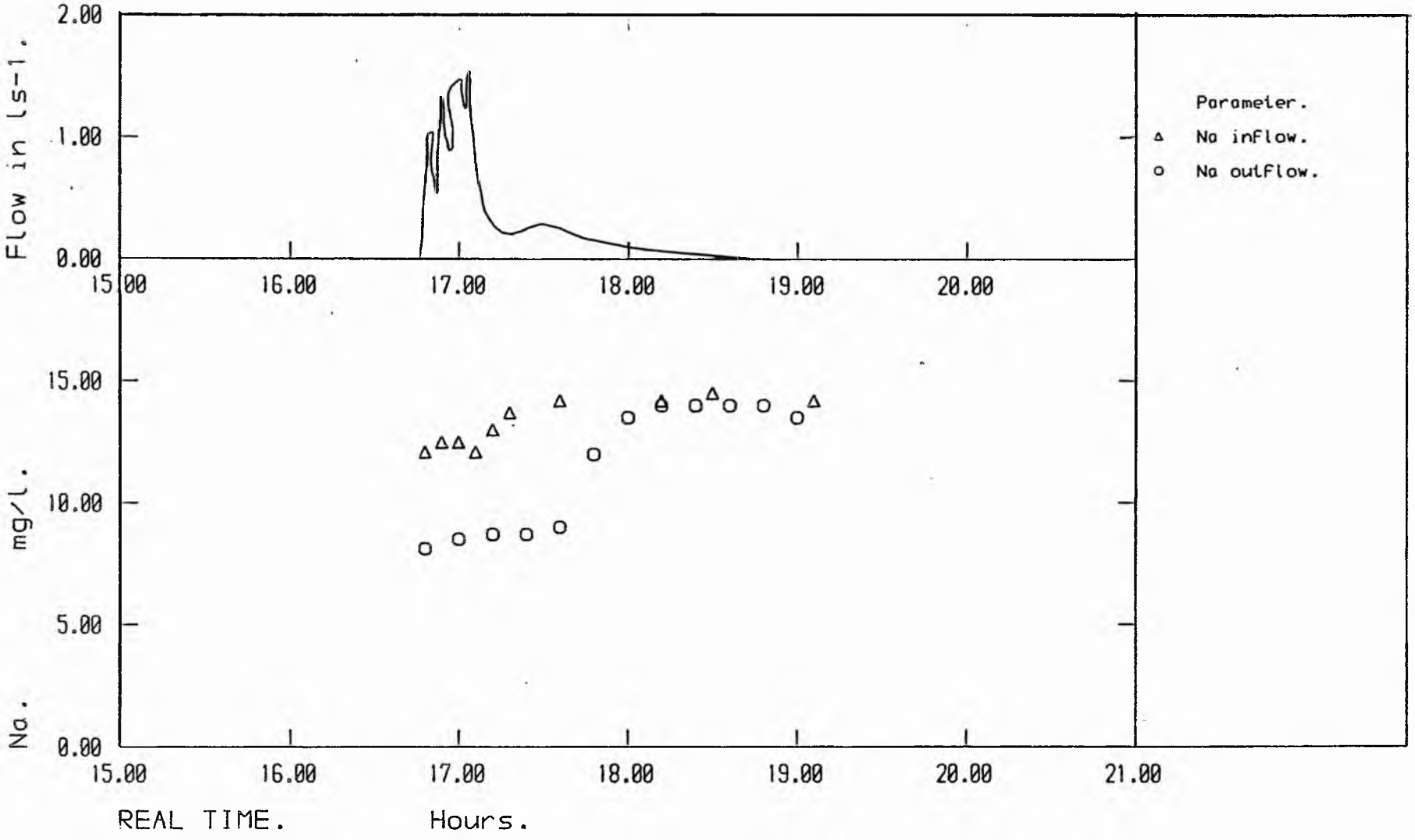
Graph of Chloride For Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



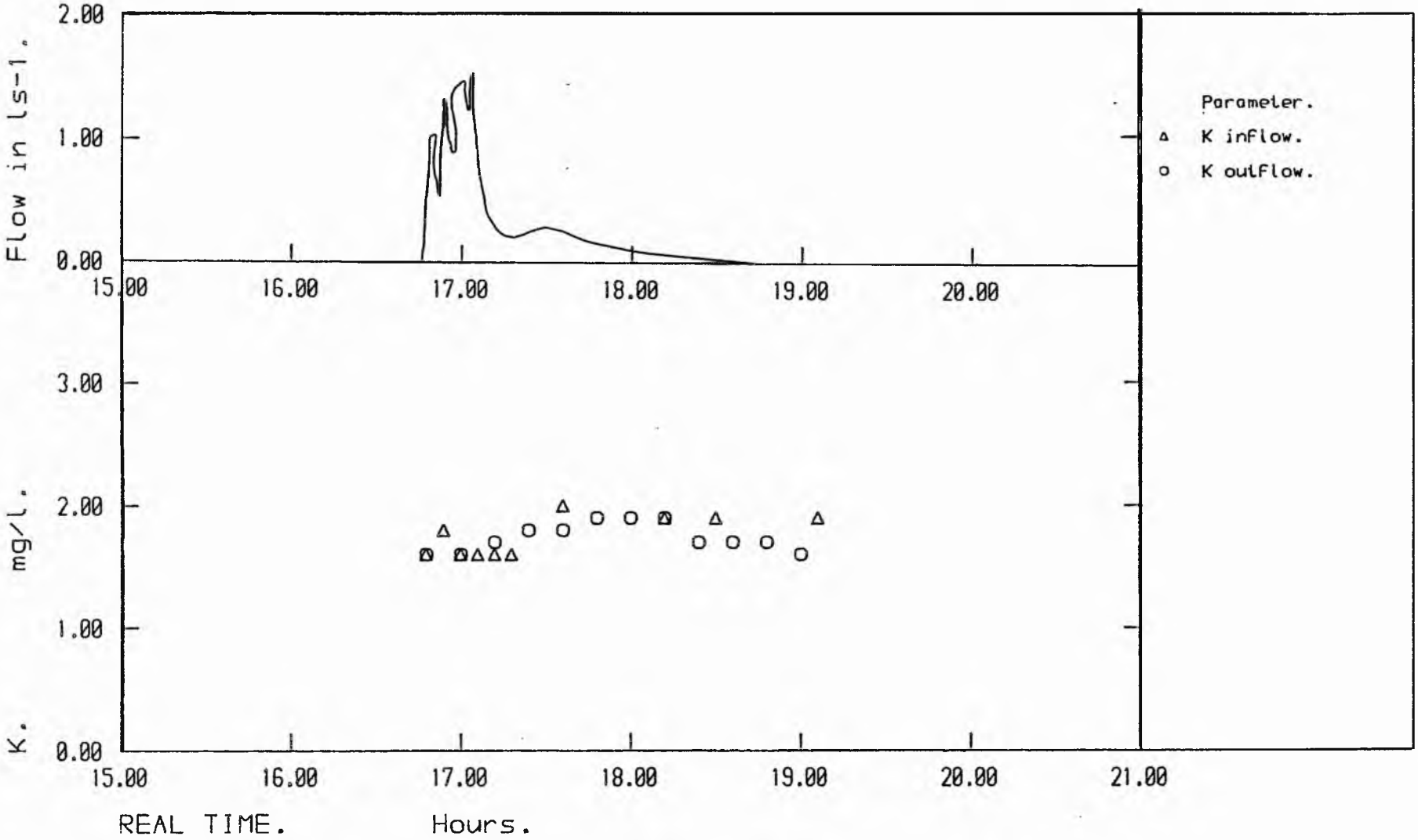
Graph of Ammonia for Storm 1 on Twyford Gardens.
The graph shows inflow and outflow water quality data.



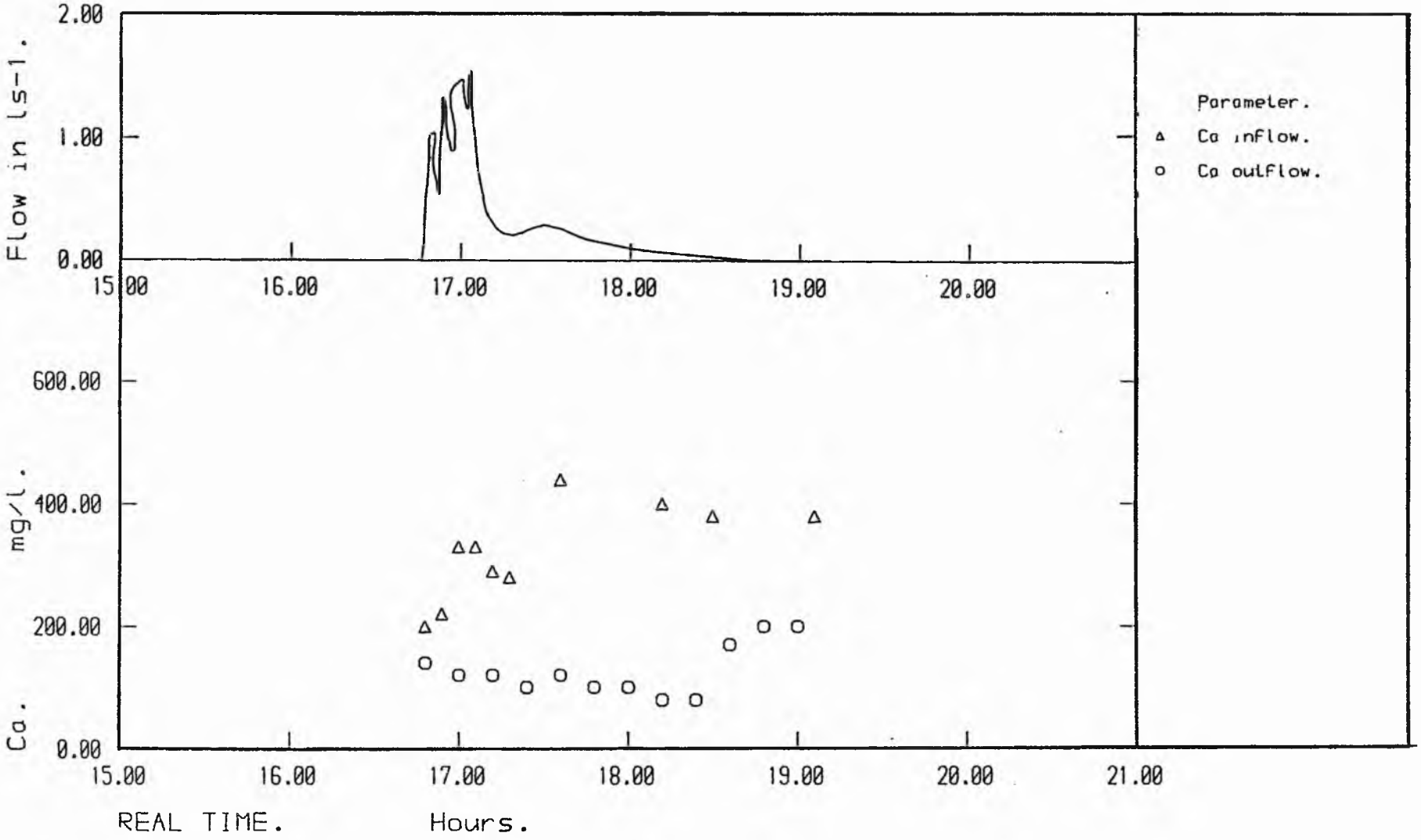
Graph of Nitrate for Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



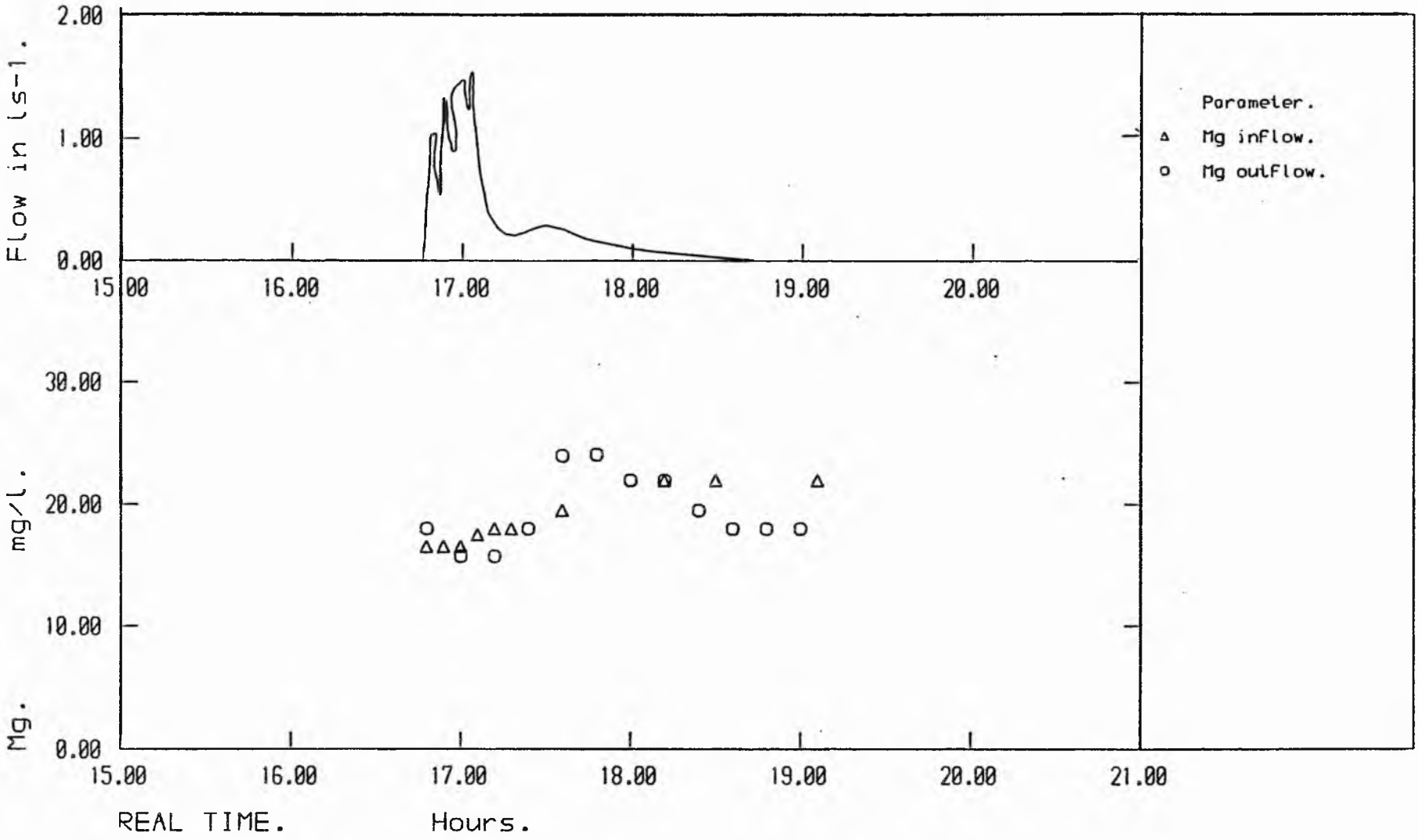
Graph of Sodium For Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



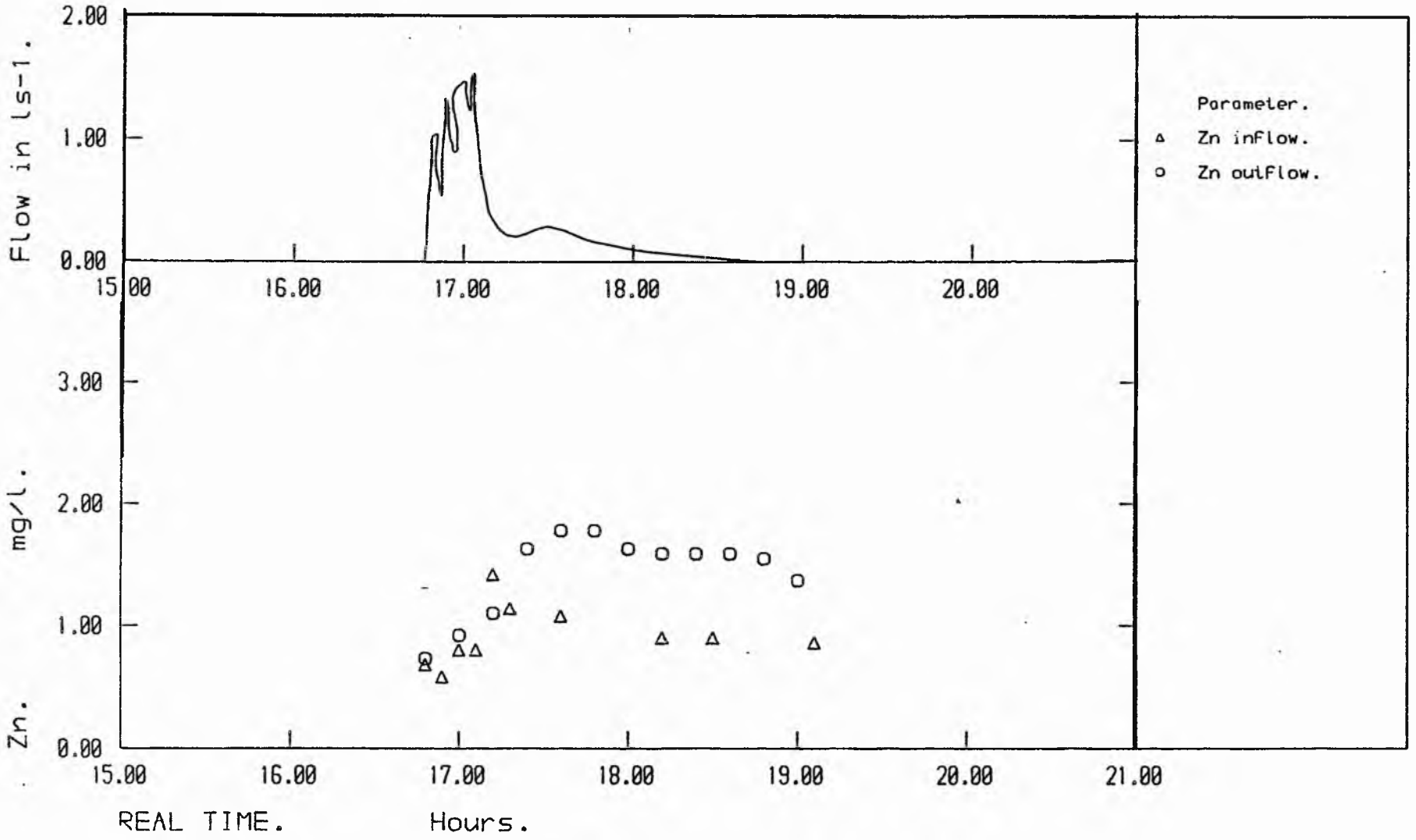
Graph of Potassium for Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



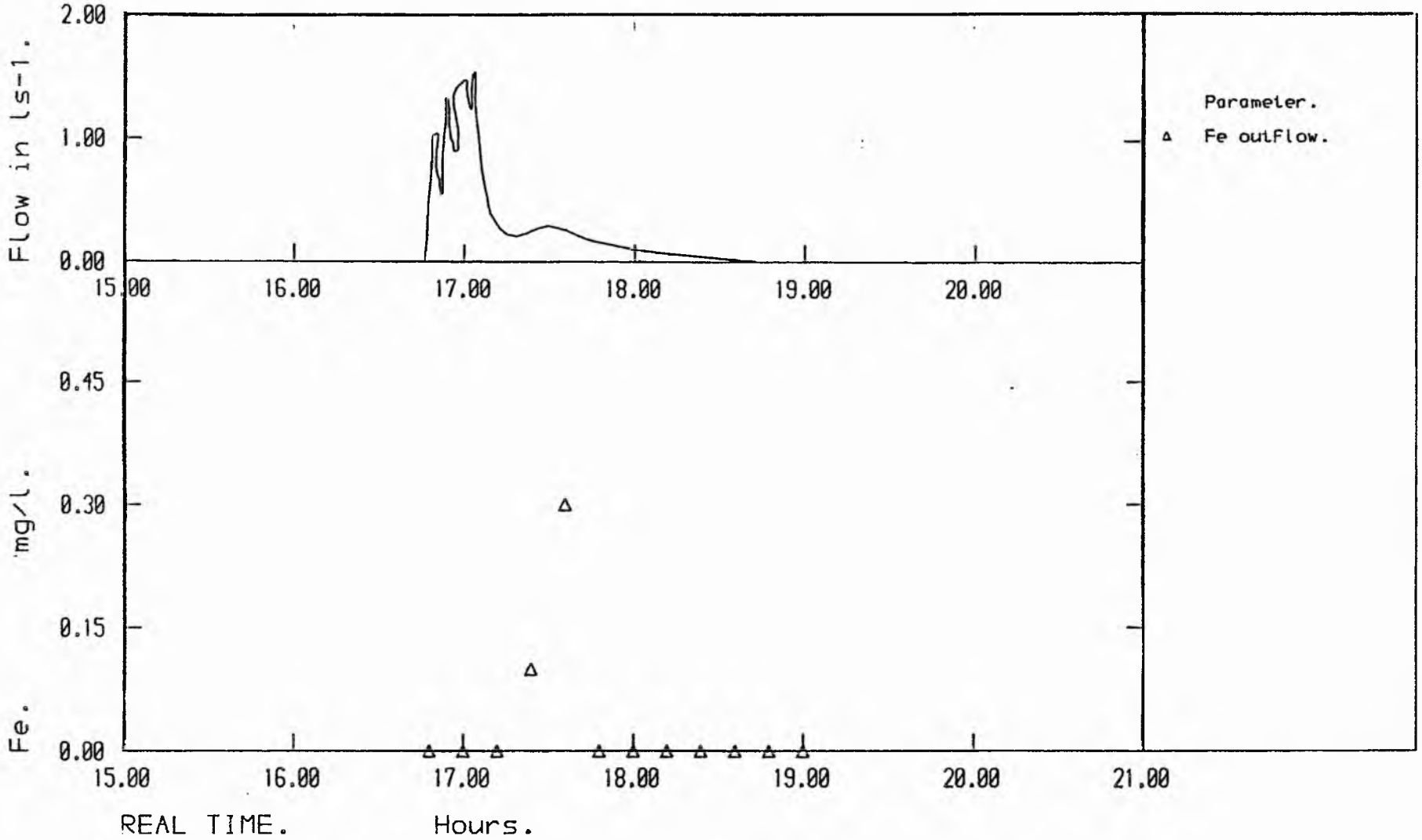
Graph of Calcium for Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



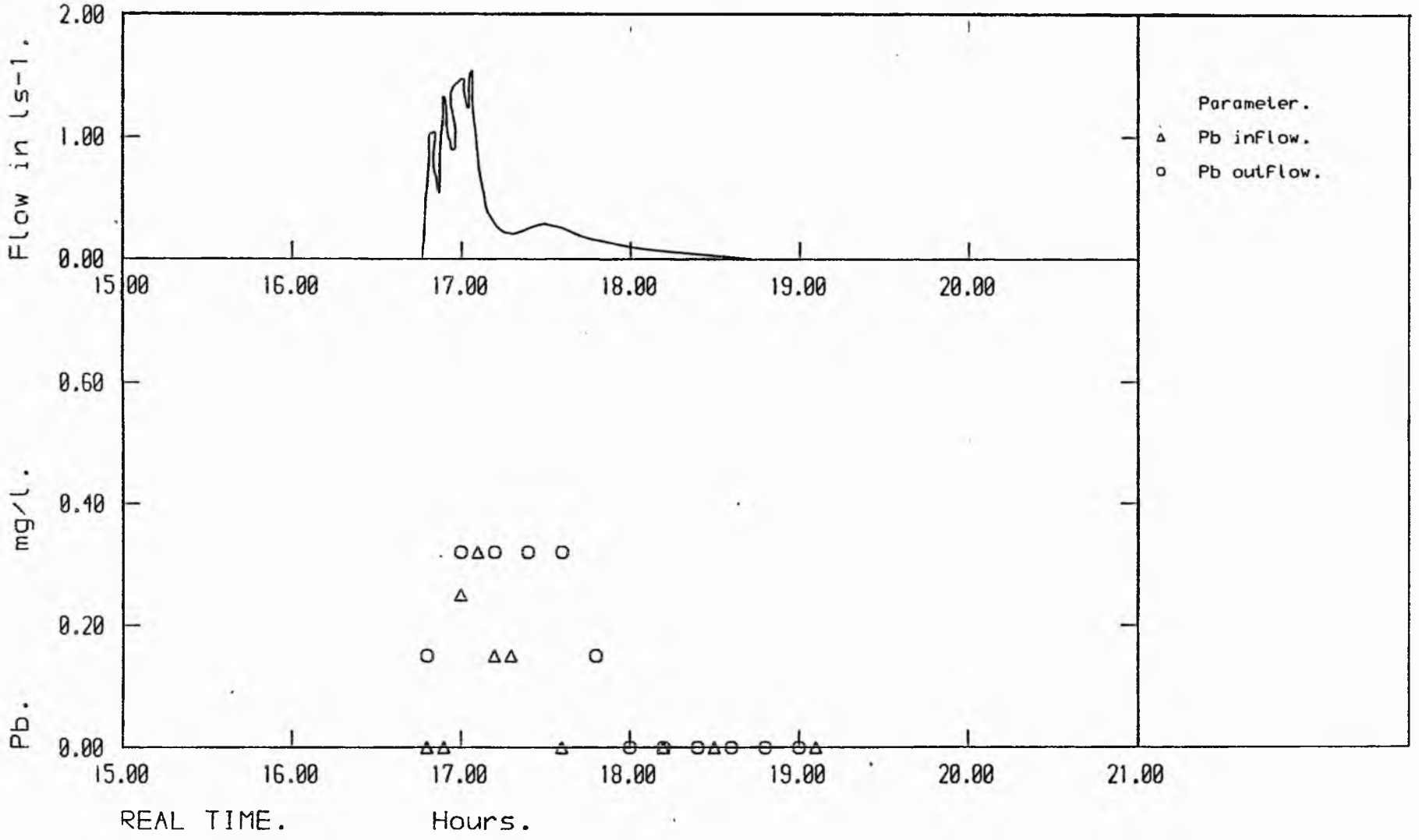
Graph of Magnesium for Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



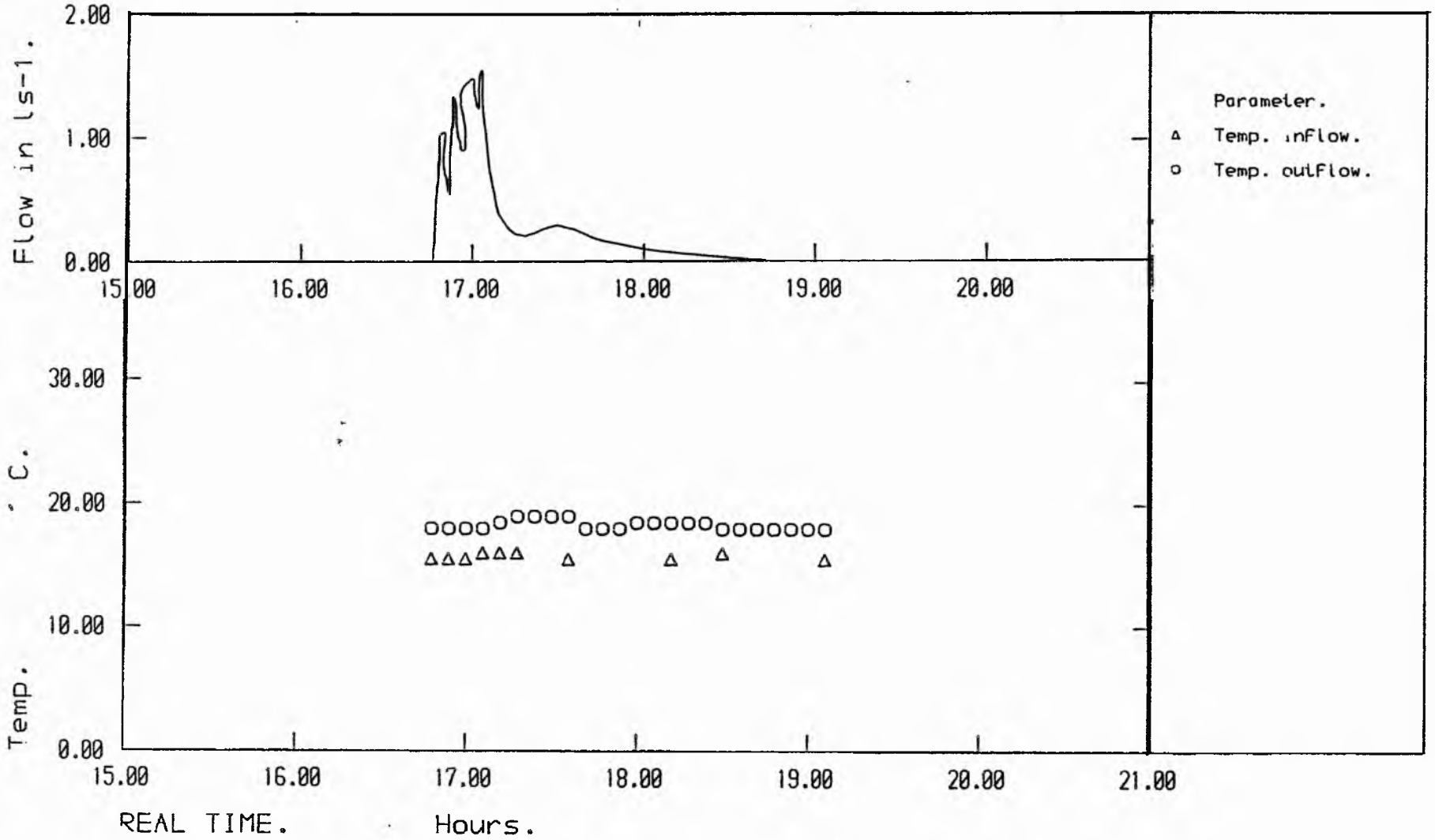
Graph of Zinc For Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Iron for Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Lead for Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Liquor Temperature for Storm I on Twyford Gardens.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
1850	29	20	40
1856	30	25	58
1902	44	20	67
1908	48	30	63
1914	62	25	72
1920	68	30	77
1938	52	40	75
1956	50	35	63
2014	42	35	58
2032	45	30	58

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
1850	80	20	77
1902	85	30	81
1914	87	30	89
1926	94	40	110
1938	132	35	110
1950	141	40	110
2002	149	38	89
2014	129	40	81
2026	120	40	81
2038	94	30	77
2050	90	30	81
2102	67	30	77

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
1850	0.11	6.7	6.8
1856	0.12	6.9	6.7
1902	0.14	6.8	6.7
1908	0.17	6.8	6.8
1914	0.23	6.8	6.7
1920	0.29	6.8	6.7
1938	0.30	7.0	6.8
1956	0.31	7.2	6.8
2014	0.31	7.2	6.8
2032	0.37	7.2	6.9

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH mgl-1
1850	0.24	4.8	6.8
1902	0.28	4.8	7.0
1914	0.28	5.0	7.2
1926	0.31	5.2	7.0
1938	0.31	5.2	6.9
1950	0.30	6.5	6.9
2002	0.35	6.5	6.9
2014	0.39	7.0	7.2
2026	0.38	7.0	7.2
2038	0.38	6.8	7.4
2050	0.38	6.8	7.4
2102	0.40	6.8	7.4

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	Fe mgl-1
1850	200	100.0	0.4
1856	220	120.0	0.4
1902	220	120.0	0.3
1908	240	140.0	0.3
1914	300	130.0	0.3
1920	310	140.0	0.3
1938	280	200.0	0.2
1956	270	180.0	0.2
2014	270	180.0	0.2
2032	220	180.0	0.2

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	Fe mgl-1	Cd mgl-1
1850	140.0	110.0	0.2	0.1
1902	140.0	140.0	0.2	0.1
1914	180.0	140.0	0.2	0.0
1926	190.0	140.0	0.2	0.0
1938	200.0	140.0	0.2	0.0
1950	250.0	140.0	0.3	0.0
2002	250.0	180.0	0.3	0.0
2014	250.0	200.0	0.3	0.0
2026	210.0	140.0	0.3	0.0
2038	180.0	140.0	0.3	0.0
2050	180.0	140.0	0.2	0.0
2102	180.0	140.0	0.2	0.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
1850	14.1	28.9	45.0	34.1
1856	12.2	27.3	29.2	29.7
1902	8.7	25.4	21.7	29.7
1908	8.7	29.3	22.0	24.6
1914	8.2	31.7	18.5	22.7
1920	8.2	32.6	18.2	14.2
1938	10.1	28.9	15.6	19.1
1956	11.2	28.9	15.6	14.2
2014	11.7	25.4	14.1	14.2
2032	11.5	25.4	11.2	19.1

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close

DATE OF THE STORM EVENT : 12th. July 1984 (840712)

STORM NUMBER : II

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
1850	30.0	41.1	25.4	19.1
1902	28.2	57.6	28.2	19.1
1914	40.1	59.9	25.4	19.1
1926	40.1	62.5	25.4	14.2
1938	29.5	72.5	32.1	22.7
1950	29.5	48.3	25.4	29.7
2002	28.2	41.1	25.4	19.1
2014	28.2	41.7	22.7	19.1
2026	27.8	32.9	22.7	19.1
2038	27.8	32.9	22.7	14.2
2050	30.0	32.9	25.2	19.1
2102	30.0	32.9	25.2	19.1

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF INFLOW WATER TO THE GULLY POT

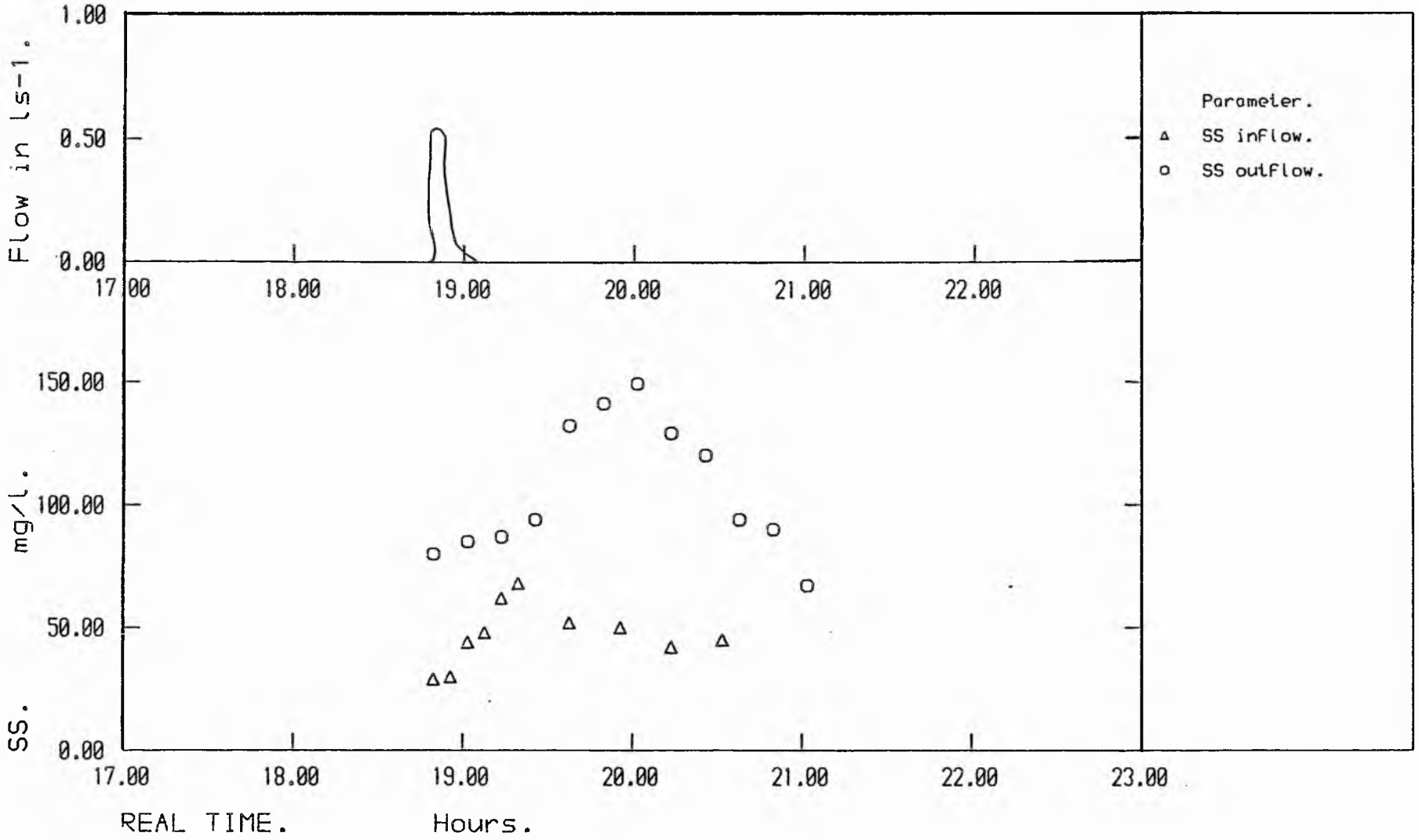
REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Zn mgl-1
1850	0.9	14.4	0.1
1856	0.9	12.7	0.1
1902	1.1	12.7	0.1
1908	1.1	14.4	0.1
1914	1.1	14.4	0.1
1920	1.7	15.8	0.1
1938	1.7	14.4	0.1
1956	1.1	14.4	0.1
2014	1.1	11.8	0.1
2032	0.9	11.8	0.1

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

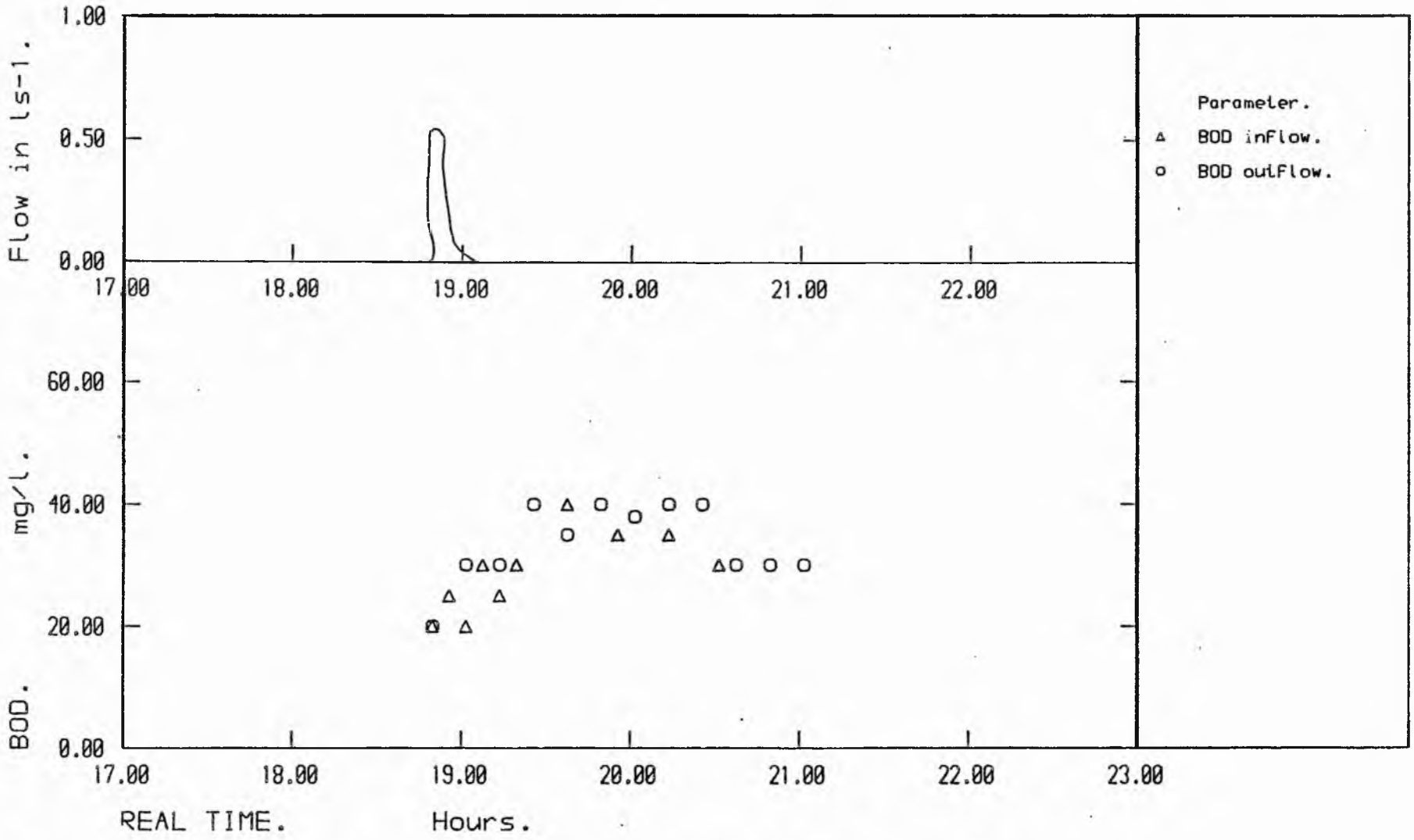
CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

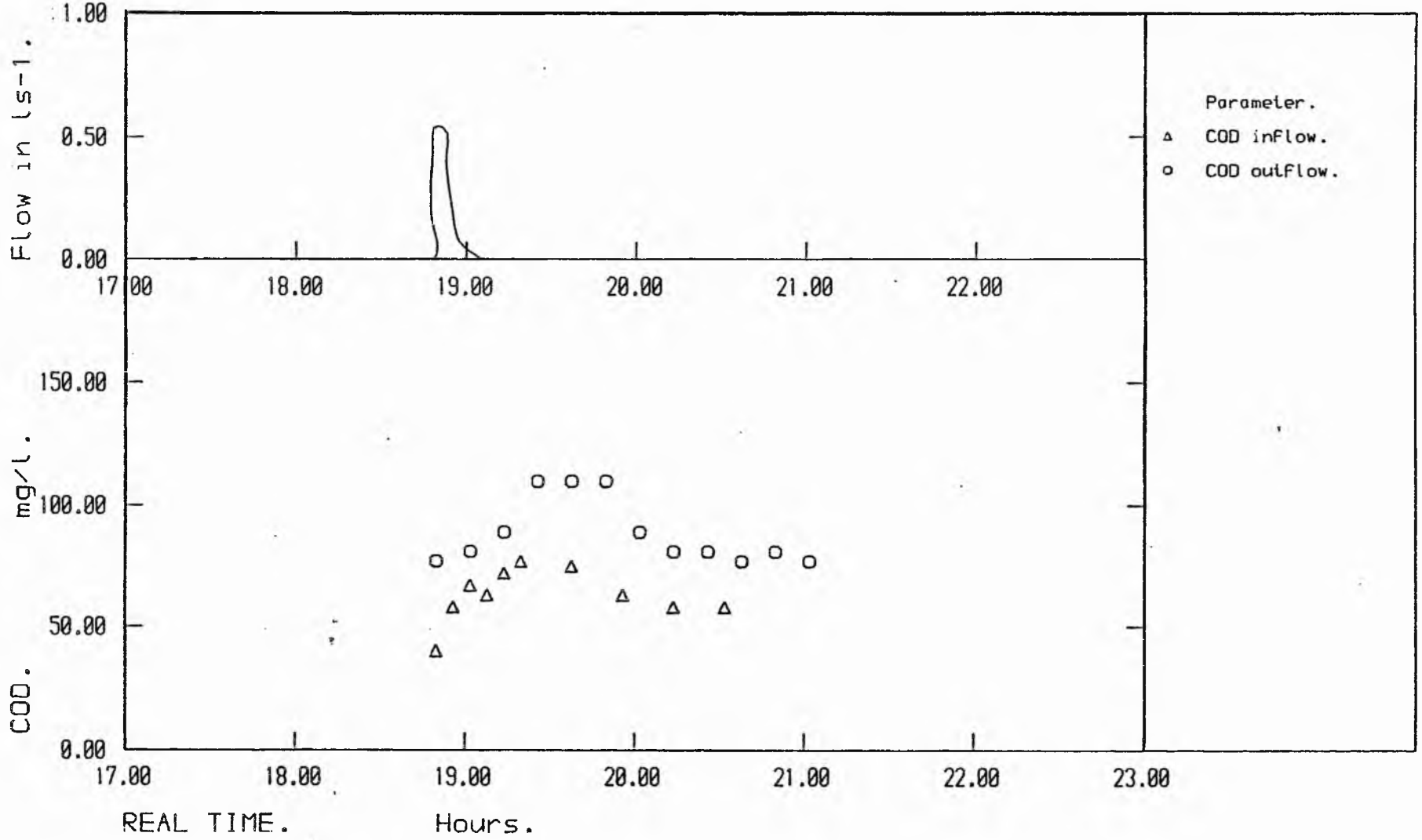
REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Zn mgl-1
1850	1.2	11.1	0.2
1902	1.1	12.2	0.2
1914	2.0	13.3	0.4
1926	2.7	13.3	0.3
1938	2.1	13.3	0.3
1950	2.3	12.2	0.2
2002	2.5	12.2	0.2
2014	2.5	15.7	0.2
2026	2.5	15.7	0.2
2038	1.9	12.2	0.2
2050	1.9	12.2	0.1
2102	1.2	11.1	0.0



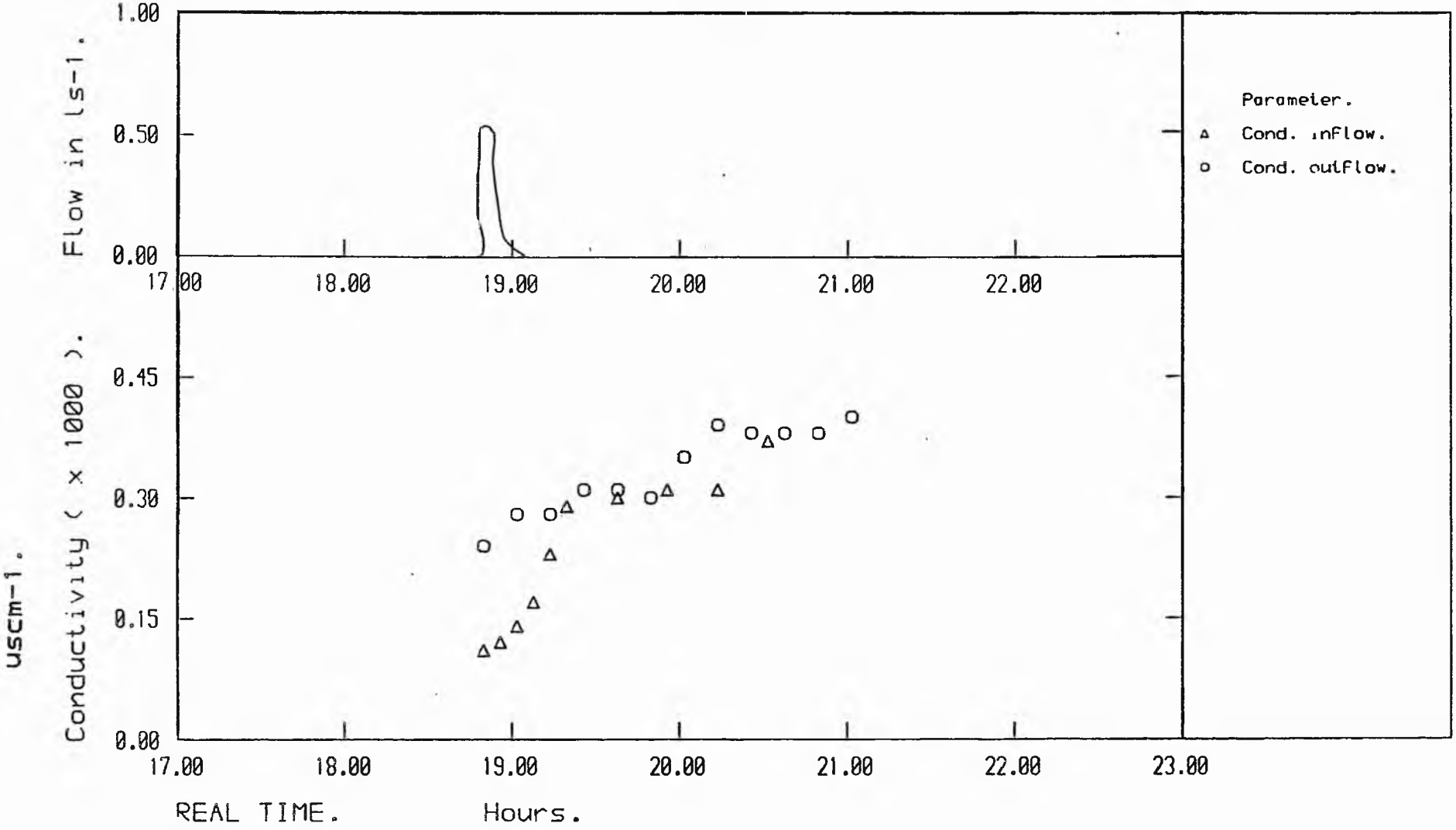
Graph of Suspended Solids for Storm II on Tame Close.
The graph shows inflow and outflow water quality data.



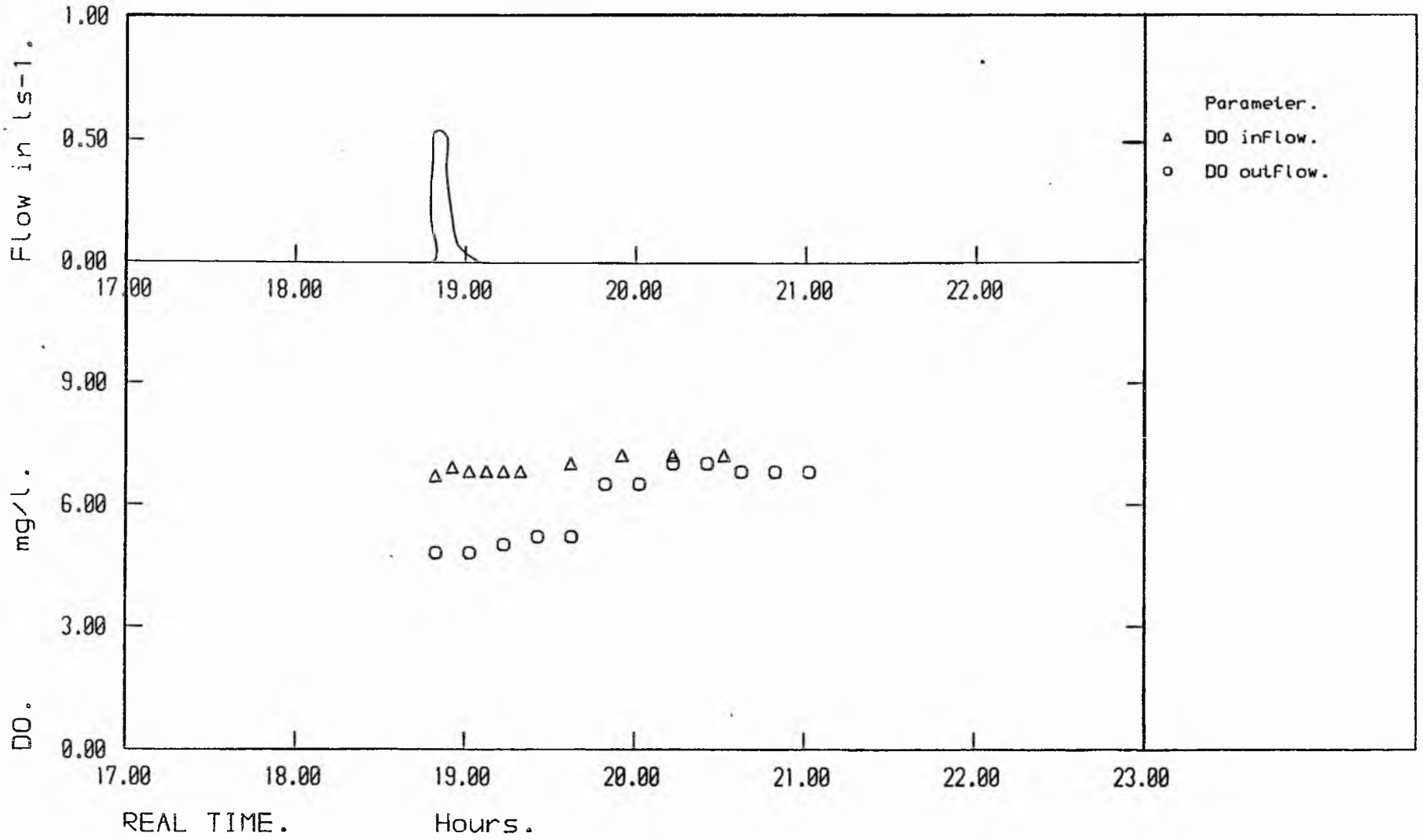
Graph of Biochemical Oxygen Demand for Storm II on Tame Close.
The graph shows inflow and outflow water quality data.



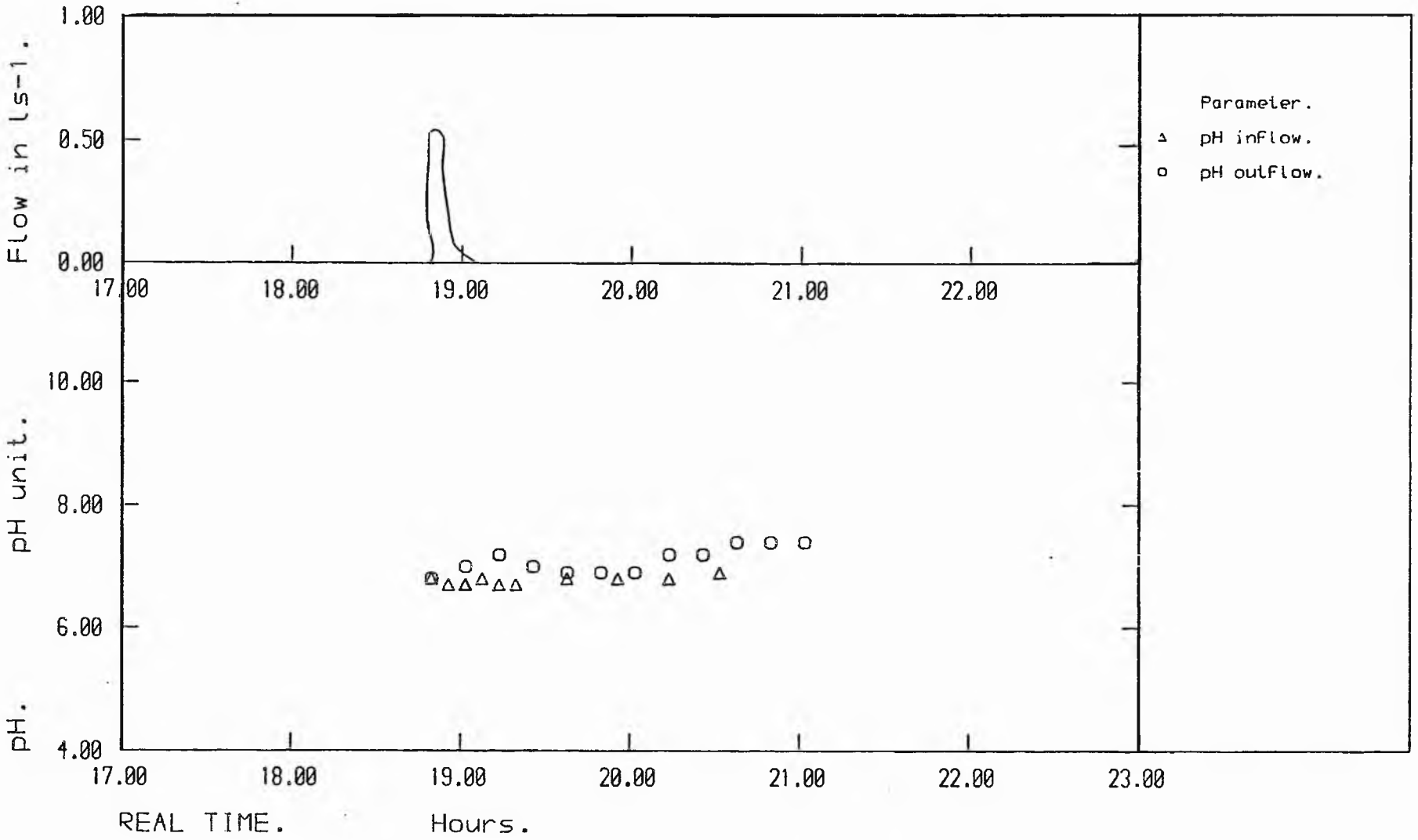
Graph of Chemical Oxygen Demand For Storm II on Tame Close.
The graph shows inflow and outflow water quality data:



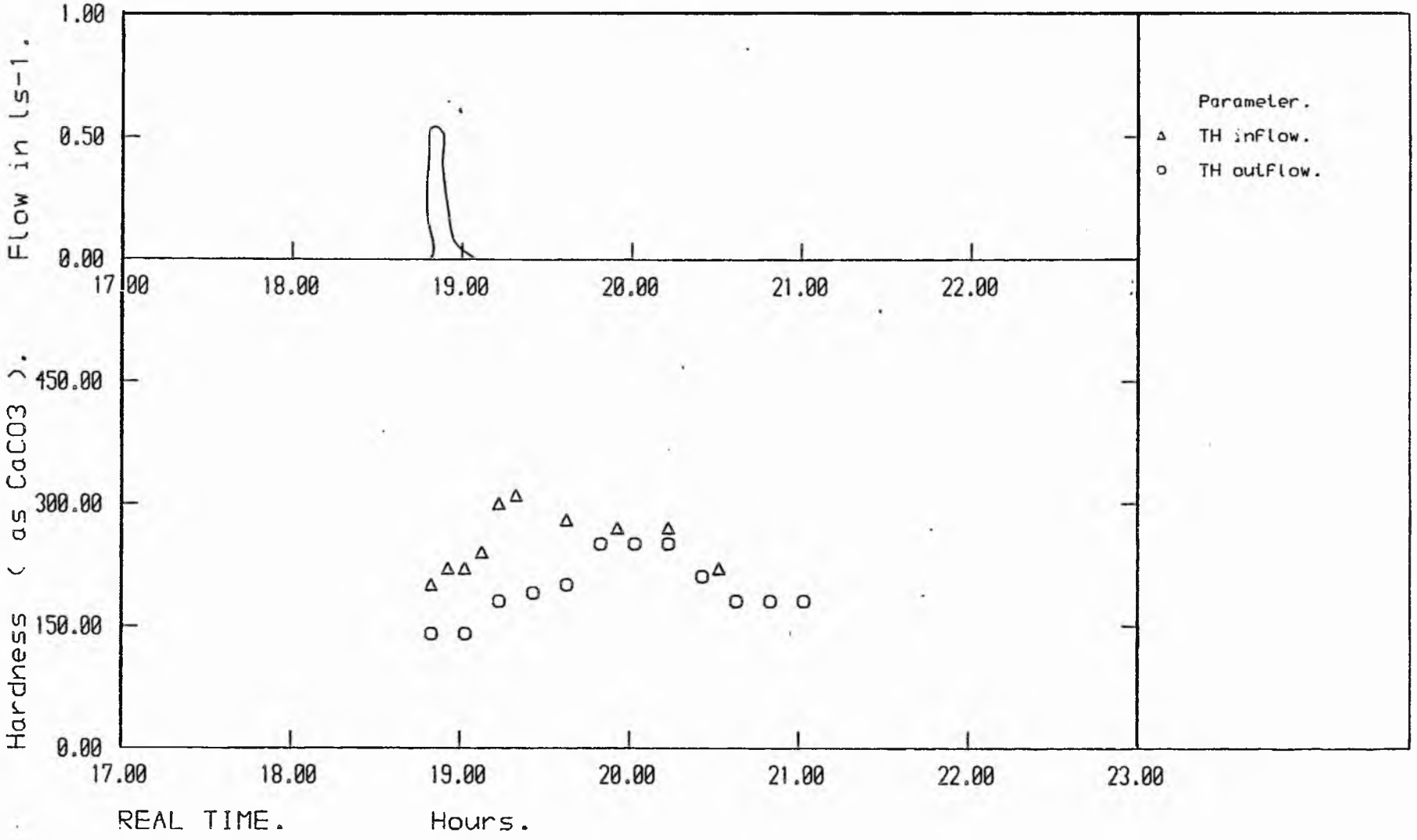
Graph of Conductivity for Storm II on Tame Close.
The graph shows inflow and outflow water quality data:



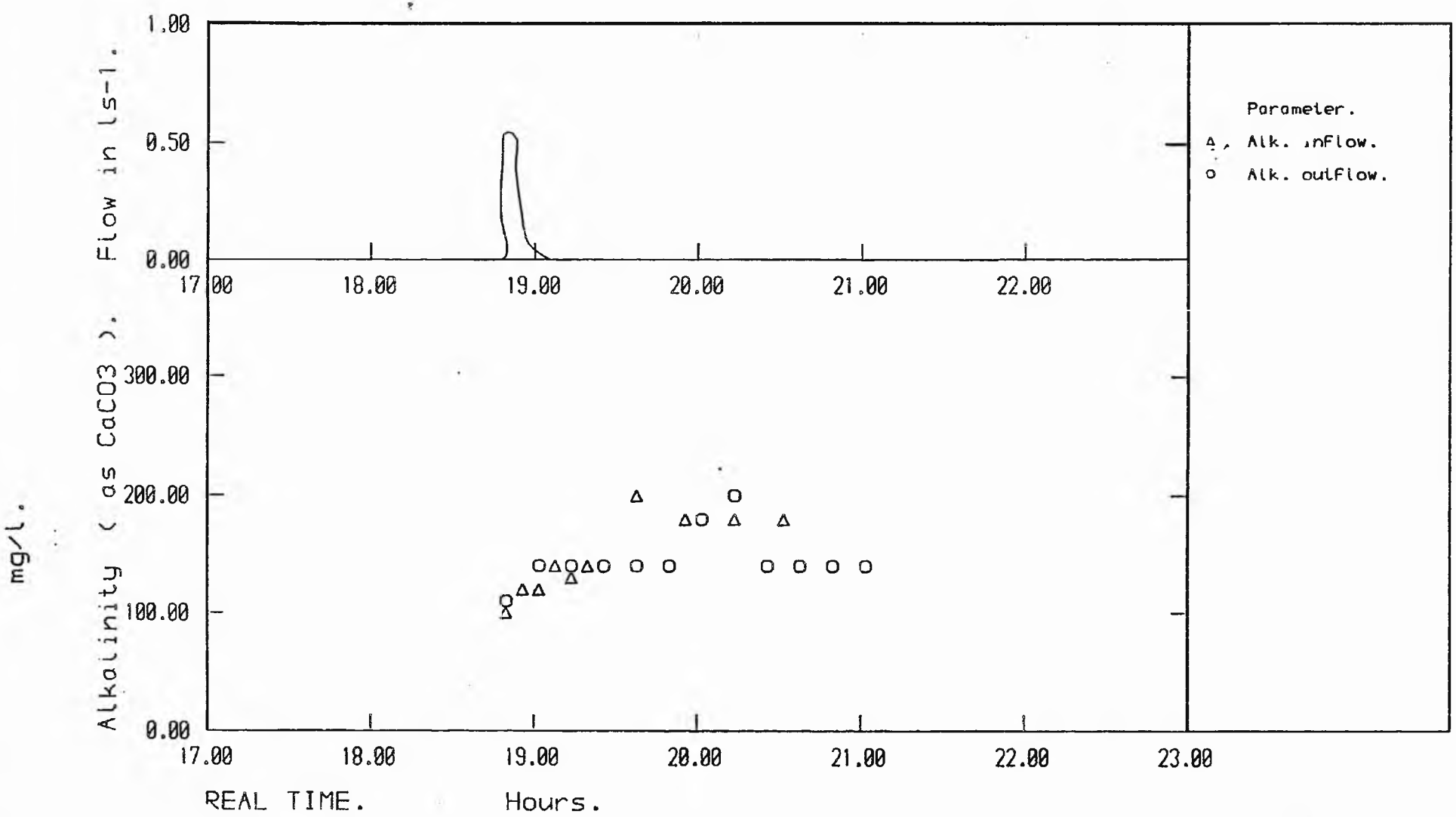
Graph of Dissolved Oxygen for Storm II on Tame Close.
The graph shows inflow and outflow water quality data.



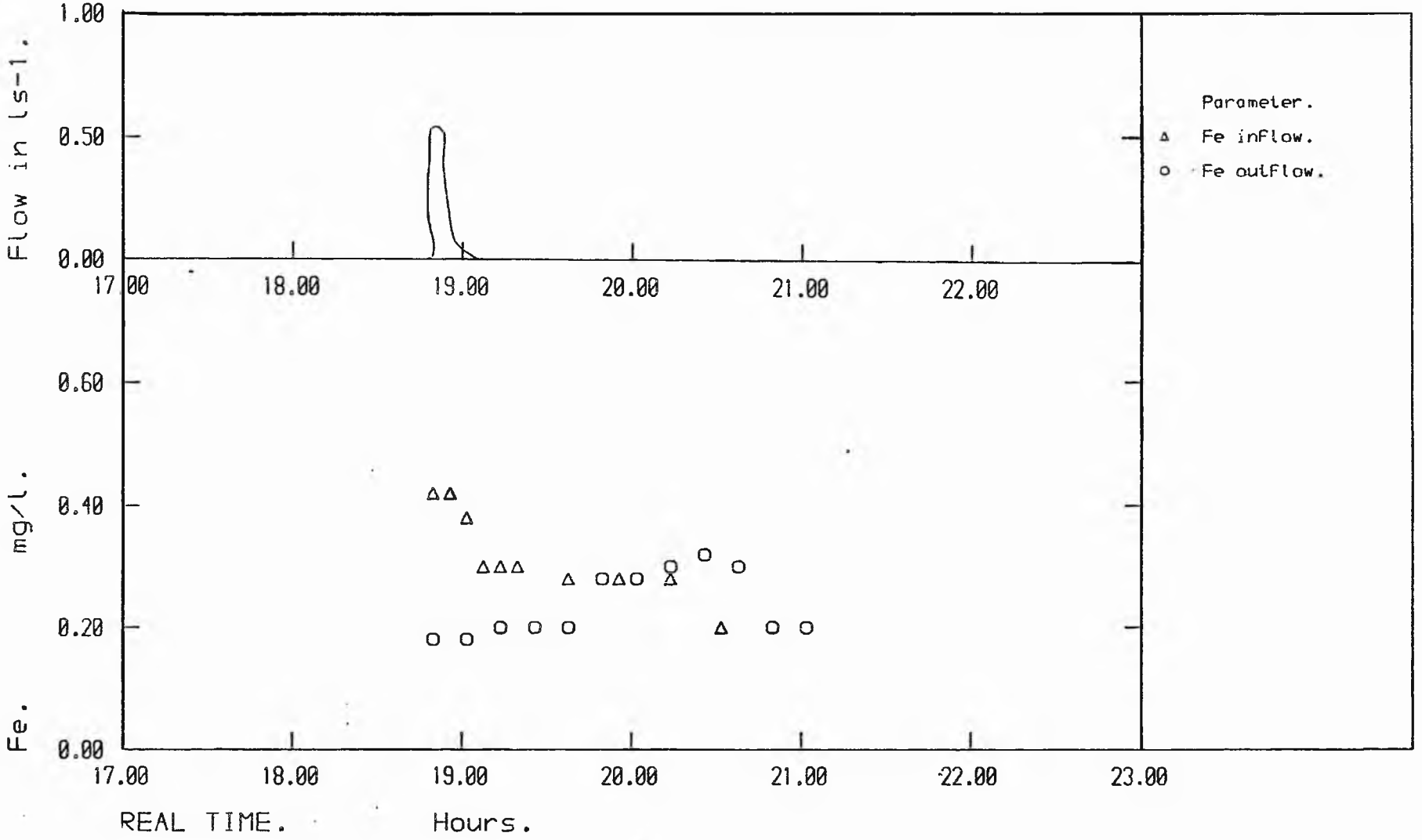
Graph of pH For Storm II on Tame Close.
The graph shows inflow and outflow water quality data.



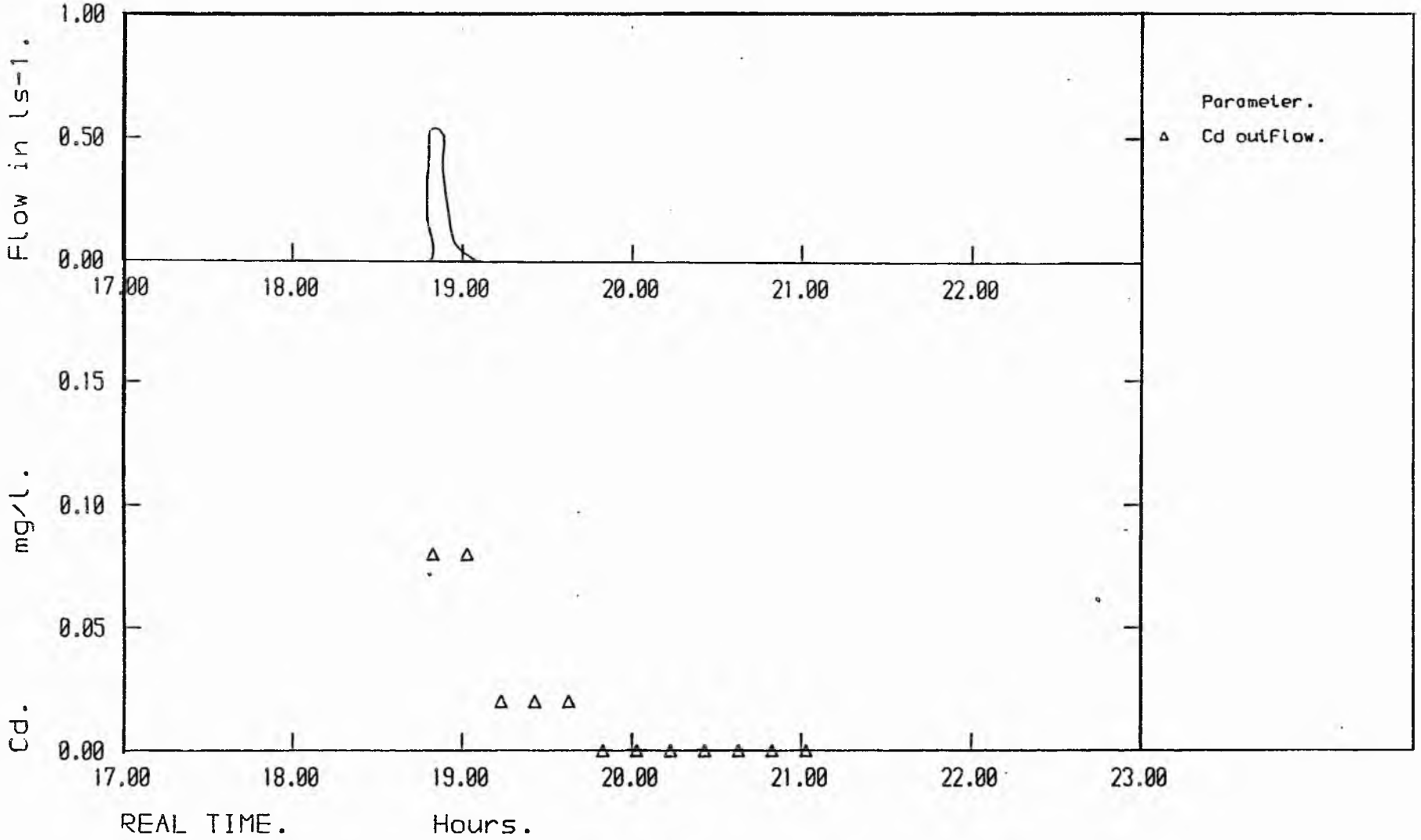
Graph of Total Hardness for Storm II on Tame Close.
The graph shows inflow and outflow water quality data.



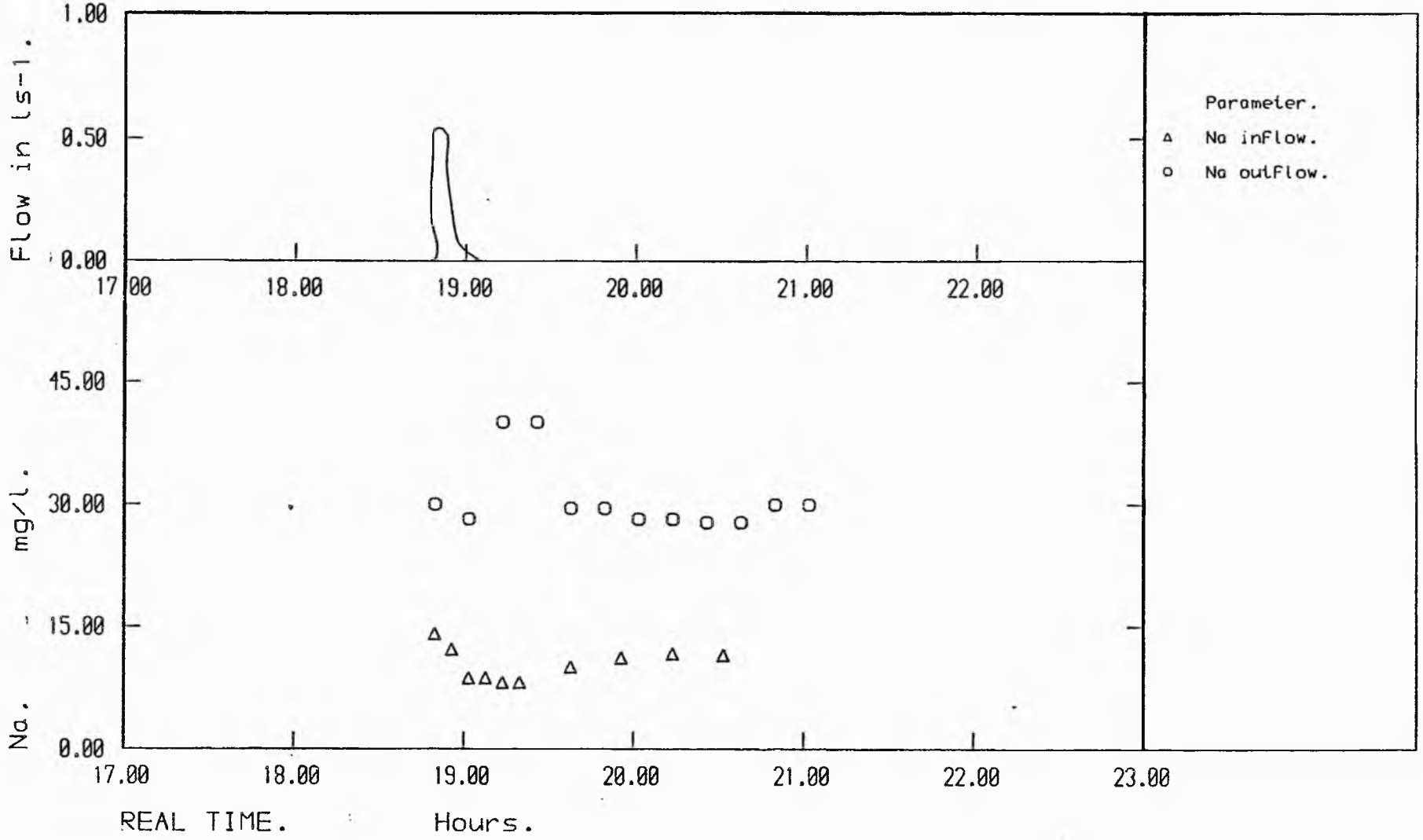
Graph of Total Alkalinity for Storm II on Tame Close.
The graph shows inflow and outflow water quality data.



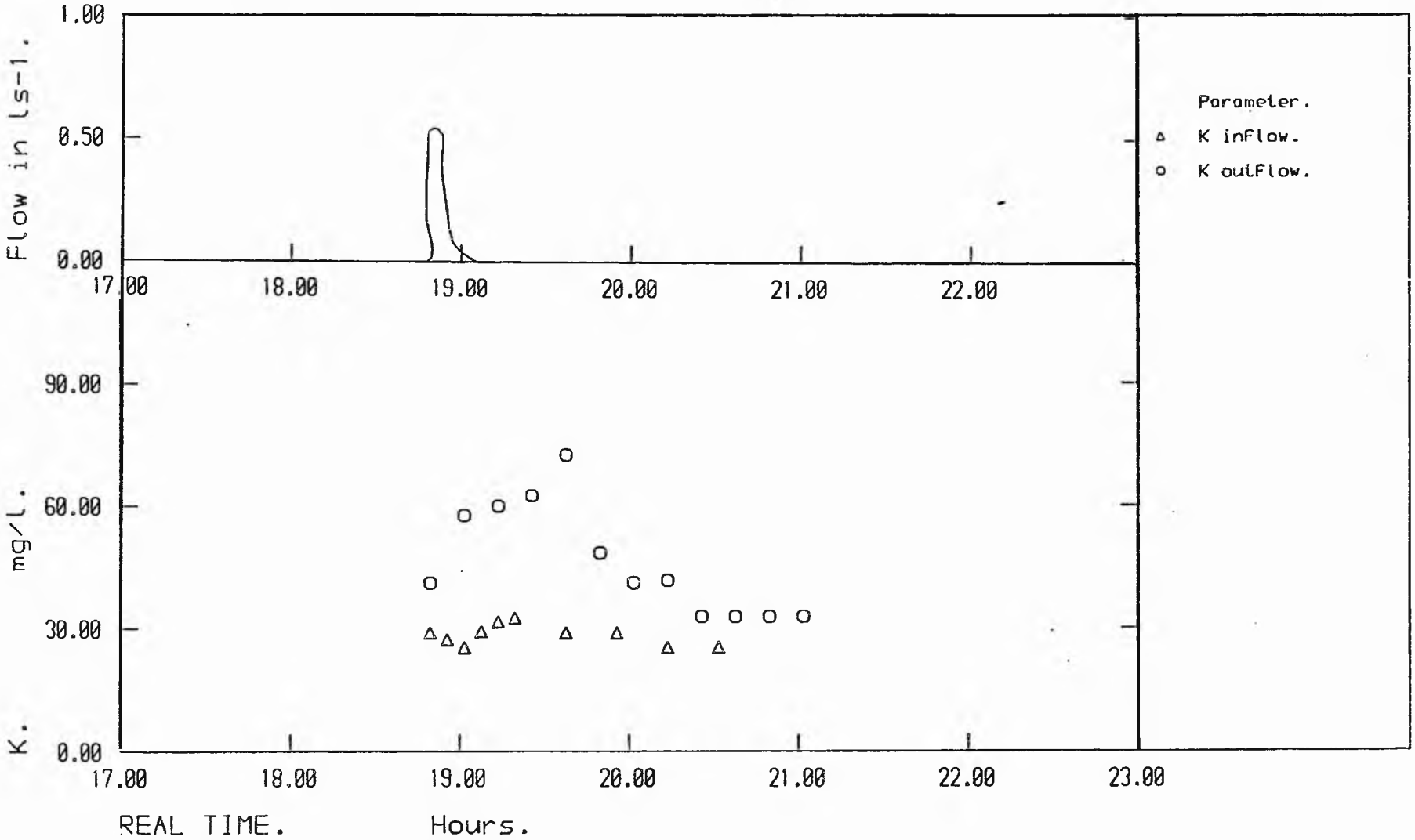
Graph of Iron For Storm II on Tame Close.
The graph shows inflow and outflow water quality data.



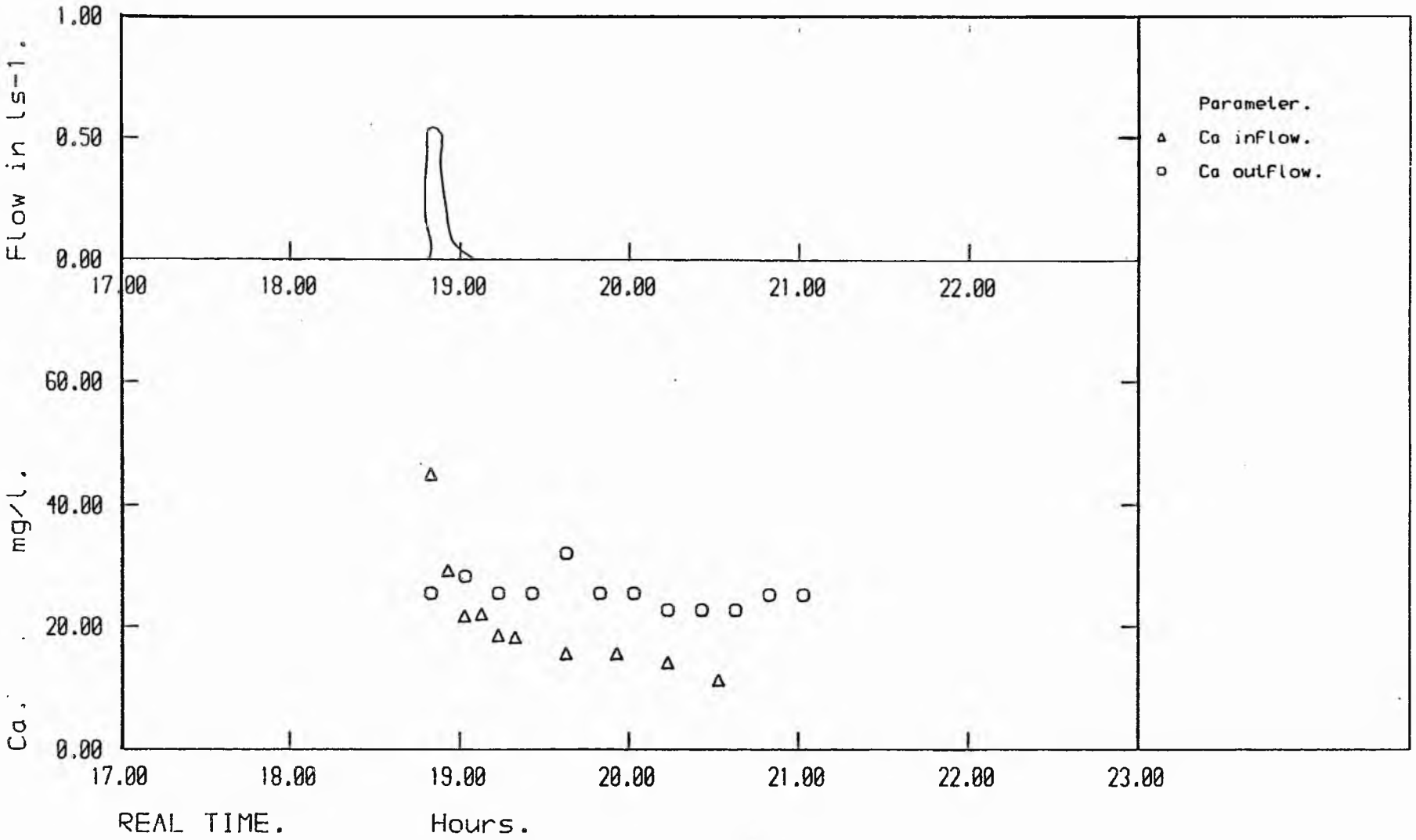
Graph of Cadmium for Storm II on Tame Close.
The graph shows inflow and outflow water quality data.



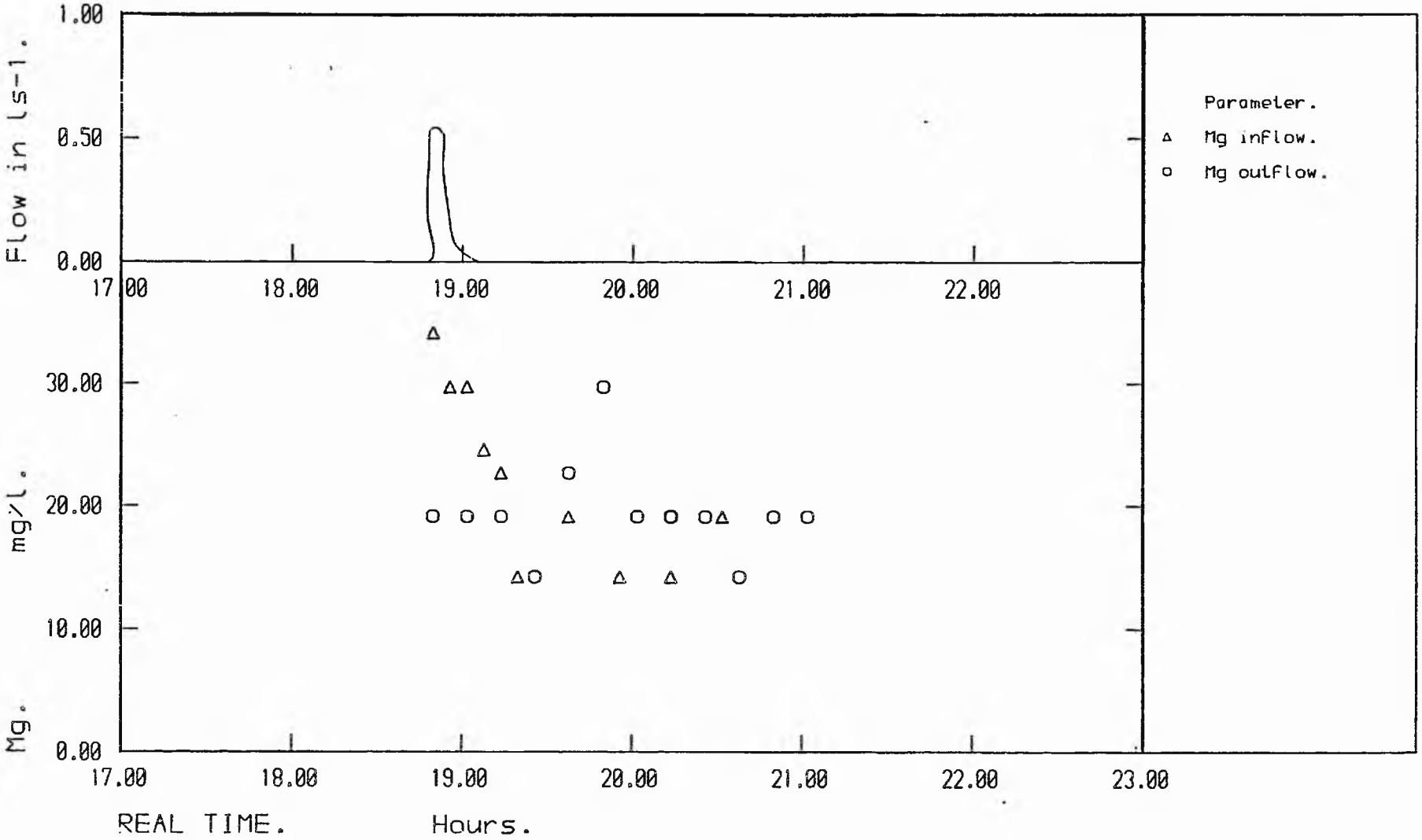
Graph of Sodium For Storm II on Tame Close.
The graph shows inflow and outflow water quality data.



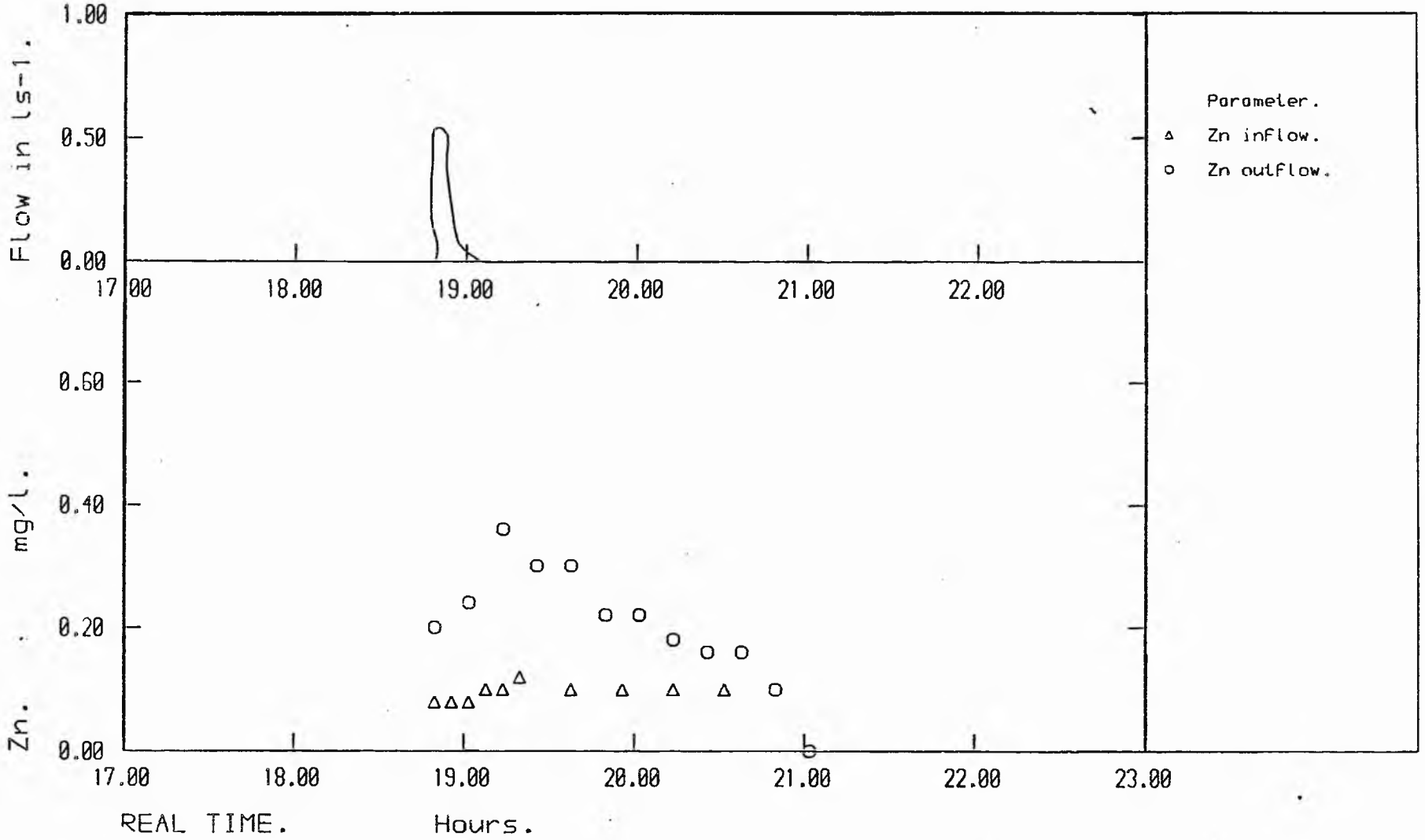
Graph of Potassium for Storm II on Tame Close.
The graph shows inflow and outflow water quality data.



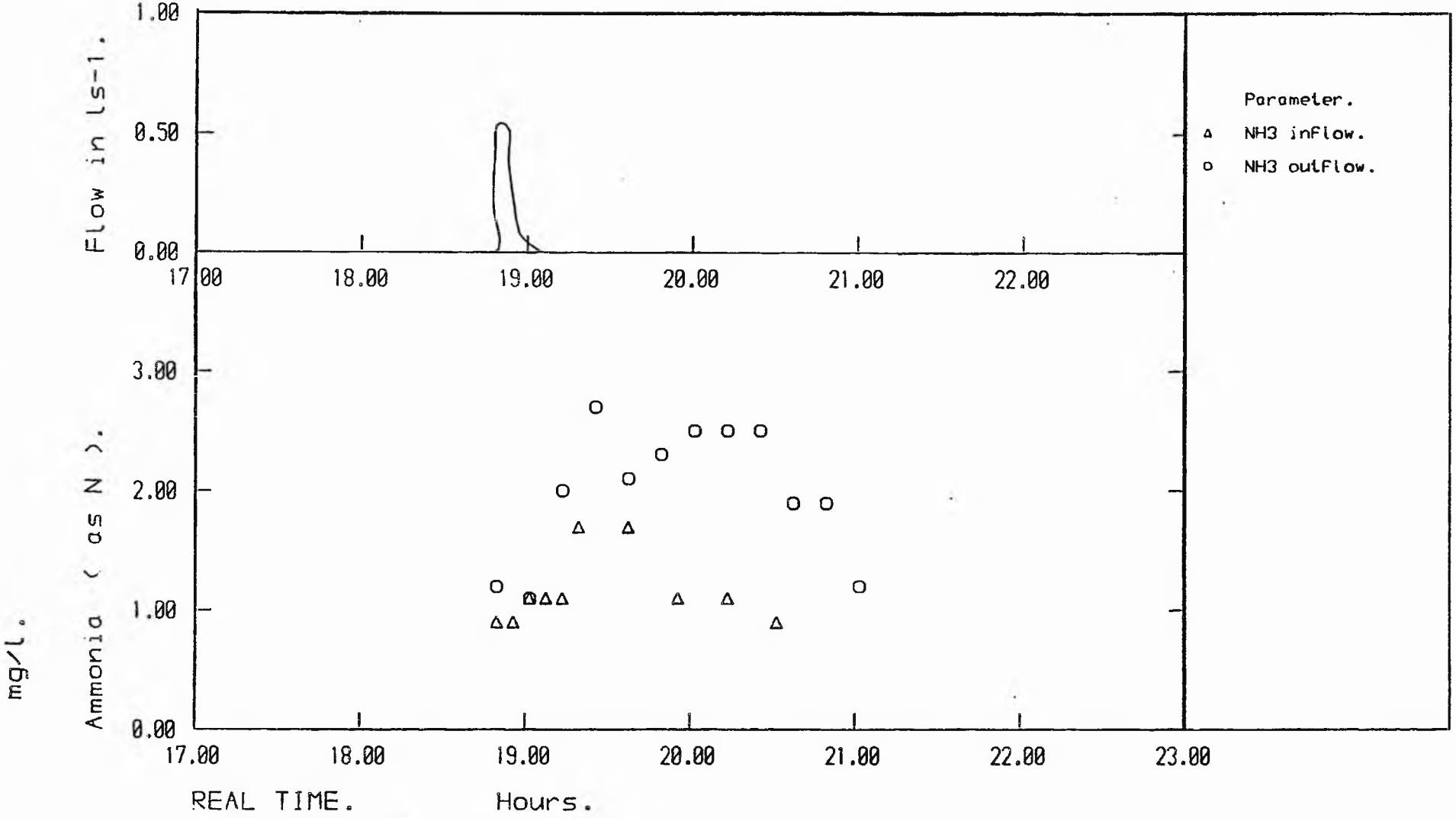
Graph of Calcium For Storm II on Tame Close.
The graph shows inflow and outflow water quality data.



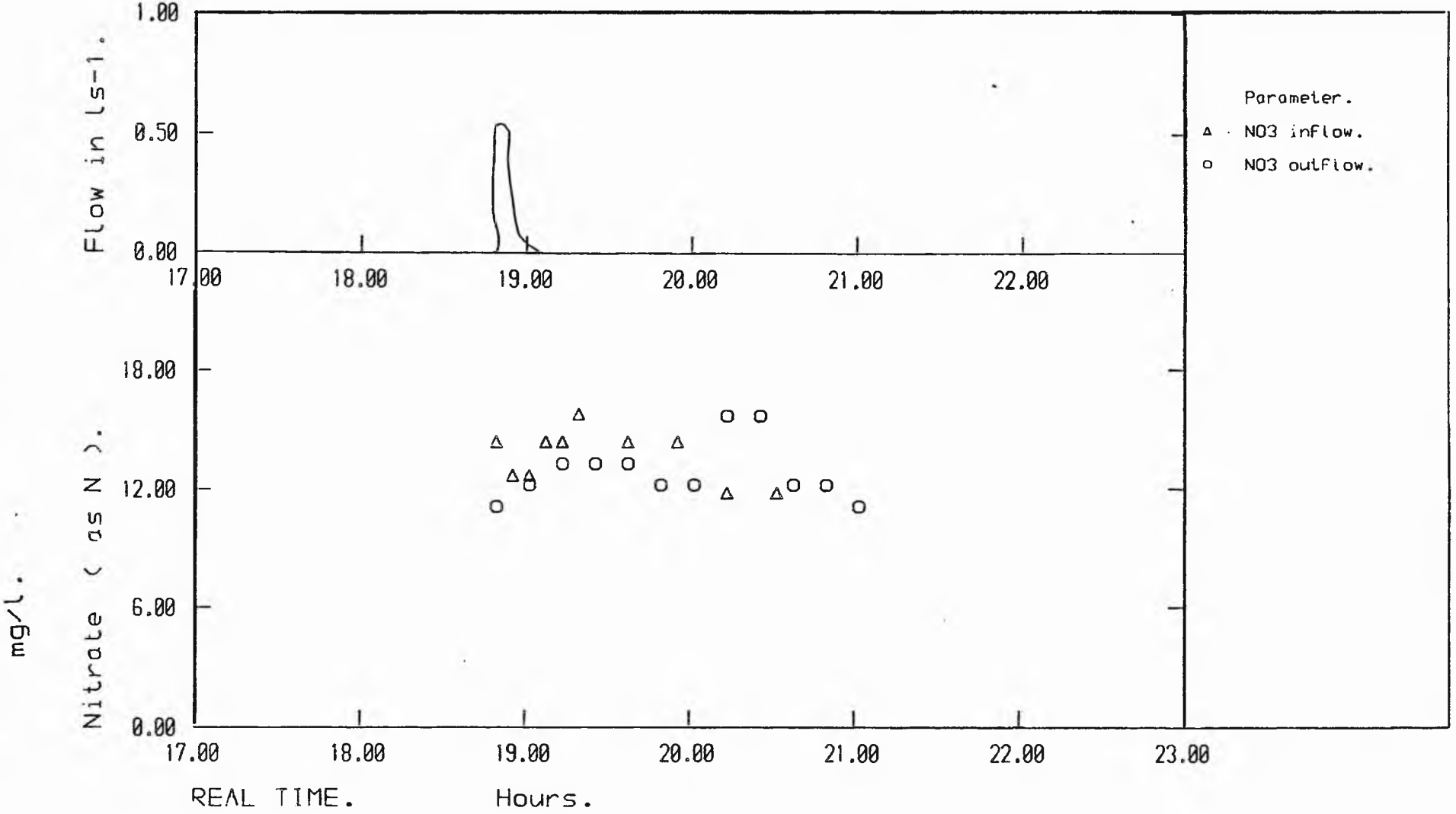
Graph of Magnesium For Storm II on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm II on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Ammonia For Storm II on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Nitrate for Storm II on Tame Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
1850	20	25	84
1856	25	28	89
1902	28	28	94
1908	23	19	94
1914	31	19	81
1920	28	19	79
1938	31	19	69
1956	38	12	61

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
1850	42	38	82
1902	48	38	78
1914	57	47	89
1926	123	47	95
1938	141	52	95
1950	147	59	110
2002	132	47	110
2014	98	38	95
2026	110	38	98
2038	90	35	95
2050	81	38	95
2102	69	38	78

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
1850	0.11	7.8	6.2
1856	0.19	7.8	6.4
1902	0.22	7.8	6.4
1908	0.22	8.0	6.6
1914	0.35	8.2	6.6
1920	0.35	8.5	6.6
1938	0.29	8.5	6.7
1956	0.29	8.5	6.7

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
1850	0.29	4.9	6.8
1902	0.27	4.9	6.8
1914	0.31	5.1	6.8
1926	0.31	4.3	6.7
1938	0.31	4.7	6.8
1950	0.22	5.5	6.9
2002	0.21	5.8	6.9
2014	0.17	5.8	7.2
2026	0.17	6.2	7.2
2038	0.11	6.7	6.9
2050	0.13	6.7	7.0
2102	0.11	6.7	7.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	Fe mgl-1
1850	140.0	110.0	0.2
1856	160.0	150.0	0.2
1902	180.0	150.0	0.2
1908	180.0	180.0	0.0
1914	220.0	200.0	0.0
1920	280.0	200.0	0.0
1938	250.0	200.0	0.0
1956	200.0	150.0	0.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	Fe mgl-1
1850	200	140.0	0.10
1902	210	180.0	0.10
1914	210	180.0	0.12
1926	310	180.0	0.12
1938	330	210.0	0.10
1950	330	230.0	0.05
2002	340	230.0	0.00
2014	280	290.0	0.00
2026	280	210.0	0.00
2038	280	210.0	0.00
2050	280	220.0	0.00
2102	210	190.0	0.00

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
1850	28.0	52.4	12.2	49.7
1856	28.0	48.7	39.4	49.7
1902	34.6	48.7	47.9	80.7
1908	38.8	38.4	74.1	80.1
1914	41.2	38.4	71.7	74.8
1920	36.4	31.7	70.1	72.0
1938	32.0	31.7	68.4	54.0
1956	28.0	31.7	39.4	0.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
1850	24.2	78.9	25.4	29.1
1902	24.2	78.9	25.4	19.3
1914	30.9	82.1	22.7	19.3
1926	43.7	82.1	22.7	21.4
1938	55.0	82.1	35.7	19.3
1950	55.0	94.7	35.7	19.3
2002	47.4	91.7	40.1	22.7
2014	55.0	91.7	29.2	22.7
2026	43.7	82.1	25.4	19.1
2038	43.7	82.1	22.7	19.1
2050	30.9	78.9	22.7	19.1
2102	43.7	78.9	22.7	19.1

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF INFLOW WATER TO THE GULLY POT

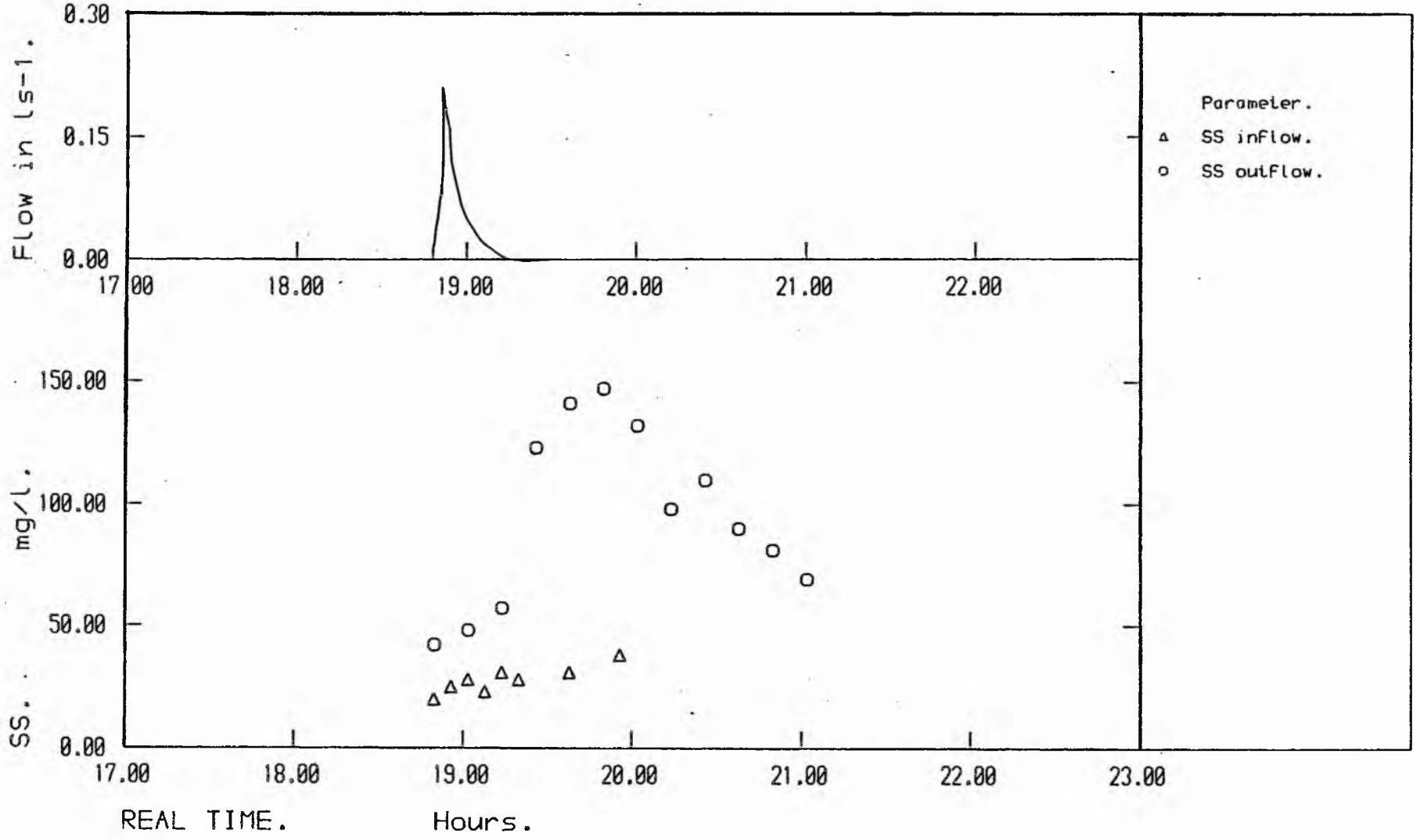
REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Zn mgl-1
1850	1.9	10.7	0.1
1856	2.3	10.4	0.1
1902	2.1	10.7	0.1
1908	1.7	11.2	0.1
1914	1.1	11.9	0.1
1920	1.1	12.0	0.1
1938	1.1	10.9	0.1
1956	1.1	10.7	0.1

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

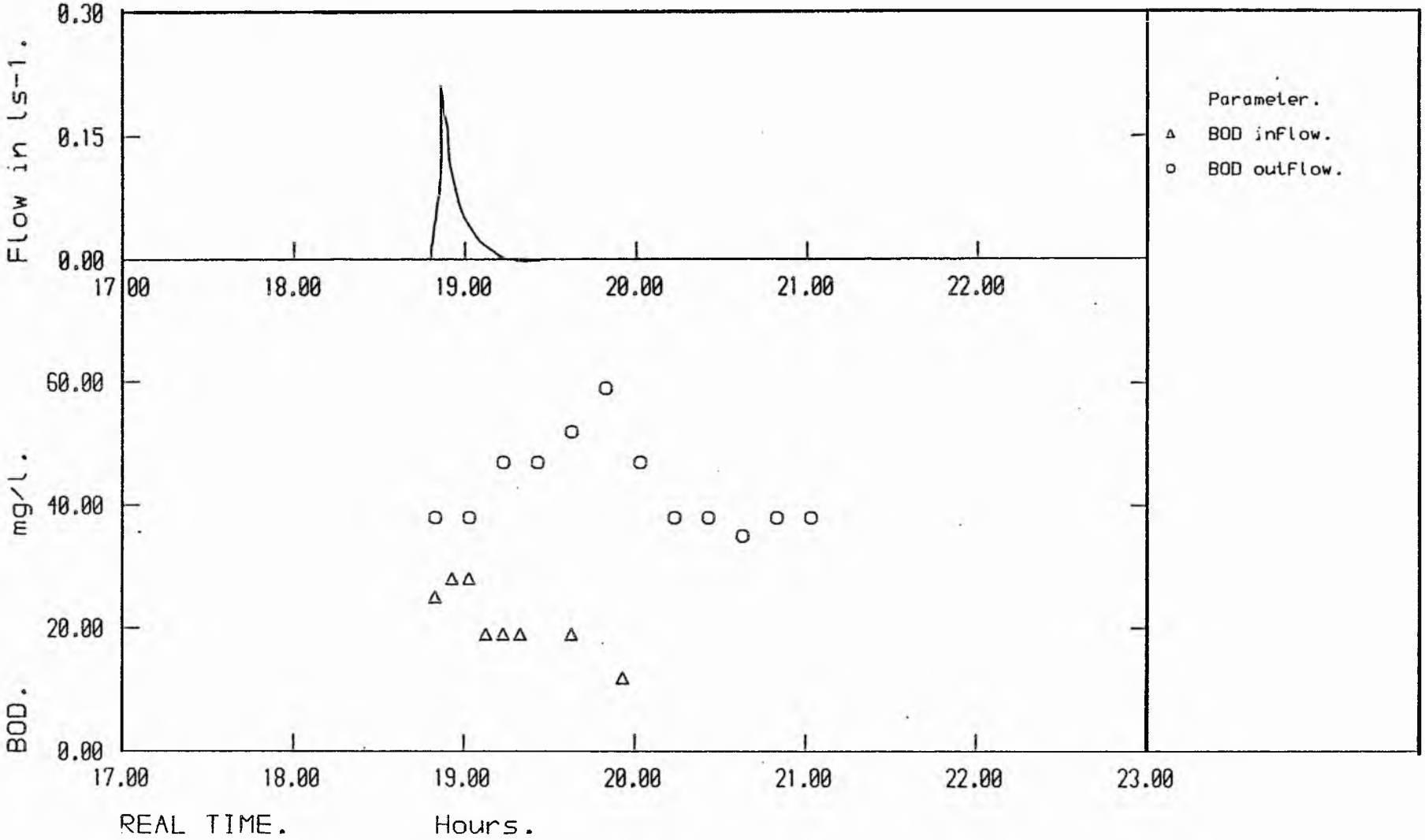
CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 12th. July 1984 (840712)
STORM NUMBER : II

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

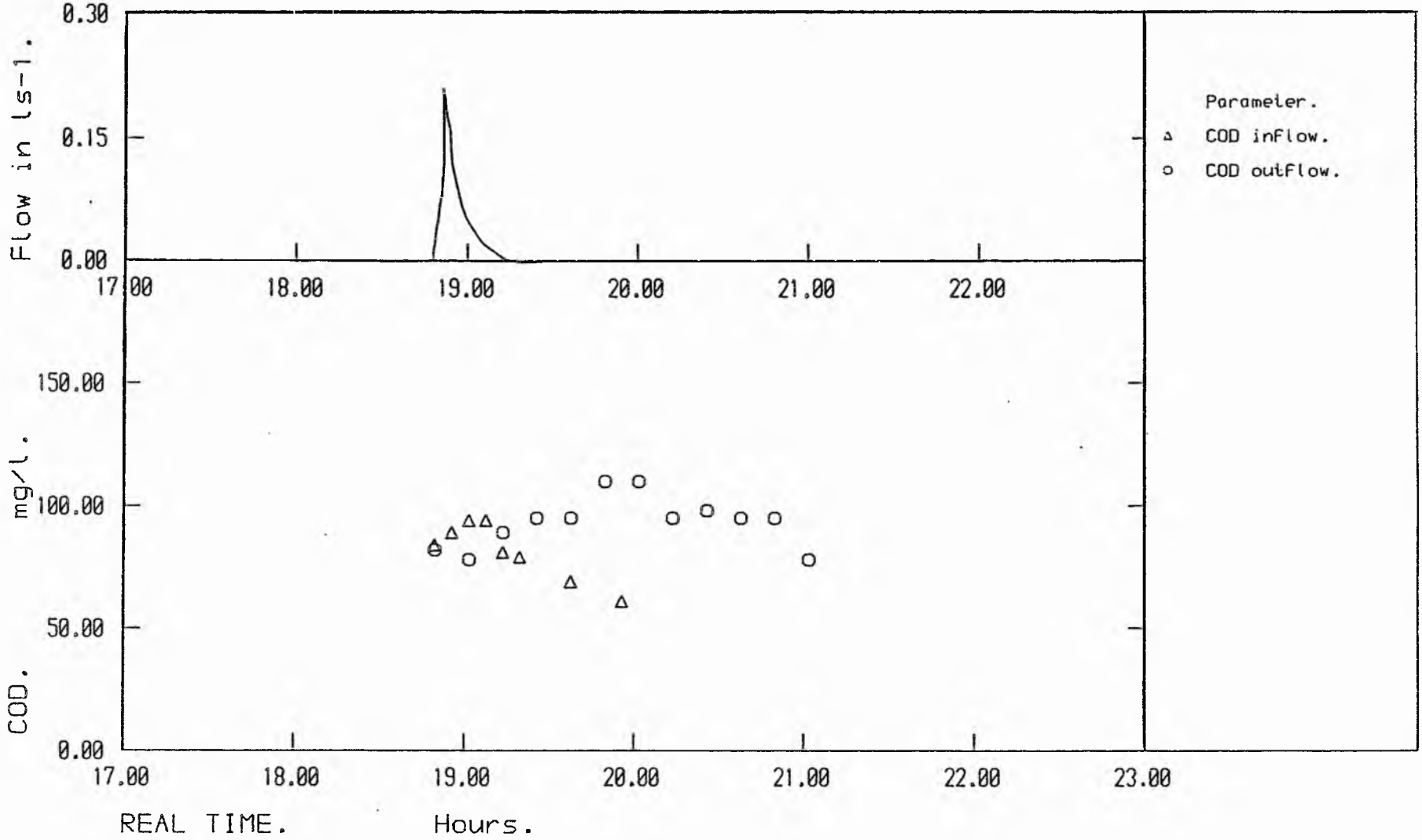
REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Zn mgl-1
1850	0.9	4.7	0.1
1902	0.9	11.2	0.1
1914	0.9	11.9	0.2
1926	1.1	11.9	0.2
1938	1.1	11.9	0.2
1950	1.7	11.2	0.1
2002	1.7	11.2	0.1
2014	1.4	11.2	0.1
2026	1.2	10.7	0.1
2038	1.2	10.7	0.0
2050	1.2	10.7	0.0
2102	1.0	9.4	0.0



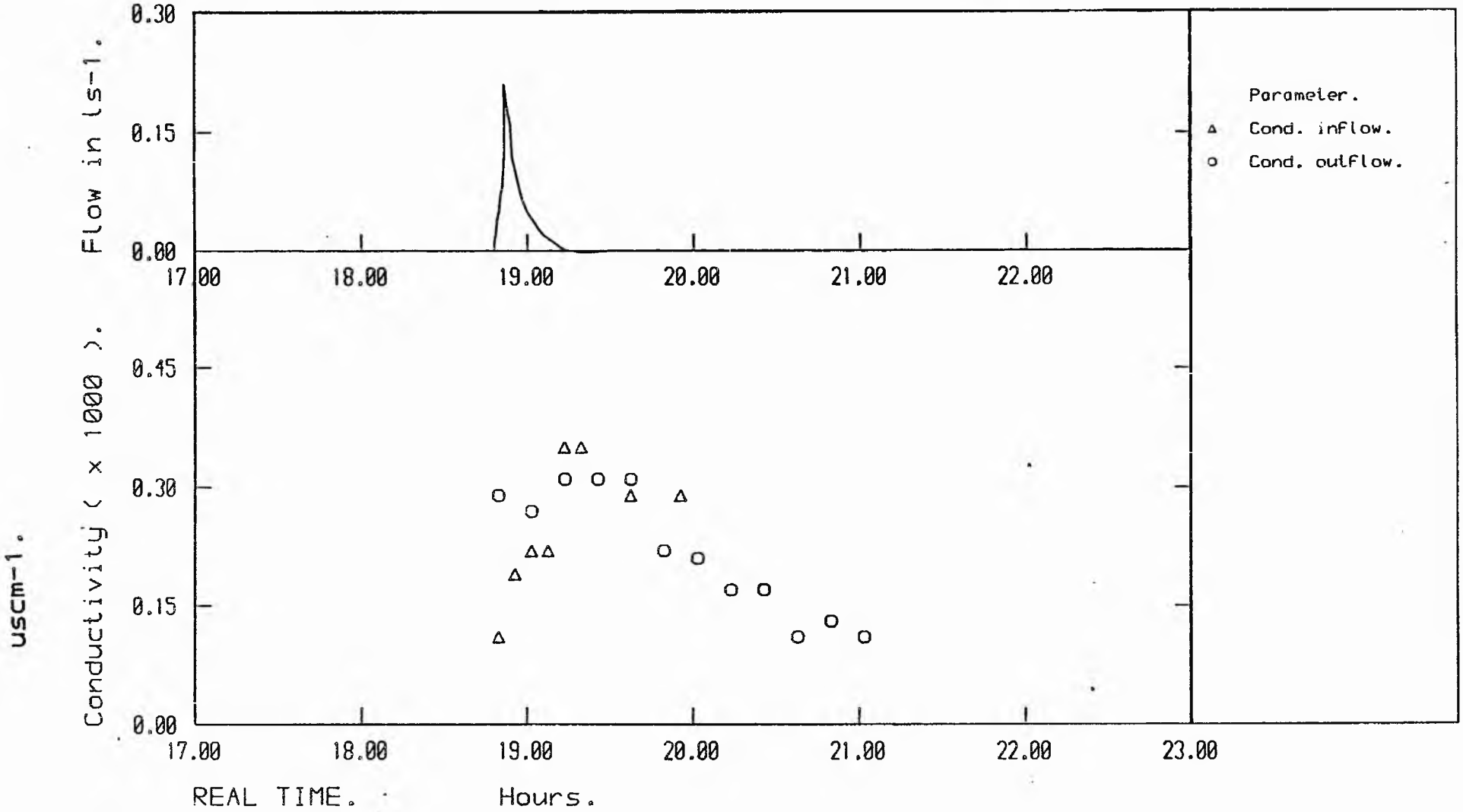
Graph of Suspended Solids for Storm II on Twyford Gardens.
The graph shows inflow and outflow water quality data.



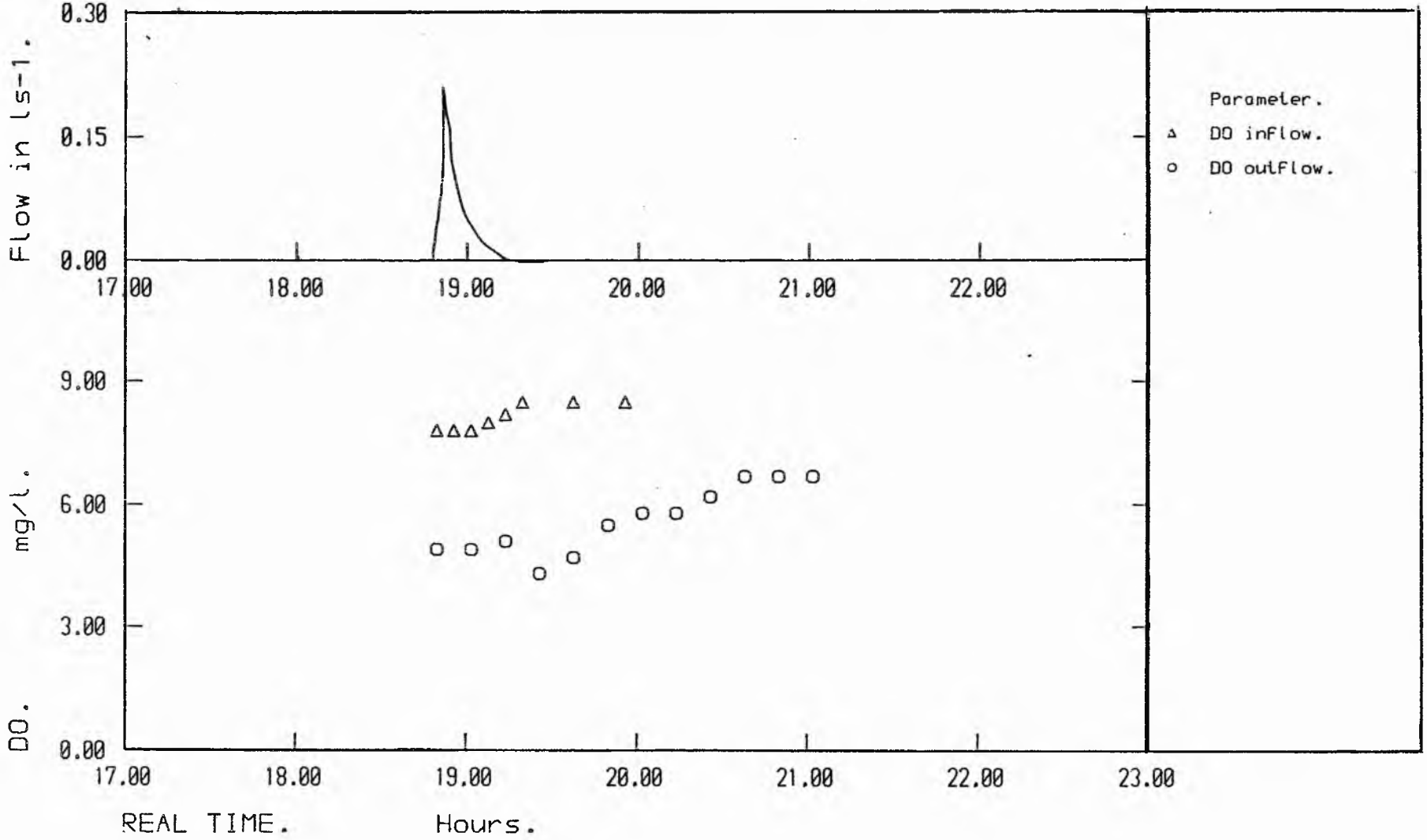
Graph of Biochemical Oxygen Demand for Storm II on Twyford Gardens.
The graph shows inflow and outflow water quality data.



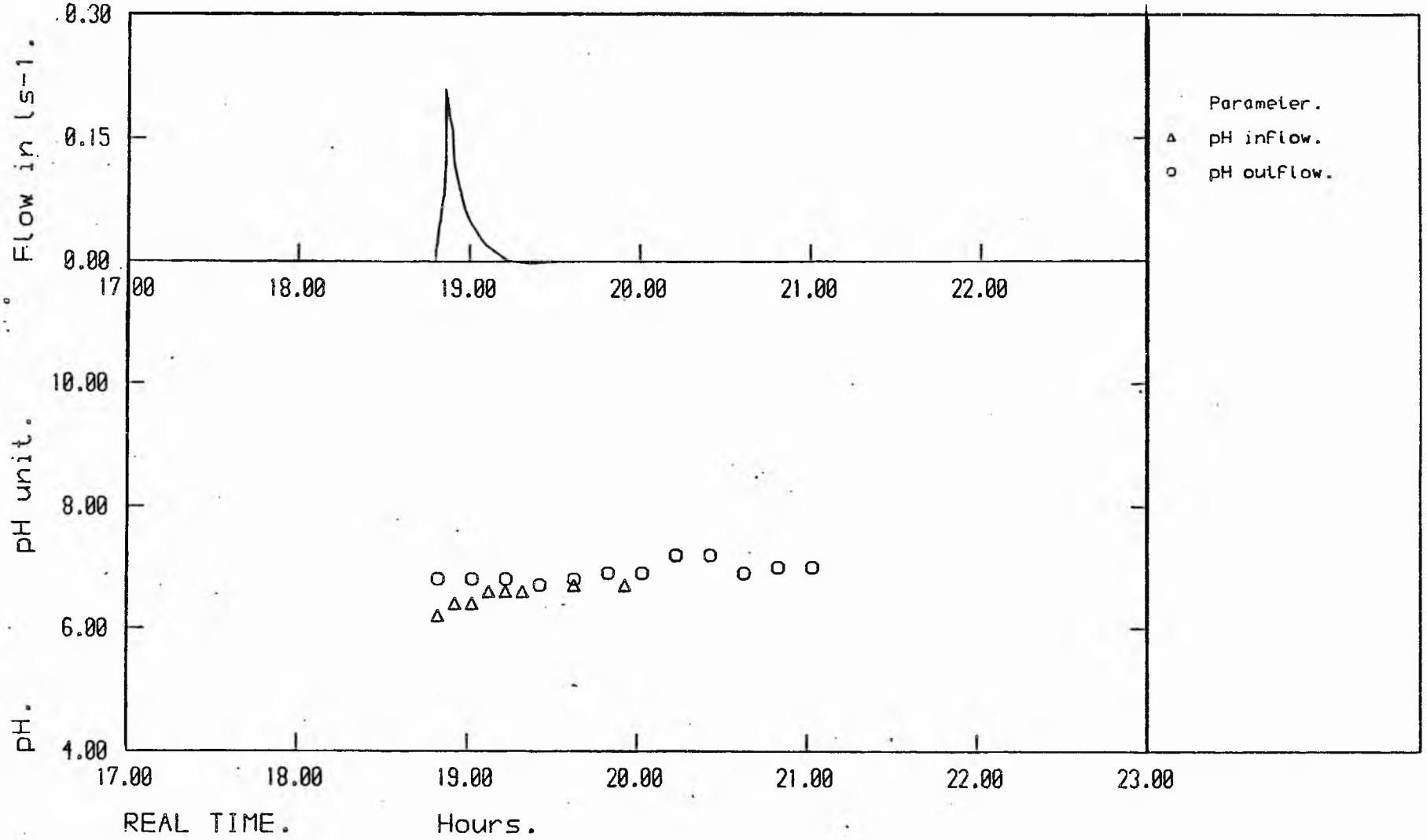
Graph of Chemical Oxygen Demand for Storm II on Twyford Gardens.
The graph shows inflow and outflow water quality data.



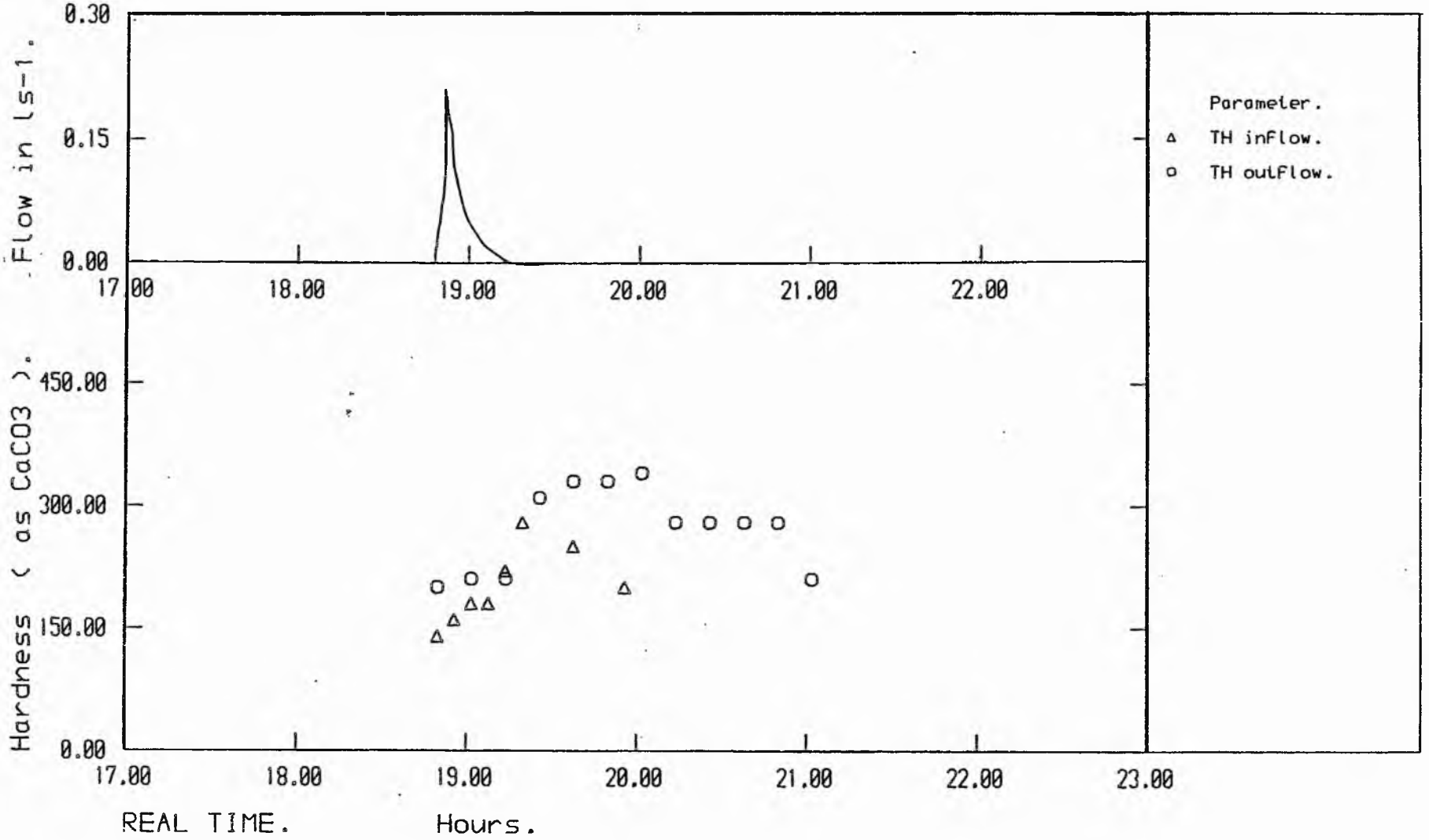
Graph of Conductivity for Storm II on Twyford Gardens.
The graph shows inflow and outflow water quality data.



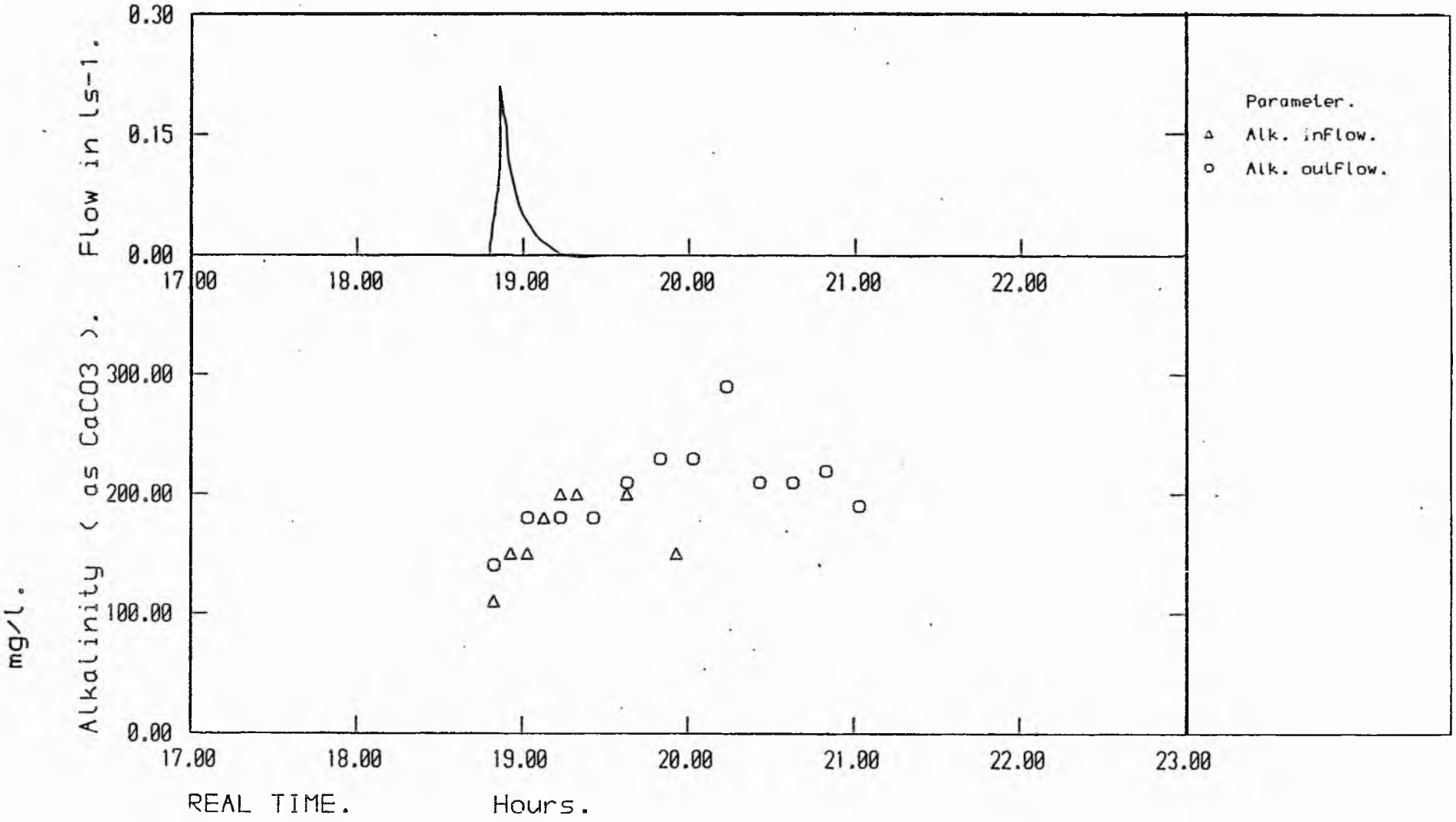
Graph of Dissolved Oxygen for Storm II on Twyford Gardens.
The graph shows inflow and outflow water quality data.



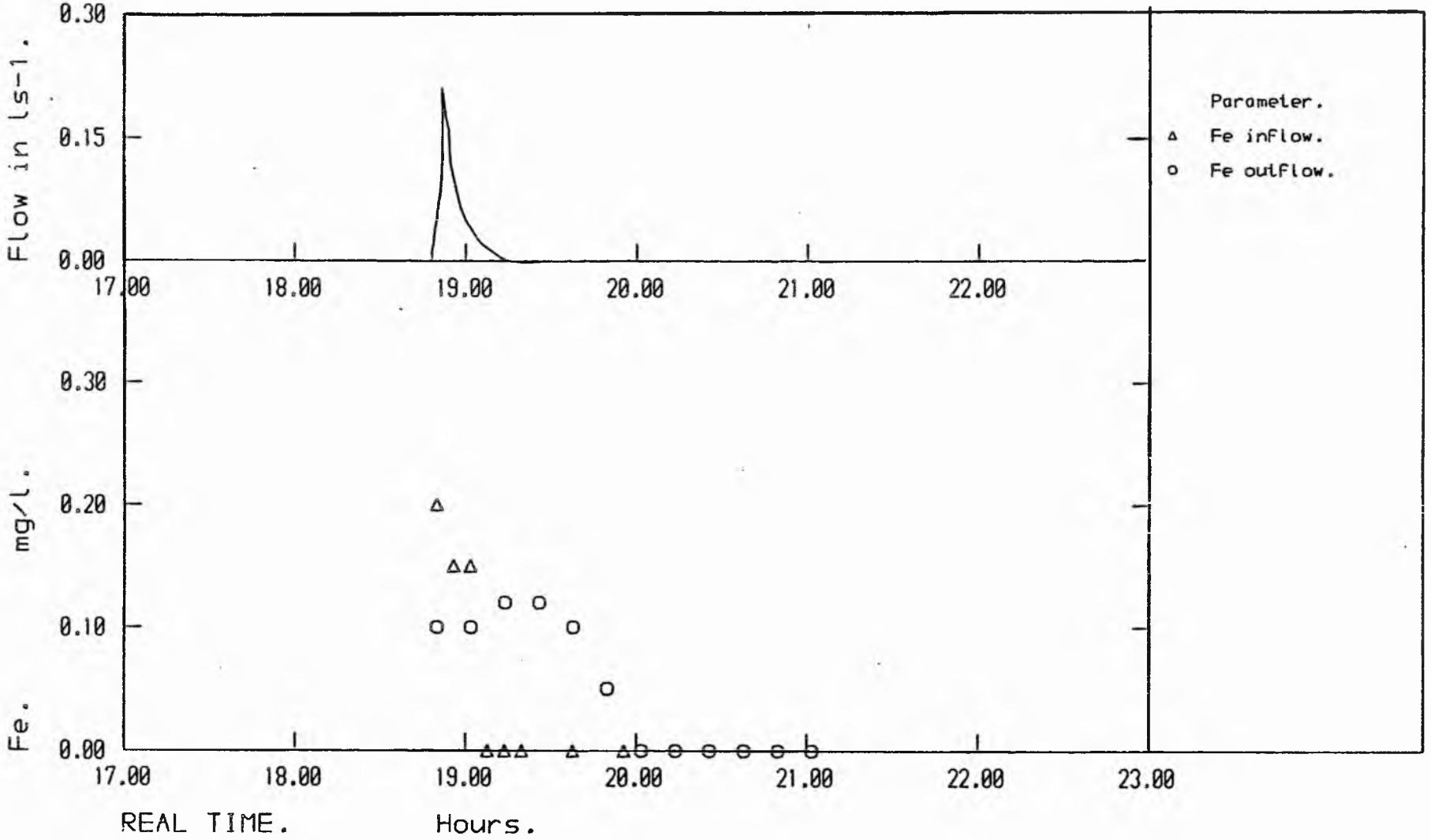
Graph of pH for Storm II on Twyford Gardens:
The graph shows inflow and outflow water quality data:



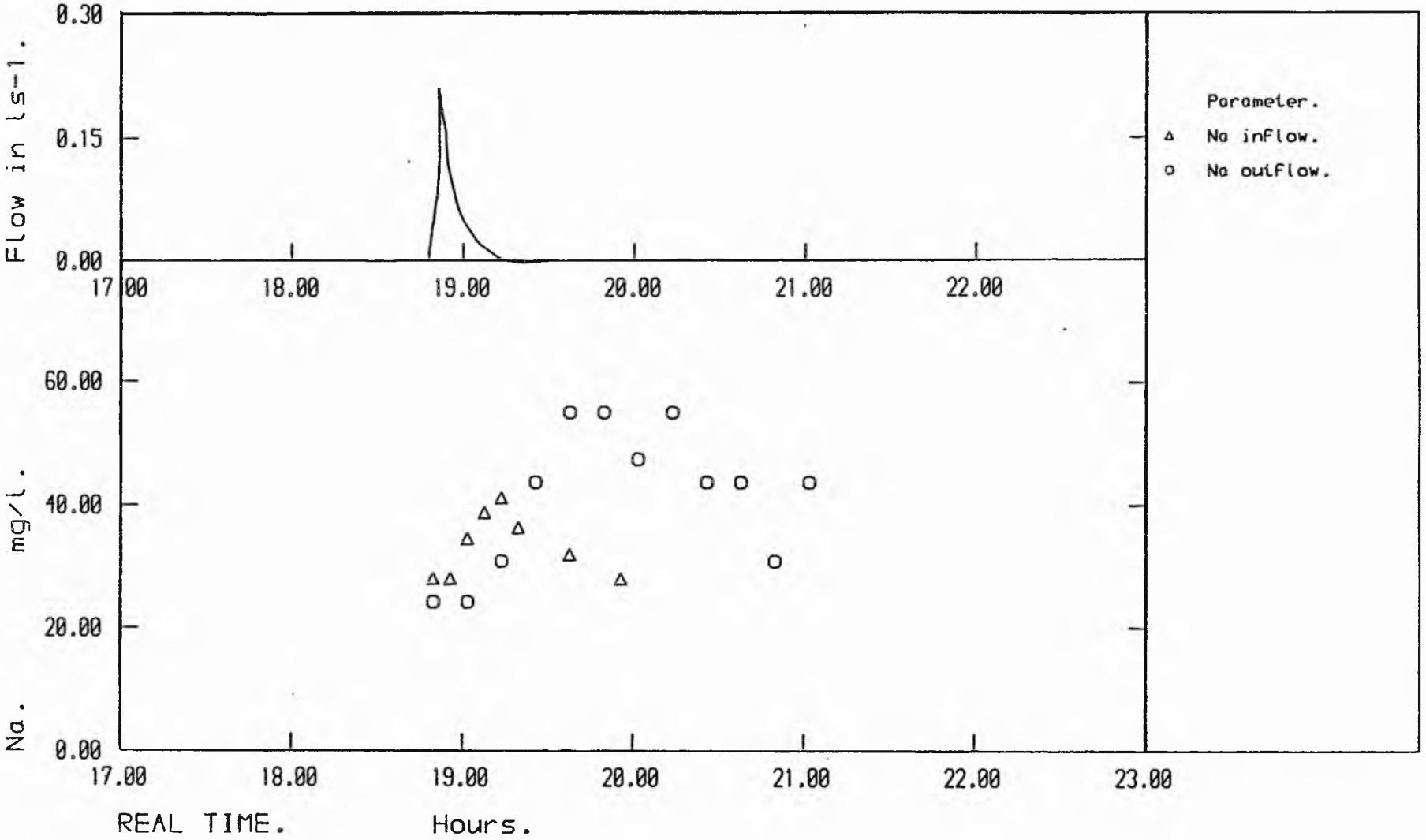
Graph of Total Hardness for Storm II on Twyford Gardens.
The graph shows inflow and outflow water quality data.



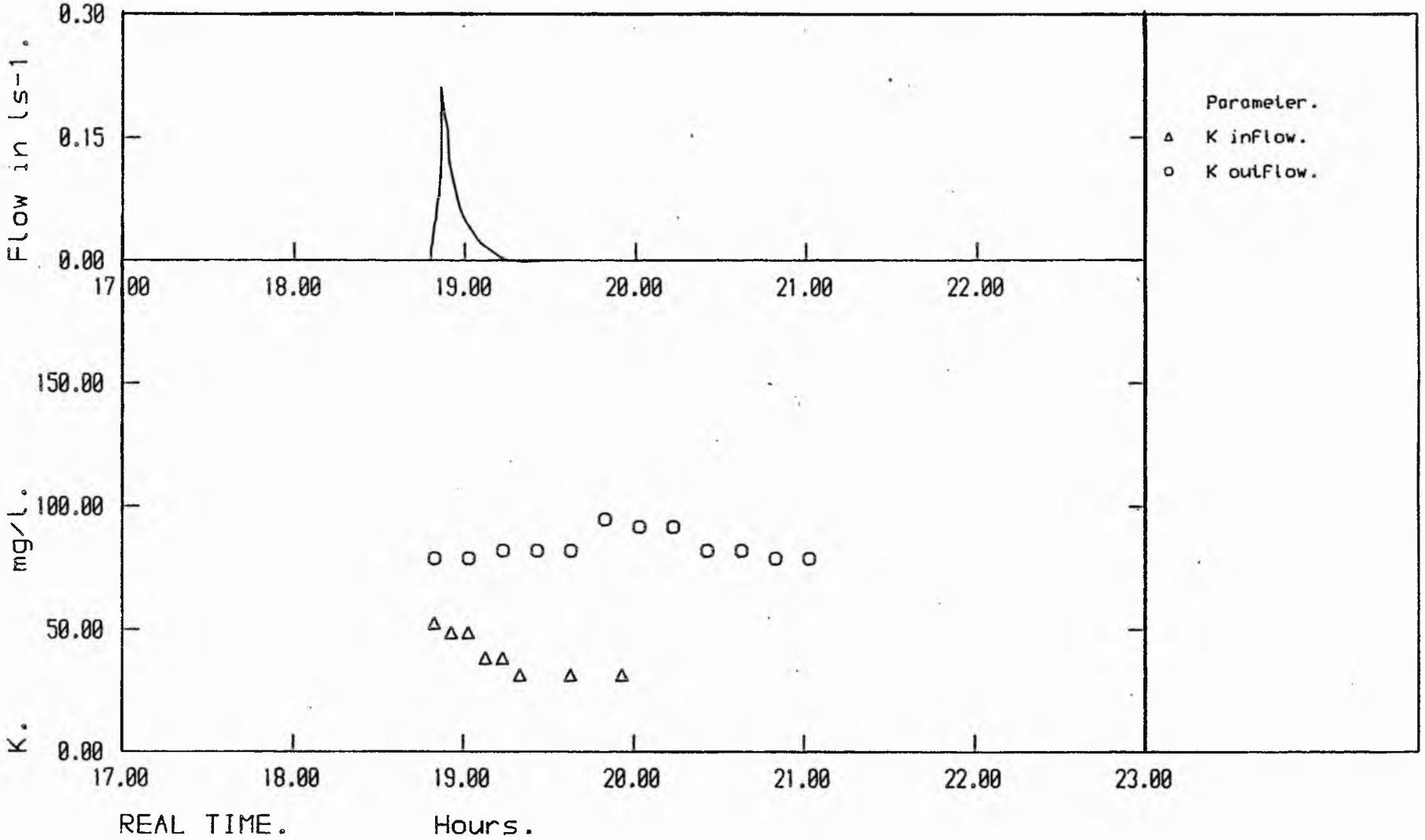
Graph of Total Alkalinity For Storm II on Twyford Gardens.
The graph shows inflow and outflow water quality data.



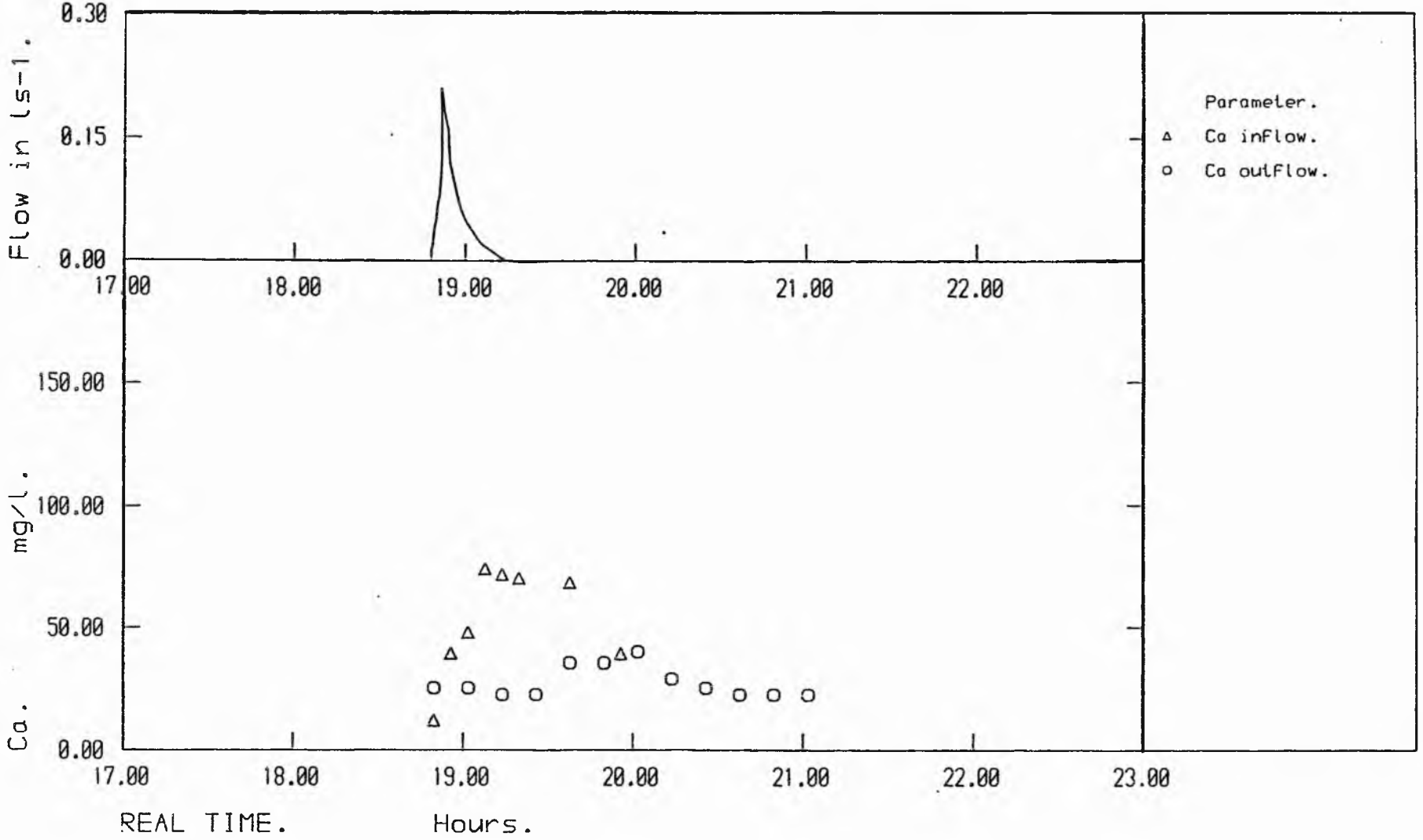
Graph of Iron for Storm II on Twyford Gardens.
The graph shows inflow and outflow water quality data.



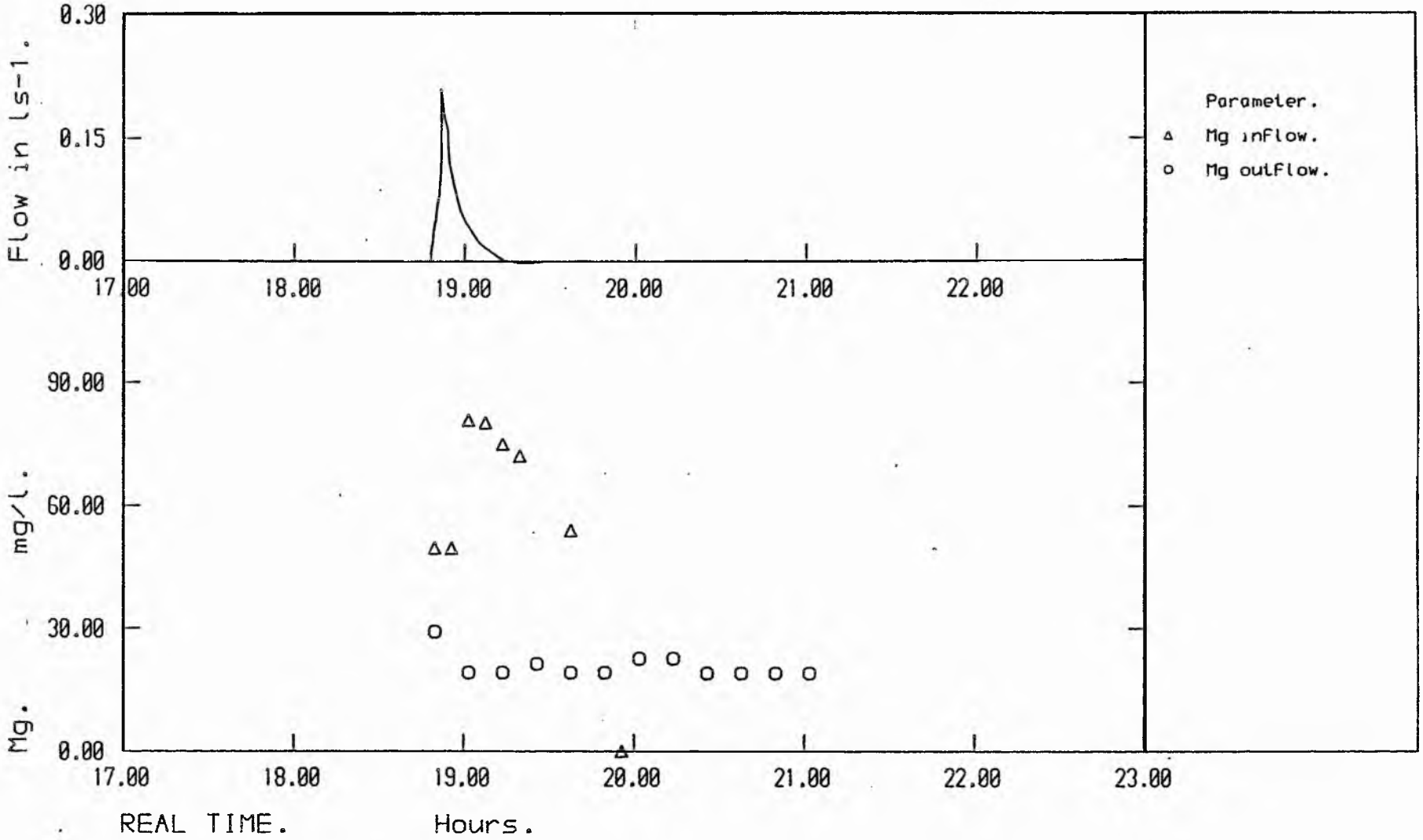
Graph of Sodium for Storm II on Twyford Gardens.
The graph shows inflow and outflow water quality data.



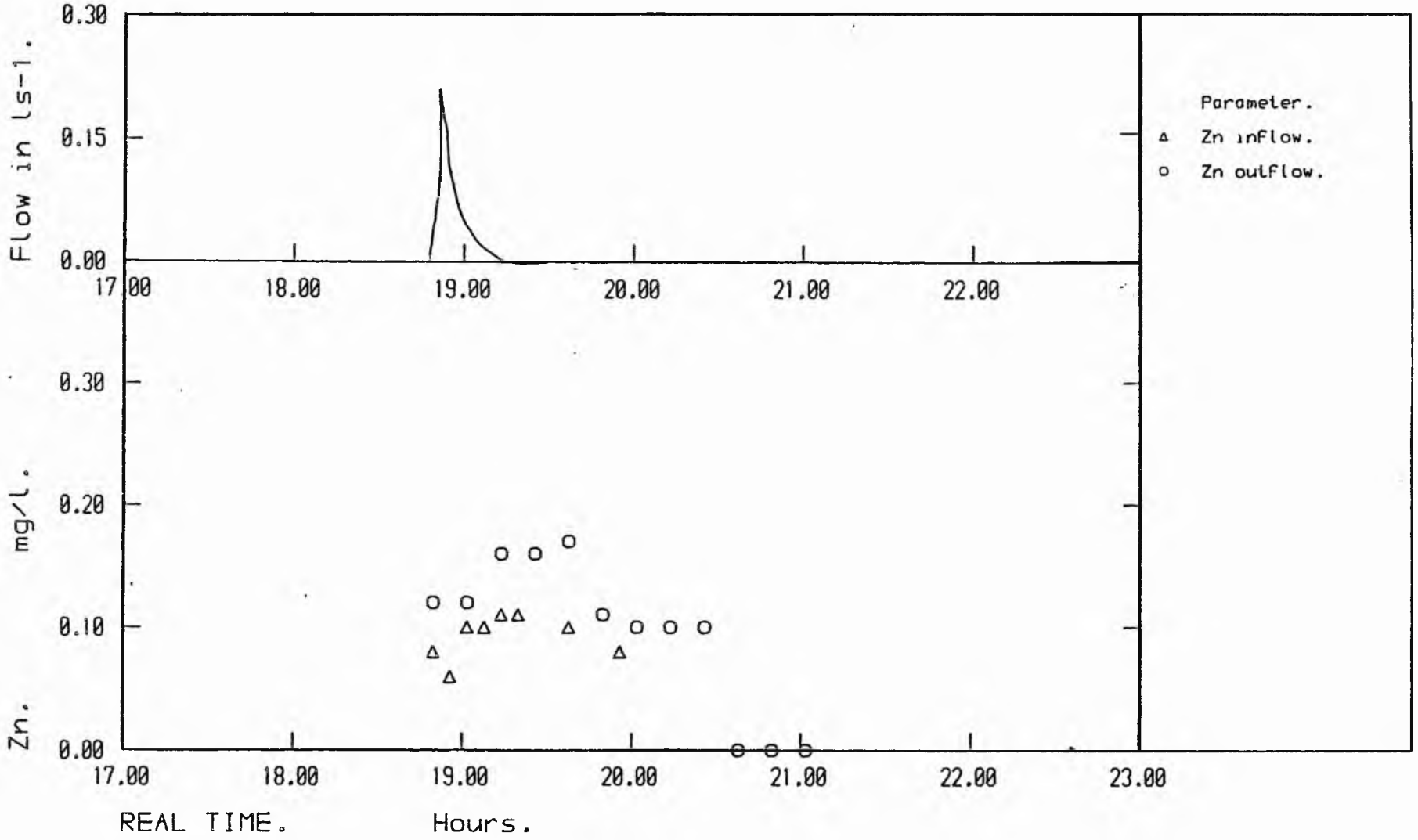
Graph of Potassium for Storm II on Twyford Gardens.
The graph shows inflow and outflow water quality data.



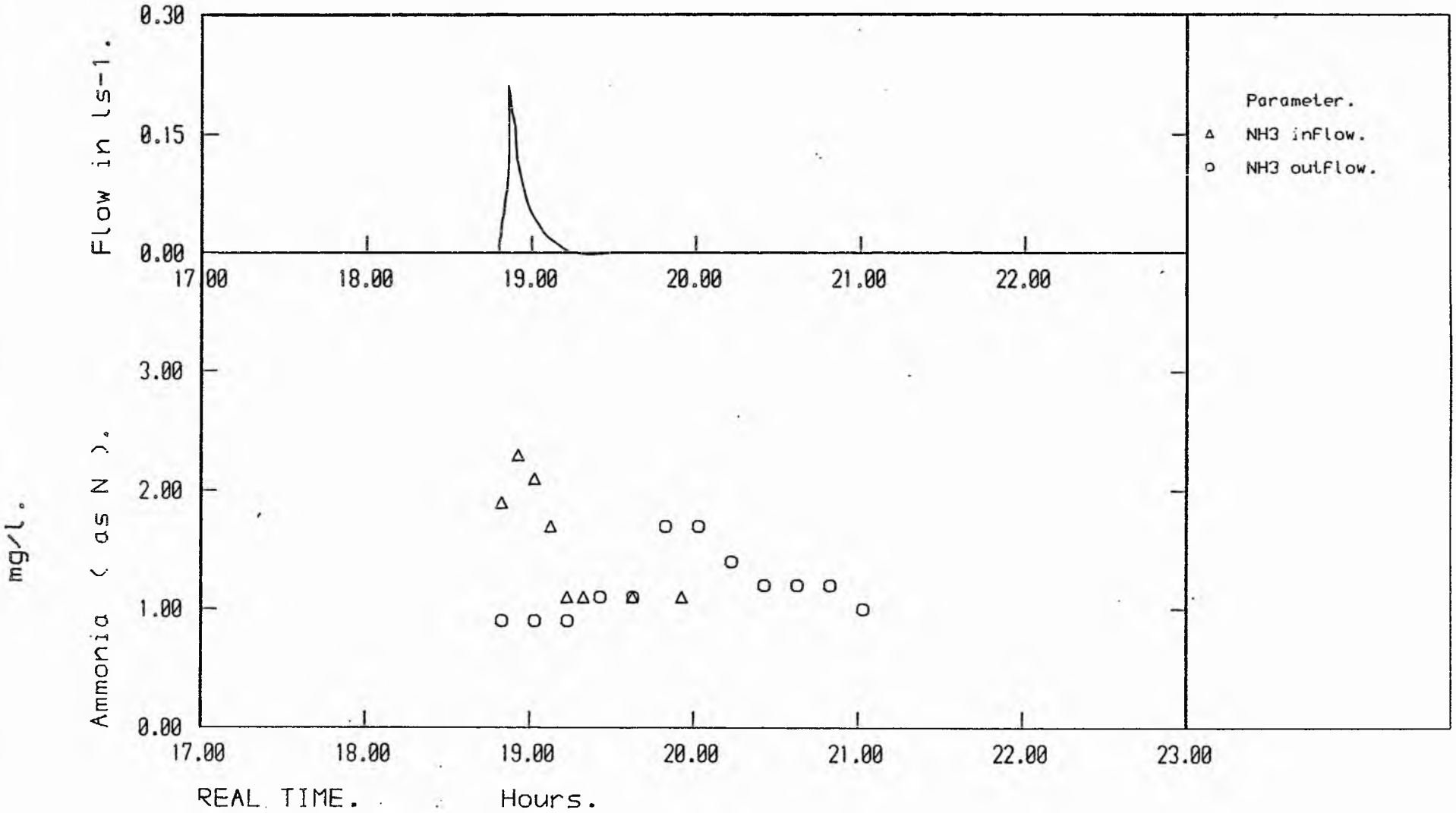
Graph of Calcium for Storm II on Twyford Gardens.
The graph shows inflow and outflow water quality data.



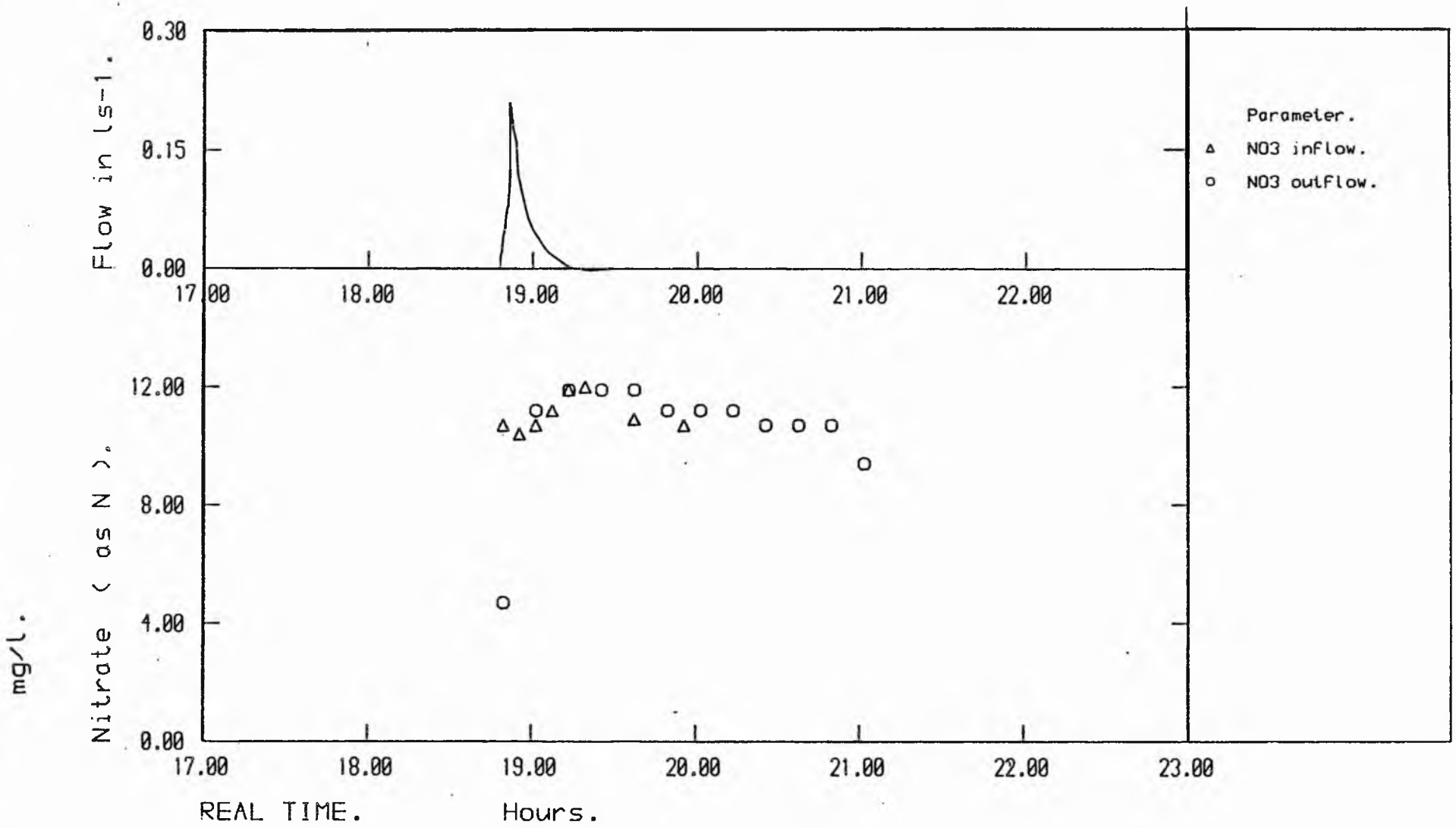
Graph of Magnesium for Storm II on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm II on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Ammonia For Storm II on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Nitrate for Storm II on Twyford Gardens.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
0300	84	3	5
0306	85	3	20
0312	80	12	41
0318	80	13	41
0324	120	11	117
0330	115	13	77
0336	106	13	240
0348	87	8	230
0400	80	16	240
0412	81	22	255
0424	57	20	245
0436	61	14	286
0448	53	18	296
0500	52	19	286
0512	50	18	281

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close

DATE OF THE STORM EVENT : 2nd. August 1984 (840802)

STORM NUMBER : III

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
0300	71	15	61
0312	110	3	128
0324	220	17	102
0336	217	20	107
0348	151	10	270
0400	134	12	281
0412	110	14	270
0424	94	23	224
0436	81	25	316
0448	47	23	255
0500	52	6	265
0512	21	8	224

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
0300	0.34	2.4	6.5
0306	0.35	2.3	6.5
0312	0.34	2.1	6.5
0318	0.36	2.1	6.4
0324	0.32	2.2	6.4
0330	0.32	2.2	6.4
0336	0.30	2.8	6.3
0348	0.30	2.7	6.3
0400	0.30	3.8	6.2
0412	0.33	3.2	6.2
0424	0.33	3.1	6.3
0436	0.34	2.9	6.5
0448	0.33	3.4	6.3
0500	0.31	3.4	6.3
0512	0.33	3.6	6.3

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
0300	0.71	3.2	6.1
0312	0.72	3.1	6.2
0324	0.58	3.1	6.1
0336	0.59	3.7	6.4
0348	0.55	3.4	6.4
0400	0.55	3.1	6.2
0412	0.51	2.7	6.2
0424	0.62	3.8	6.2
0436	0.55	3.8	6.4
0448	0.51	3.6	6.2
0500	0.51	3.8	6.2
0512	0.54	3.8	6.4

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
0300	540.0	400.0	577	429.0
0306	510.0	250.0	520	503.0
0312	510.0	370.0	471	464.0
0318	640.0	340.0	509	450.0
0324	720.0	440.0	721	500.0
0330	670.0	260.0	577	500.0
0336	710.0	80.0	711	482.0
0348	540.0	130.0	500	450.0
0400	570.0	110.0	384	486.0
0412	580.0	140.0	144	510.0
0424	610.0	150.0	577	372.0
0436	620.0	60.0	509	440.0
0448	600.0	120.0	317	432.0
0500	580.0	150.0	452	230.0
0512	540.0	70.0	548	496.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
0300	430.0	180.0	1336	39.0
0312	580.0	110.0	1144	28.0
0324	390.0	110.0	663	17.0
0336	480.0	150.0	740	64.0
0348	410.0	170.0	769	174.0
0400	390.0	130.0	855	25.0
0412	490.0	100.0	567	78.0
0424	400.0	190.0	672	191.0
0436	570.0	150.0	980	96.0
0448	350.0	110.0	855	50.0
0500	360.0	130.0	1028	46.0
0512	430.0	110.0	403	43.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Fe mgl-1
0300	7.3	336.0	0.4
0306	6.0	350.0	0.3
0312	6.3	420.0	0.3
0318	4.2	588.0	0.0
0324	4.8	532.0	0.0
0330	3.9	490.0	0.0
0336	0.8	392.0	0.0
0348	1.5	294.0	0.0
0400	1.2	294.0	0.0
0412	1.2	315.0	0.0
0424	1.5	336.0	0.0
0436	1.1	364.0	0.0
0448	1.3	364.0	0.0
0500	1.8	364.0	0.0
0512	2.0	364.0	0.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Fe mgl-1
0300	0.8	3.9	0.4
0312	2.5	2.8	0.4
0324	0.6	2.7	0.4
0336	3.4	2.5	0.4
0348	2.8	4.6	0.4
0400	2.2	5.2	0.0
0412	2.7	5.2	0.0
0424	2.8	2.4	0.0
0436	2.5	1.8	0.0
0448	1.1	2.8	0.0
0500	1.8	2.8	0.0
0512	1.7	2.8	0.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
0300	0.8	1.0	13.2	0.3
0306	0.9	1.1	11.5	0.3
0312	1.2	1.1	10.5	0.4
0318	1.3	1.2	10.5	0.4
0324	1.3	1.3	11.0	0.4
0330	1.3	1.3	10.5	0.4
0348	1.2	1.0	6.8	0.4
0406	1.1	1.0	6.8	0.4
0424	1.1	0.9	6.8	0.4
0442	0.8	0.9	4.5	0.3
0500	0.9	0.8	5.0	0.4
0518	0.8	0.8	5.0	0.3

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close

DATE OF THE STORM EVENT : 2nd. August 1984 (840802)

STORM NUMBER : III

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
0300	1.5	1.6	15.5	0.5
0312	1.4	1.7	16.0	0.6
0324	1.4	1.8	15.0	0.7
0336	1.3	1.6	15.0	0.8
0348	1.3	1.6	15.0	0.8
0400	1.6	1.6	10.5	0.8
0412	1.6	1.5	11.0	0.8
0424	1.6	1.3	10.5	0.8
0436	1.6	1.3	8.0	0.7
0448	1.4	1.3	8.0	0.6
0500	1.2	1.2	8.0	0.6
0512	1.3	1.2	8.0	0.6

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close

DATE OF THE STORM EVENT : 2nd. August 1984 (840802)

STORM NUMBER : III

ANALYSIS OF INFLOW WATER TO THE GULLY POT

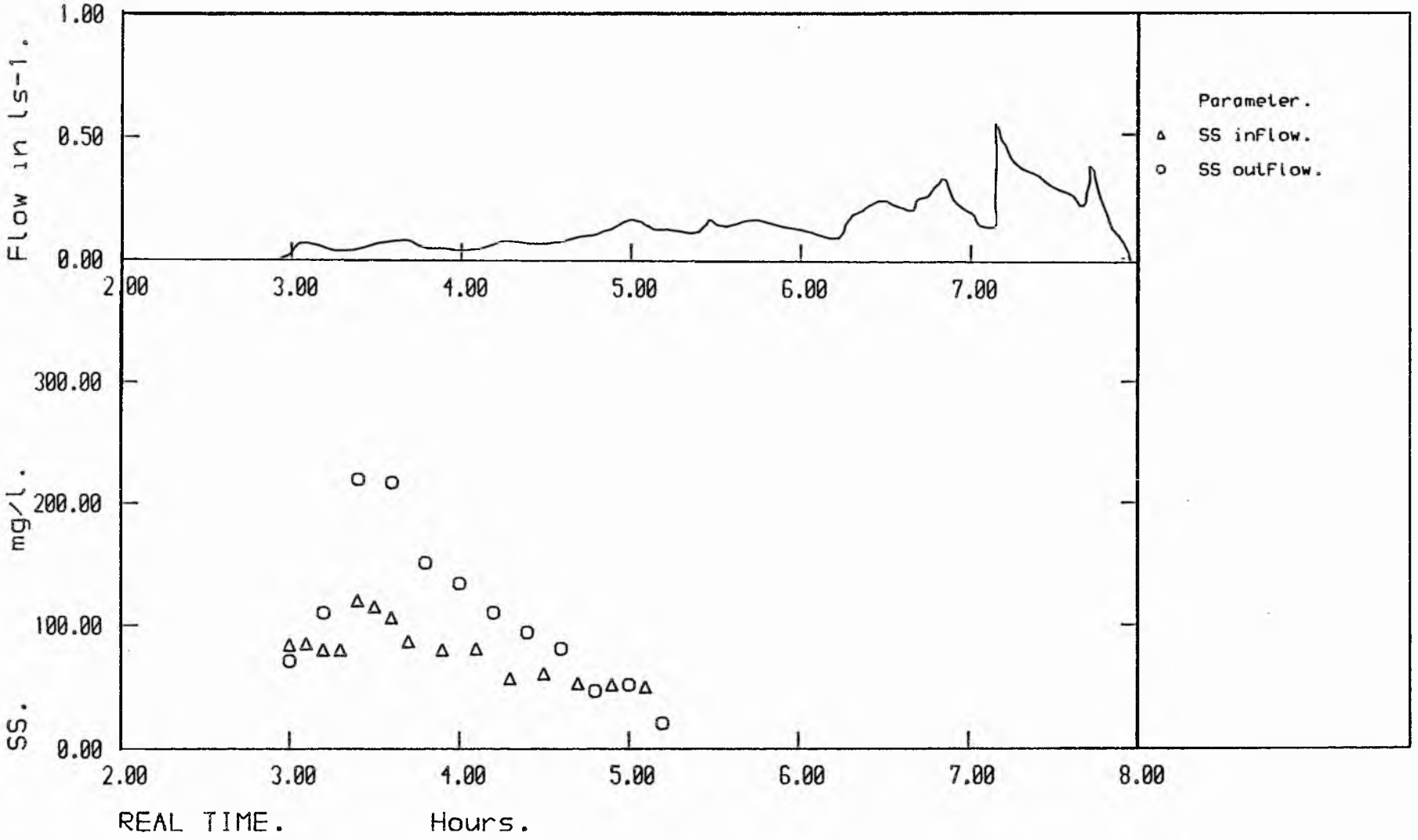
REAL TIME Hours	Zn mgl-1	Mn mgl-1	Pb mgl-1
0300	0.1	0.0	0.0
0306	0.1	0.0	0.0
0312	0.2	0.1	0.0
0318	0.1	0.1	0.0
0324	0.1	0.1	0.0
0330	0.1	0.1	0.0
0348	0.1	0.0	0.2
0406	0.1	0.0	0.0
0424	0.1	0.0	0.0
0442	0.1	0.0	0.0
0500	0.1	0.0	0.0
0518	0.1	0.0	0.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

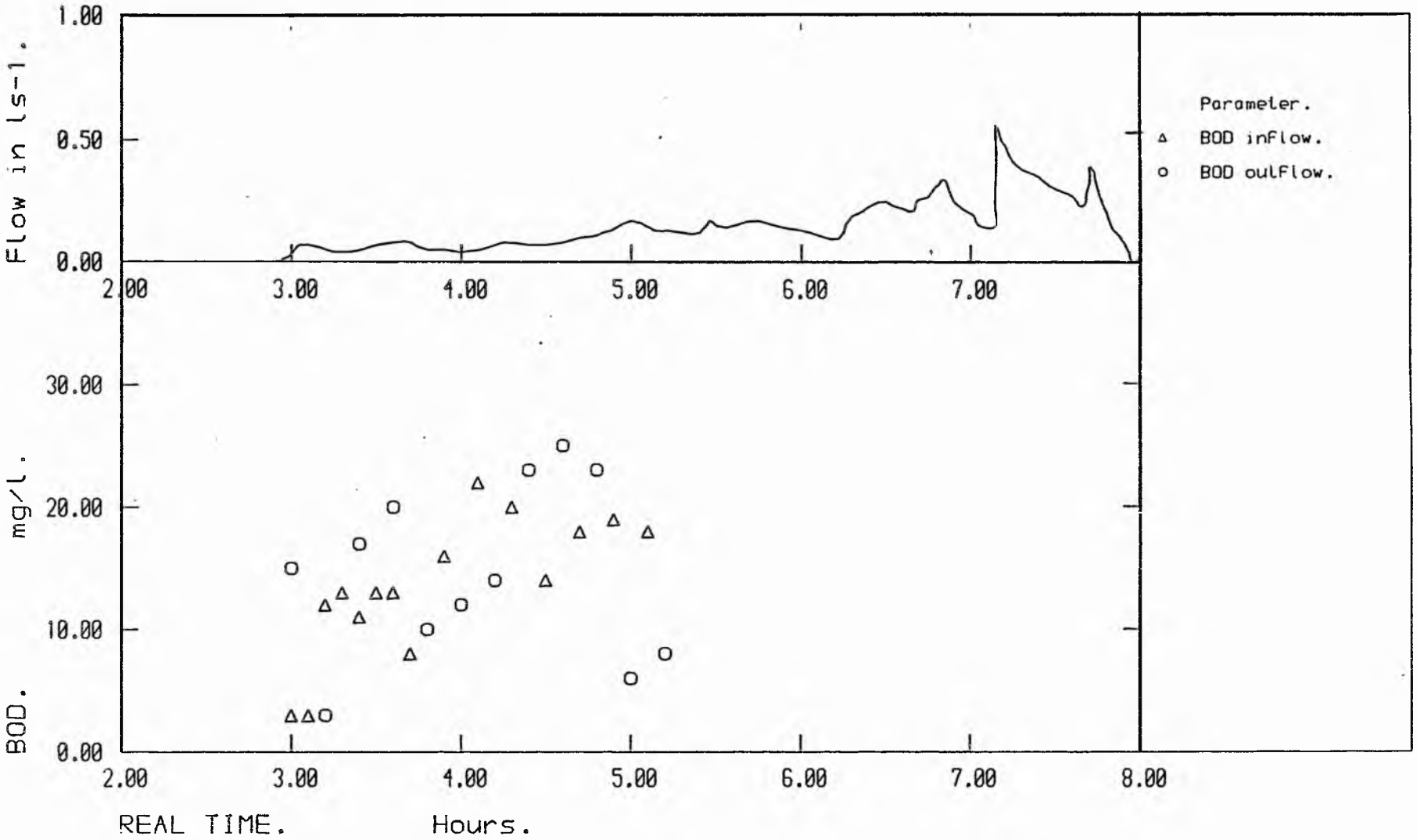
CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

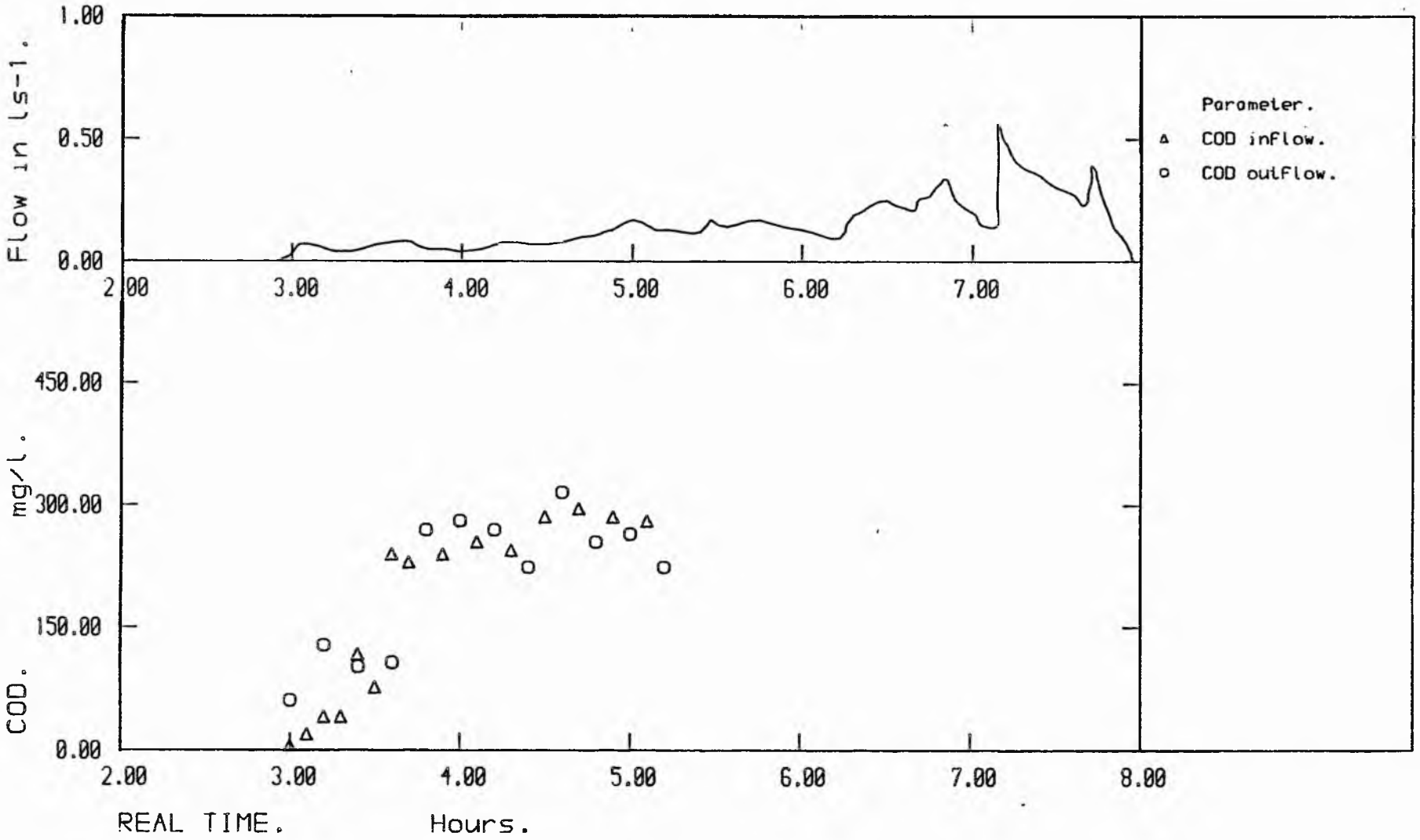
REAL TIME Hours	Zn mgl-1	Mn mgl-1	Pb mgl-1
0300	0.2	0.0	0.0
0312	0.2	0.0	0.1
0324	0.2	0.0	0.3
0336	0.2	0.0	0.3
0348	0.2	0.0	0.3
0400	0.2	0.0	0.1
0412	0.2	0.1	0.0
0424	0.2	0.1	0.0
0436	0.2	0.1	0.0
0448	0.2	0.0	0.0
0500	0.1	0.0	0.0
0512	0.1	0.0	0.0



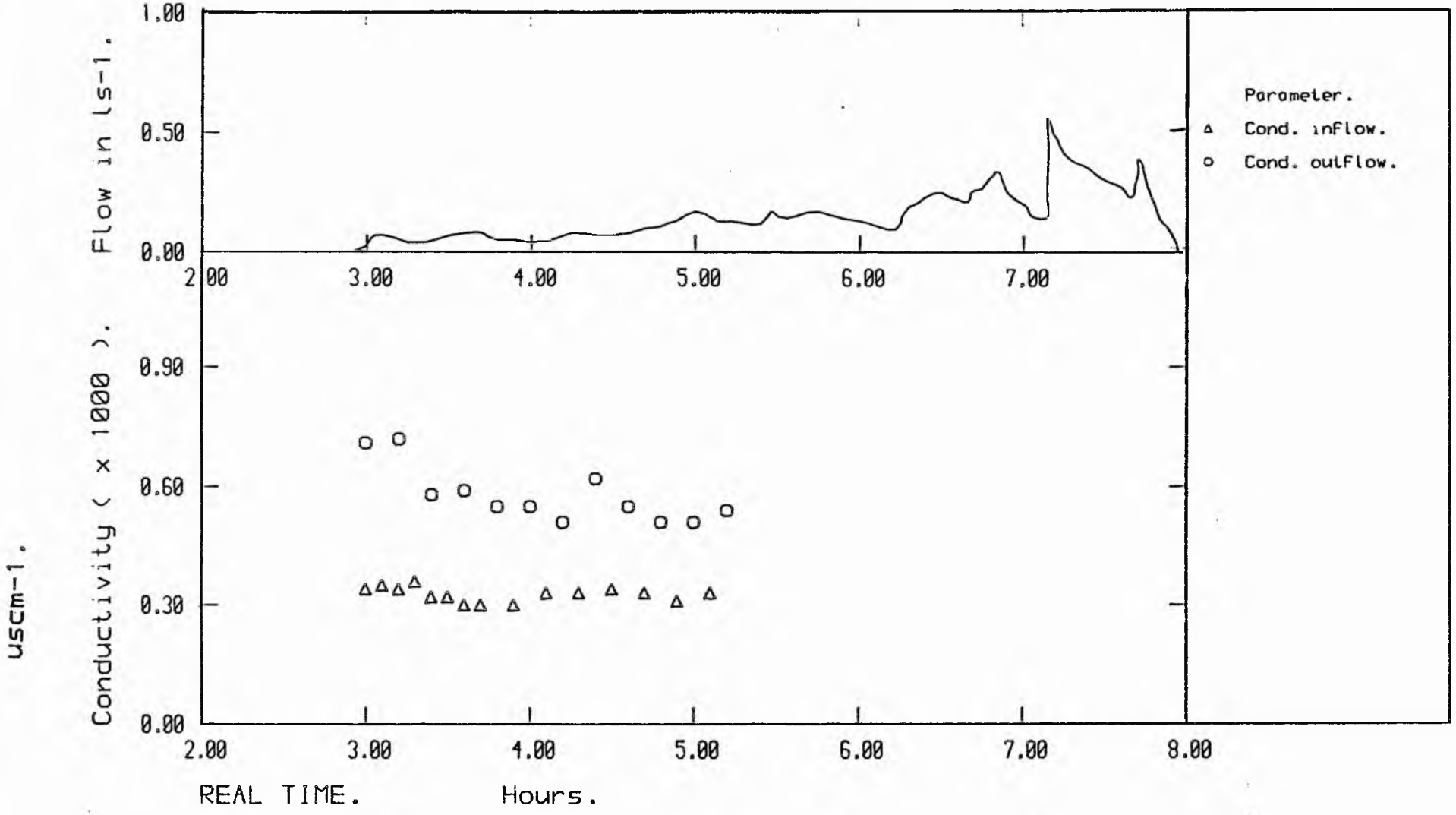
Graph of Suspended Solids for Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



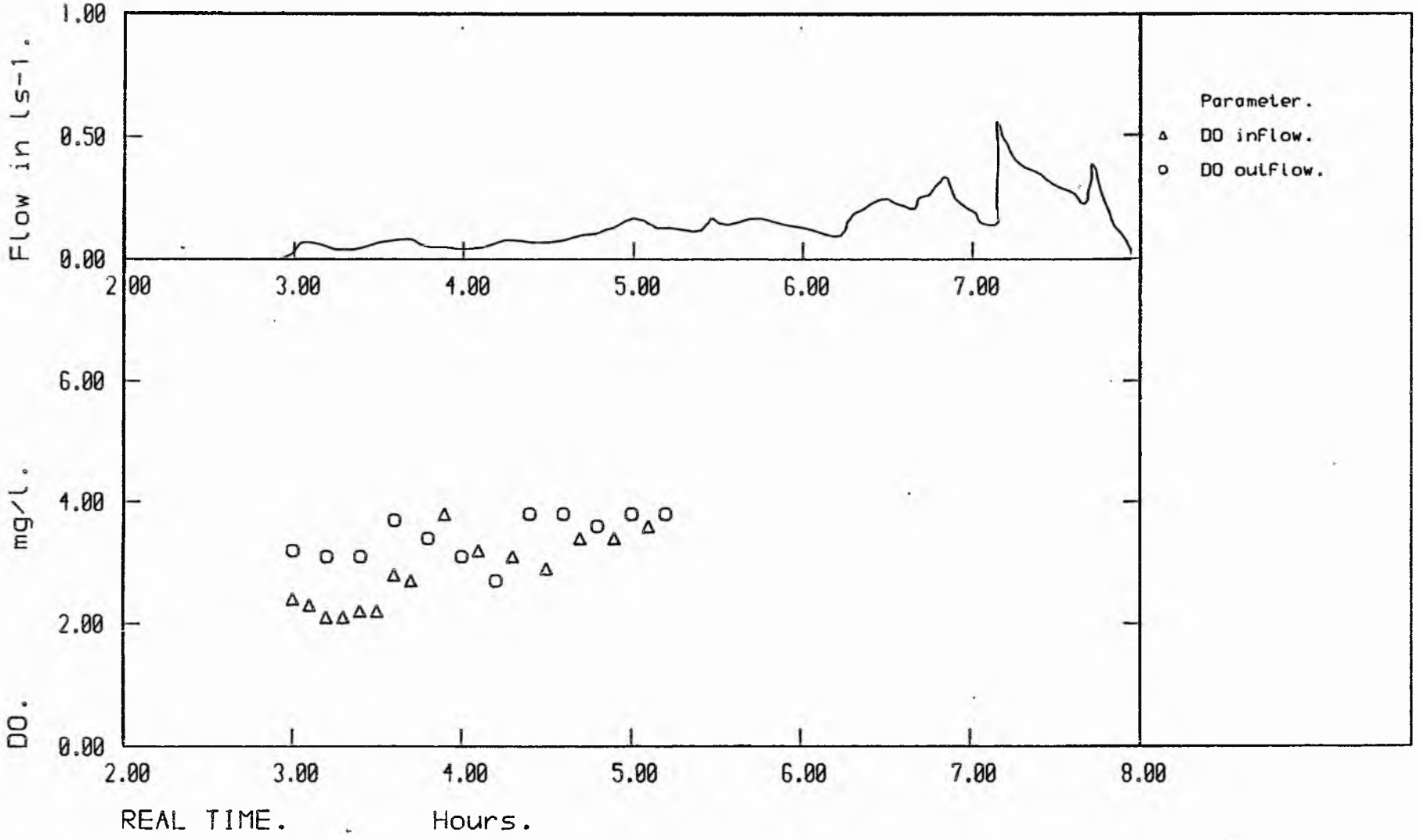
Graph of Biochemical Oxygen Demand for Storm III on Tame Close.
The graph shows inflow and outflow water qudlity data.



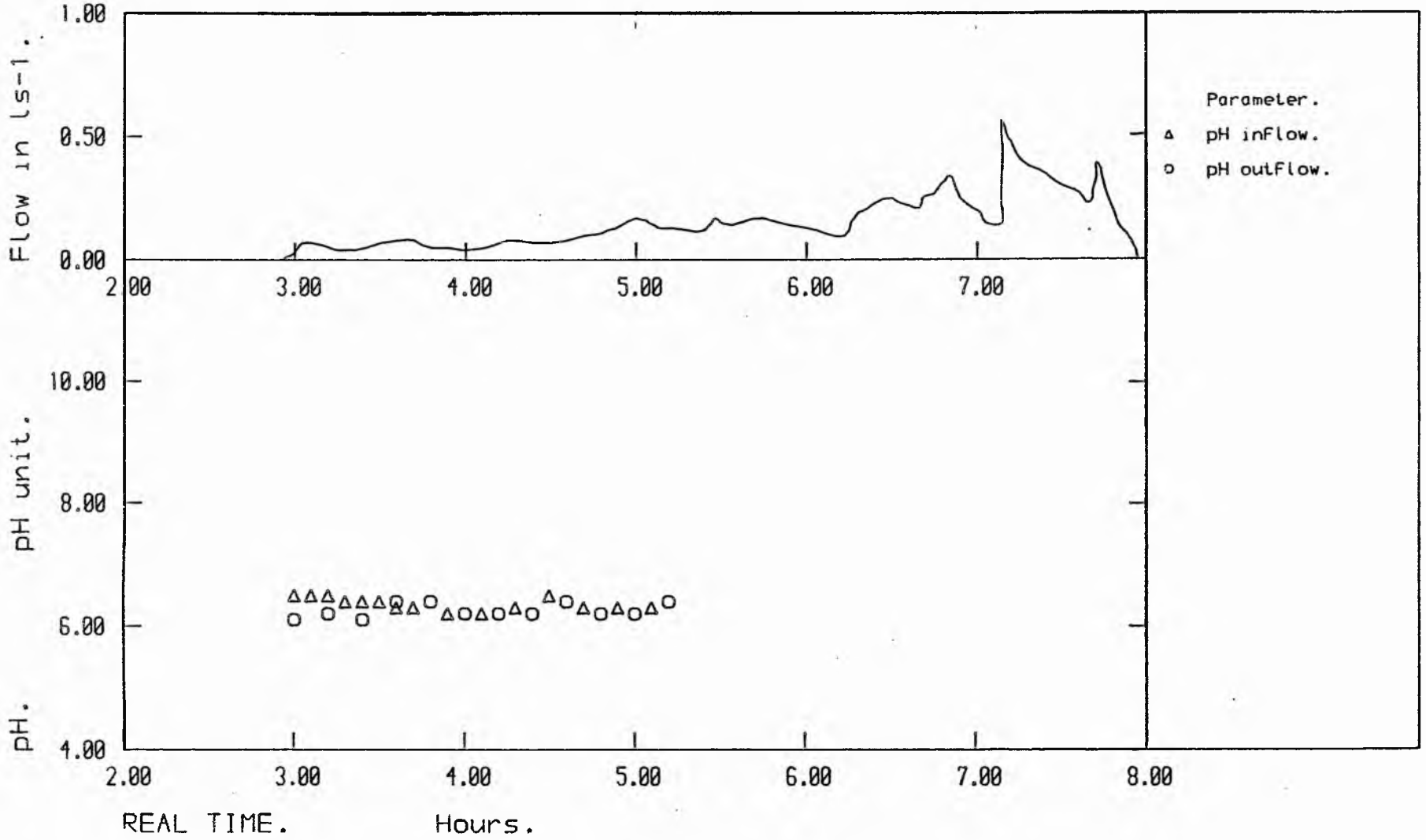
Graph of Chemical Oxygen Demand for Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



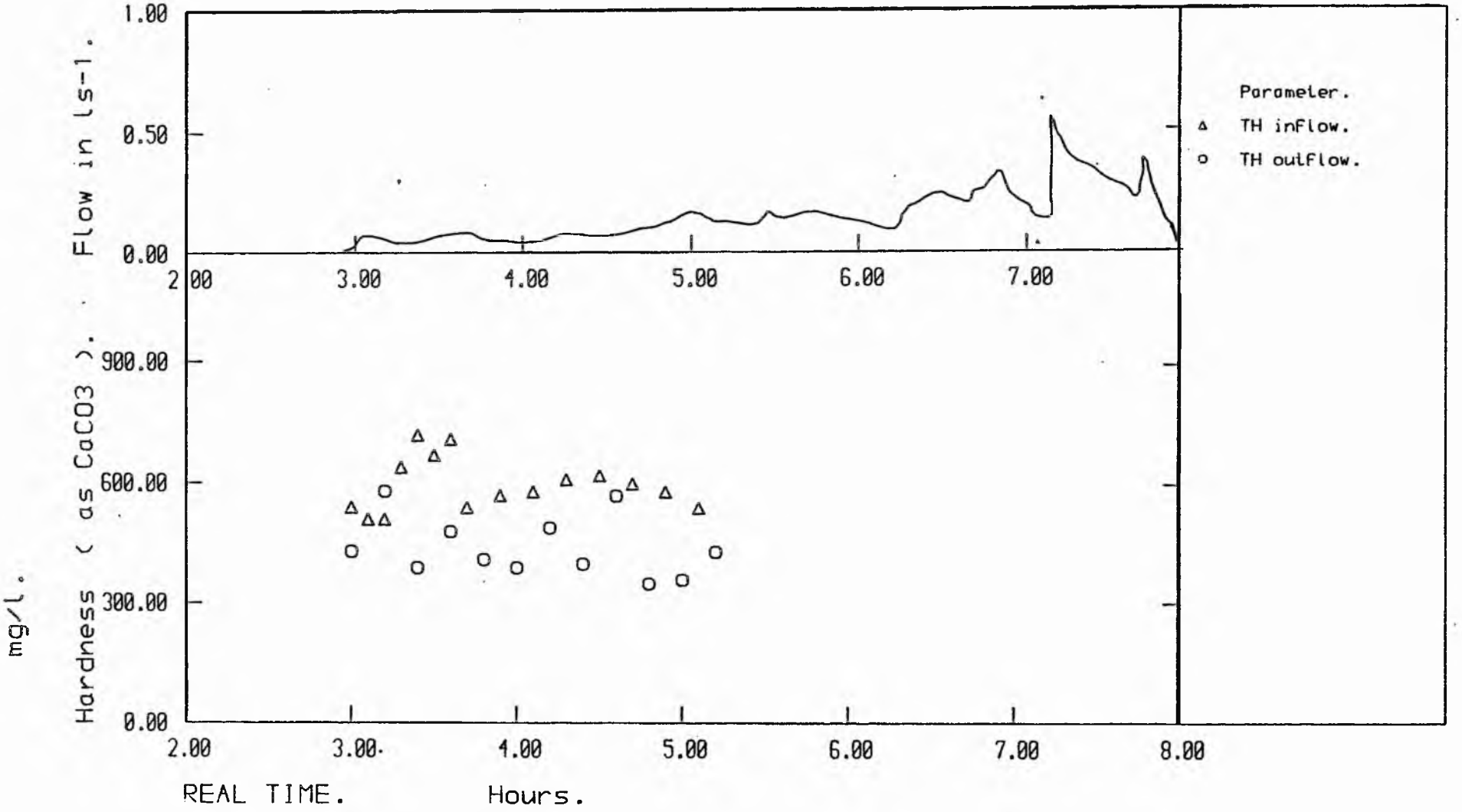
Graph of Conductivity For Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



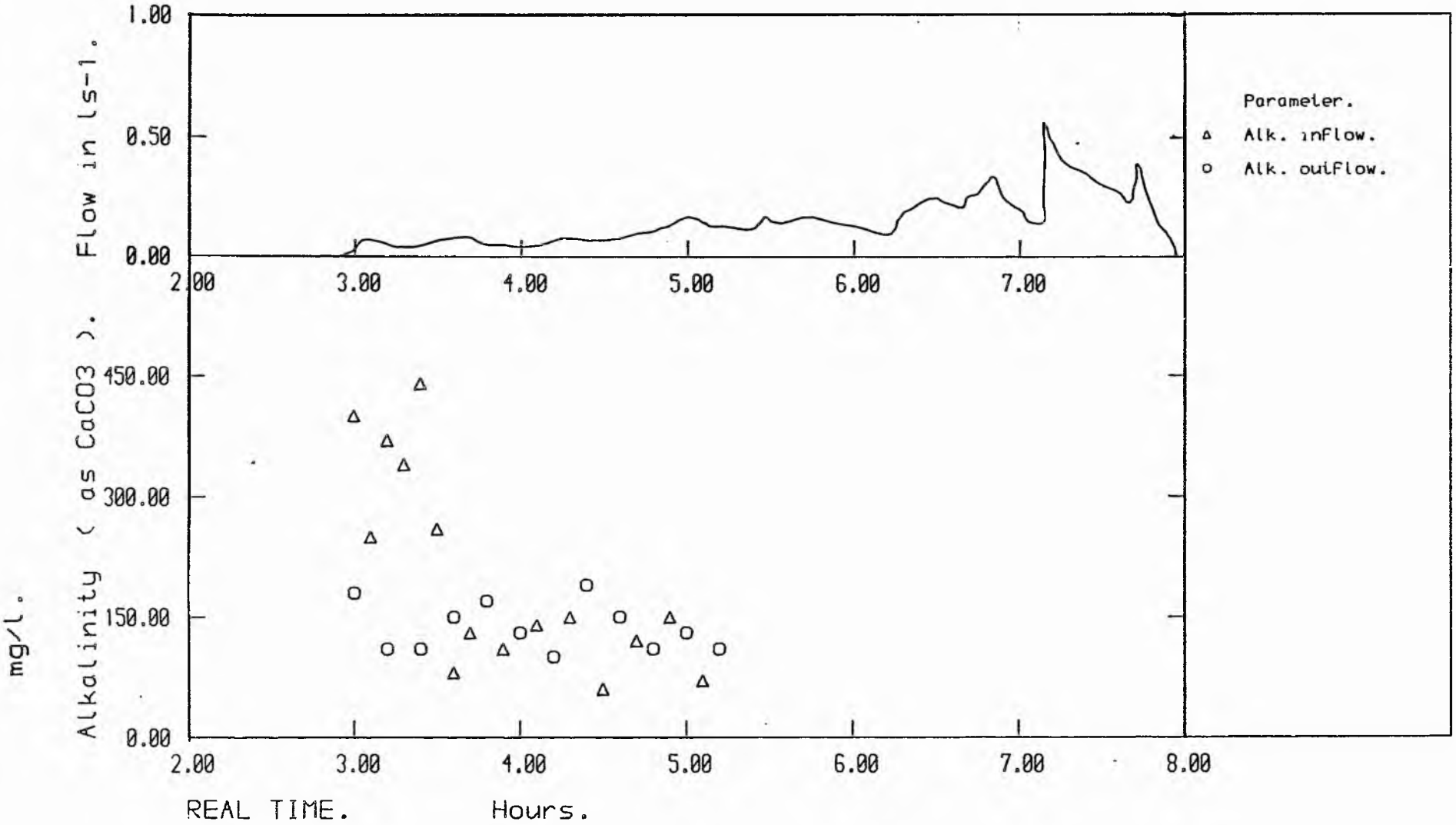
Graph of Dissolved Oxygen for Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



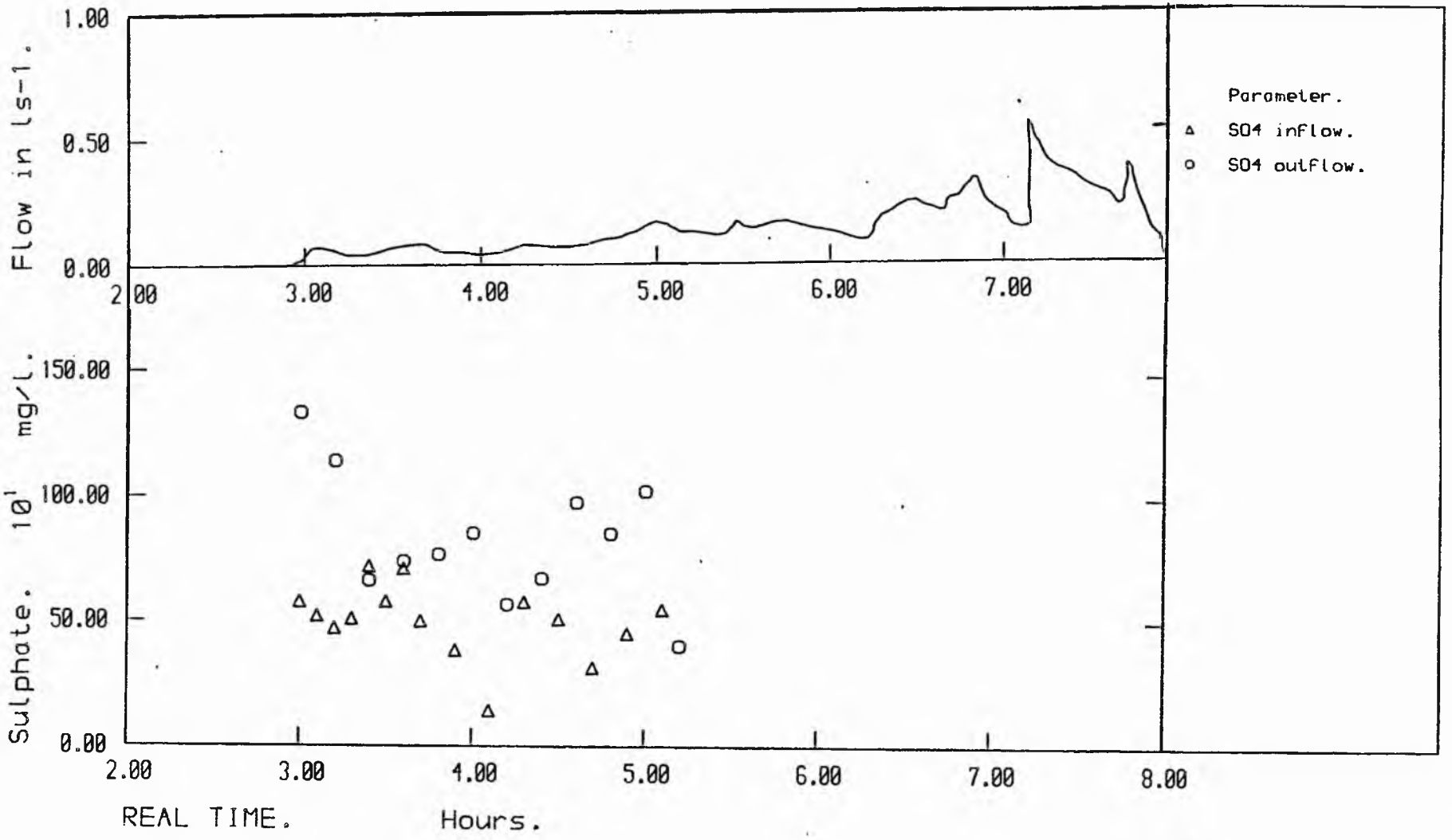
Graph of pH for Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



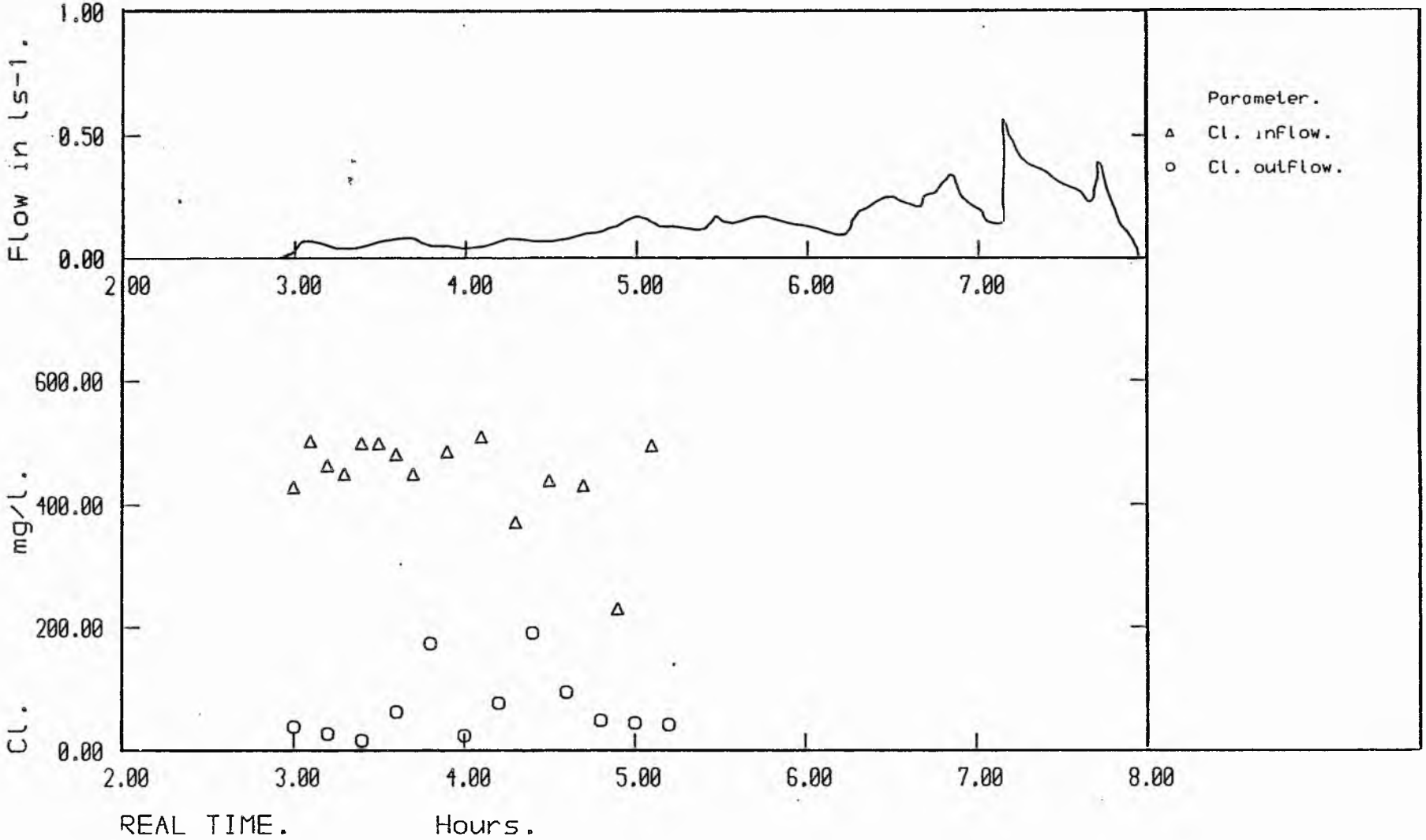
Graph of Total Hardness for Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



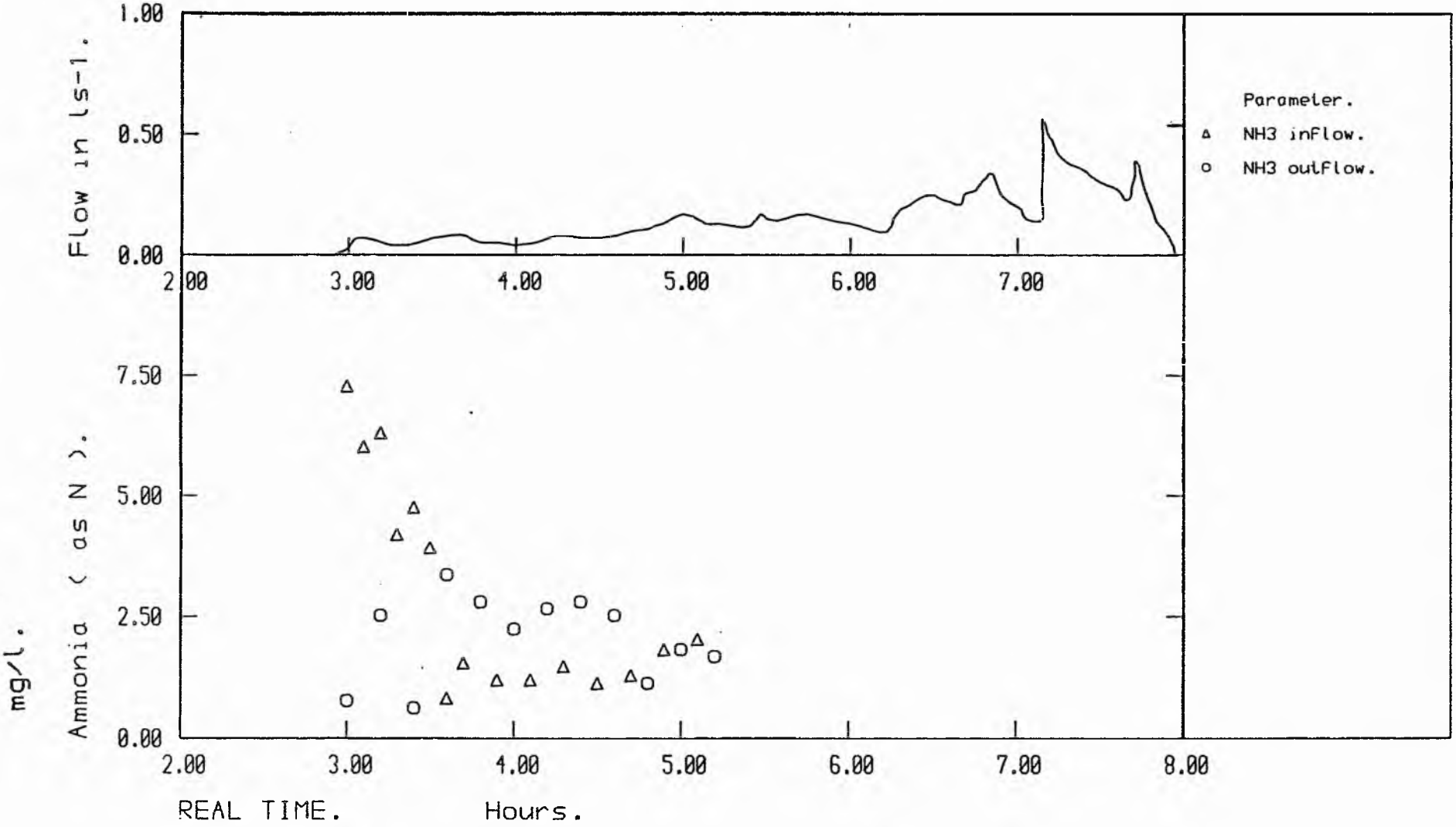
Graph of Total Alkalinity for Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



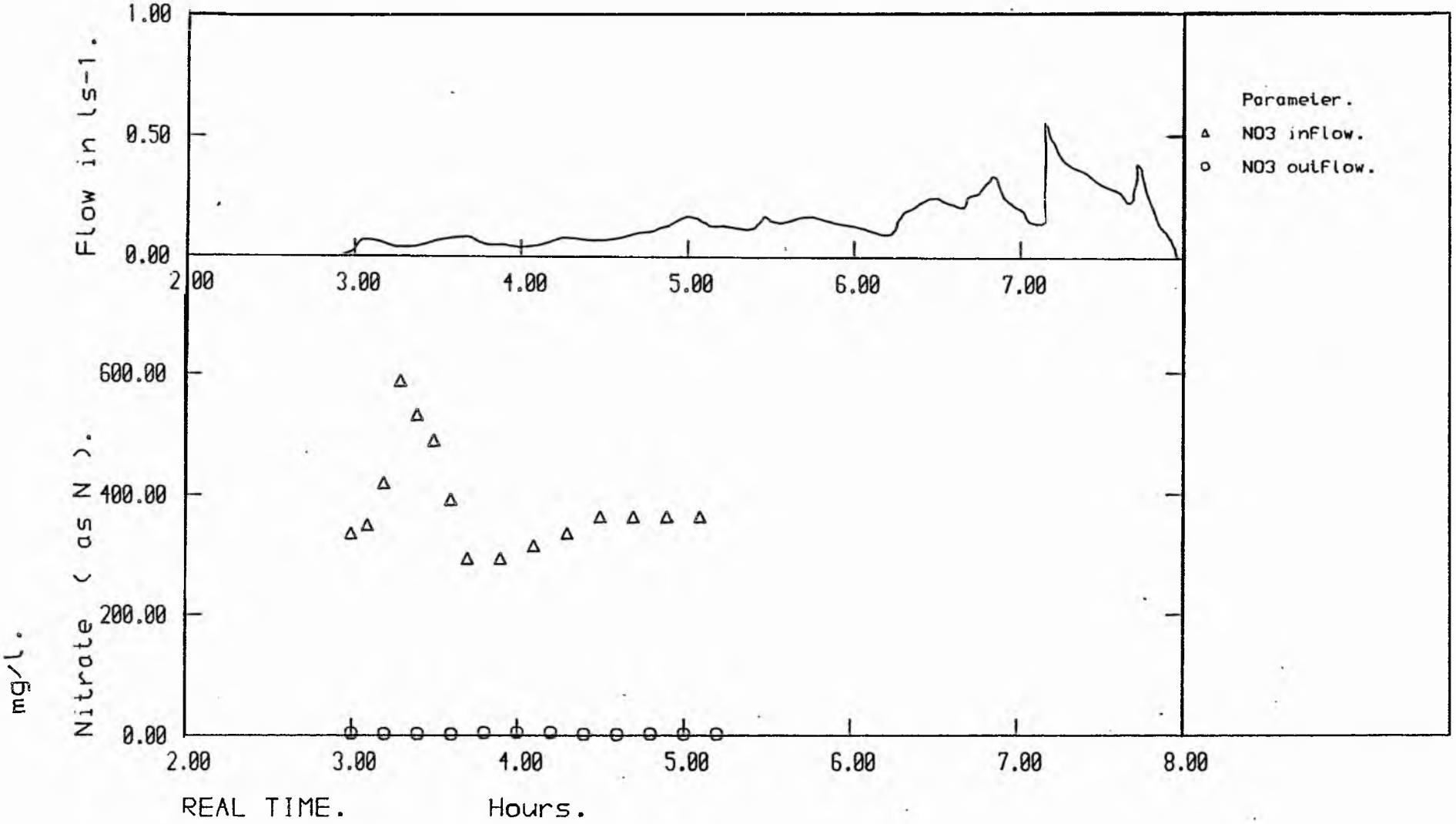
Graph of Sulphate For Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



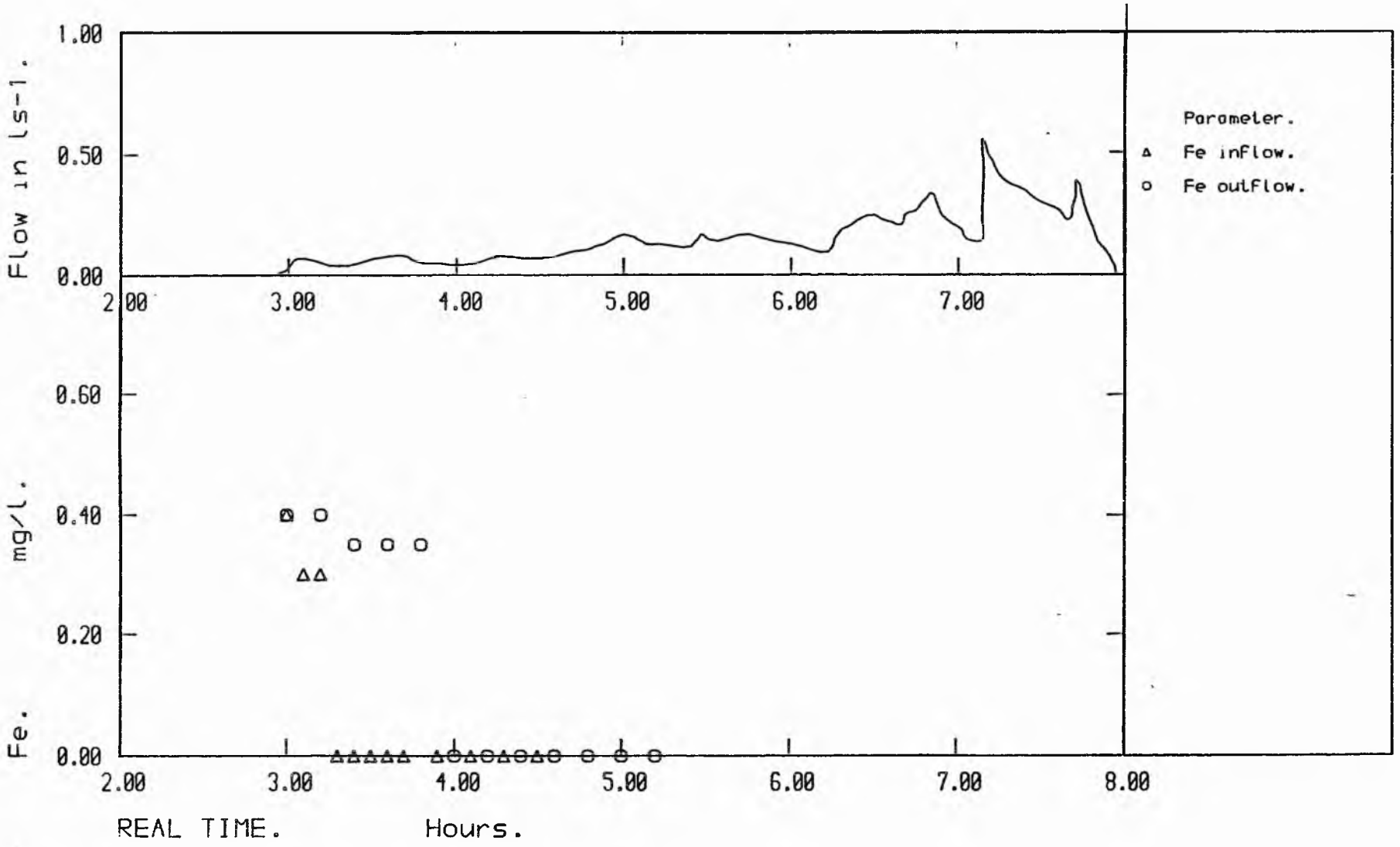
Graph of Chloride for Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



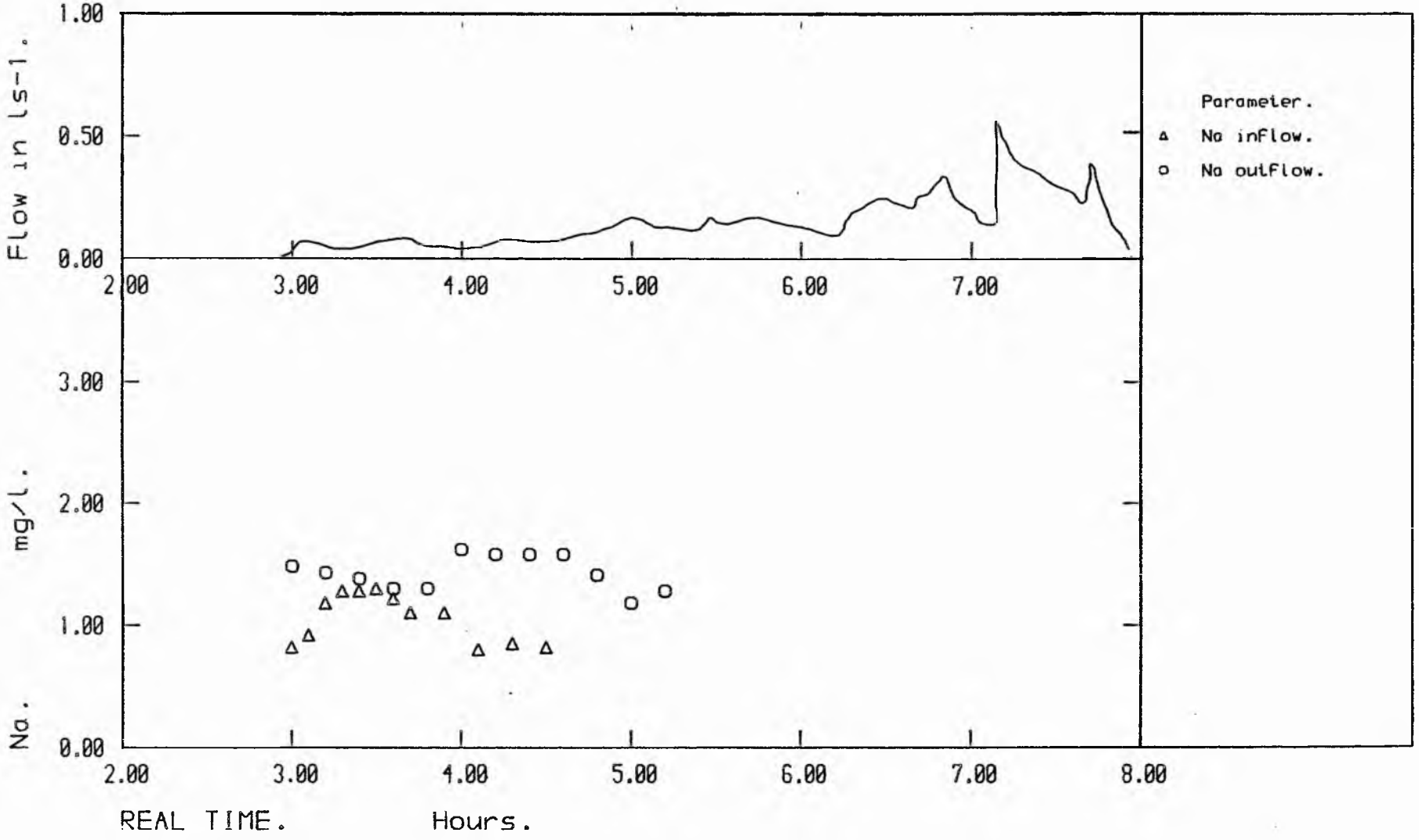
Graph of Ammonia For Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



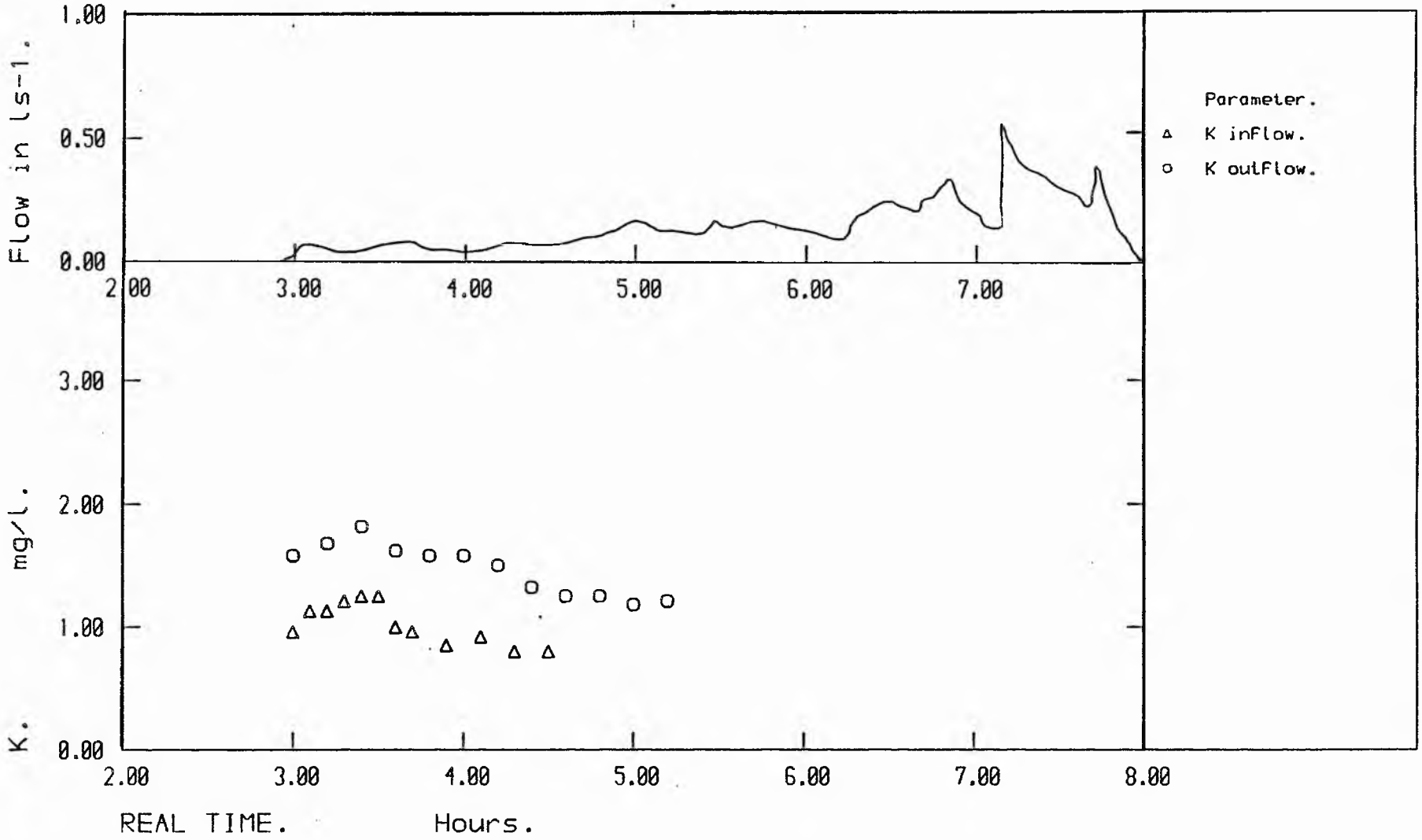
Graph of Nitrate For Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



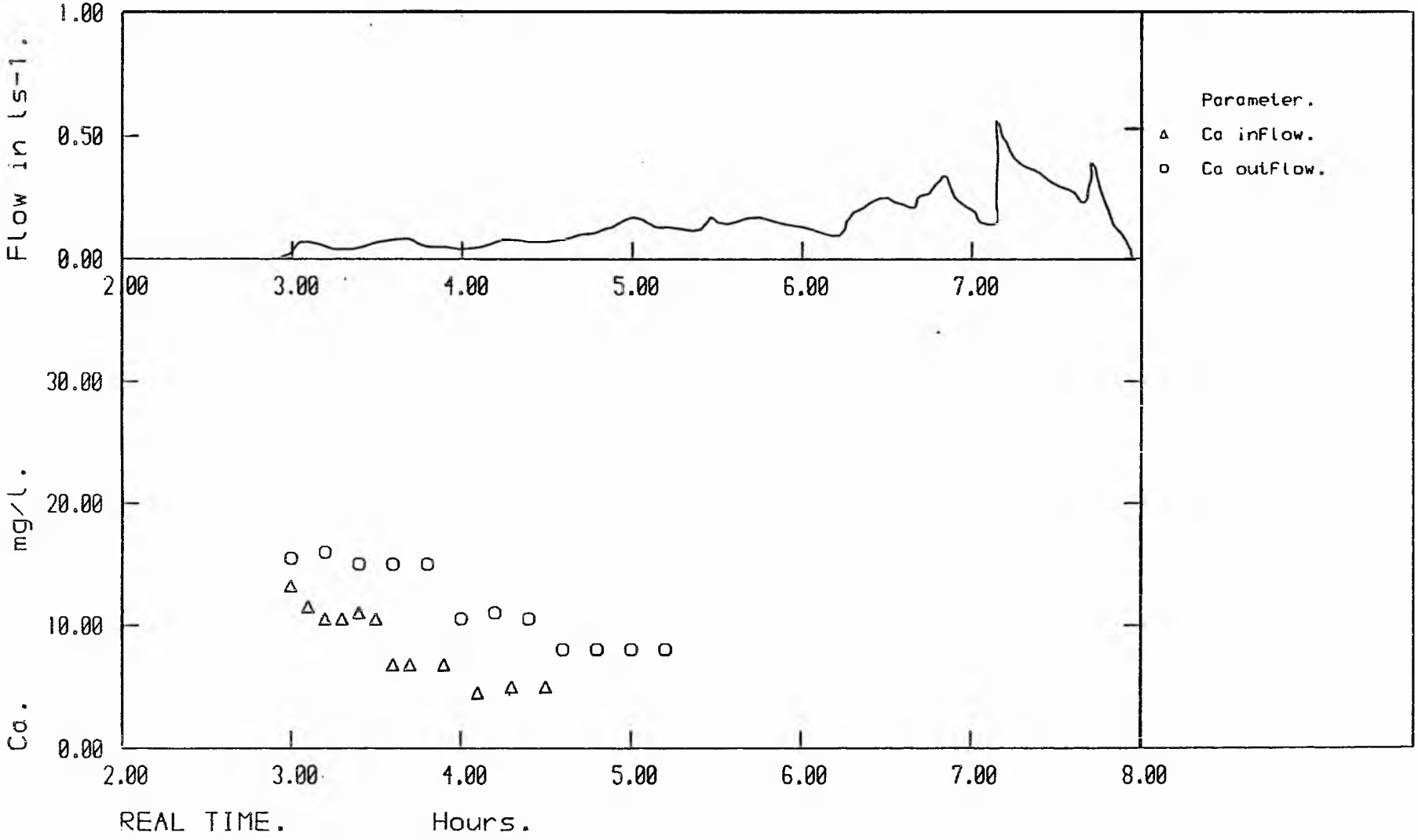
Graph of Iron For Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



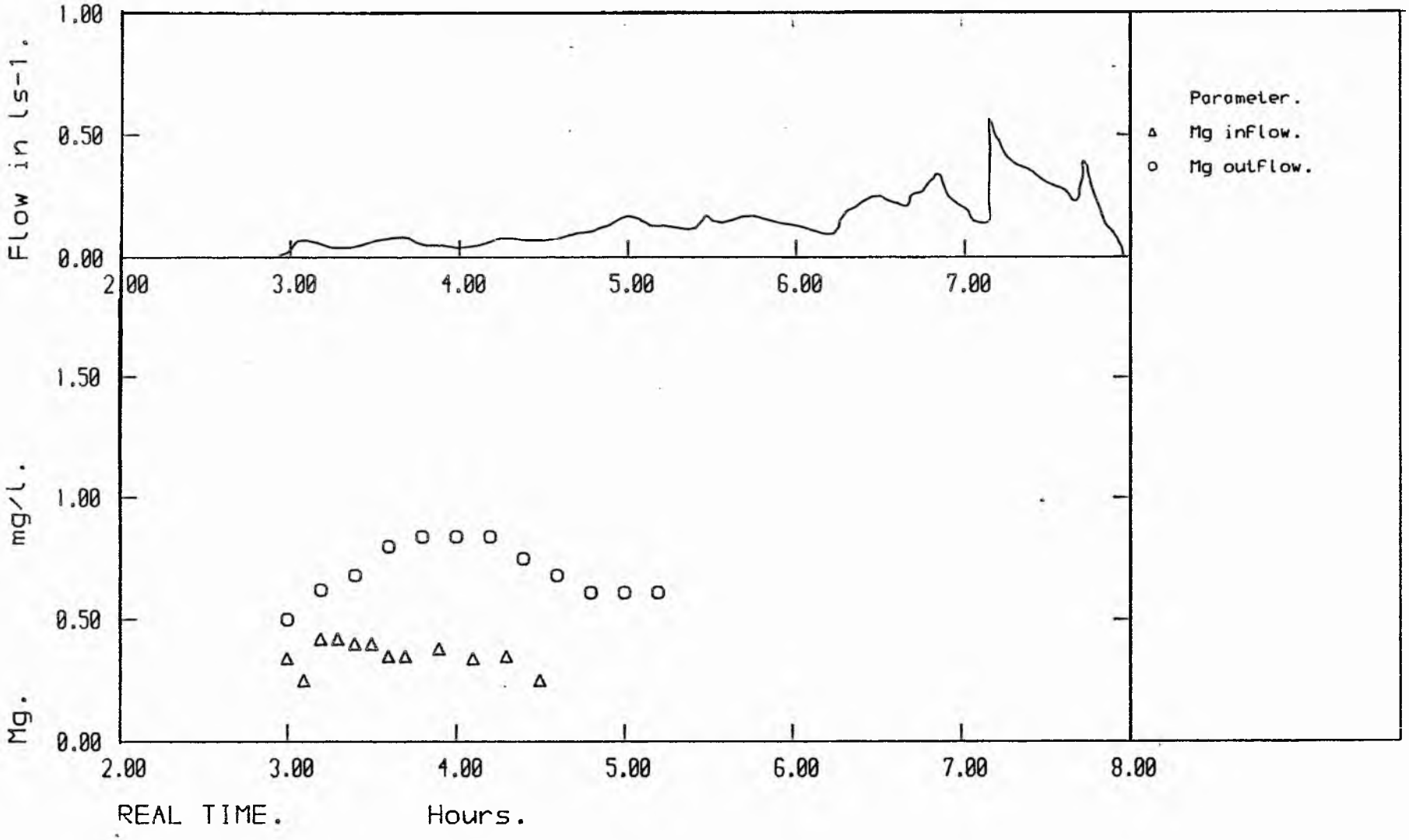
Graph of Sodium For Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



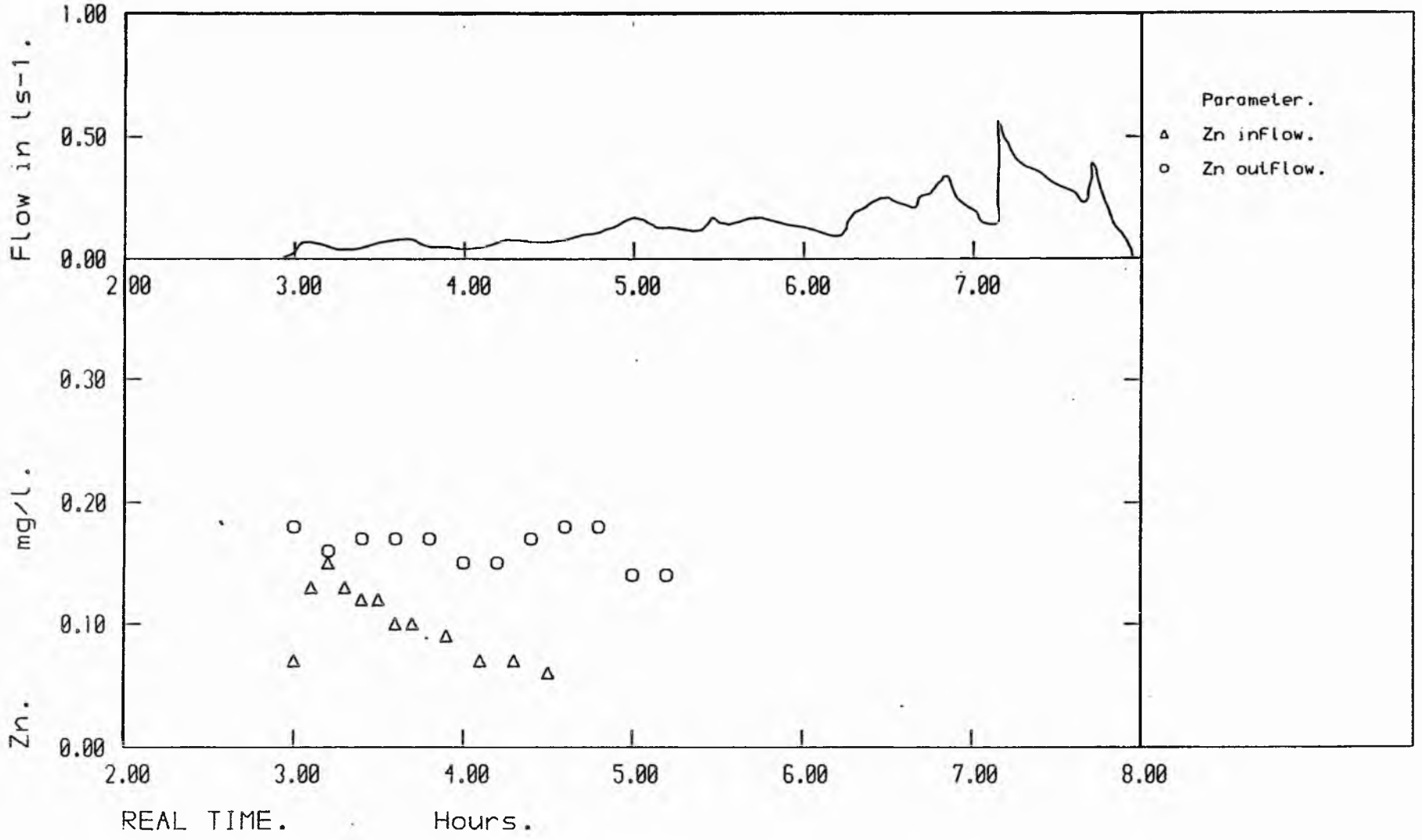
Graph of Potassium for Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



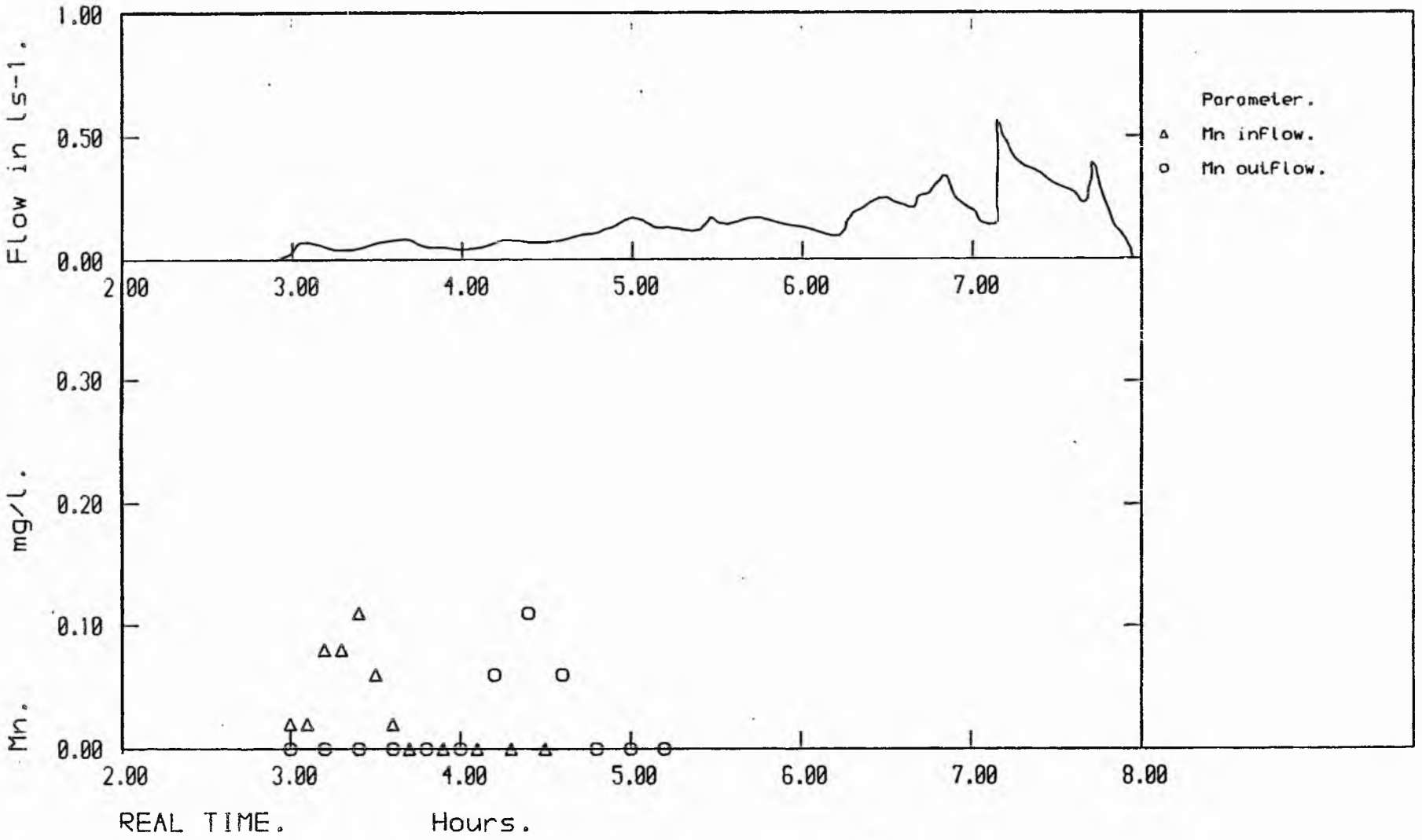
Graph of Calcium For Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



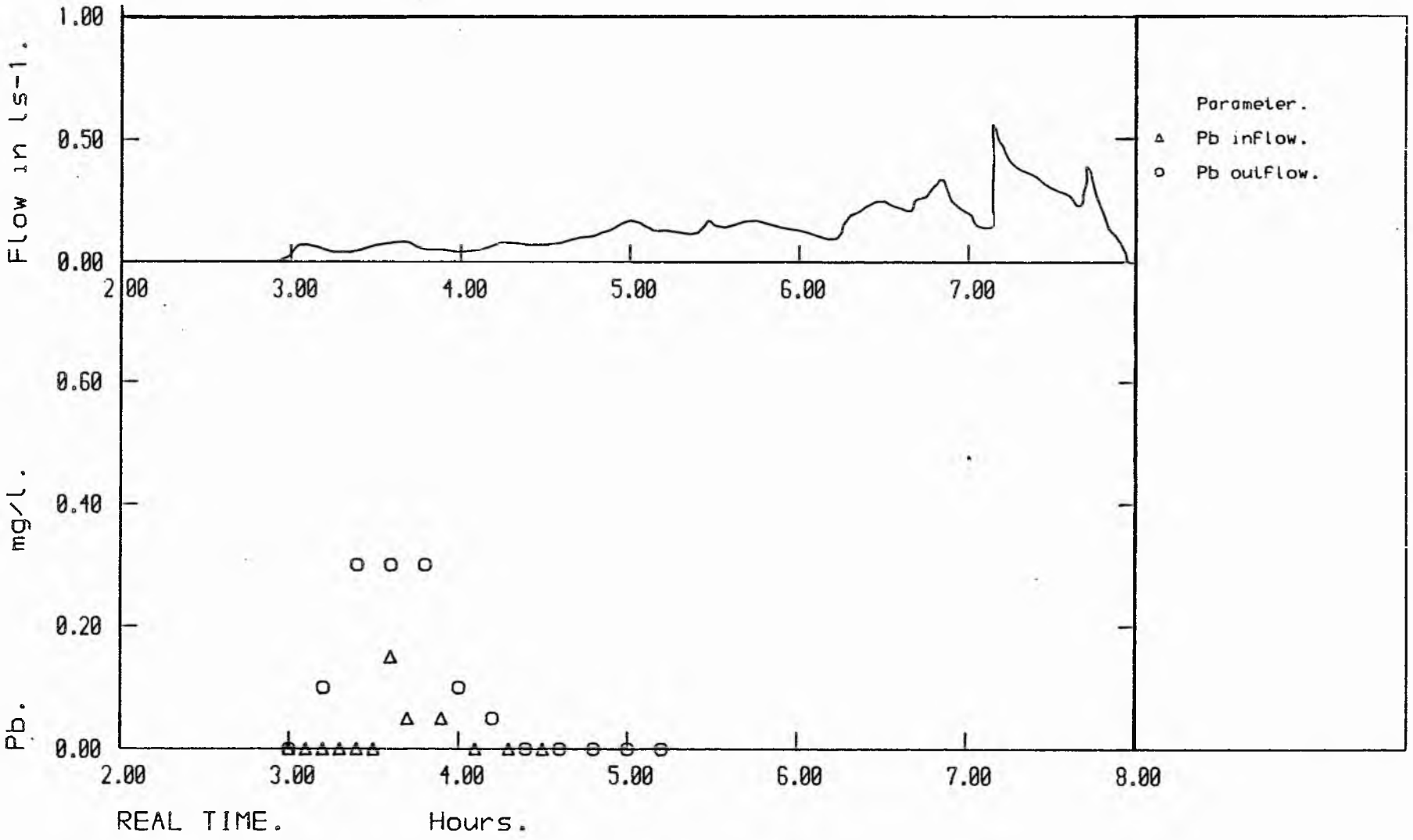
Graph of Magnesium for Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc For Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Manganese for Storm III on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Lead For Storm III on Tame Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
0328	72	54	416
0334	75	52	352
0340	72	53	352
0346	47	54	397
0352	38	53	402

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens

DATE OF THE STORM EVENT : 2nd. August 1984 (840802)

STORM NUMBER : III

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
0328	80	59	451
0340	101	64	432
0352	72	67	446
0404	77	29	466
0416	51	24	169
0428	10	21	263
0440	13	10	283
0452	15	51	298
0504	39	44	248
0516	81	50	308
0528	32	63	312
0540	37	38	317

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
0328	0.34	2.2	6.5
0334	0.37	2.7	6.4
0340	0.31	1.9	6.4
0346	0.42	2.3	6.4
0352	0.41	2.7	6.4

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
0328	0.52	3.4	6.5
0340	0.48	3.1	6.7
0352	0.52	2.7	6.4
0404	0.52	2.9	6.9
0416	0.52	2.7	7.1
0428	0.50	3.4	6.4
0440	0.51	3.4	6.9
0452	0.46	3.7	6.6
0504	0.50	3.7	6.7
0516	0.49	3.4	6.7
0528	0.49	4.2	6.6
0540	0.49	4.1	6.5

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
0328	550.0	230.0	509	252.0
0334	440.0	150.0	672	337.0
0340	660.0	170.0	875	305.0
0346	460.0	120.0	634	199.0
0352	430.0	170.0	567	627.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
0328	320.0	220.0	202	50.0
0340	390.0	180.0	577	57.0
0352	310.0	210.0	721	167.0
0404	390.0	190.0	1288	89.0
0416	510.0	300.0	644	167.0
0428	410.0	170.0	413	103.0
0440	390.0	220.0	192	184.0
0452	410.0	230.0	634	177.0
0504	440.0	400.0	269	316.0
0516	420.0	230.0	0	167.0
0528	340.0	200.0	308	393.0
0540	480.0	290.0	913	355.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Pb mgl-1
0328	4.2	1.8	0.2
0334	2.0	1.8	0.2
0340	1.7	1.9	0.0
0346	0.7	1.6	0.0
0352	0.5	1.3	0.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Pb mgl-1
0328	8.7	1.8	0.1
0340	9.0	1.6	0.1
0352	9.0	1.7	0.2
0404	10.4	1.7	0.3
0416	12.5	1.7	0.1
0428	14.7	1.9	0.0
0440	14.7	1.8	0.0
0452	14.0	1.7	0.0
0504	12.6	1.6	0.0
0516	14.7	1.7	0.0
0528	14.7	1.7	0.0
0540	14.7	1.7	0.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
0328	1.8	0.8	16.5	2.1
0334	1.8	0.7	16.0	2.2
0340	1.9	0.7	13.8	1.6
0346	1.6	0.6	10.5	1.5
0352	1.3	0.5	5.0	1.5

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
0328	1.8	1.4	20.0	0.9
0340	1.6	1.3	20.0	0.9
0352	1.7	1.5	21.0	0.9
0404	1.7	1.5	22.8	0.9
0416	1.7	1.2	17.0	0.9
0428	1.9	1.1	17.8	0.8
0440	1.8	1.0	16.0	0.8
0452	1.7	1.0	14.2	0.6
0504	1.6	1.0	9.5	0.6
0516	1.7	0.8	9.0	0.5
0528	1.7	0.9	4.1	0.4
0540	1.7	0.8	4.1	0.4

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF INFLOW WATER TO THE GULLY POT

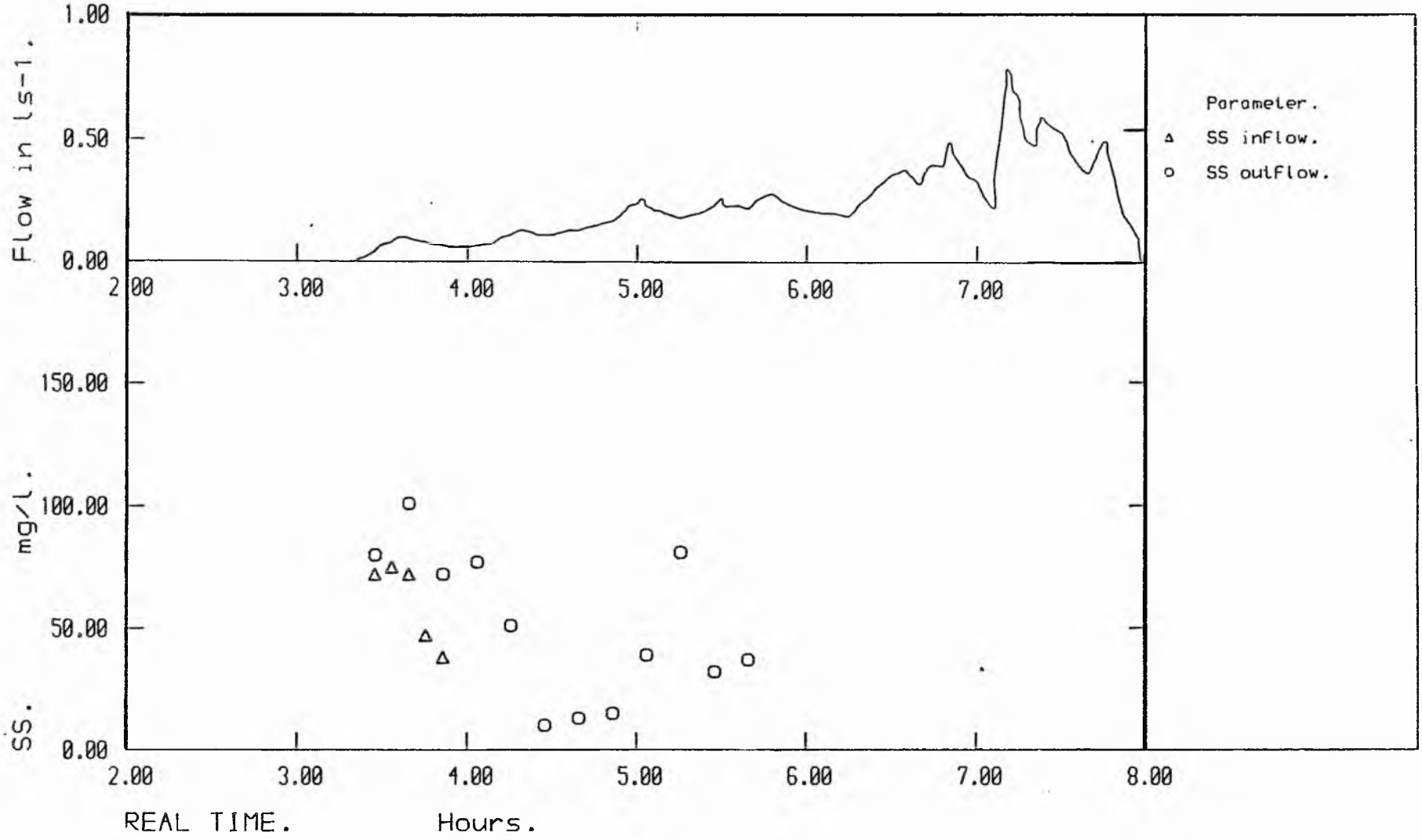
REAL TIME Hours	Zn mgl-1	Mn mgl-1
0328	0.1	0.1
0334	0.1	0.1
0340	0.1	0.1
0346	0.1	0.0
0352	0.1	0.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

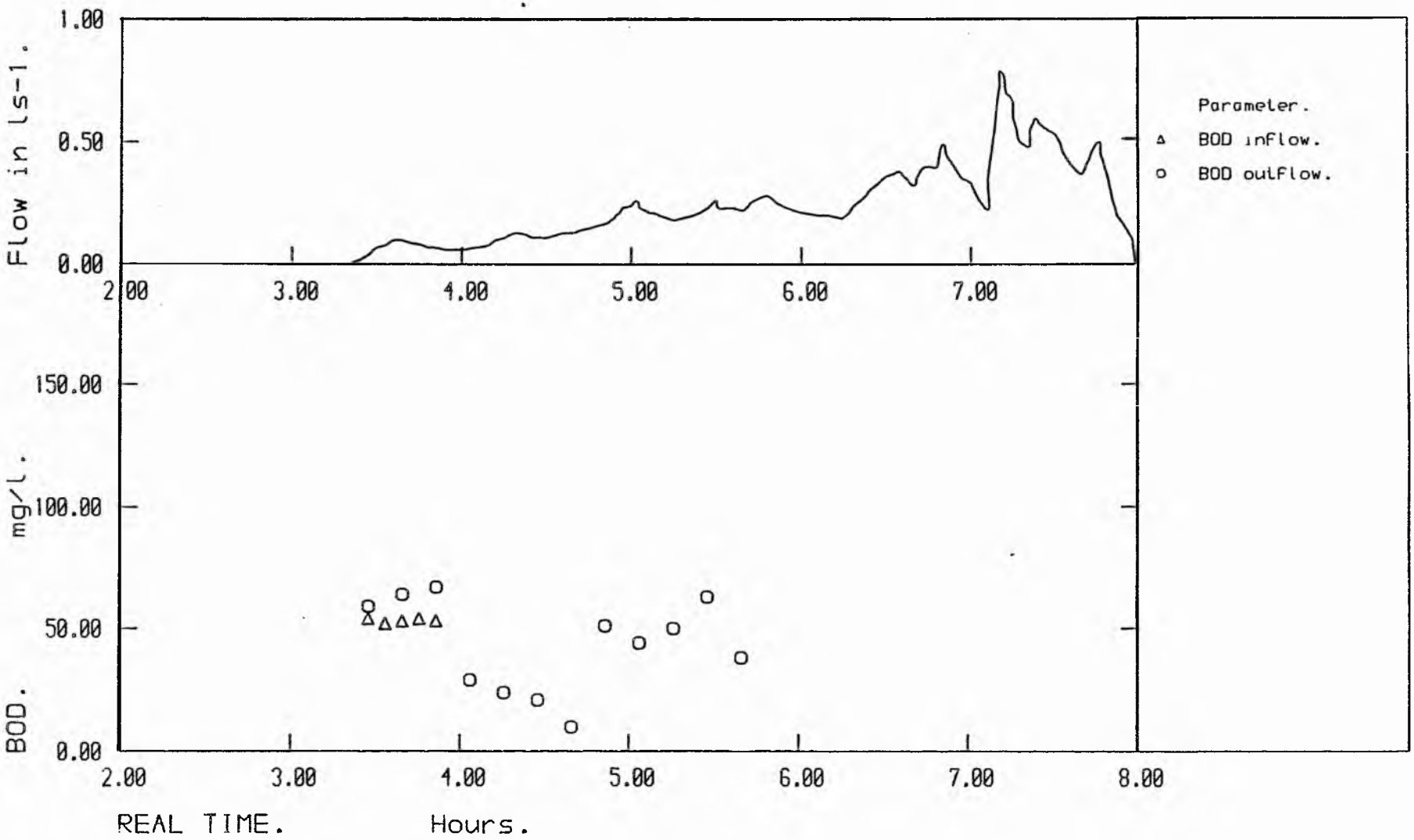
CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. August 1984 (840802)
STORM NUMBER : III

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

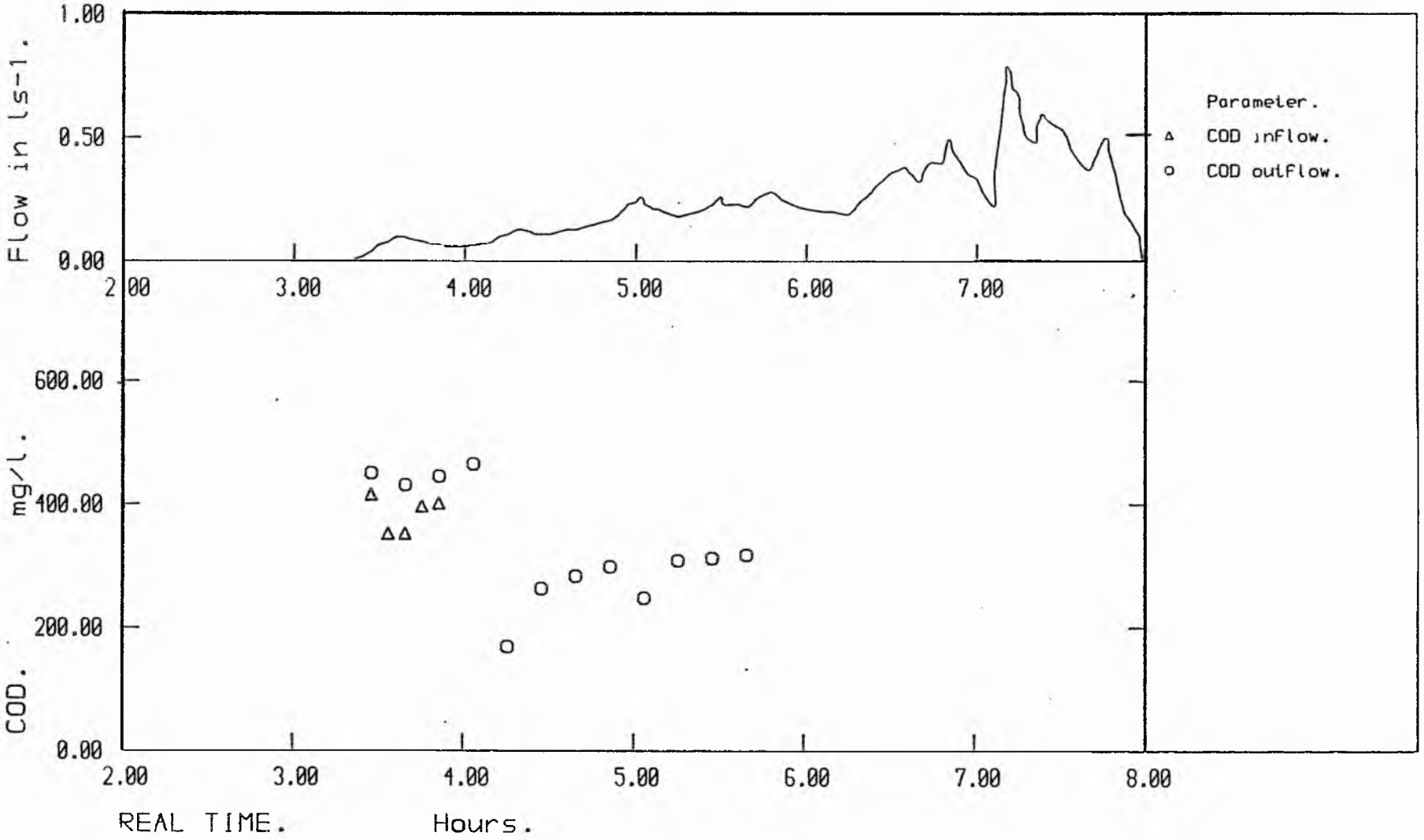
REAL TIME Hours	Zn mgl-1	Mn mgl-1
0328	0.1	0.0
0340	0.1	0.0
0352	0.1	0.0
0404	0.1	0.1
0416	0.1	0.1
0428	0.1	0.1
0440	0.1	0.0
0452	0.1	0.0
0504	0.1	0.0
0516	0.1	0.0
0528	0.1	0.0
0540	0.1	0.0



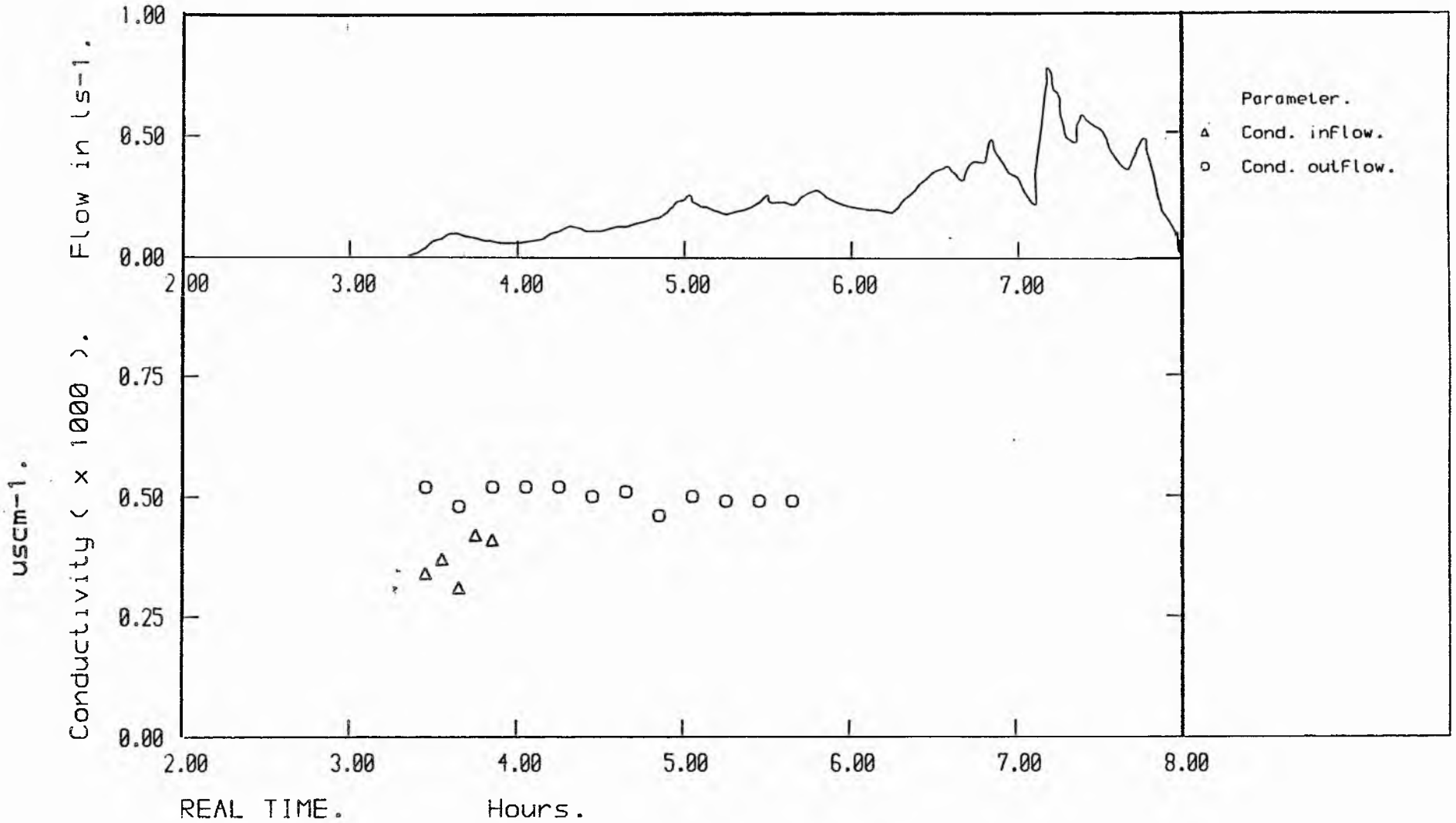
Graph of Suspended Solids for Storm III on TwyFord Gardens.
The graph shows inflow and outflow water quality data.



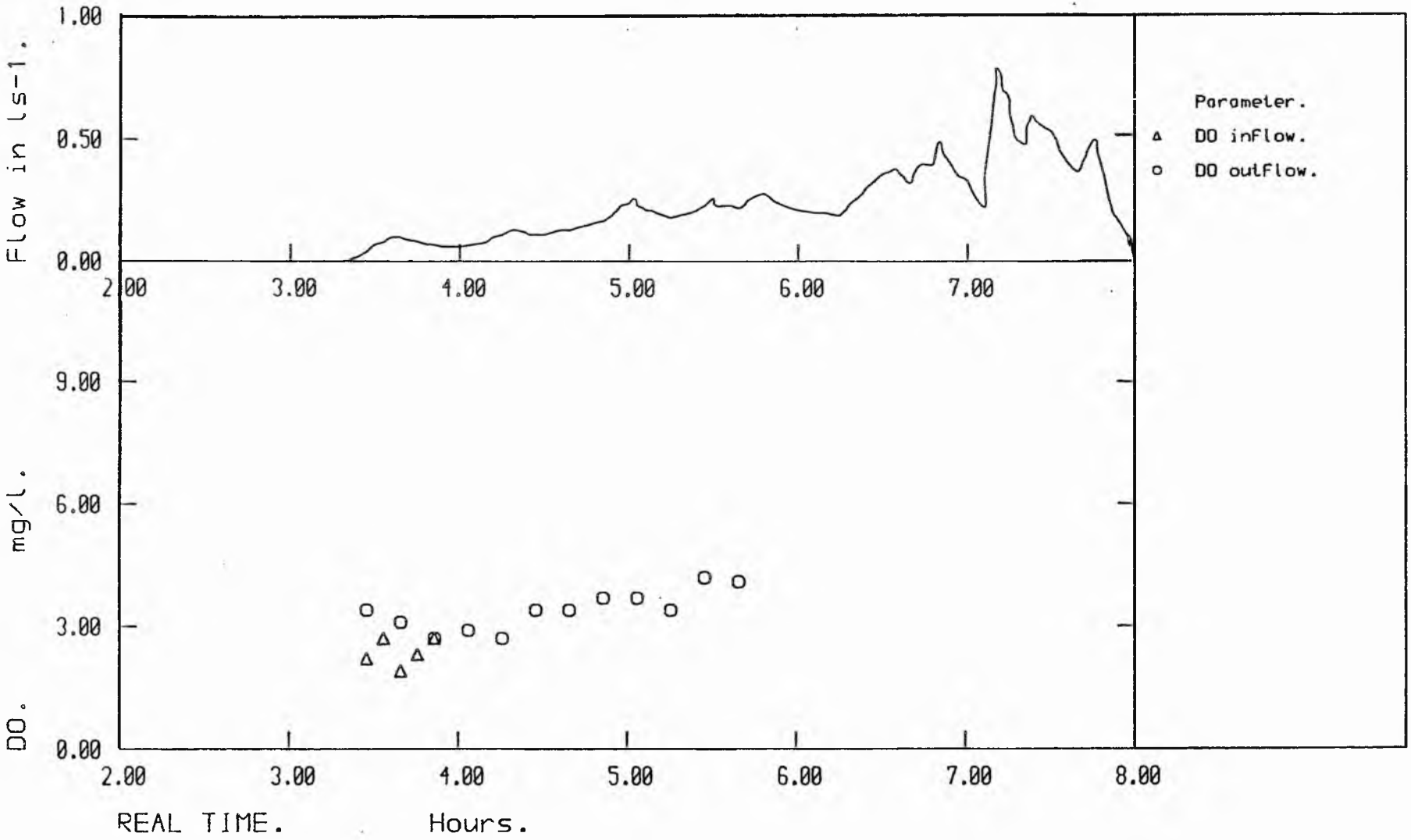
Graph of Biochemical Oxygen Demand For Storm III on Twyford Gardens.
The graph shows inflow and outflow water quality data.



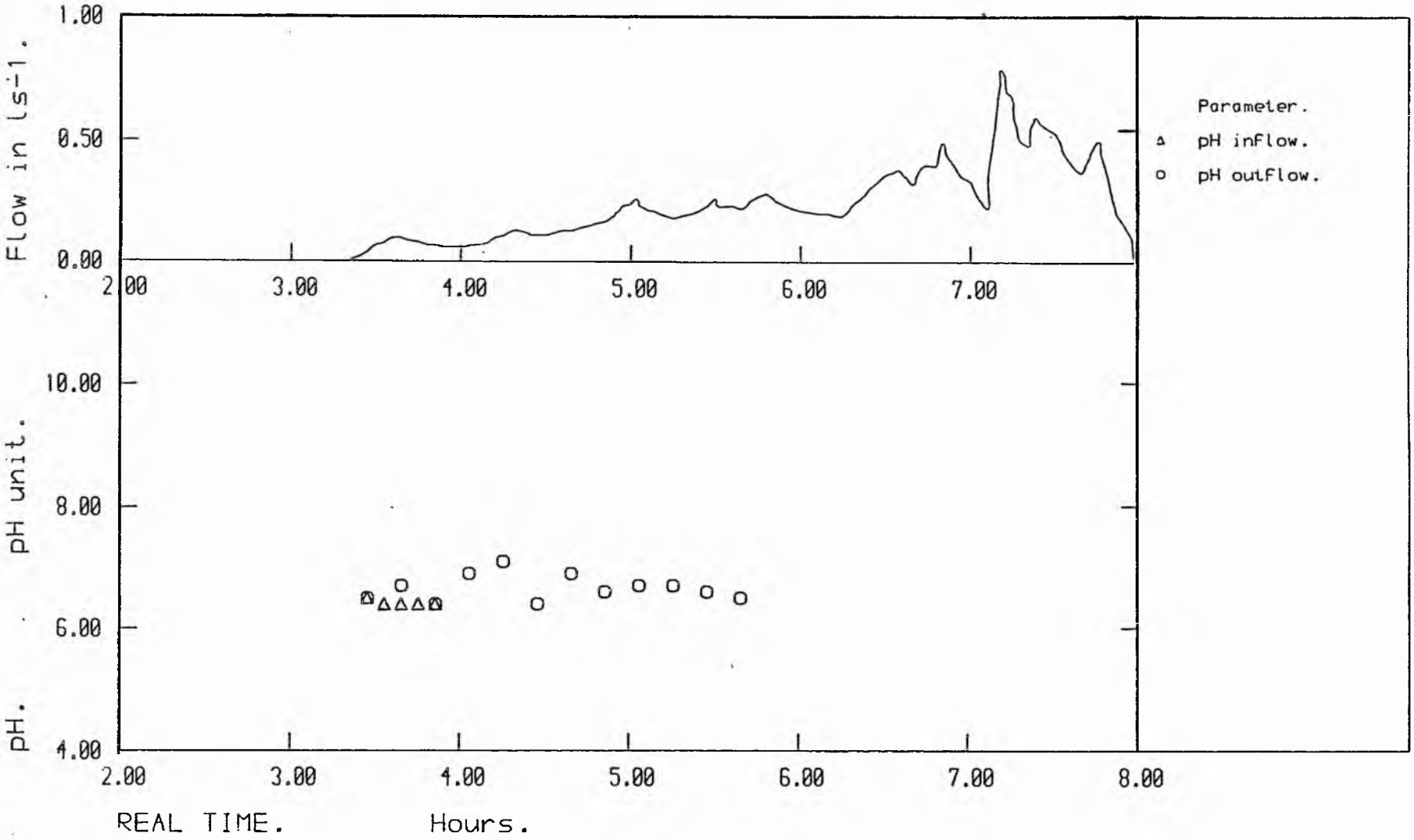
Graph of Chemical Oxygen Demand for Storm III on Twyford Gardens.
The graph shows inflow and outflow water quality data.



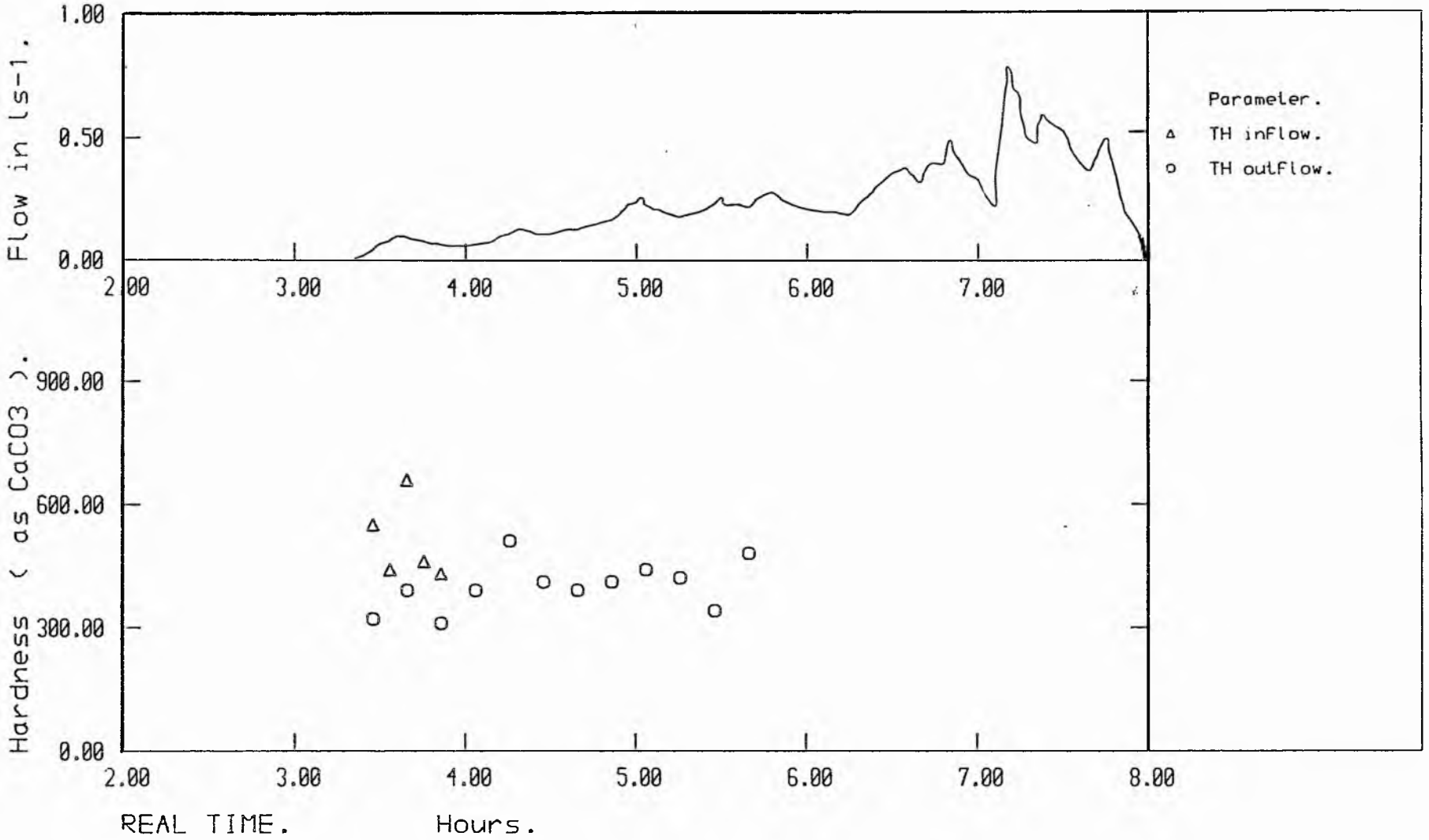
Graph of Conductivity for Storm III on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Dissolved Oxygen For Storm III on Twyford Gardens.
The graph shows inflow and outflow water quality data.

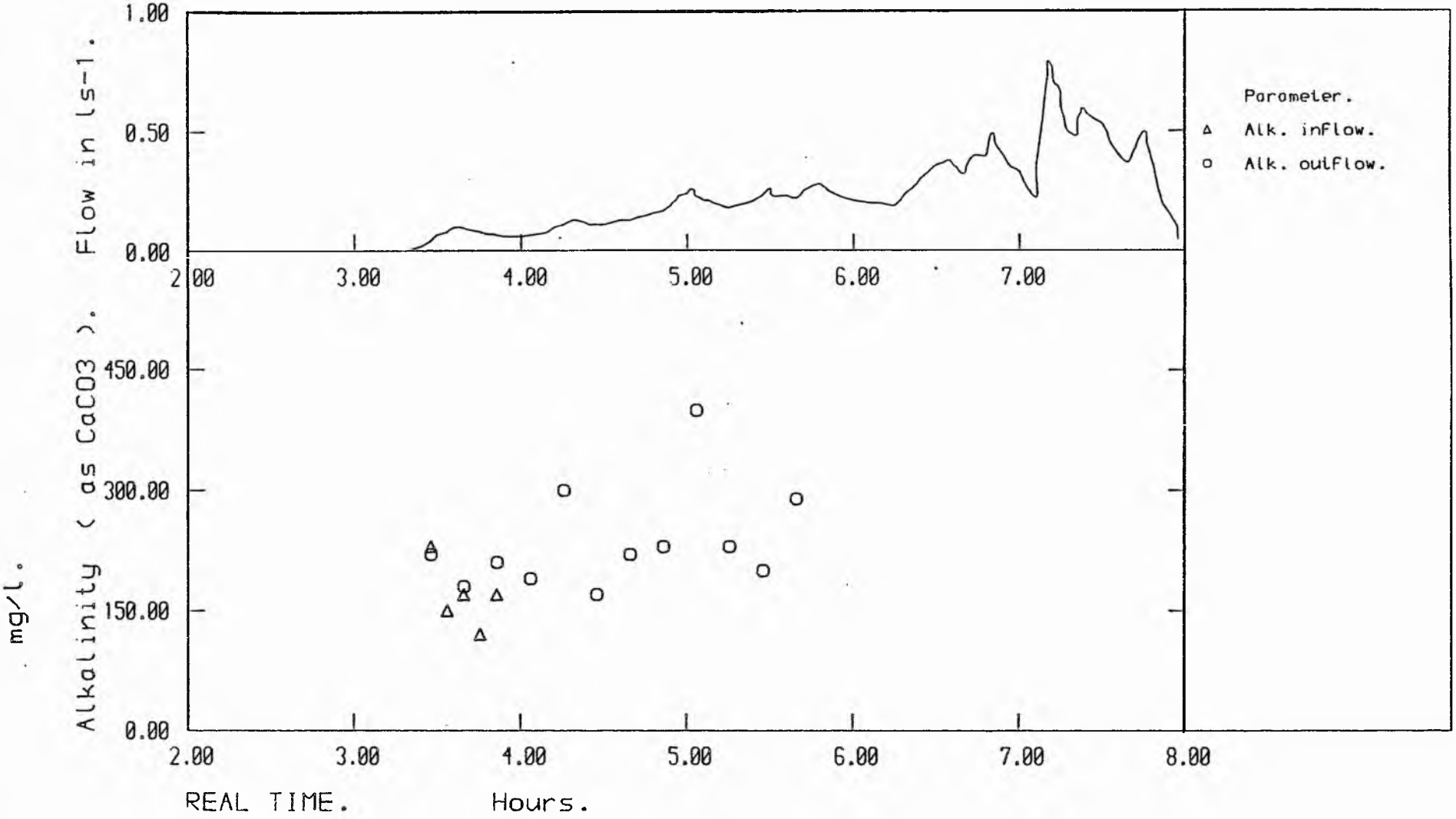


Graph of pH for Storm III on Twyford Gardens.
The graph shows inflow and outflow water quality data.

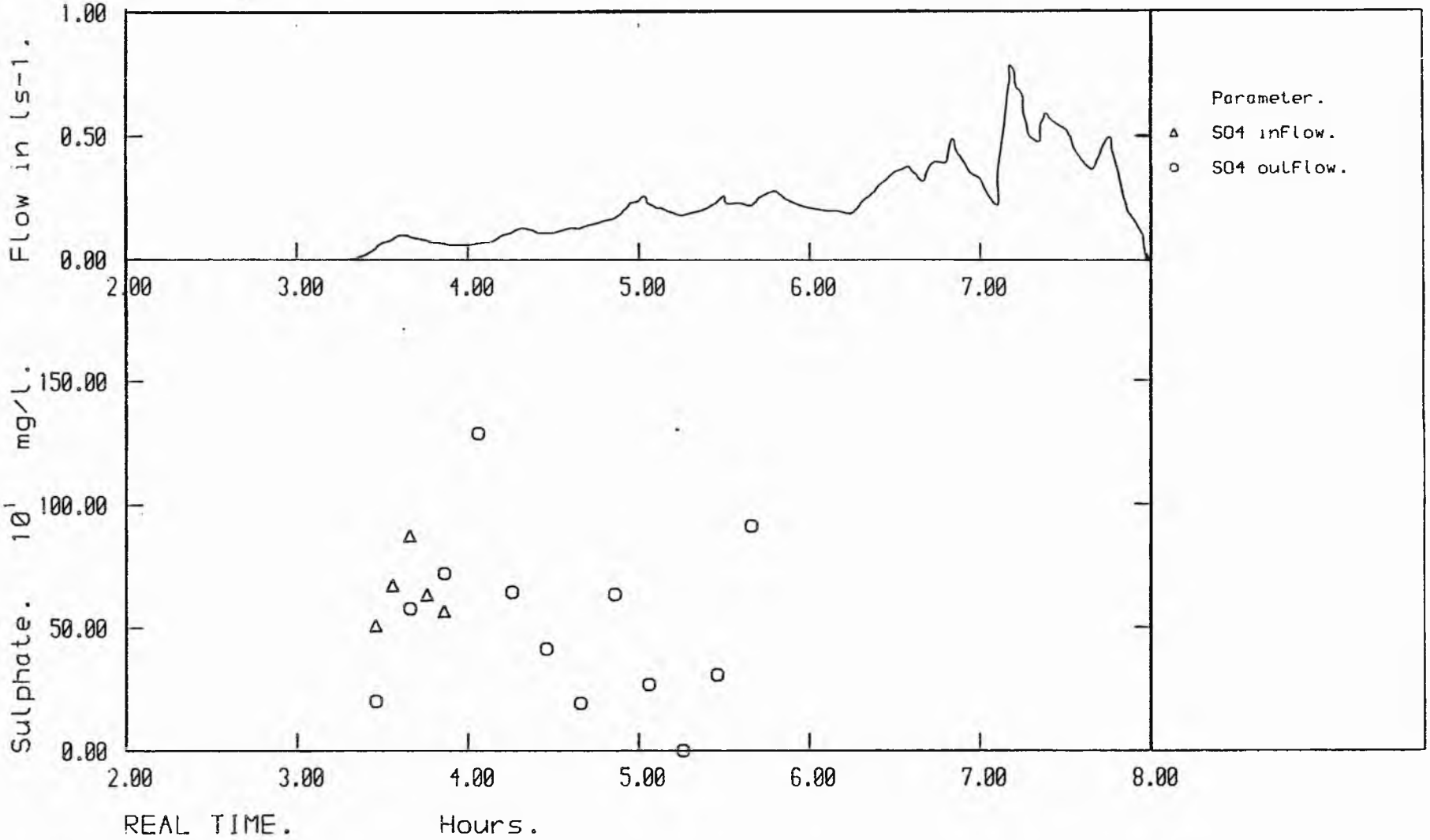


mg/l.

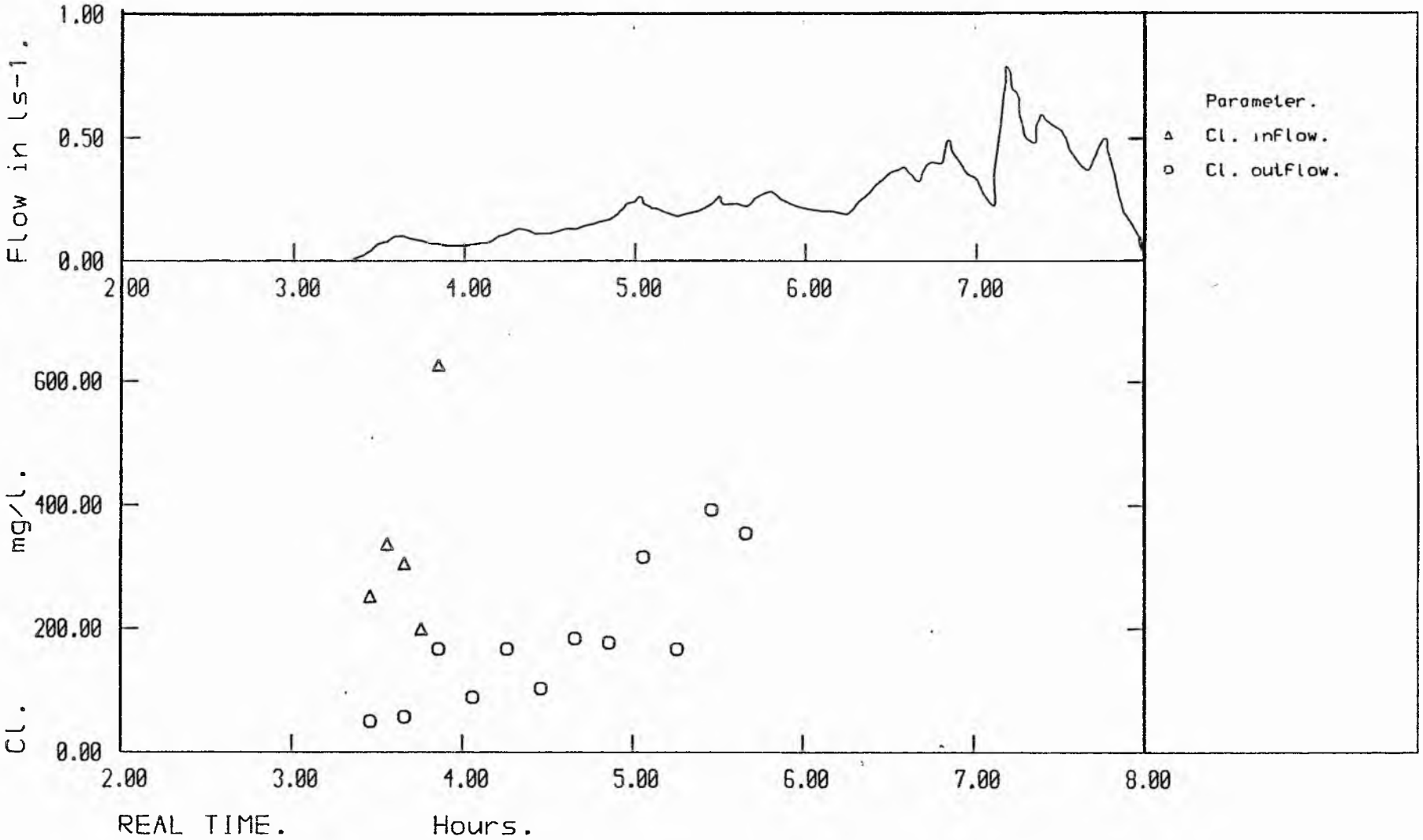
Graph of Total Hardness For Storm III on Twyford Gardens.
The graph shows inflow and outflow water quality data.



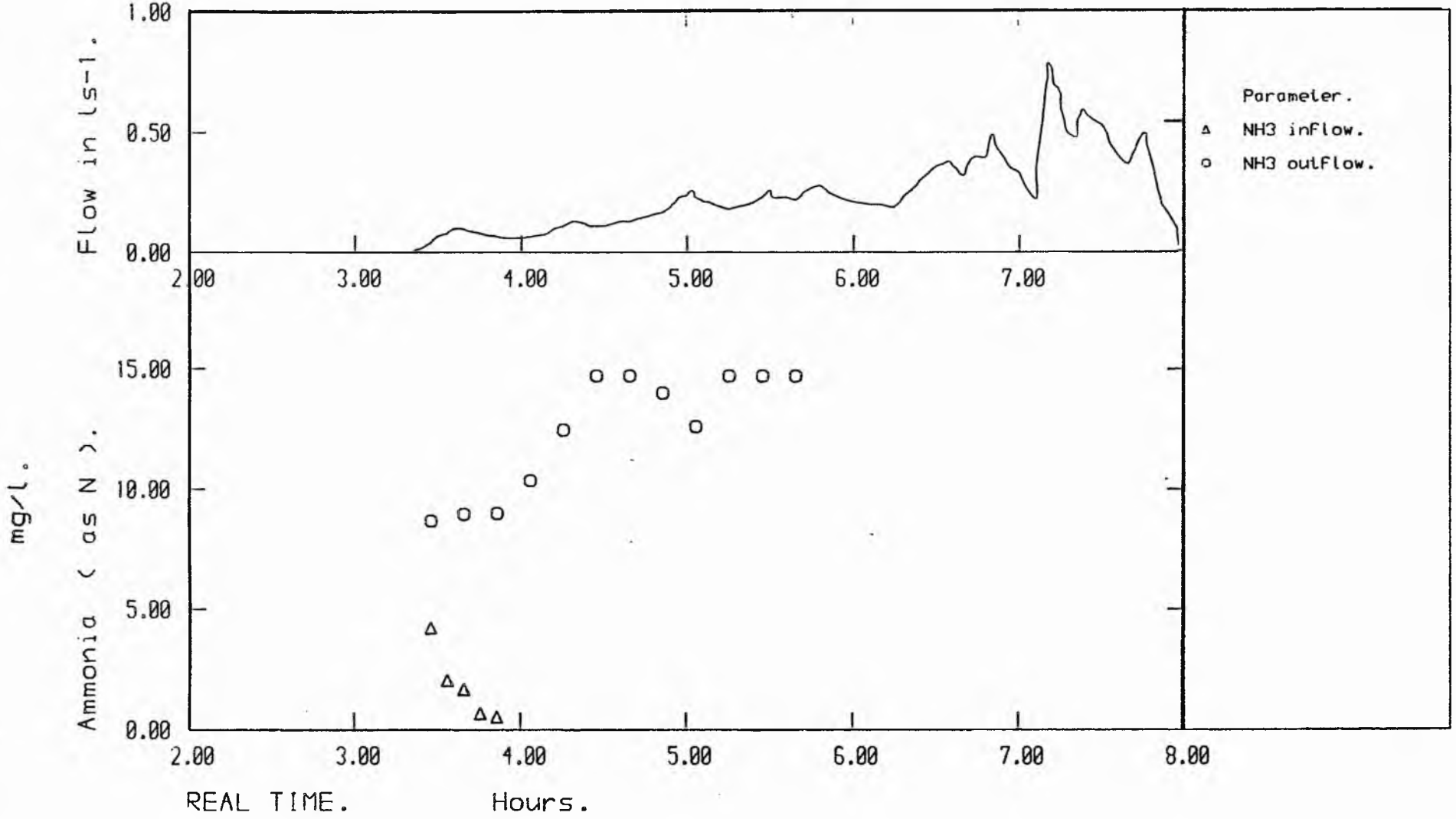
Graph of Total Alkalinity for Storm III on Twyford Gardens.
The graph shows inflow and outflow water quality data.



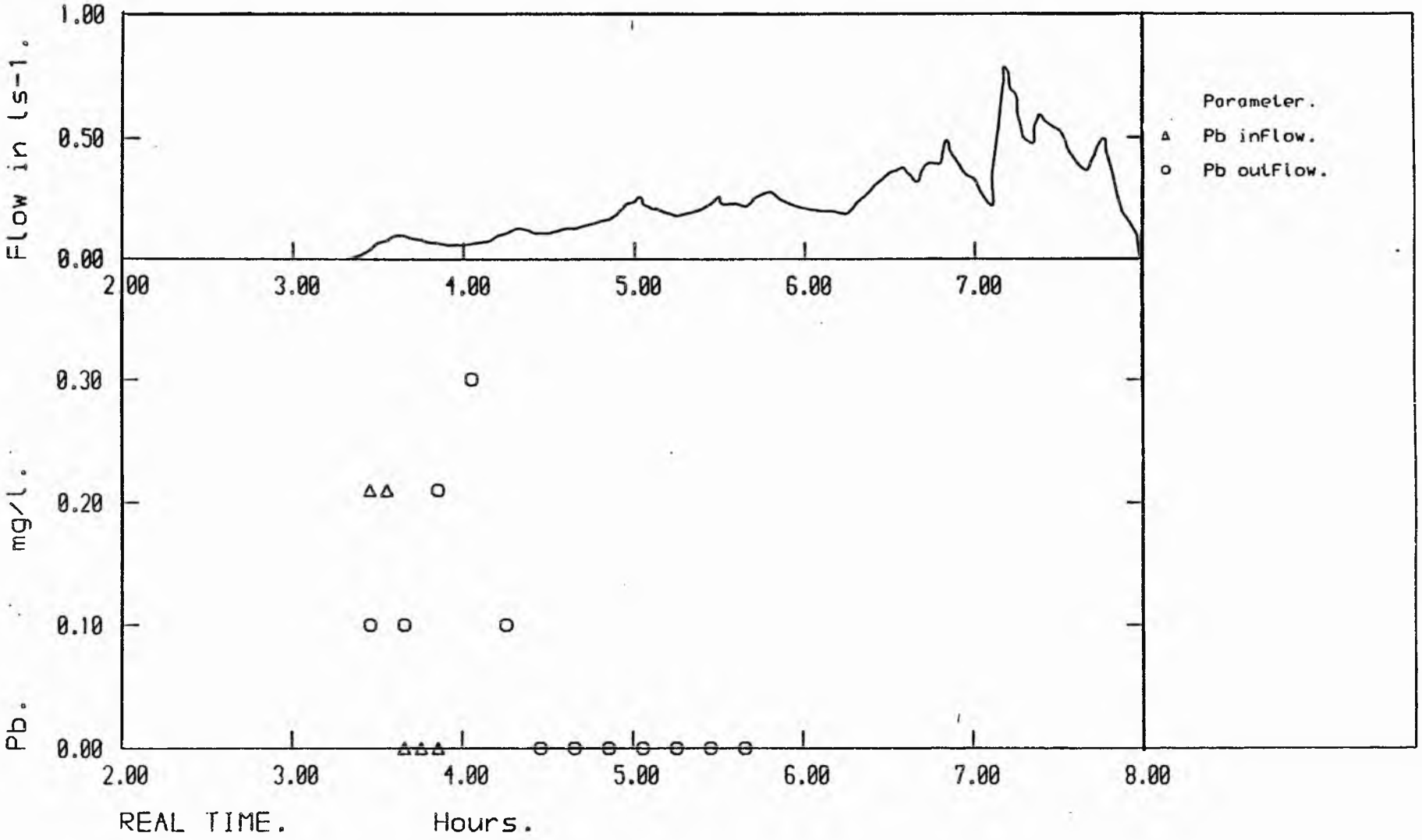
Graph of Sulphate for Storm III on Twyford Gardens.
The graph shows inflow and outflow water quality data.



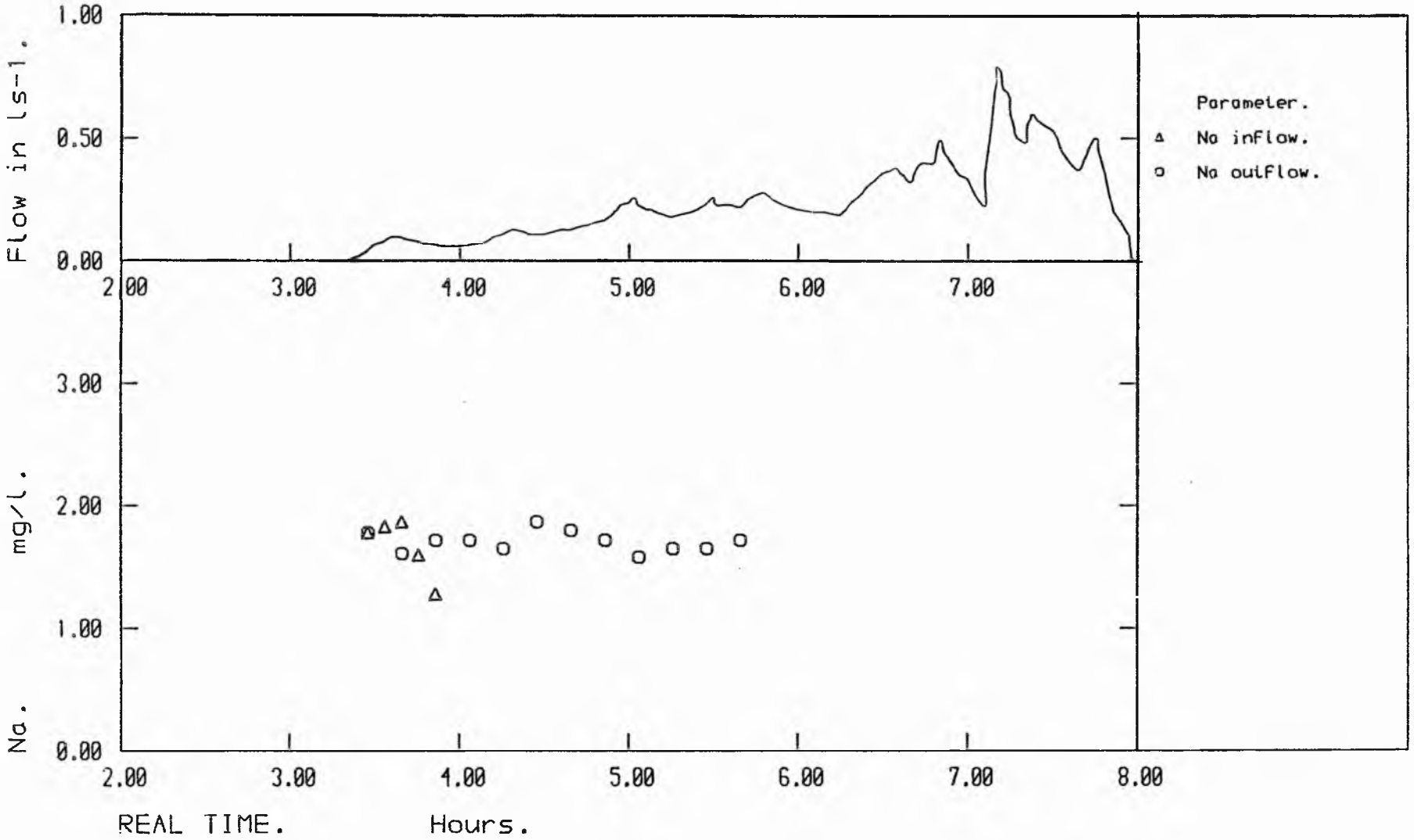
Graph of Chloride For Storm III on Twyford Gardens.
The graph shows inflow and outflow water quality data.



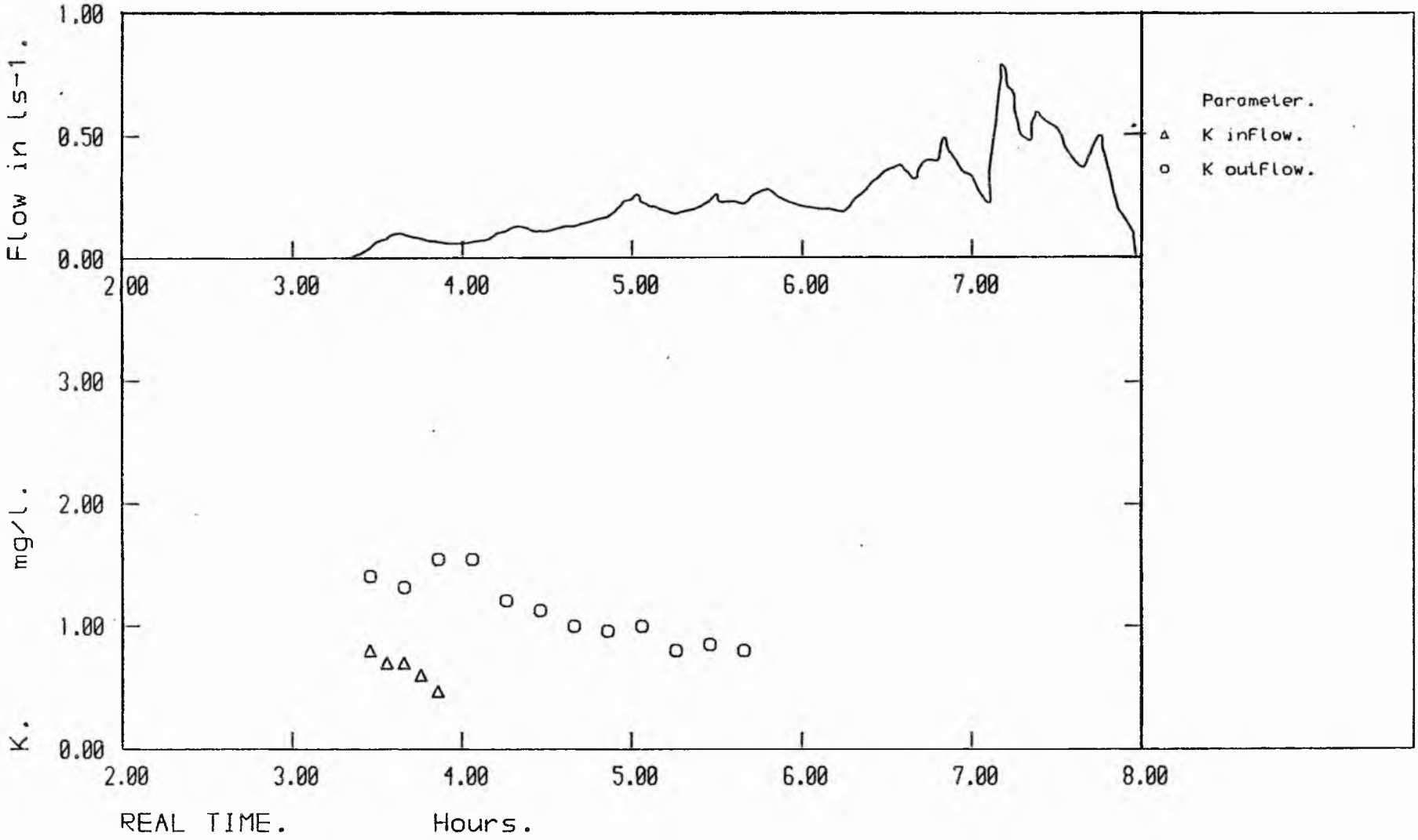
Graph of Ammonia For Storm III on Twyford Gardens.
The graph shows inflow and outflow water quality data.



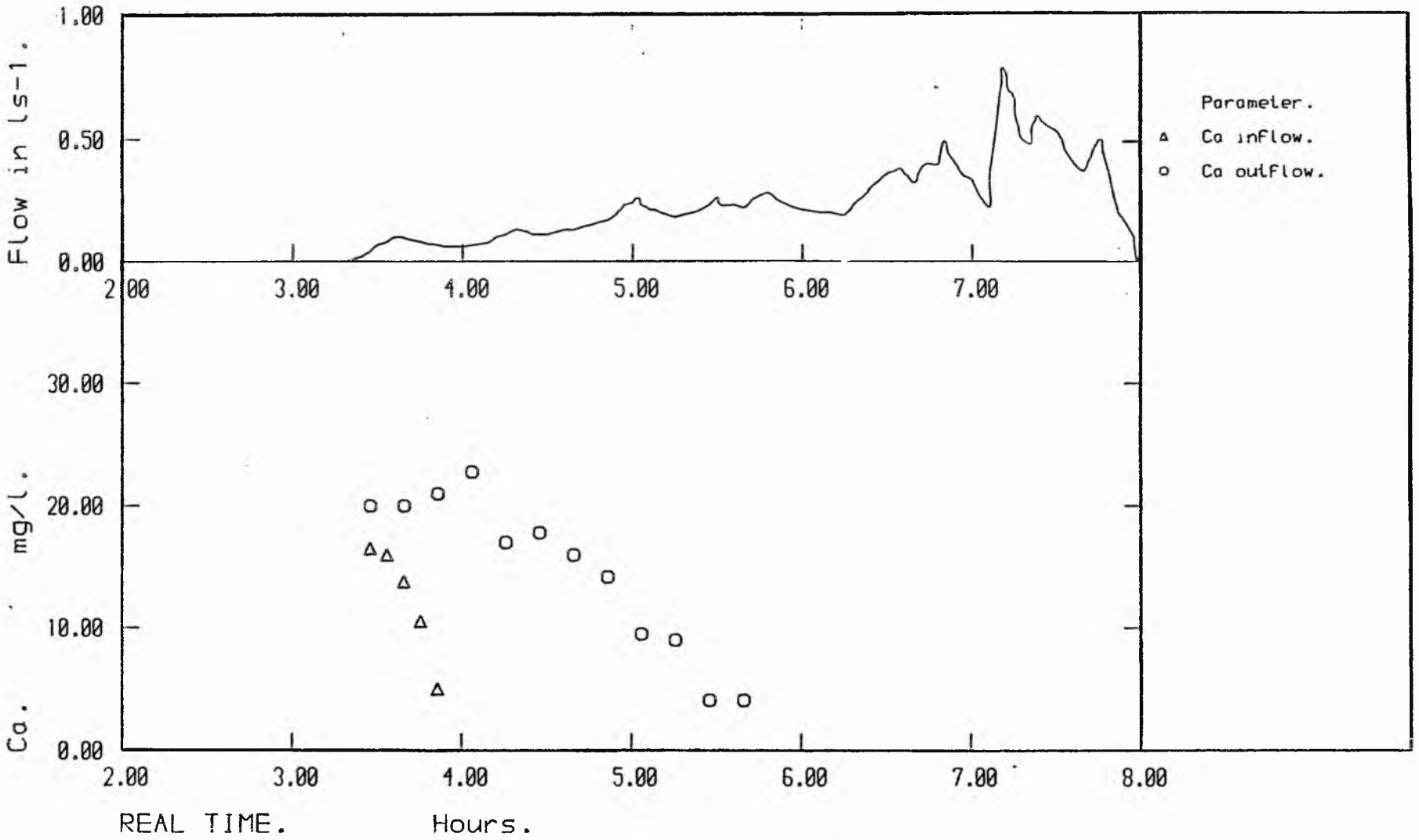
Graph of Lead for Storm III on Twyford Gardens.
The graph shows inflow and outflow water quality data.



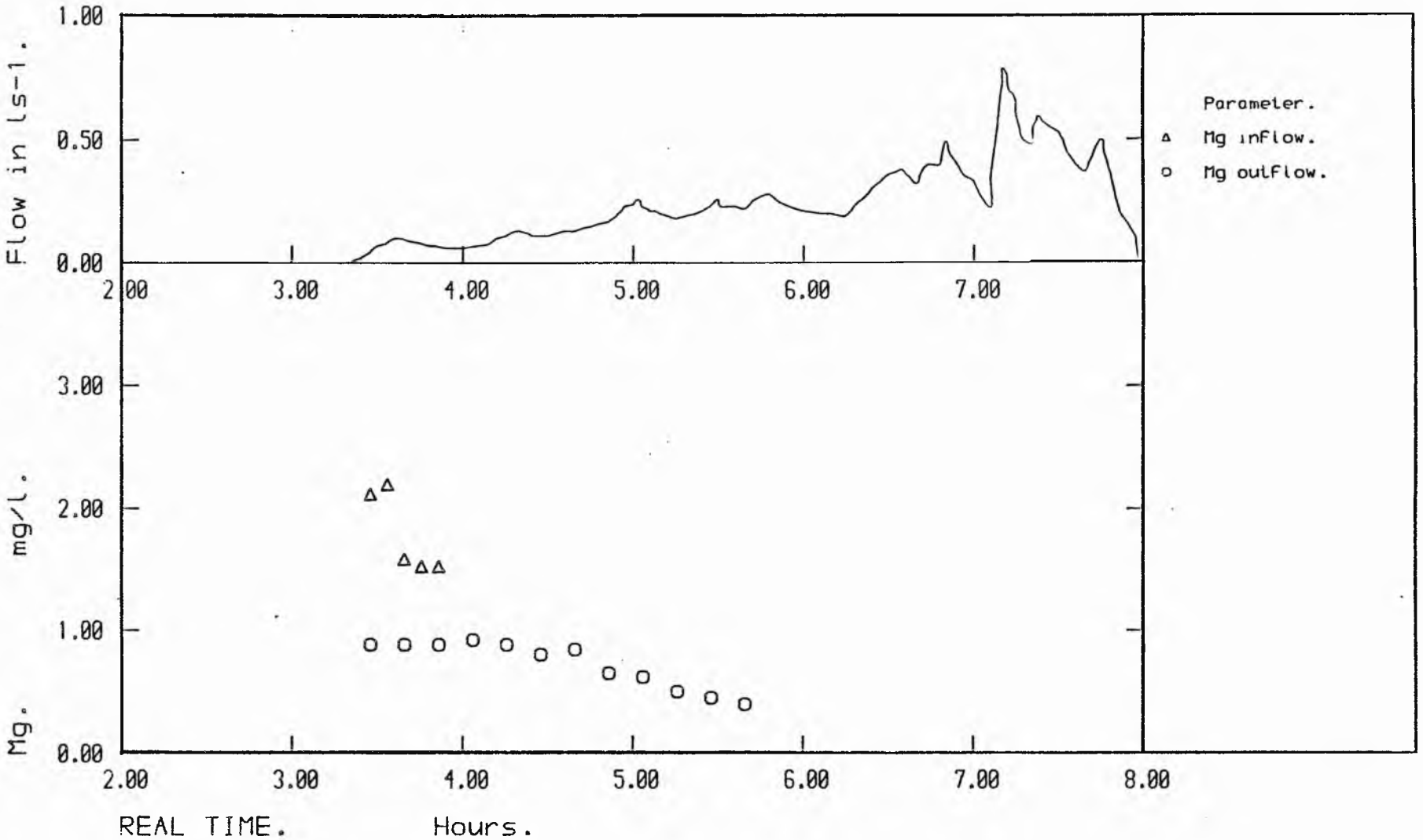
Graph of Sodium for Storm III on Twyford Gardens.
The graph shows inflow and outflow water quality data.



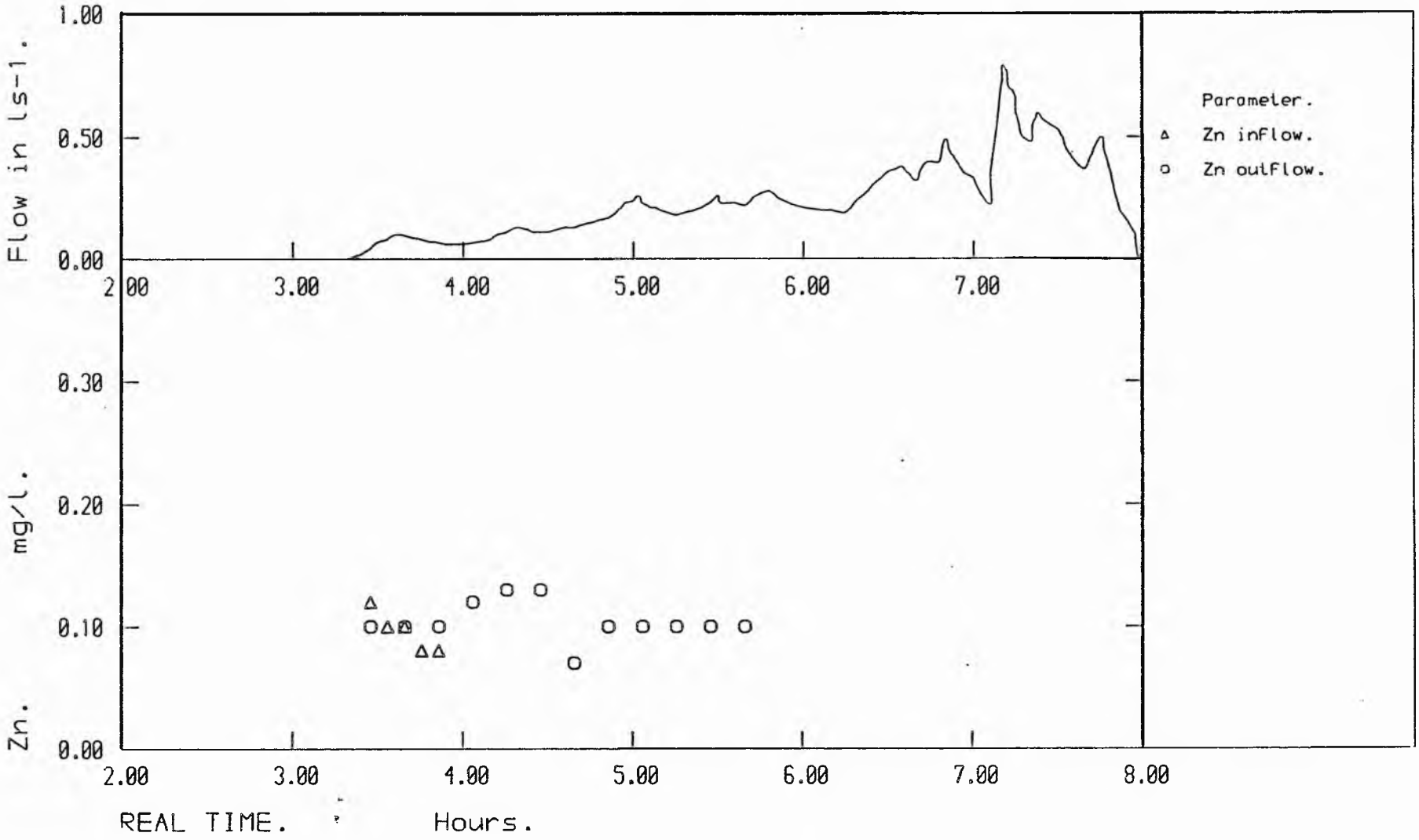
Graph of Potassium for Storm III on Twyford Gardens.
The graph shows inflow and outflow water quality data.



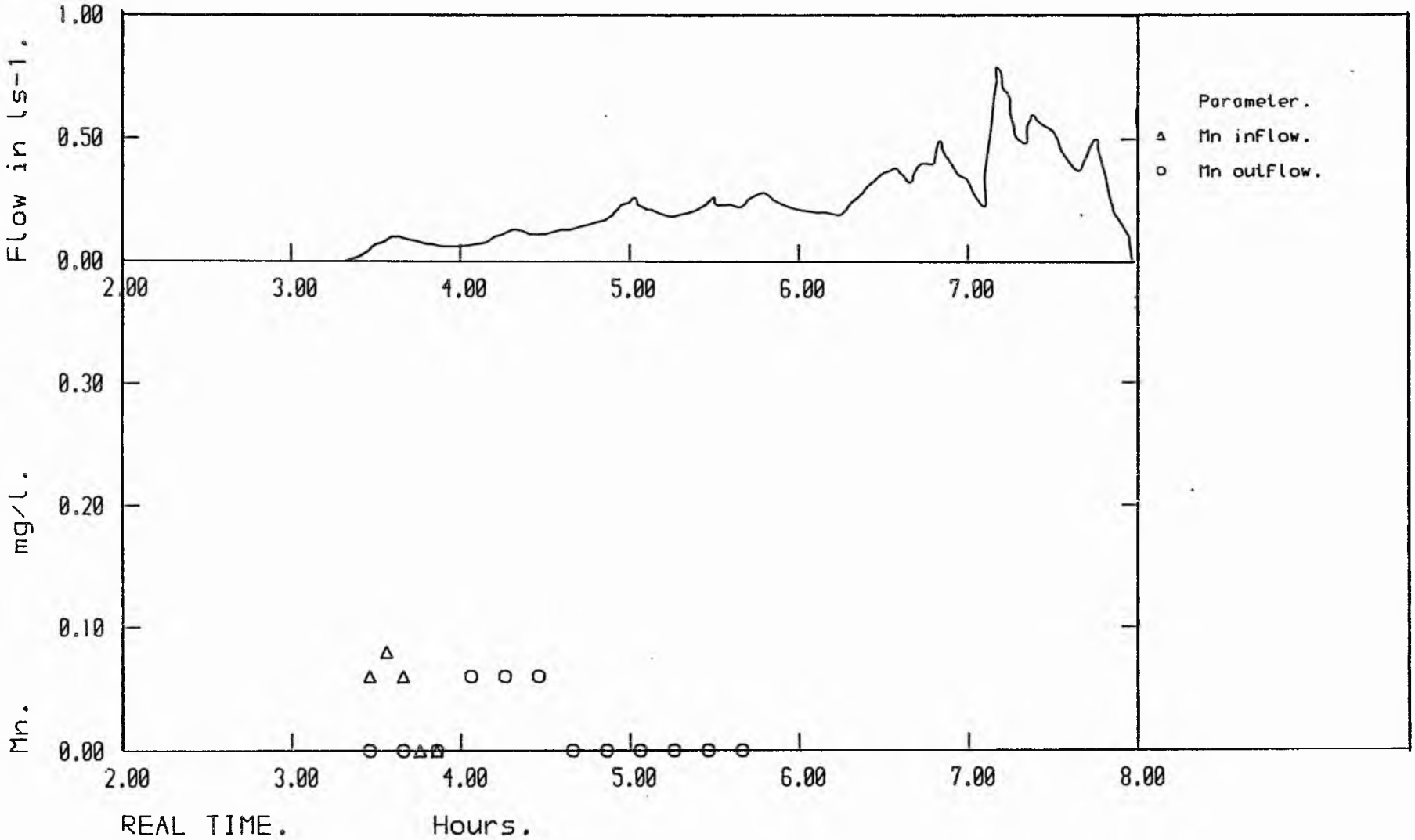
Graph of Calcium for Storm III on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Magnesium for Storm III on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm III on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Manganese for Storm III on Twyford Gardens.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 13th. September 1984 (840913)
STORM NUMBER : IV

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
2218	12	20	64
2230	10	14	50
2242	3	6	60
2254	0	6	35
2306	30	7	40
2318	18	7	40
2330	20	1	35
2342	47	3	15
2354	4	1	15
0006	2	3	15
0018	24	*	0
0030	11	*	0

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 13th. September 1984 (840913)
STORM NUMBER : IV

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
2218	1.4	2.0	23.0	0.9
2230	1.5	2.2	24.0	0.9
2242	1.3	2.6	23.0	0.9
2254	1.2	2.7	27.0	0.9
2306	1.3	2.7	34.2	1.0
2318	1.4	2.0	37.5	0.9
2330	1.2	2.4	32.0	1.1
2342	1.2	2.2	29.0	1.1
2354	1.0	2.2	24.0	0.9
0006	1.0	2.4	25.2	0.7
0018	1.1	2.4	21.2	0.7
0030	1.1	2.2	21.2	0.7

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

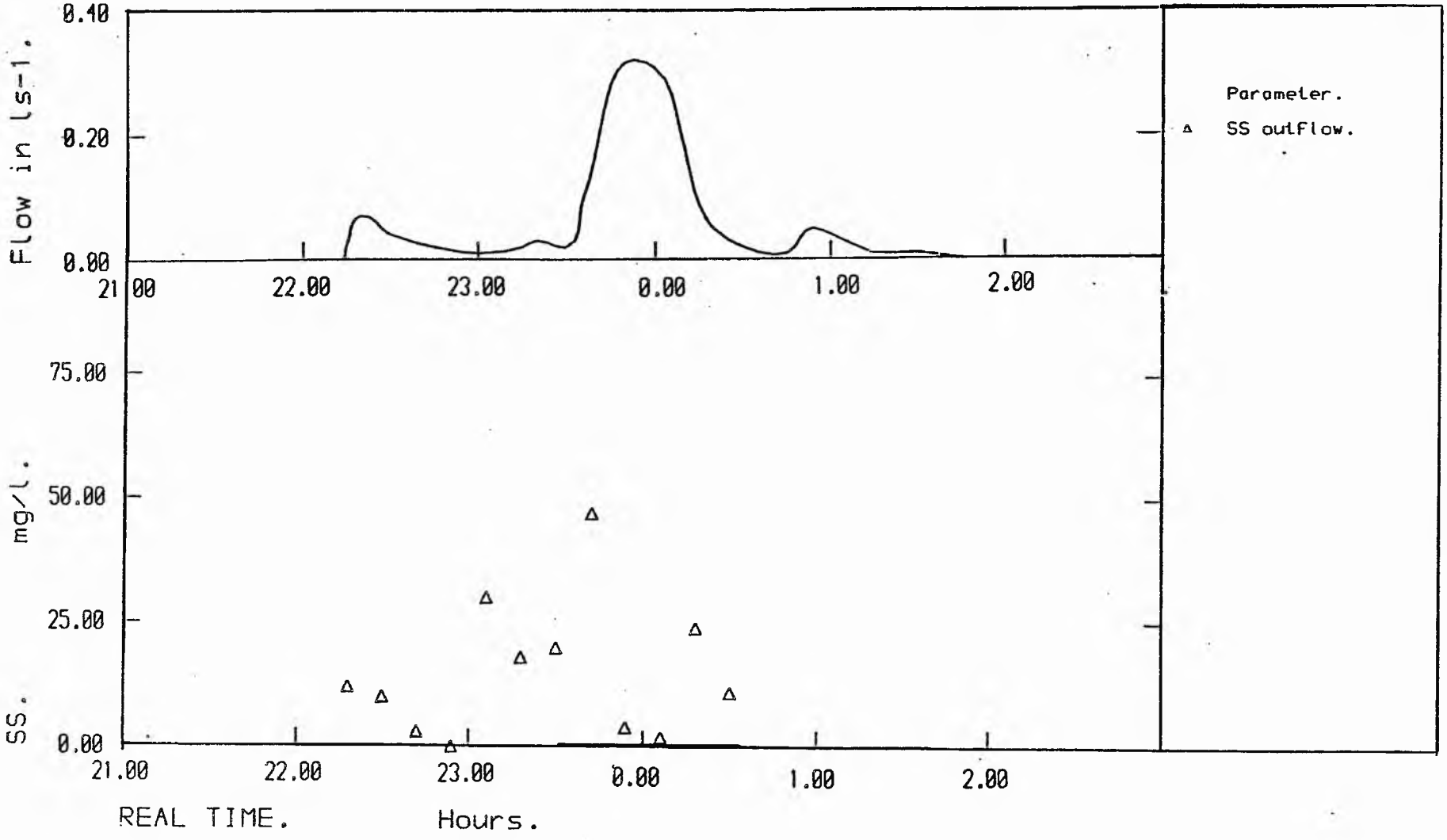
CATCHMENT : Tame Close

DATE OF THE STORM EVENT : 13th. September 1984 (840913)

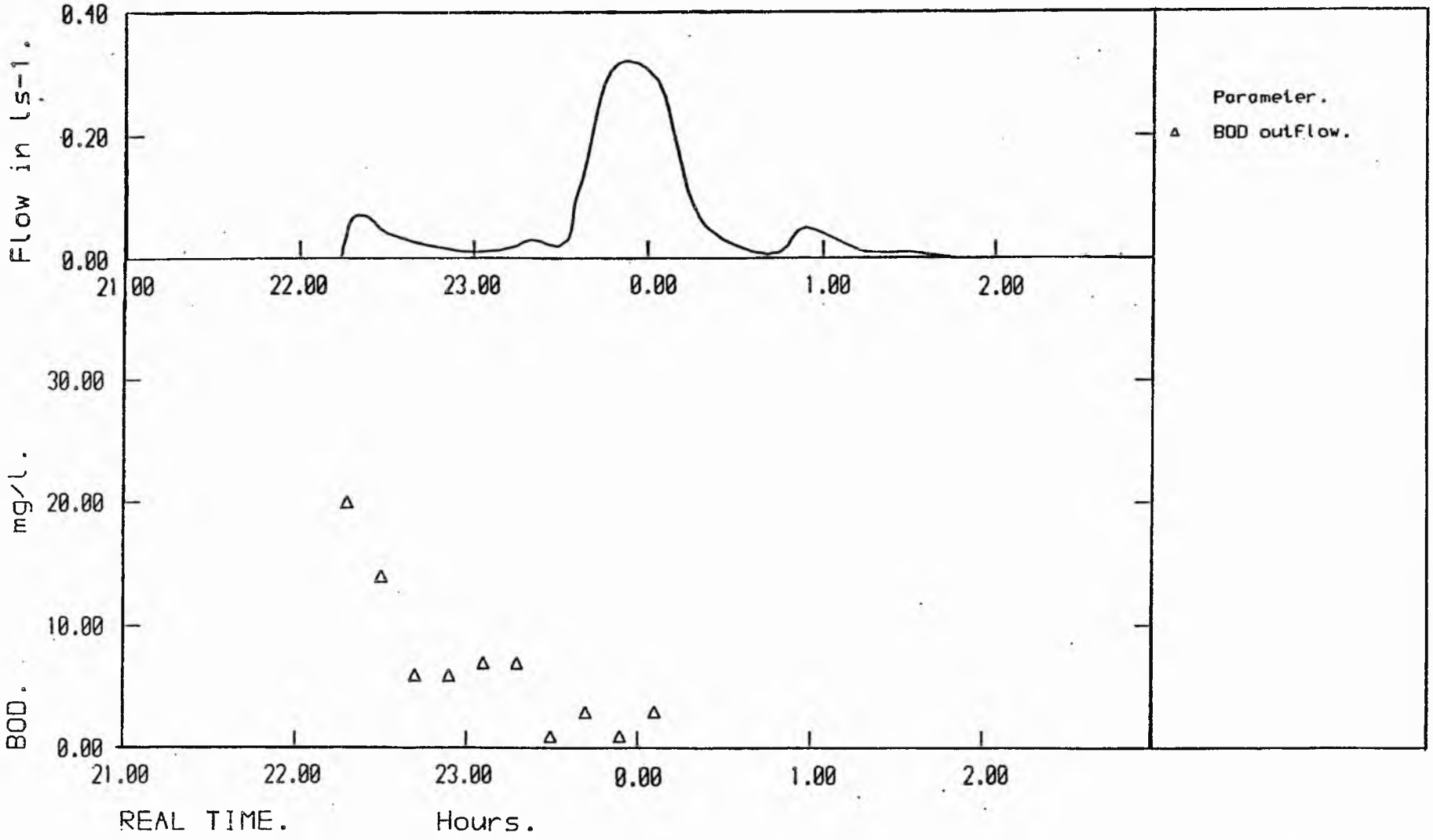
STORM NUMBER : IV

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

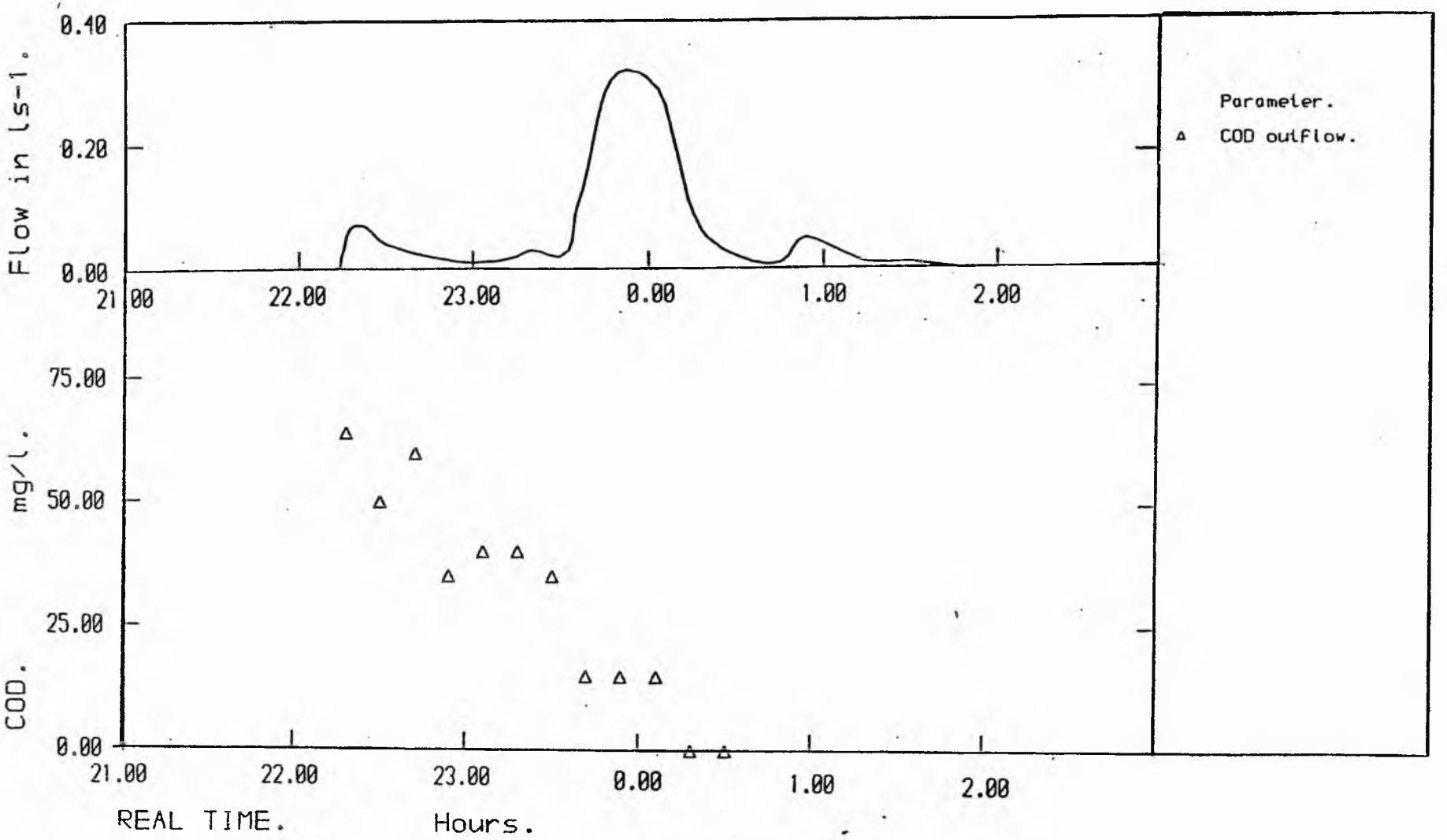
REAL TIME Hours	pH pH units	Zn mgl-1	Mn mgl-1
2218	6.3	0.0	0.1
2230	6.4	0.0	0.2
2242	6.4	0.0	0.2
2254	6.3	0.0	0.1
2306	6.2	0.0	0.1
2318	6.1	0.0	0.0
2330	6.1	0.0	0.0
2342	6.1	0.1	0.0
2354	6.1	0.0	0.1
0006	6.1	0.0	0.1
0018	6.1	0.0	0.1
0030	6.1	0.0	0.0



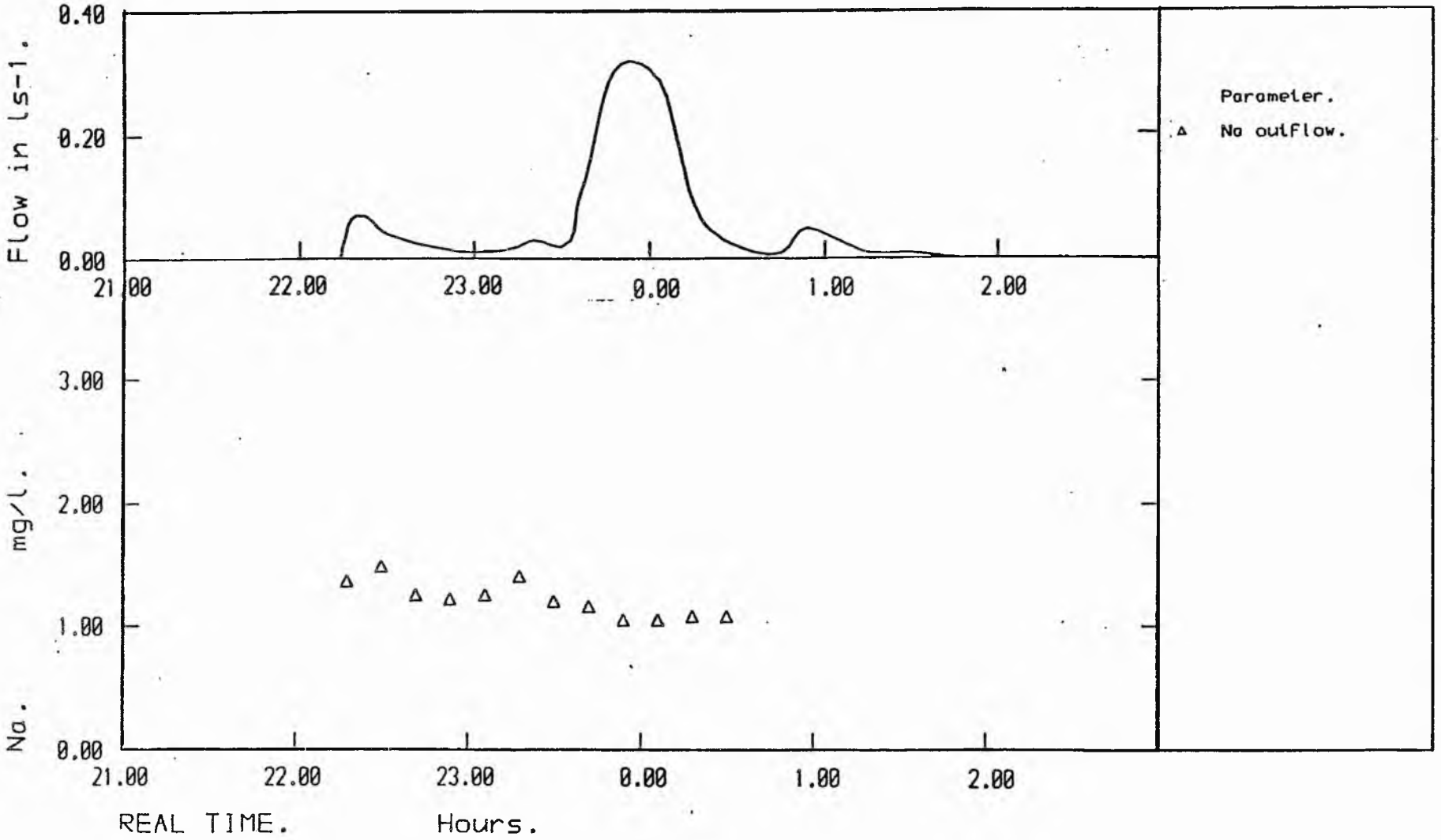
Graph of Suspended Solids for Storm IV on Tame Close.
The graph shows inflow and outflow water quality data.



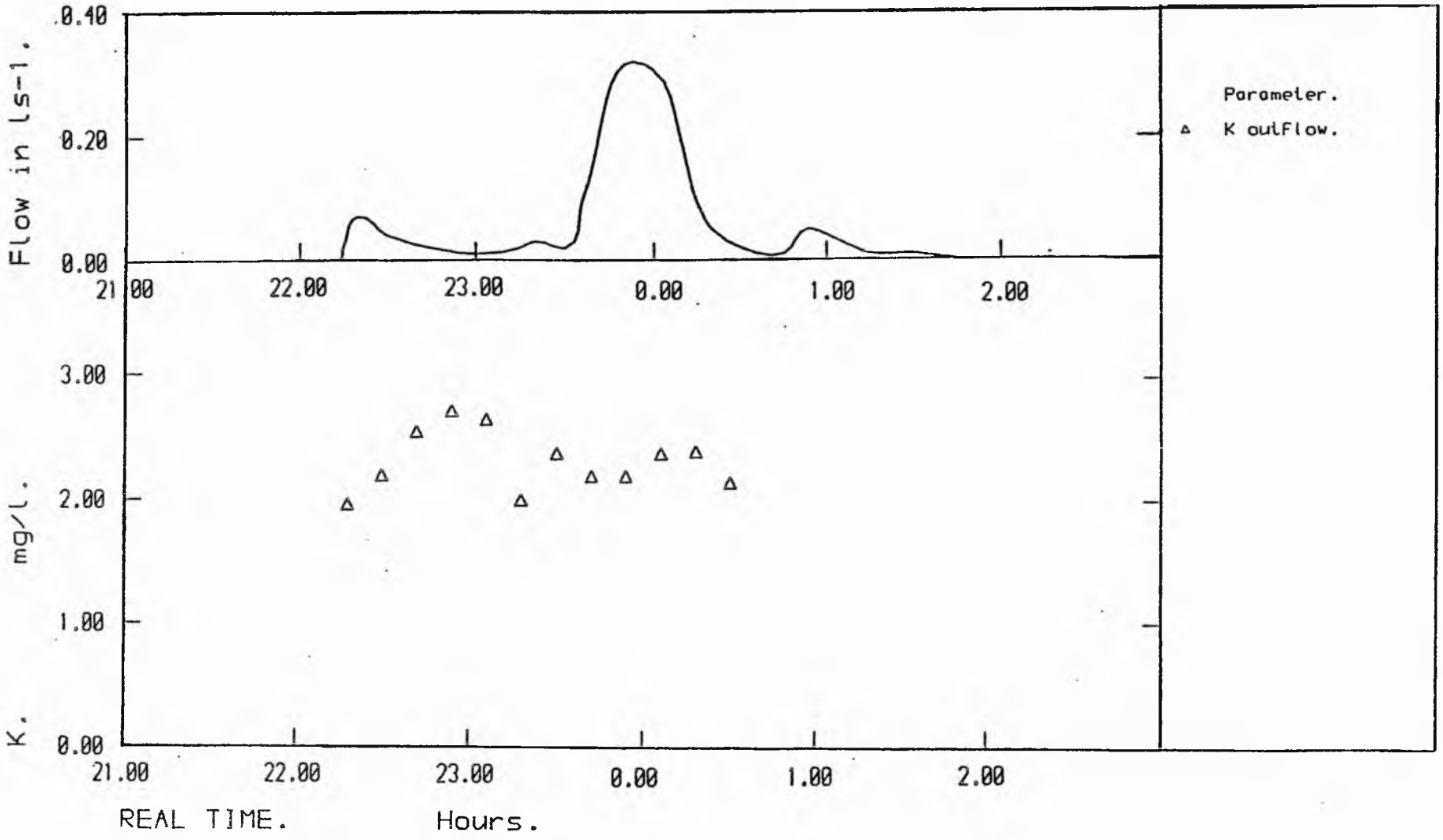
Graph of Biochemical Oxygen Demand For Storm IV on Tame Close.
The graph shows inflow and outflow water quality data.



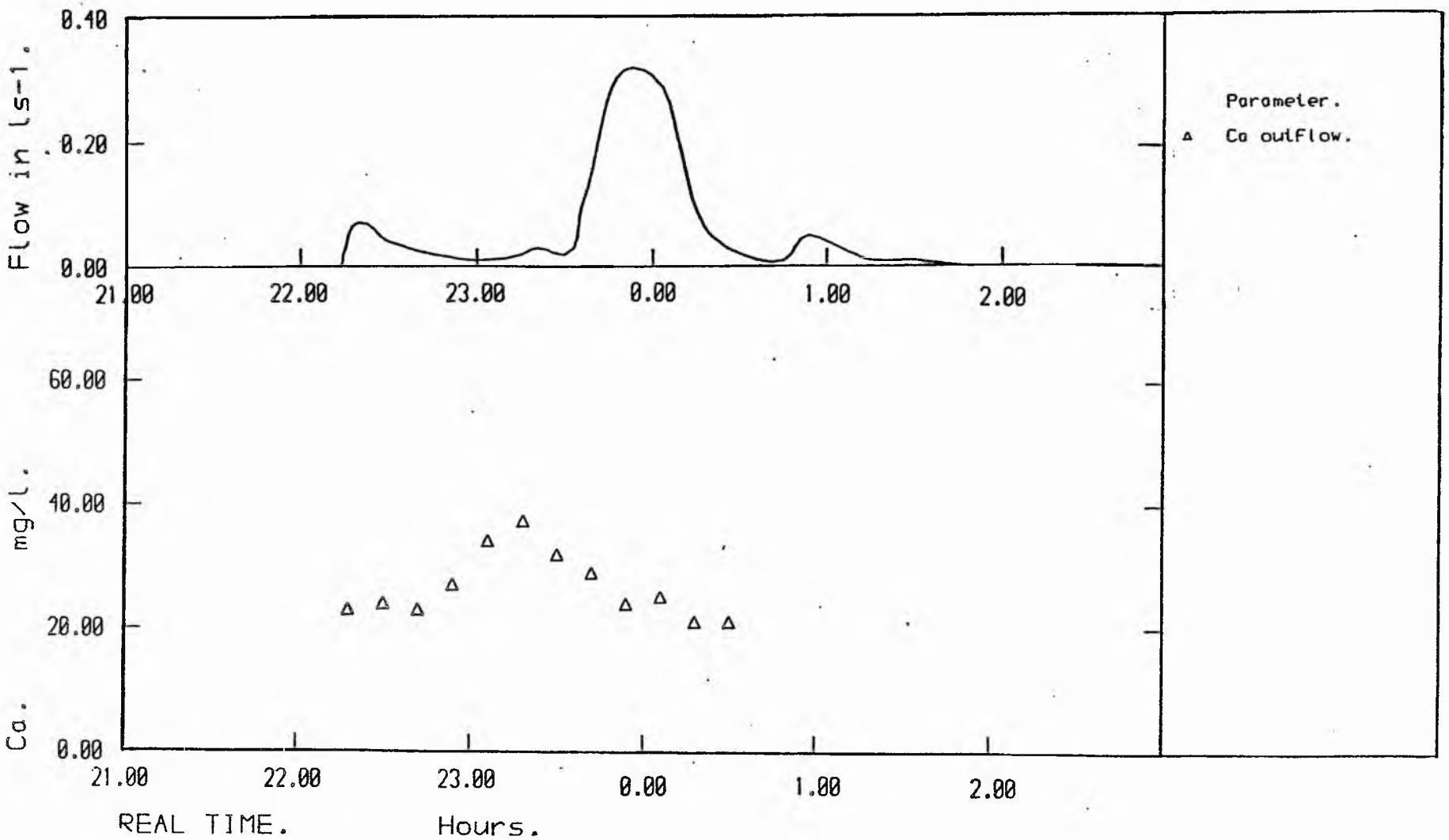
Graph of Chemical Oxygen Demand for Storm IV on Tame Close.
The graph shows inflow and outflow water quality data.



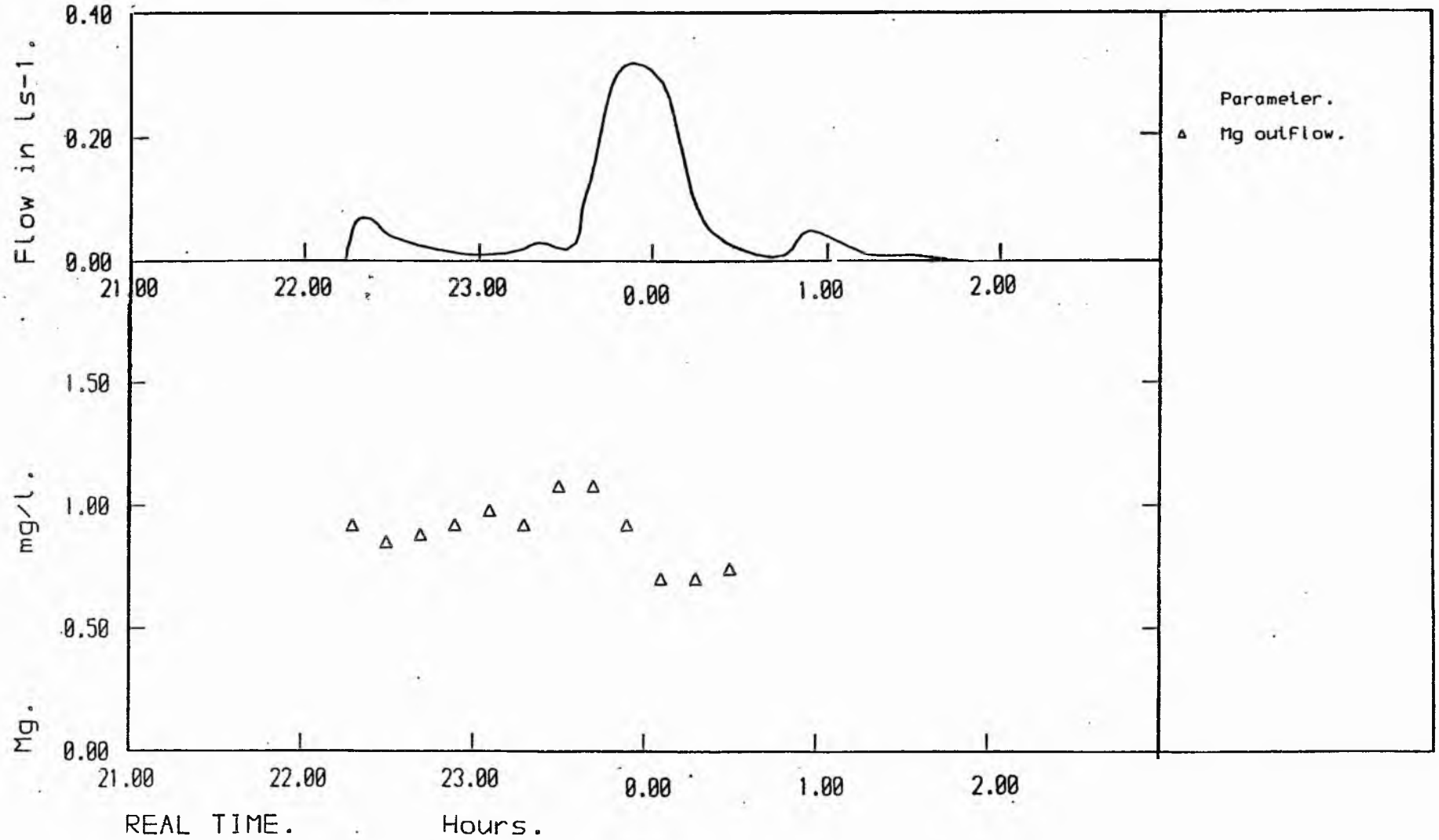
Graph of Sodium For Storm IV on Tame Close:
The graph shows inflow and outflow water quality data.



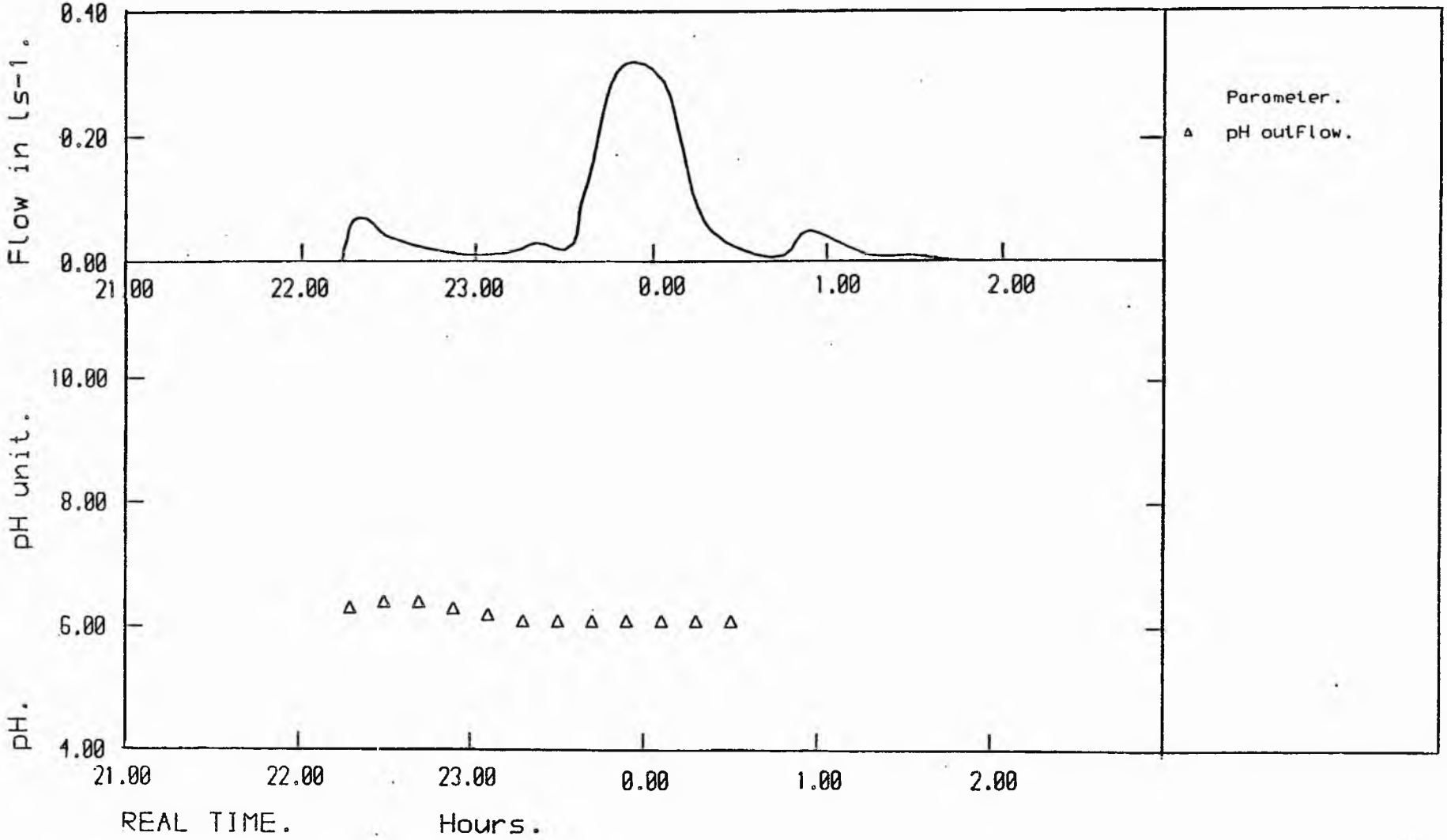
Graph of Potassium For Storm IV on Tame Close.
The graph shows inflow and outflow water quality data:



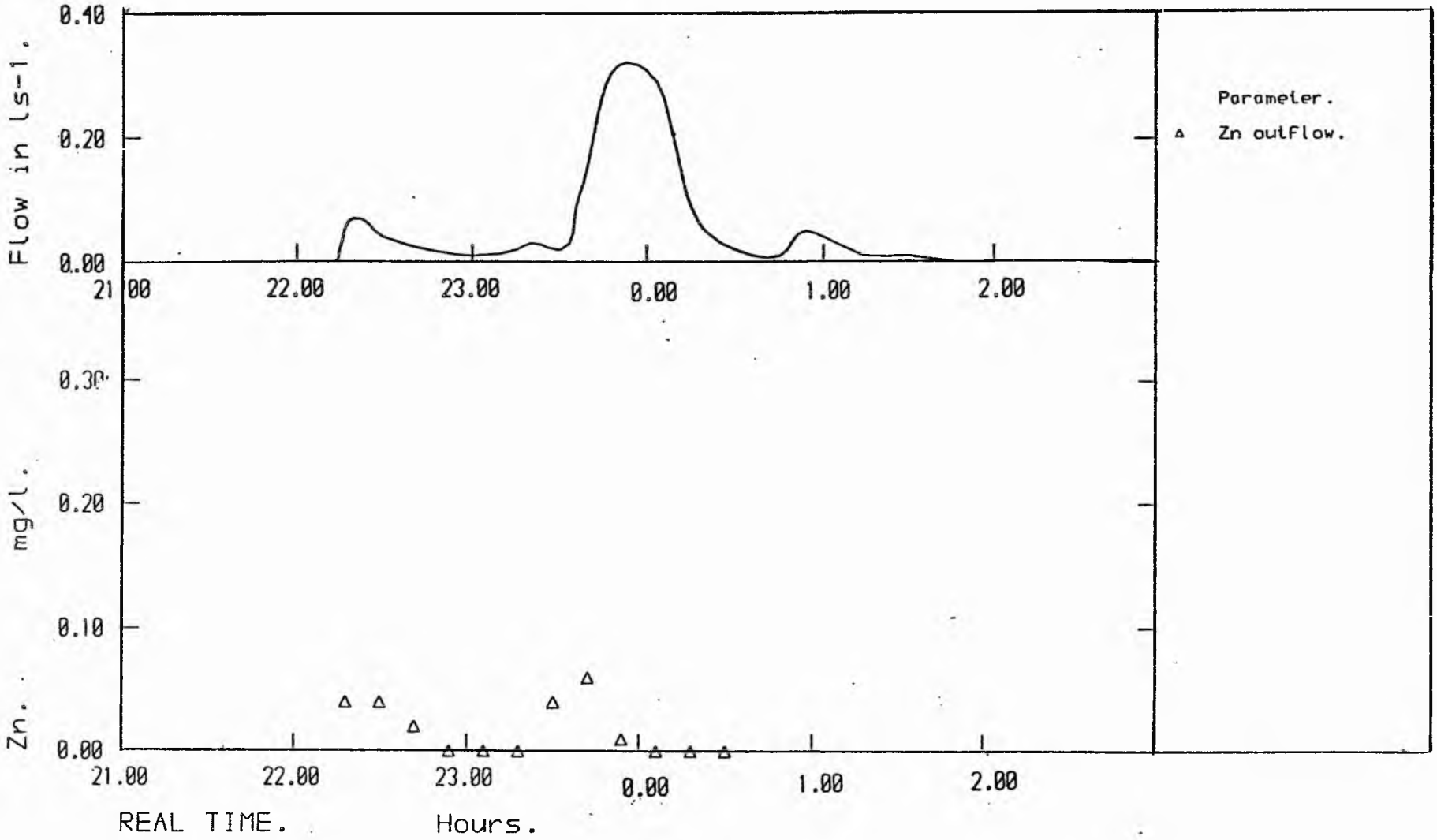
Graph of Calcium For Storm IV on Tame Close.
The graph shows inflow and outflow water quality data.



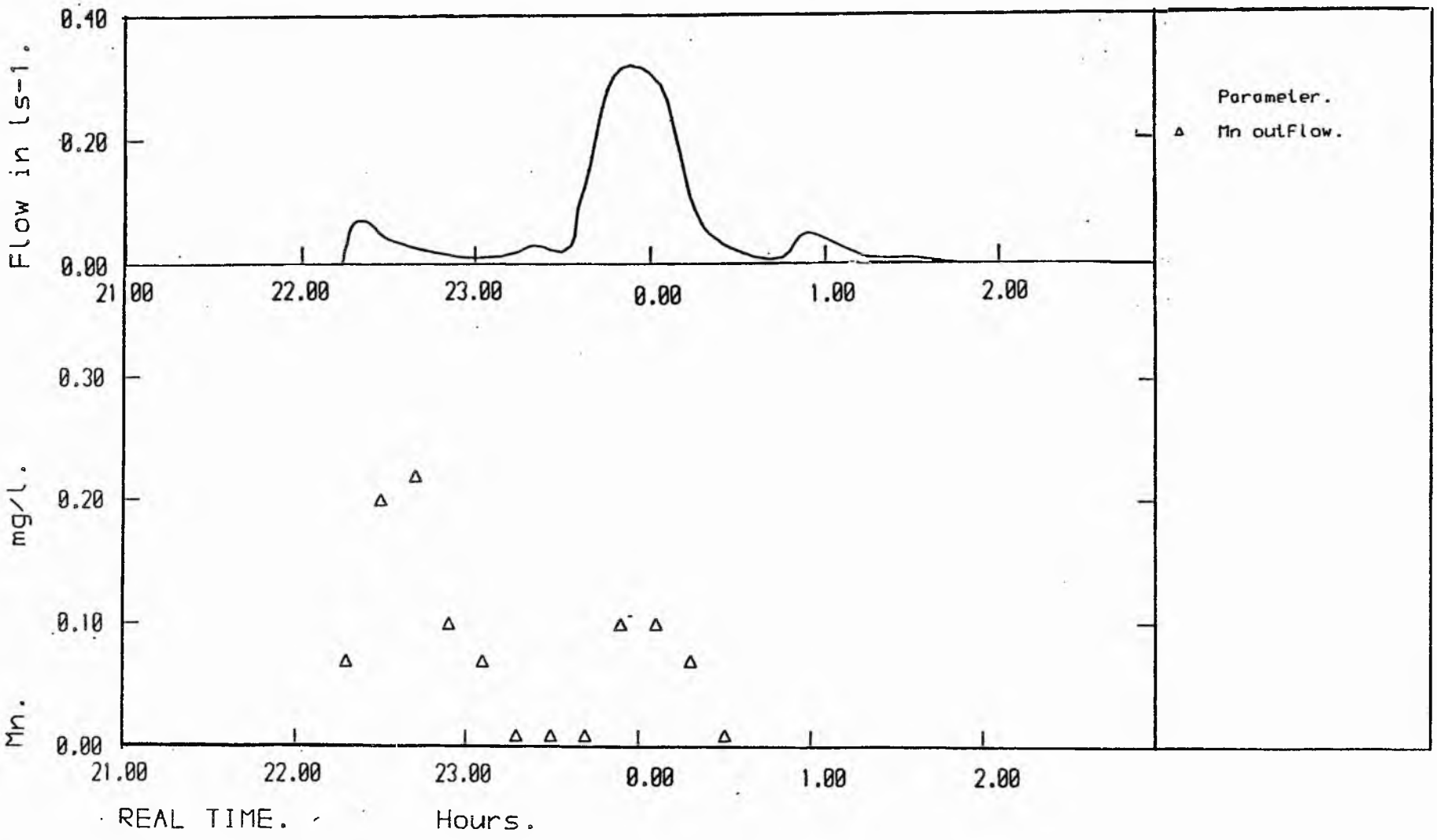
Graph of Magnesium For Storm IV on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of pH for Storm IV on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm IV on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Manganese for Storm IV on Tame Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close

DATE OF THE STORM EVENT : 13th. September 1984 (840913)

STORM NUMBER : IV

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
2218	136	9	74
2224	64	5	79
2230	26	3	79
2236	36	0	84
2242	16	0	149
2248	50	2	30
2254	10	*	*
2300	59	*	*
2306	18	0	35
2312	20	*	*
2318	53	*	*
2324	49	1	40
2330	71	*	*
2336	133	*	*
2342	89	0	60
2348	69	*	*
2354	120	*	*
0000	274	0	69
0006	251	*	*
0012	224	*	*
0018	56	0	15
0024	99	*	*
0030	11	*	*
0036	3	0	10

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 13th. September 1984 (840913)
STORM NUMBER : IV

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
2218	7	5	10
2224	27	*	*
2230	31	3	30
2236	12	*	*
2242	19	5	50
2248	9	*	*
2254	23	7	5
2300	15	*	*
2306	8	1	35
2312	2	*	*
2318	5	14	79
2324	8	*	*
2330	14	7	55
2336	12	*	*
2342	4	7	0
2348	5	*	*
2354	7	10	35
0000	9	*	*
0006	72	4	15
0012	53	*	*
0018	32	4	15
0024	26	*	*
0030	8	4	15
0036	15	*	*

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close

DATE OF THE STORM EVENT : 13th. September 1984 (840913)

STORM NUMBER : JV

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	pH pH units	Fe mgl-1
2218	5.8	1.6
2224	5.9	2.4
2230	5.9	1.2
2236	5.9	1.3
2242	5.9	2.1
2248	5.9	2.0
2254	6.2	*
2300	6.0	*
2306	5.9	1.6
2312	6.0	*
2318	6.0	*
2324	6.0	1.3
2330	5.9	*
2336	6.1	*
2342	6.0	0.7
2348	5.9	*
2354	6.0	*
0000	6.0	0.7
0006	5.9	*
0012	6.0	*
0018	6.1	0.0
0024	6.0	*
0030	6.1	*
0036	6.1	0.0

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close

DATE OF THE STORM EVENT : 13th. September 1984 (840913)

STORM NUMBER : IV

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	pH pH units	Fe mgl-1
2218	6.2	0.3
2224	6.2	*
2230	6.1	0.3
2236	6.0	*
2242	6.1	0.7
2248	6.1	*
2254	*	0.3
2300	6.0	*
2306	6.0	0.0
2312	5.9	*
2318	5.9	0.0
2324	5.9	*
2330	6.0	0.0
2336	6.0	*
2342	6.0	0.0
2348	5.9	*
2354	5.9	0.0
0000	6.0	*
0006	6.1	0.0
0012	6.0	*
0018	6.0	0.0
0024	6.0	*
0030	6.1	0.0
0036	6.1	*

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 13th. September 1984 (840913)
STORM NUMBER : IV

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
2218	0.6	0.9	25.2	0.6
2224	0.8	0.9	27.0	0.8
2230	0.9	1.1	36.0	0.7
2236	0.8	1.4	36.0	0.7
2242	1.0	1.1	36.0	0.8
2248	1.1	1.0	35.0	0.8
2306	1.0	0.9	29.0	0.6
2324	1.0	1.0	30.0	0.5
2342	0.8	0.9	24.0	0.6
0000	0.8	0.9	21.2	0.6
0018	0.8	0.8	18.0	0.6
0036	0.6	0.9	18.0	0.5

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close

DATE OF THE STORM EVENT : 13th. September 1984 (840913)

STORM NUMBER : IV

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
2218	1.3	1.5	19.5	0.4
2230	1.3	1.6	17.0	0.5
2242	1.3	1.6	17.0	0.5
2254	1.1	1.8	25.2	0.5
2306	1.3	2.2	21.0	0.5
2318	1.3	2.2	25.2	0.4
2330	1.3	2.0	27.0	0.4
2342	1.2	1.8	9.0	0.4
2354	1.2	1.5	13.2	0.4
0006	1.1	1.6	17.0	0.4
0018	1.2	1.6	15.0	0.4
0030	1.1	1.4	15.0	0.4

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 13th. September 1984 (840913)
STORM NUMBER : IV

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Zn mgl-1	Mn mgl-1
2218	0.0	0.1
2224	0.0	0.1
2230	0.0	0.1
2236	0.0	0.1
2242	0.0	0.0
2248	0.0	0.0
2306	0.0	0.0
2324	0.0	0.0
2342	0.0	0.0
0000	0.0	0.0
0018	0.0	0.0
0036	0.0	0.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

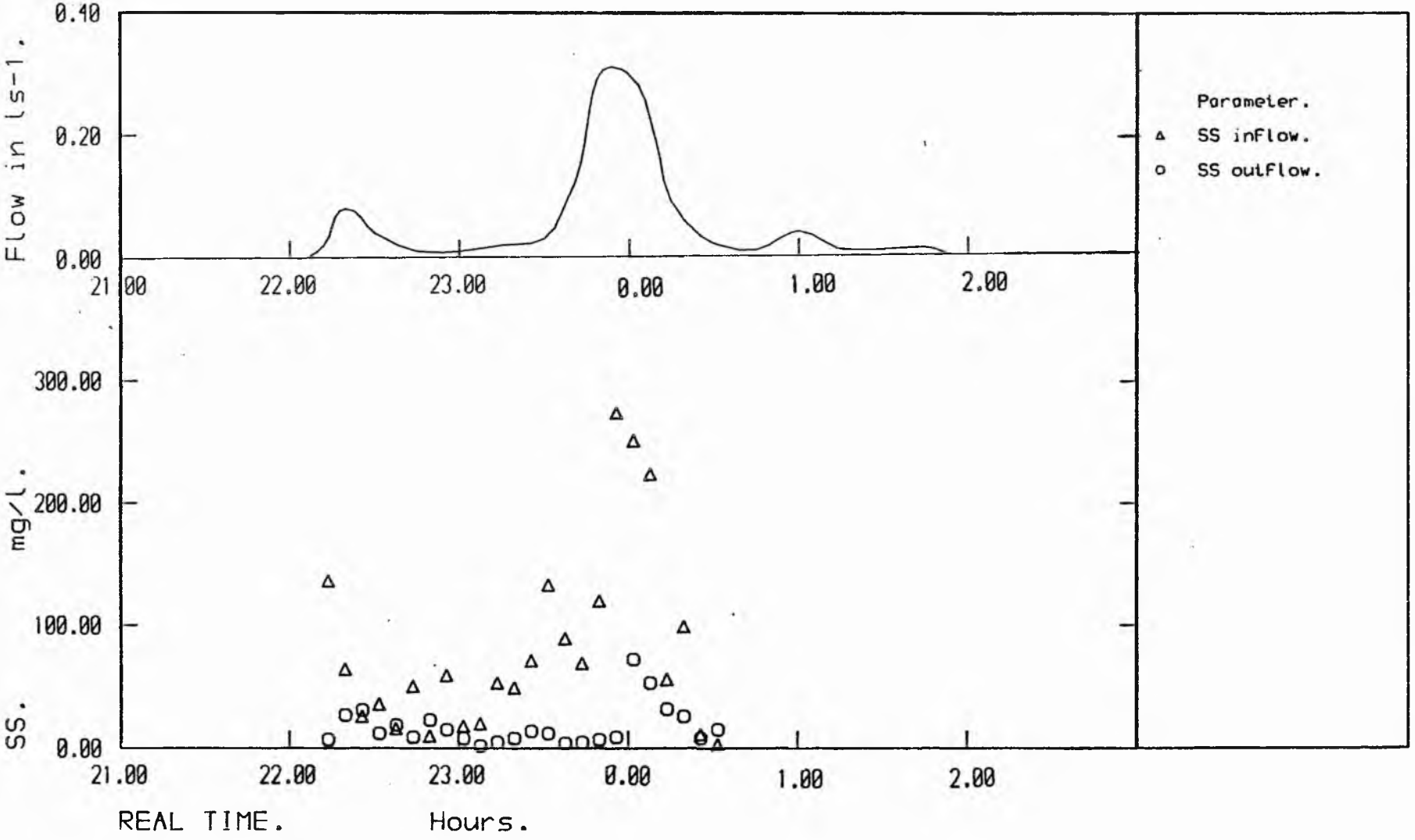
CATCHMENT : Churnet Close

DATE OF THE STORM EVENT : 13th. September 1984 (840913)

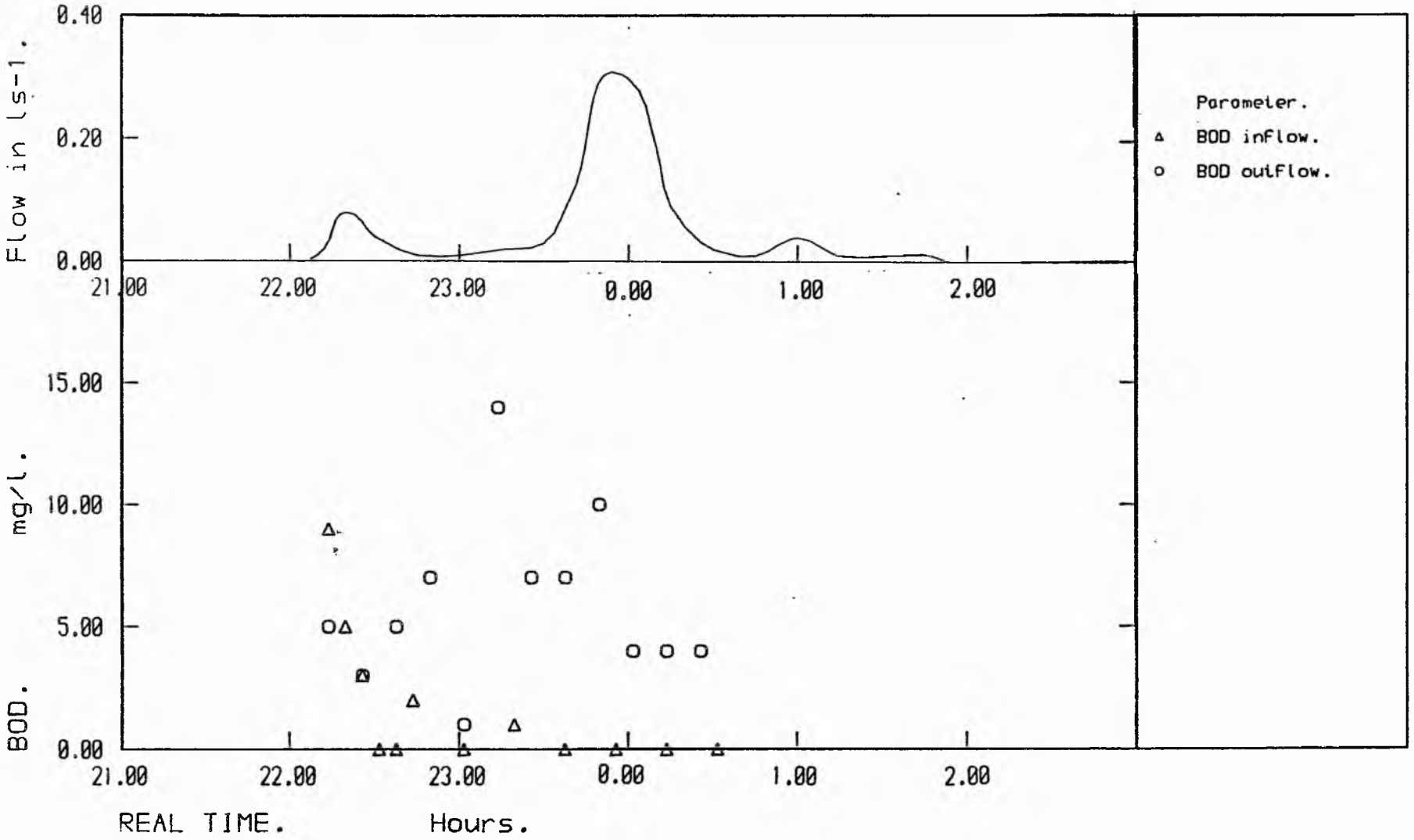
STORM NUMBER : IV

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

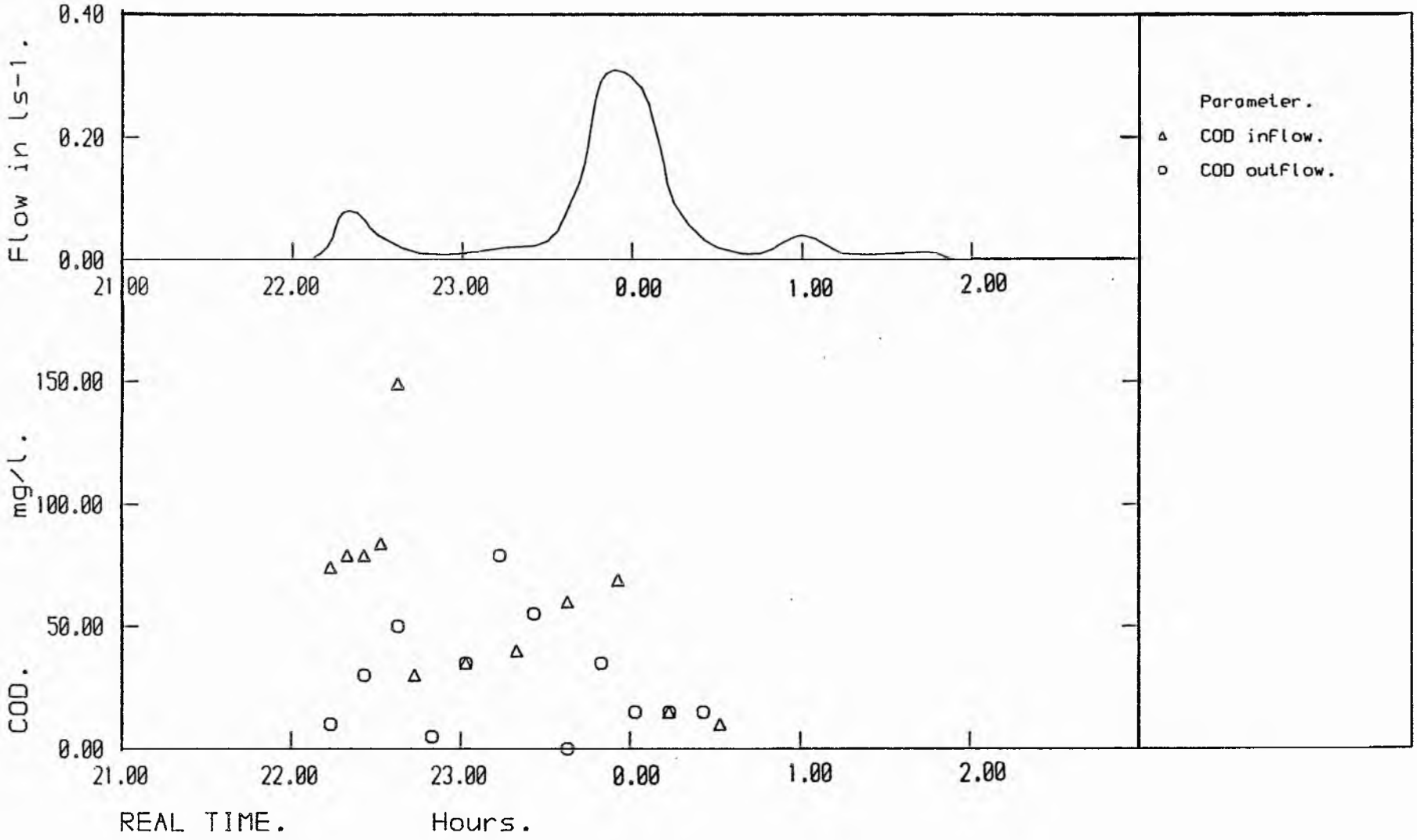
REAL TIME Hours	Zn mgl-1	Mn mgl-1
2218	0.0	0.0
2230	0.0	0.0
2242	0.0	0.0
2254	0.0	0.0
2306	0.0	0.1
2318	0.0	0.1
2330	0.1	0.1
2342	0.0	0.2
2354	0.0	0.1
0006	0.0	0.0
0018	0.0	0.0
0030	0.0	0.0



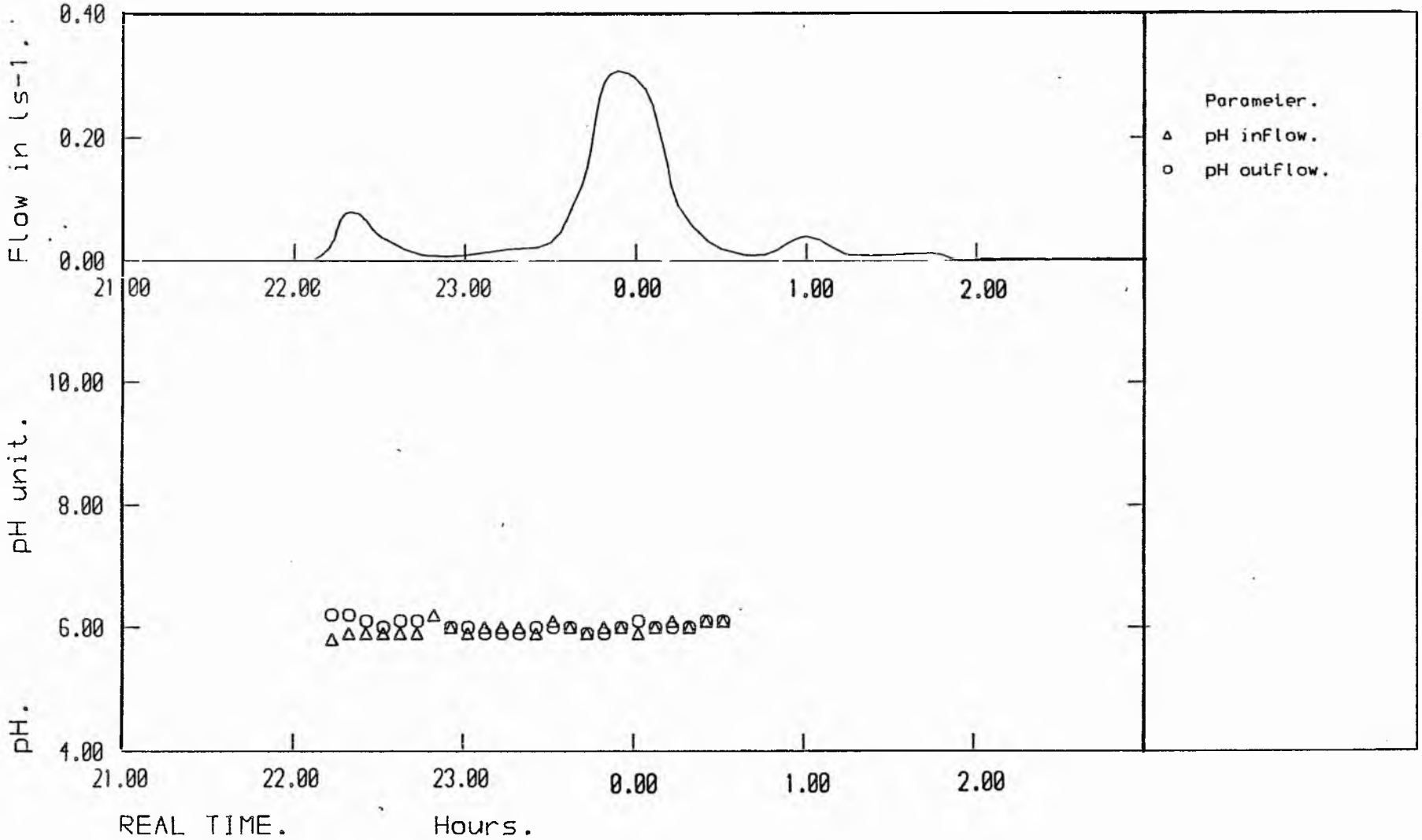
Graph of Suspended Solids for Storm IV on Churnet Close.
The graph shows inflow and outflow water quality data.



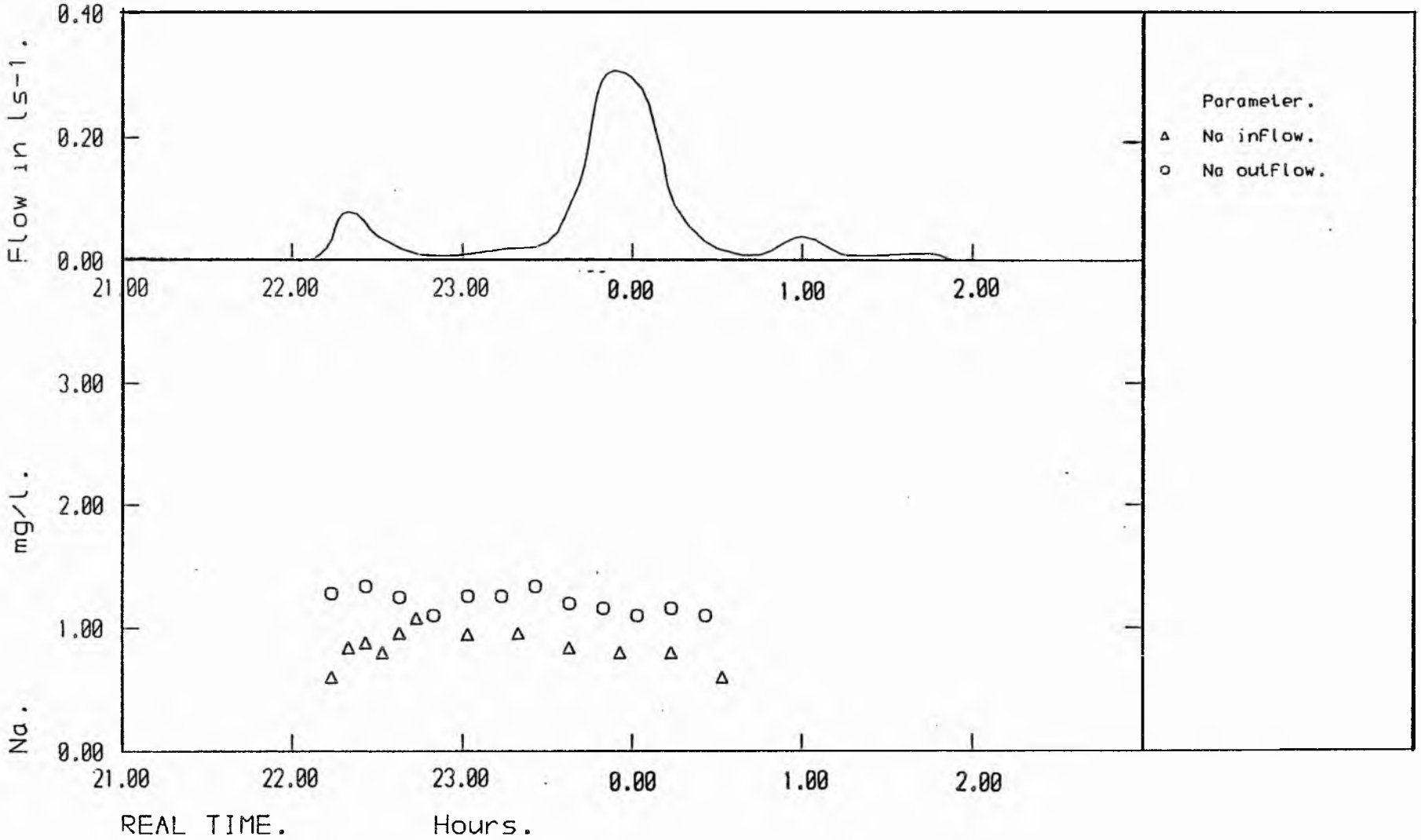
Graph of Biochemical Oxygen Demand For Storm IV on Churnet Close.
The graph shows inflow and outflow water quality data.



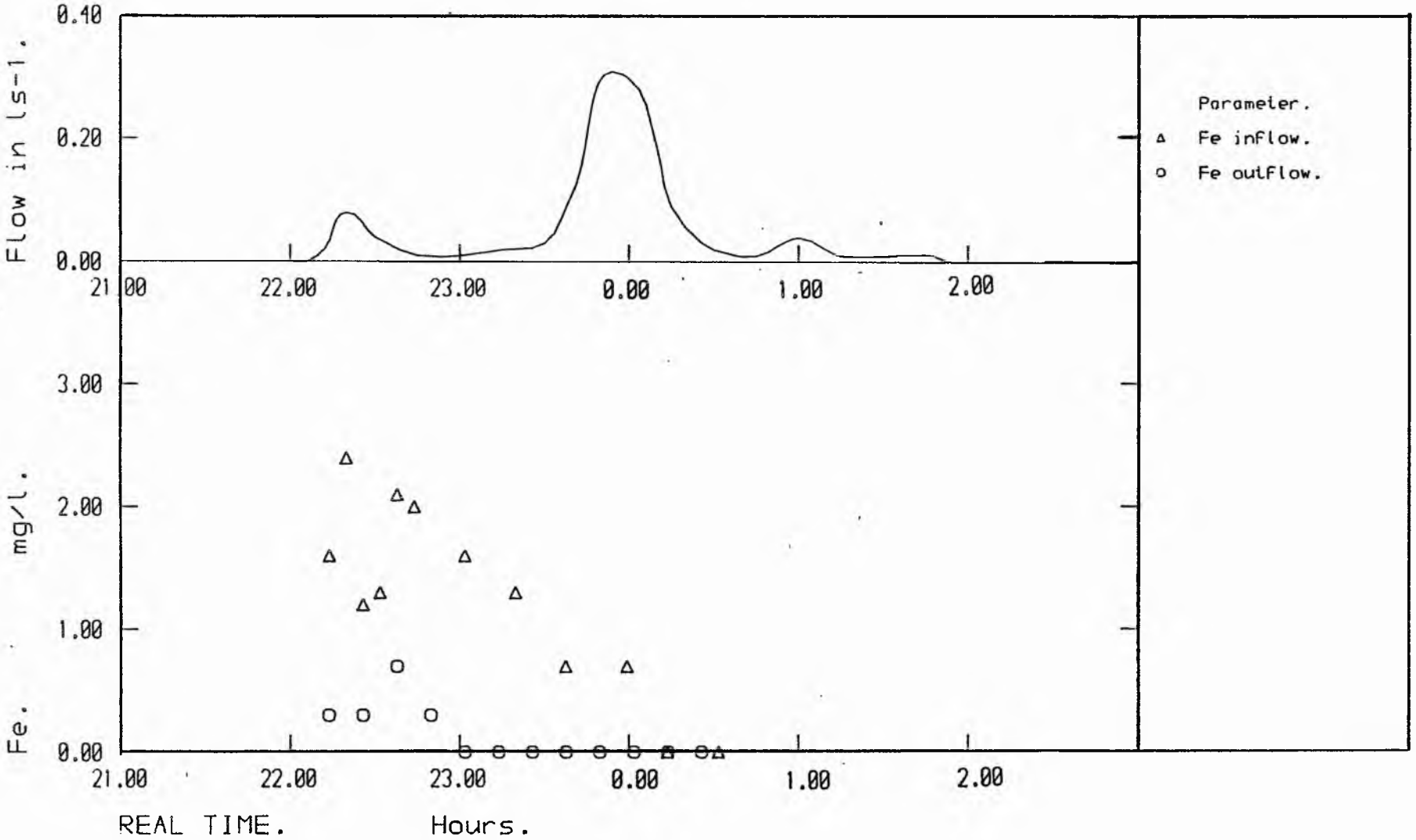
Graph of Chemical Oxygen Demand for Storm IV on Churnet Close.
The graph shows inflow and outflow water quality data.



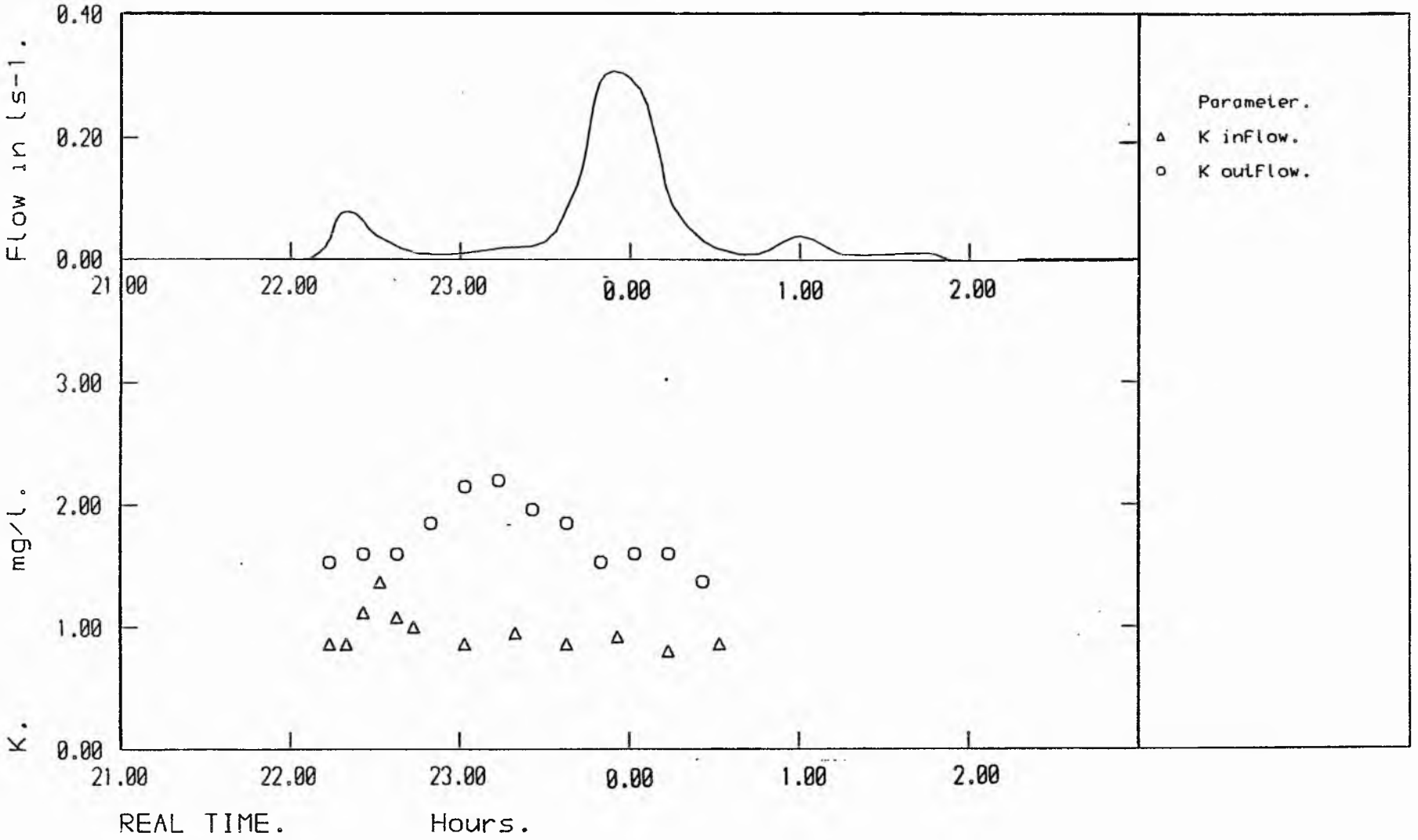
Graph of pH for Storm IV on Churnet Close.
The graph shows inflow and outflow water quality data.



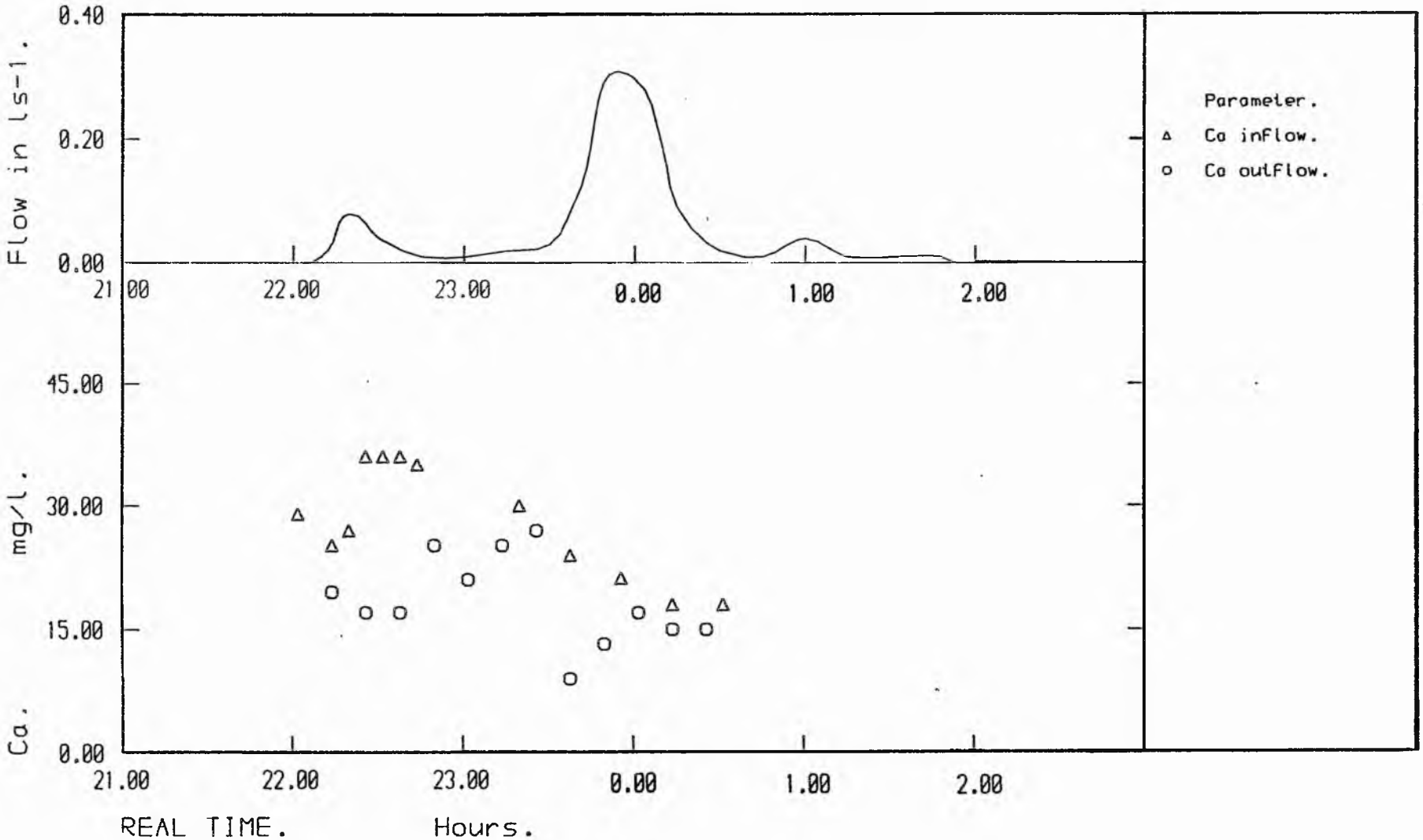
Graph of Sodium for Storm IV on Churnet Close.
The graph shows inflow and outflow water quality data.



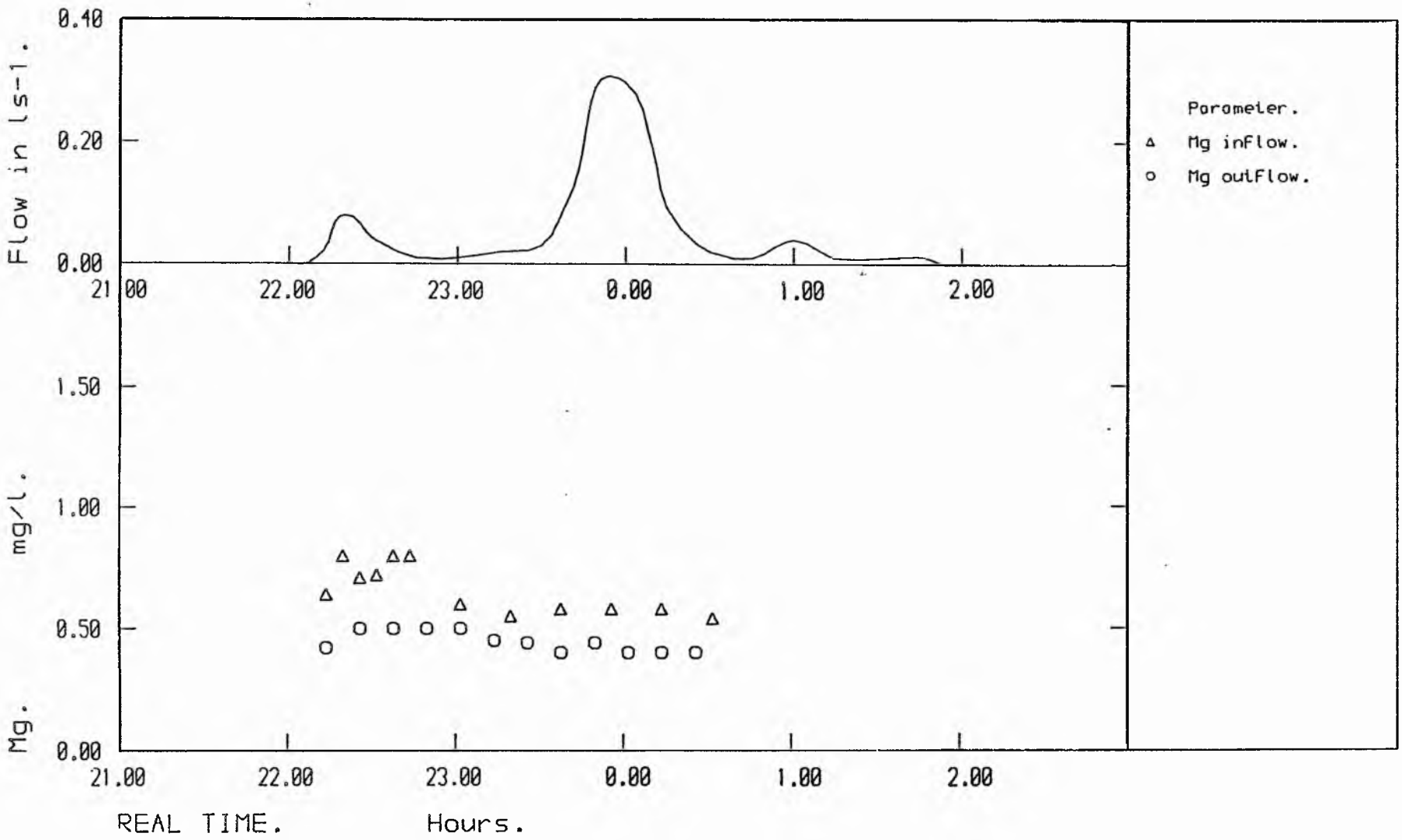
Graph of Iron for Storm IV on Churnet Close.
The graph shows inflow and outflow water quality data.



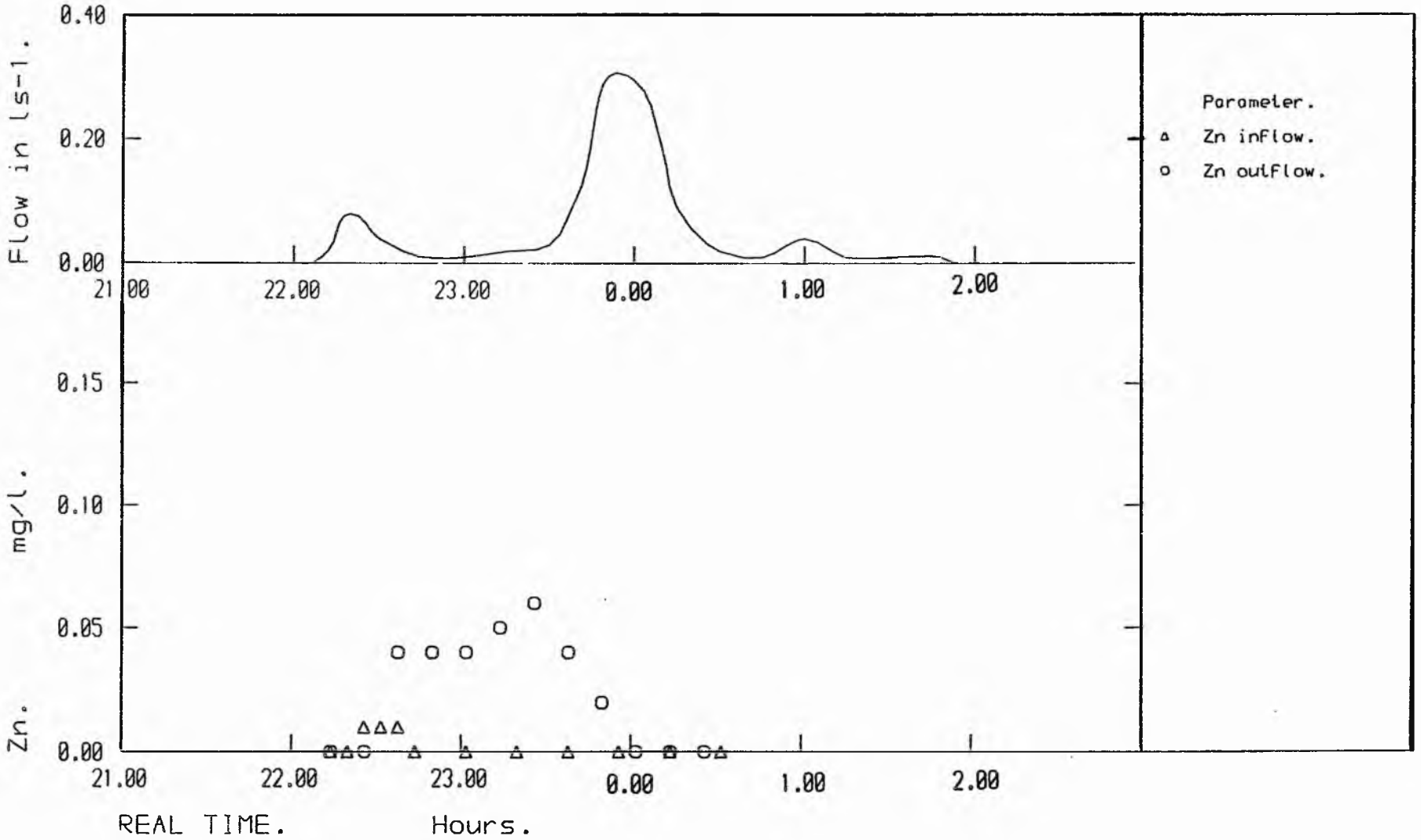
Graph of Potassium For Storm IV on Churnet Close.
The graph shows inflow and outflow water quality data.



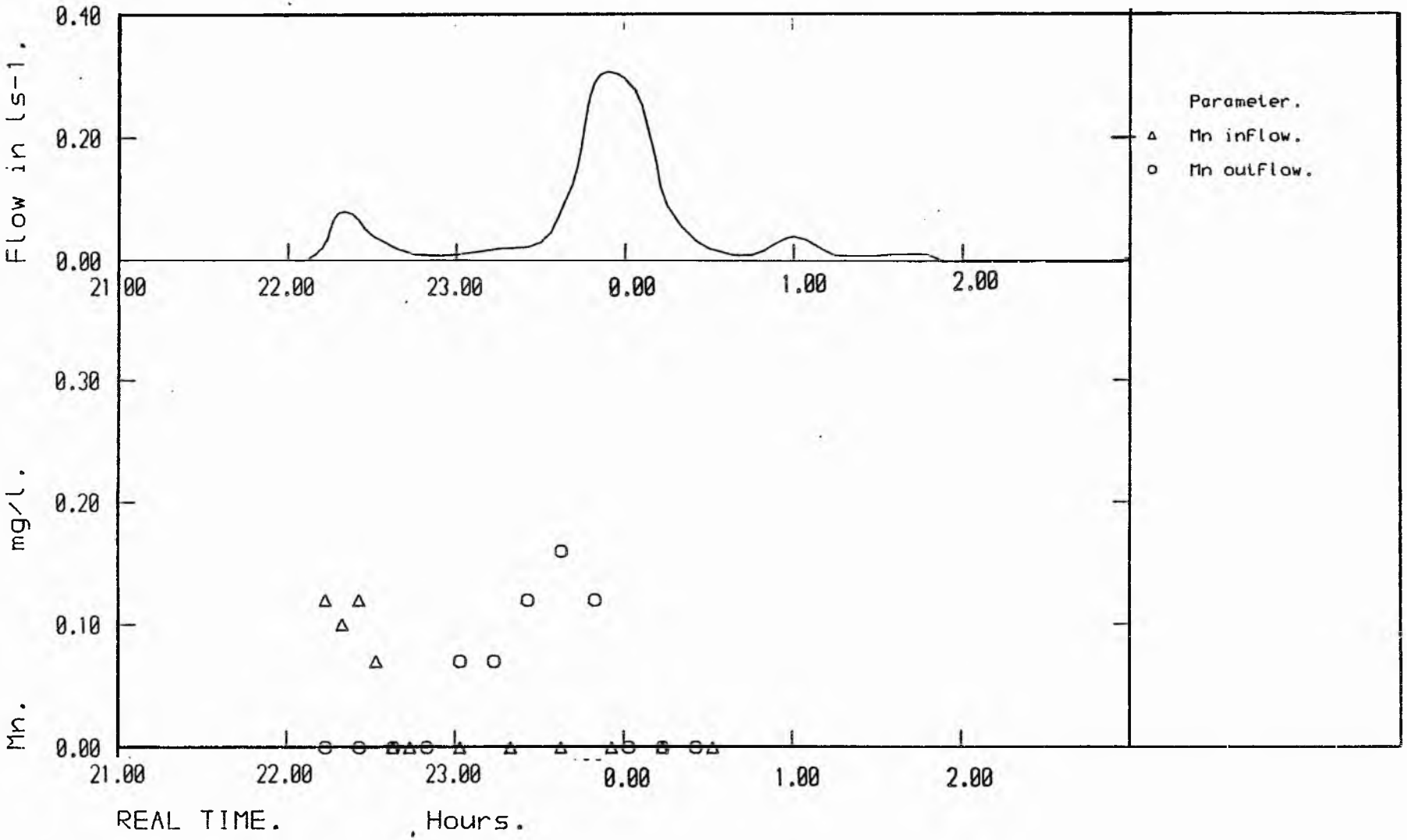
Graph of Calcium For Storm IV on Churnet Close.
The graph shows inflow and outflow water quality data.



Graph of Magnesium For Storm IV on Churnet Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm IV on Churnet Close.
The graph shows inflow and outflow water quality data.



Graph of Manganese for Storm IV on Churnet Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 13th. September 1984 (840913)
STORM NUMBER : IV

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
2218	128	3	45
2224	31	3	40
2348	21	18	50
2354	477	5	64
0018	21	3	40
0024	89	5	40
0030	77	5	35
0036	431	5	40

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 13th. September 1984 (840913)
STORM NUMBER : IV

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
2218	7	6	64
2230	1	8	74
2242	0	6	64
2254	0	11	50
2306	0	7	55
2318	4	16	55
2330	11	9	55
2342	3	7	45
2354	5	20	45
0006	19	20	40
0018	11	*	25
0030	9	*	25

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 13th. September 1984 (840913)
STORM NUMBER : IV

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
2218	1.0	1.1	48.0	0.8
2224	1.0	1.4	41.0	0.6
2348	0.8	1.3	42.2	0.5
2354	0.8	1.1	42.2	0.5
0018	0.7	1.0	55.0	0.8
0024	0.7	0.9	50.0	1.0
0030	0.7	1.1	55.0	0.9
0036	0.7	1.0	55.0	0.9

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 13th. September 1984 (840913)
STORM NUMBER : IV

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
2218	1.6	1.7	29.0	0.7
2230	1.6	1.6	29.0	0.8
2242	1.6	1.5	31.5	0.8
2254	1.5	1.7	41.0	0.9
2306	1.6	1.6	37.5	1.0
2318	1.6	1.8	42.0	1.0
2330	1.8	2.0	35.0	1.1
2342	1.6	2.3	35.0	0.8
2354	1.6	1.5	31.5	0.9
0006	1.4	1.7	33.3	0.8
0018	1.5	1.6	33.3	0.8
0030	1.4	1.6	29.0	0.6

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 13th. September 1984 (840913)
STORM NUMBER : IV

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Zn mgl-1	Mn mgl-1
2218	0.0	0.0
2224	0.0	0.0
2348	0.0	0.0
2354	0.0	0.0
0018	0.0	0.1
0024	0.0	0.2
0030	0.0	0.1
0036	0.0	0.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 13th. September 1984 (840913)
STORM NUMBER : IV

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

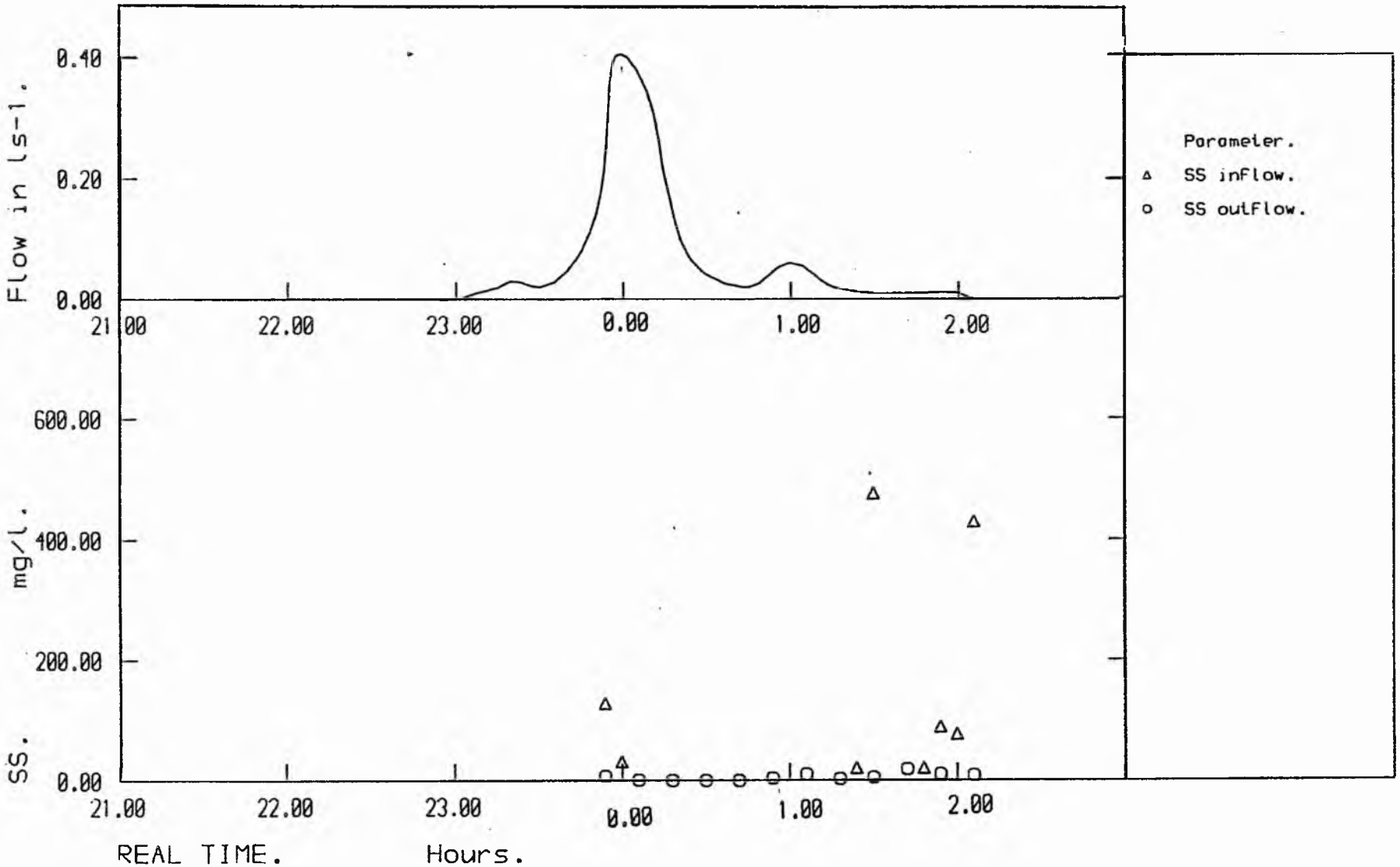
REAL TIME Hours	pH pH units	Zn mg1-1	Mn mg1-1
2218	6.6	0.0	0.0
2230	6.6	0.0	0.0
2242	6.7	0.0	0.0
2254	6.7	0.1	0.0
2306	6.5	0.1	0.1
2318	6.6	0.1	0.1
2330	6.5	0.1	0.0
2342	6.5	0.1	0.0
2354	6.6	0.1	0.1
0006	6.2	0.0	0.1
0018	6.0	0.0	0.0
0030	5.9	0.0	0.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

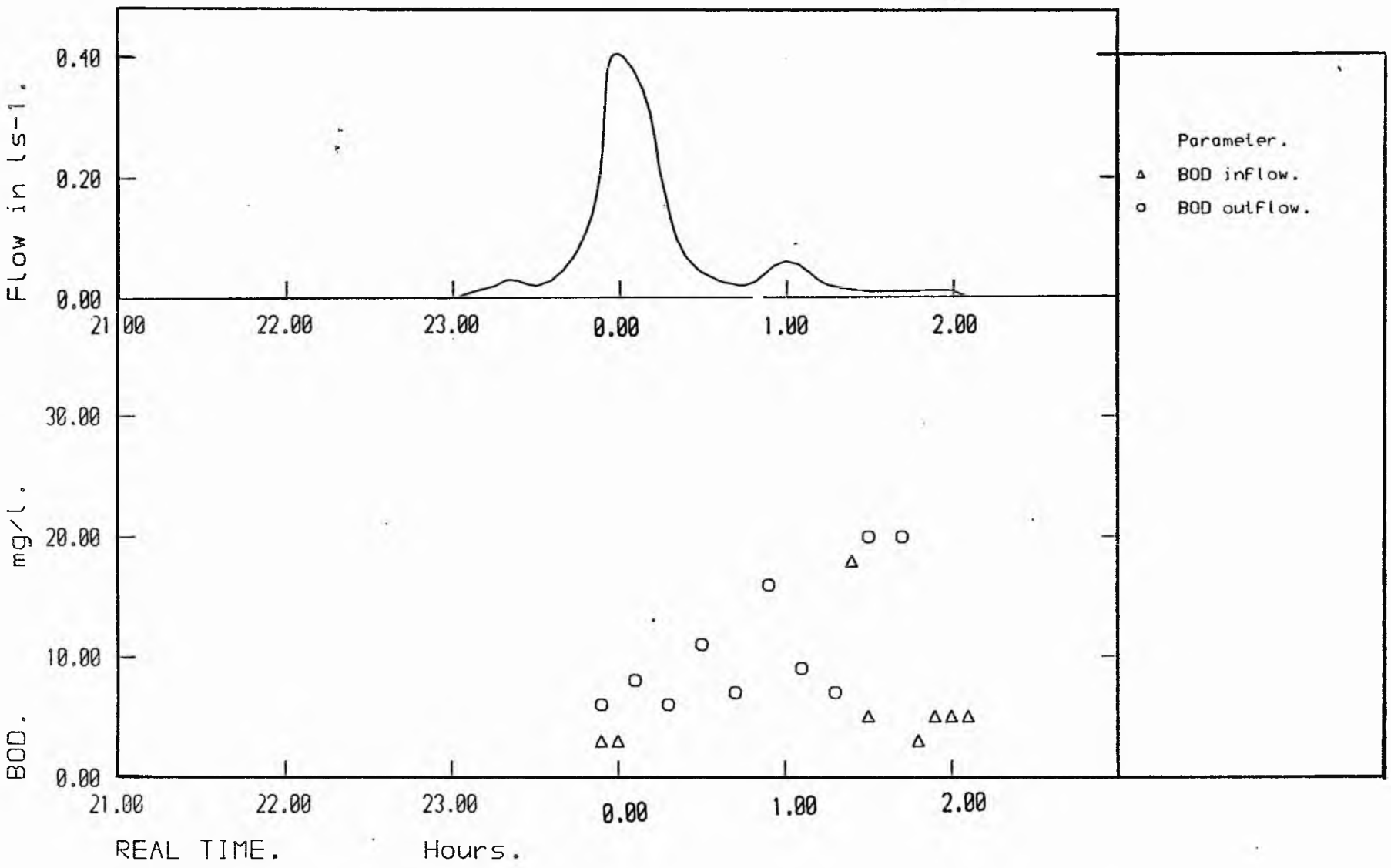
CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 13th. September 1984 (840913)
STORM NUMBER : IV

ANALYSIS OF INFLOW WATER TO THE GULLY POT

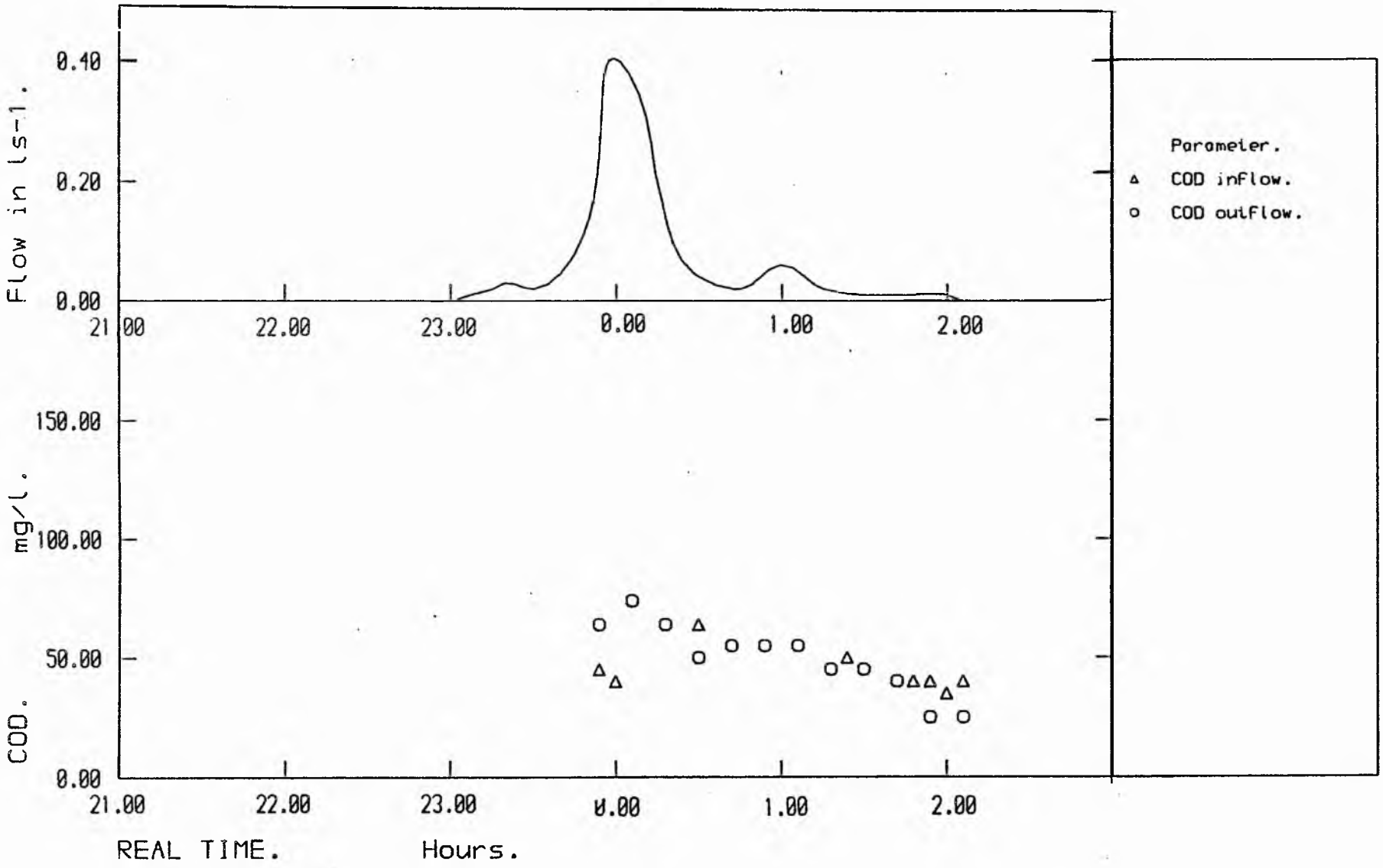
REAL TIME Hours	pH pH units	Fe mgl-1	Pb mgl-1
2218	5.8	2.4	0.4
2224	5.6	2.0	0.2
2348	5.5	1.3	0.0
2354	5.5	1.3	0.0
0018	5.7	0.7	0.0
0024	5.8	1.1	0.0
0030	5.8	0.0	0.0
0036	6.0	0.0	0.0



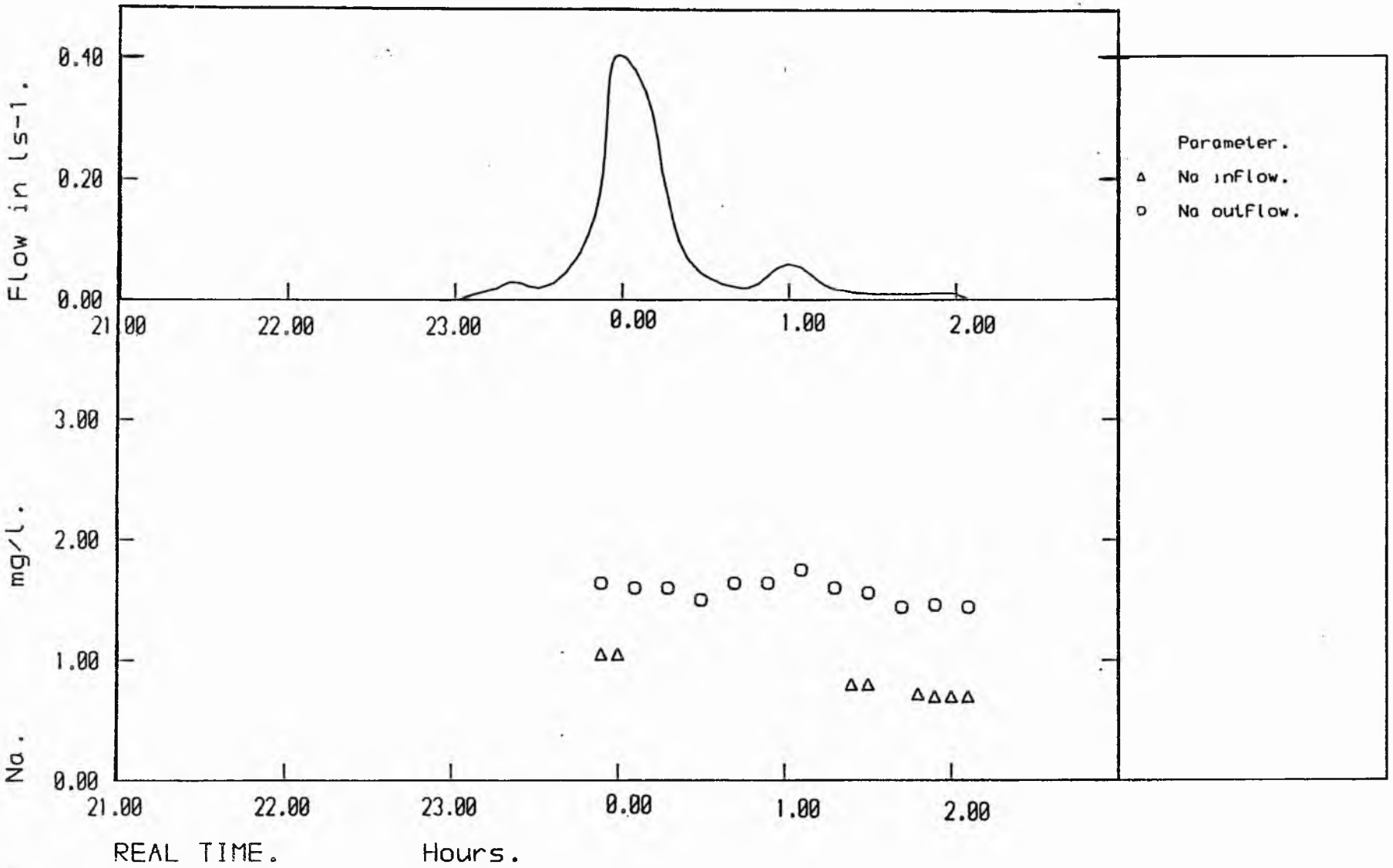
Graph of Suspended Solids for Storm IV on TwyFord Gardens.
The graph shows inflow and outflow water quality data.



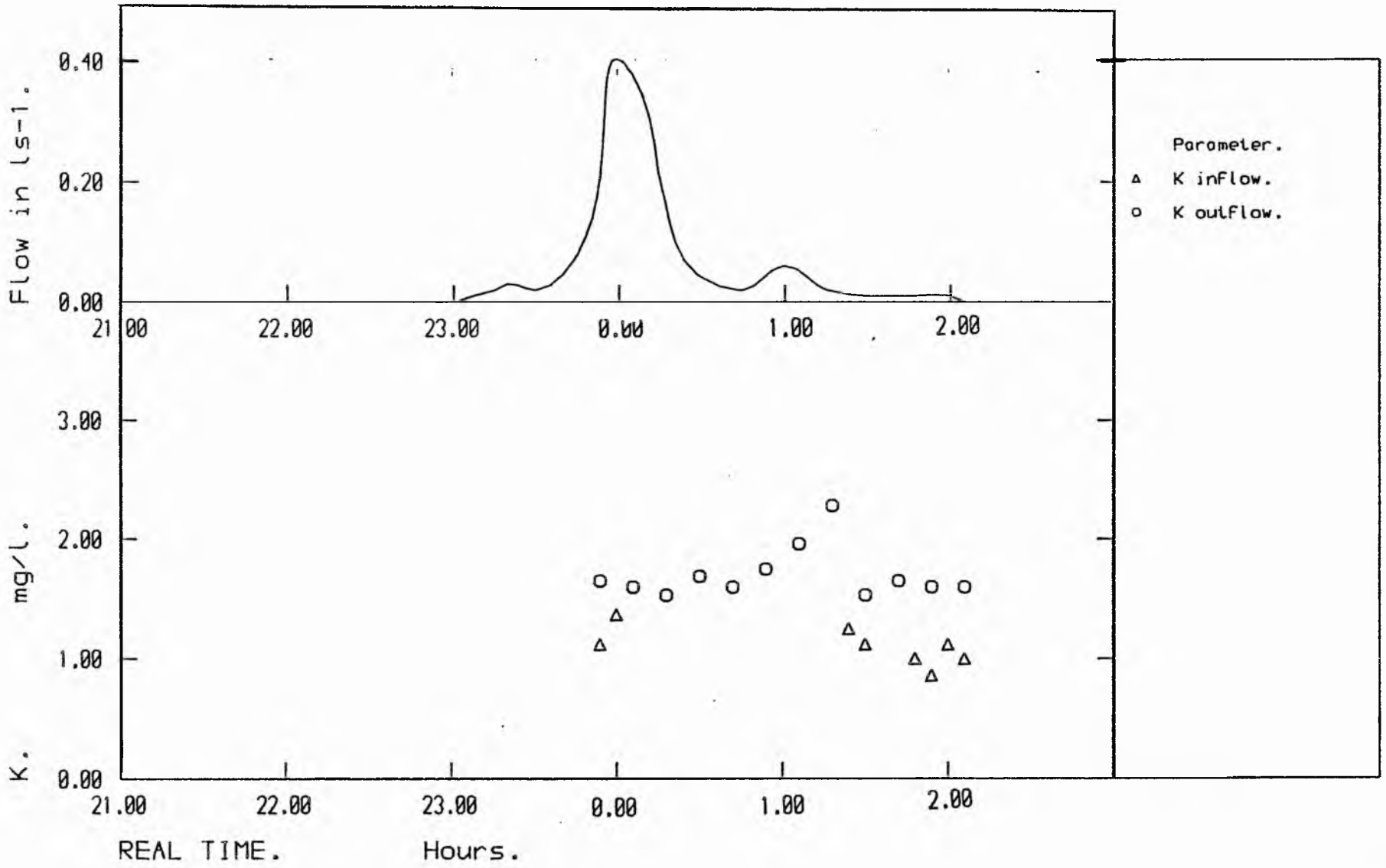
Graph of Biochemical Oxygen Demand For Storm IV on Twyford Gardens.
The graph shows inflow and outflow water quality data.



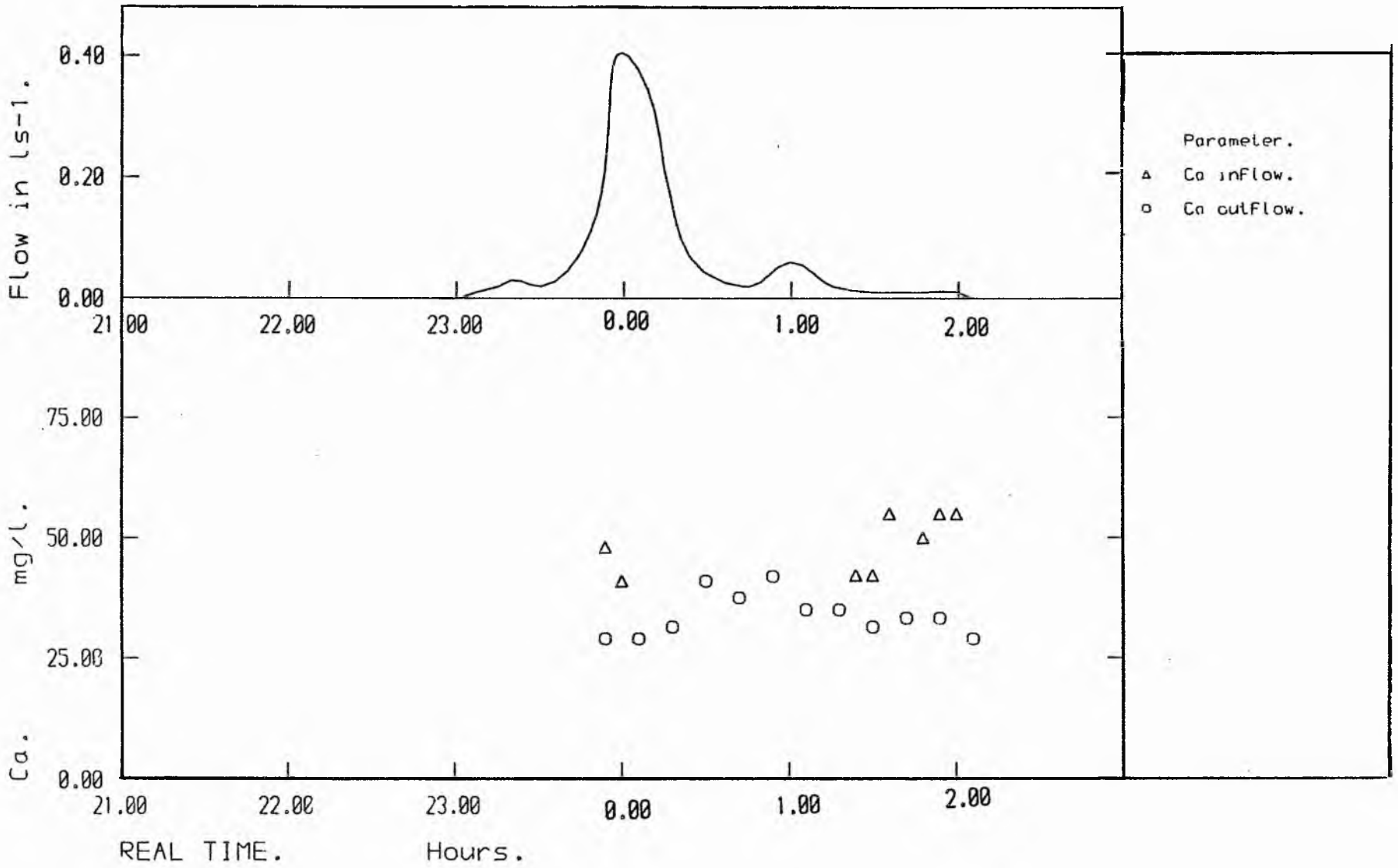
Graph of Chemical Oxygen Demand for Storm IV on Twyford Gardens.
The graph shows inflow and outflow water quality data.



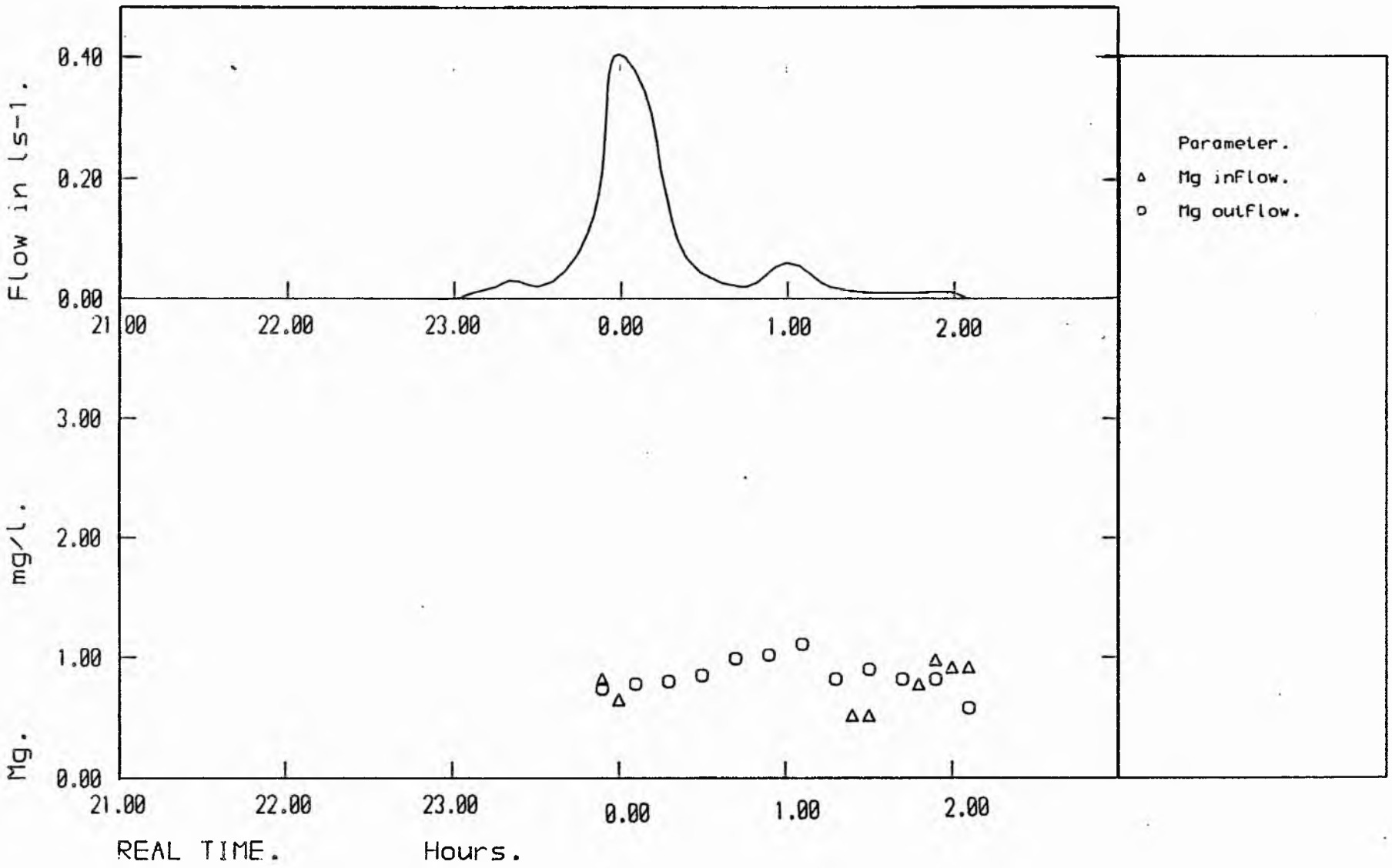
Graph of Sodium for Storm IV on Twyford Gardens.
The graph shows inflow and outflow water quality data.



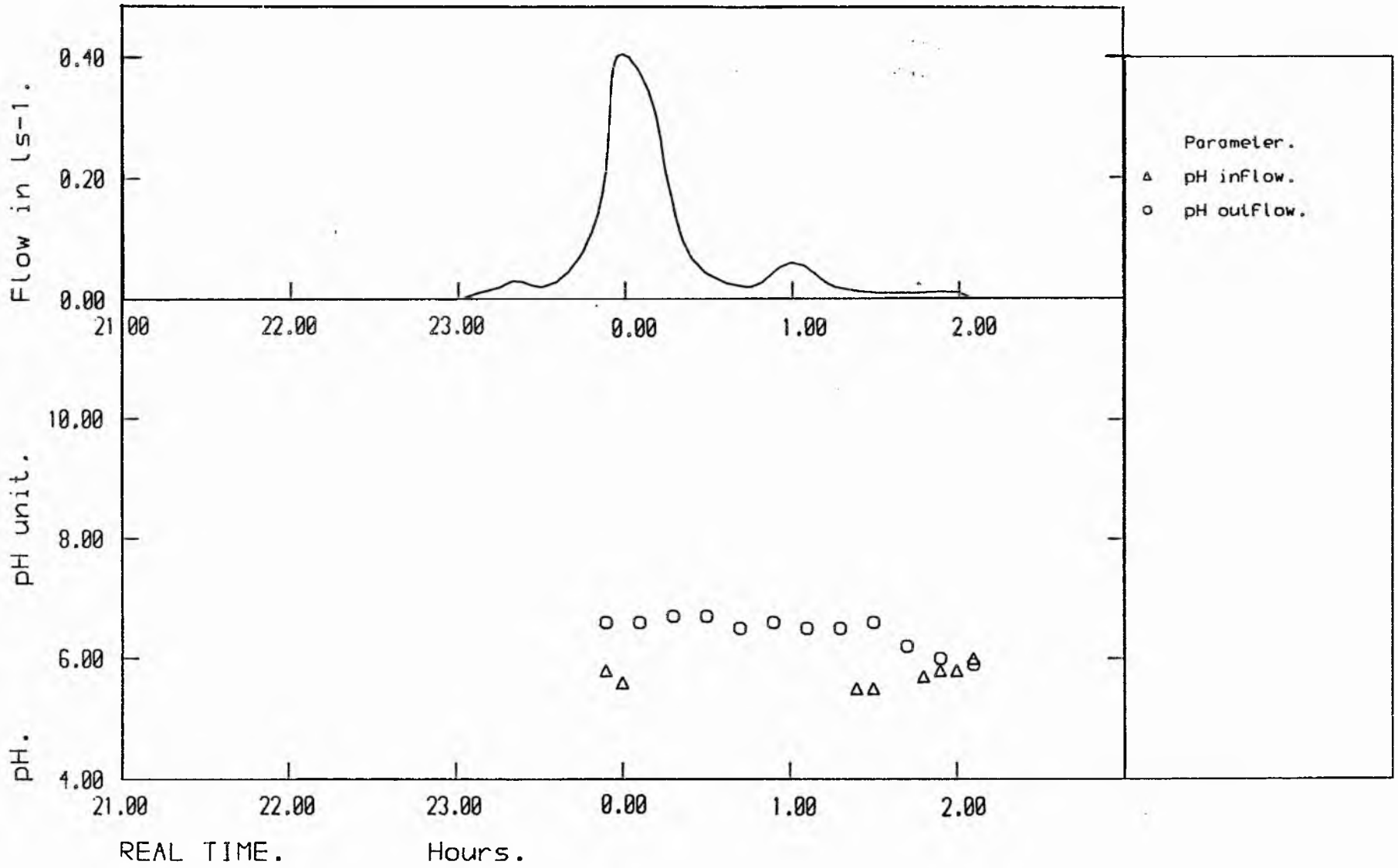
Graph of Potassium for Storm IV on Twyford Gardens.
The graph shows inflow and outflow water quality data.



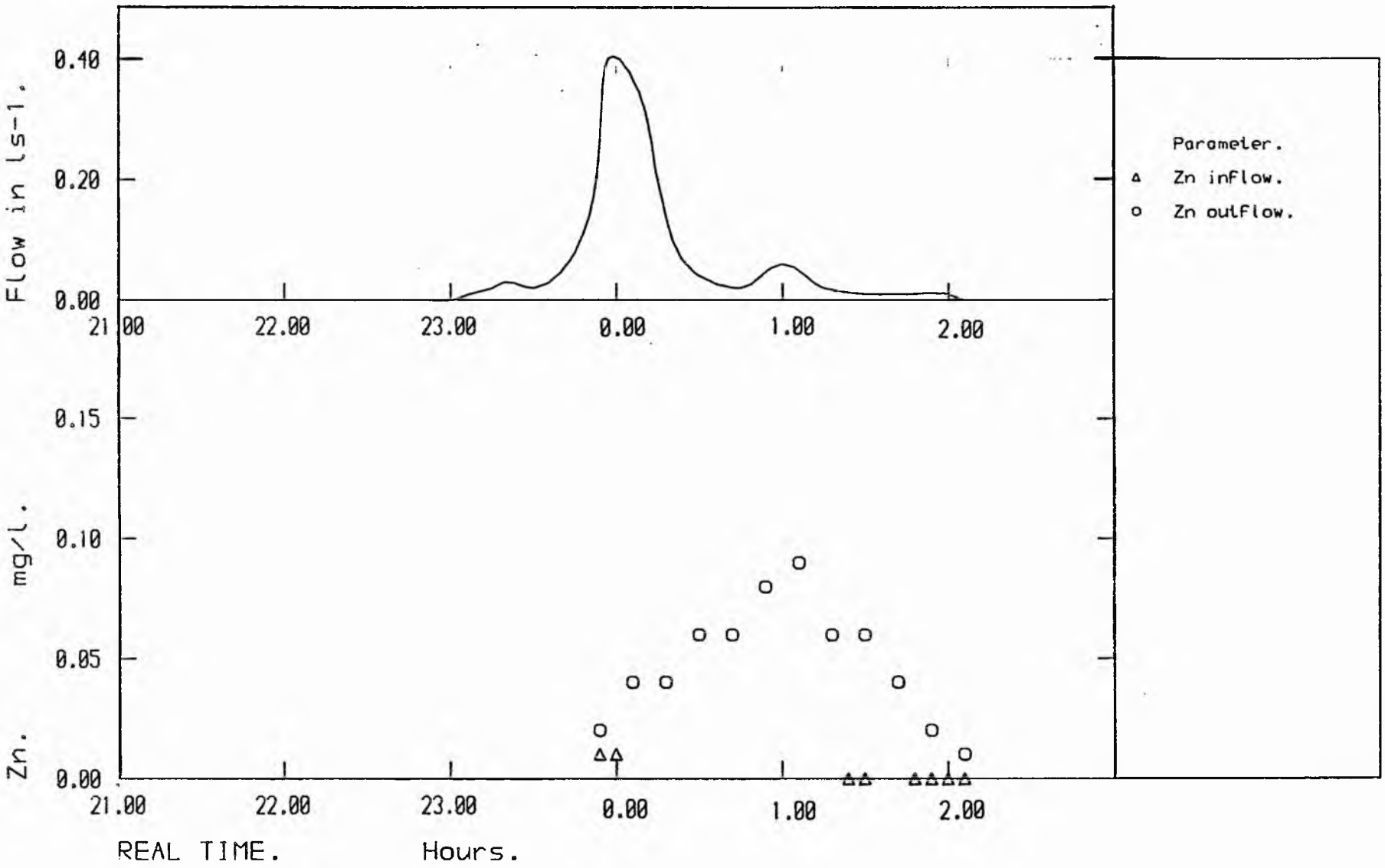
Graph of Calcium for Storm IV on Twyford Gardens.
The graph shows inflow and outflow water quality data.



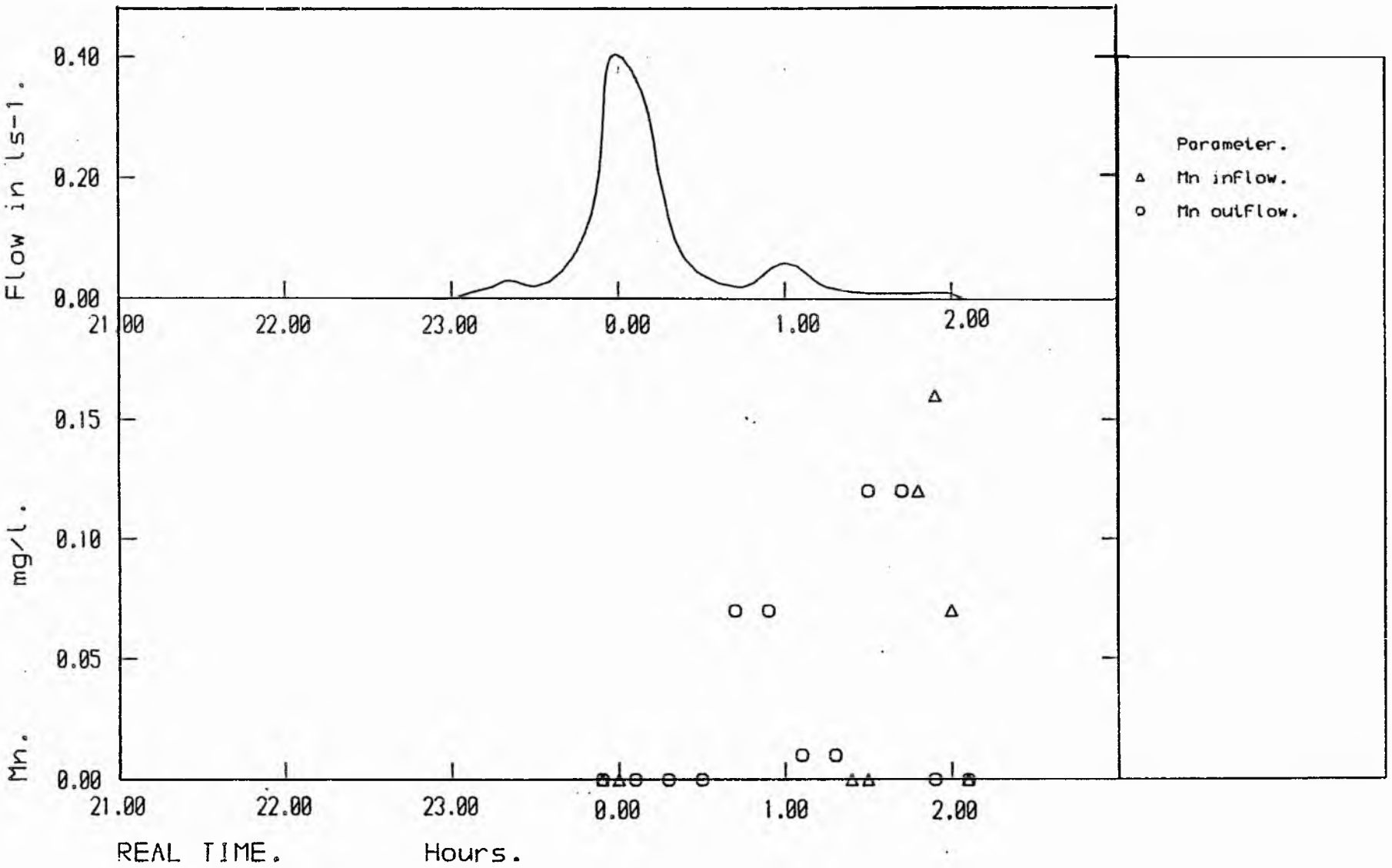
Graph of Magnesium for Storm IV on Twyford Gardens.
The graph shows inflow and outflow water quality data.



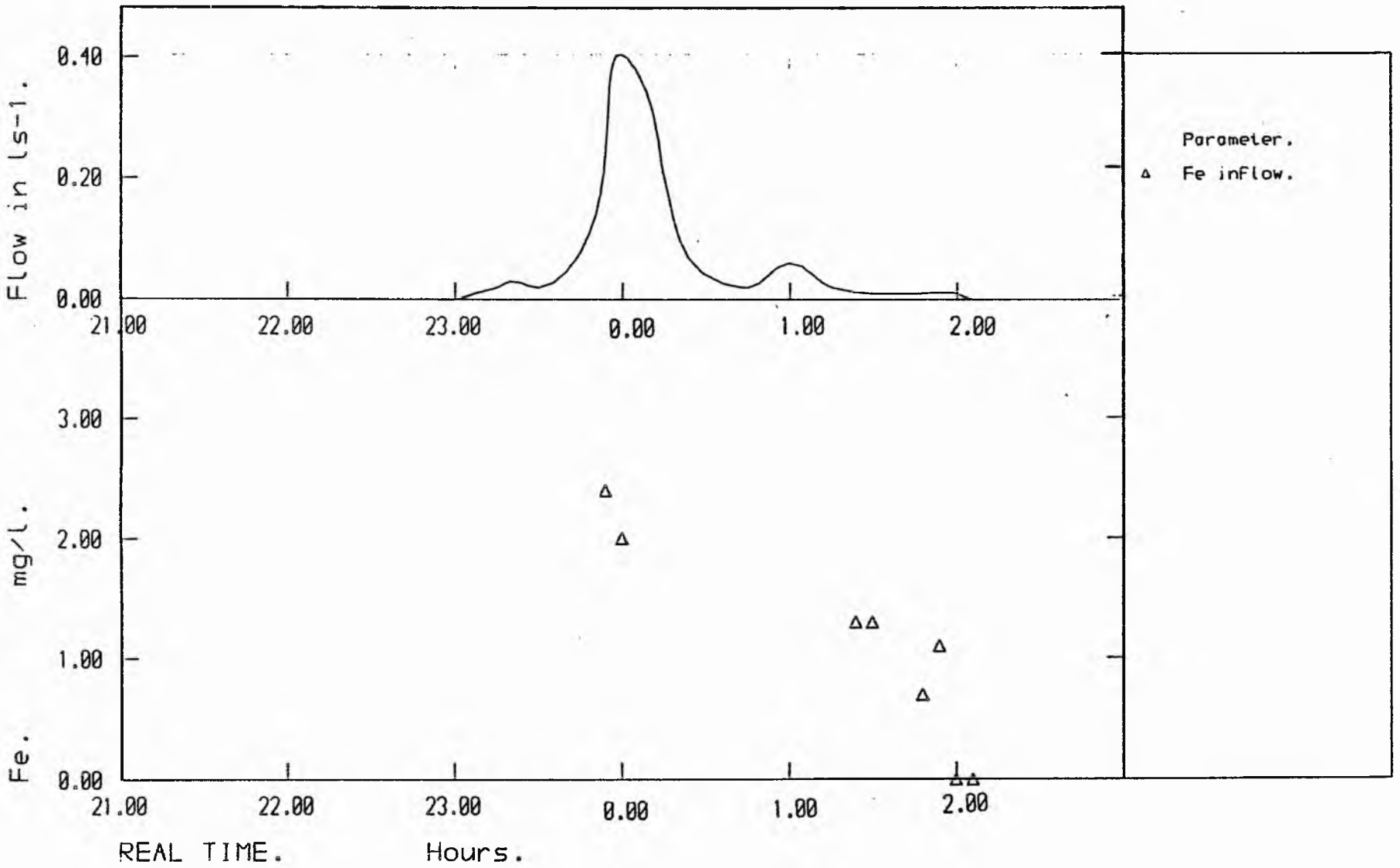
Graph of pH for Storm IV on Twyford Gardens.
The graph shows inflow and outflow water quality data.



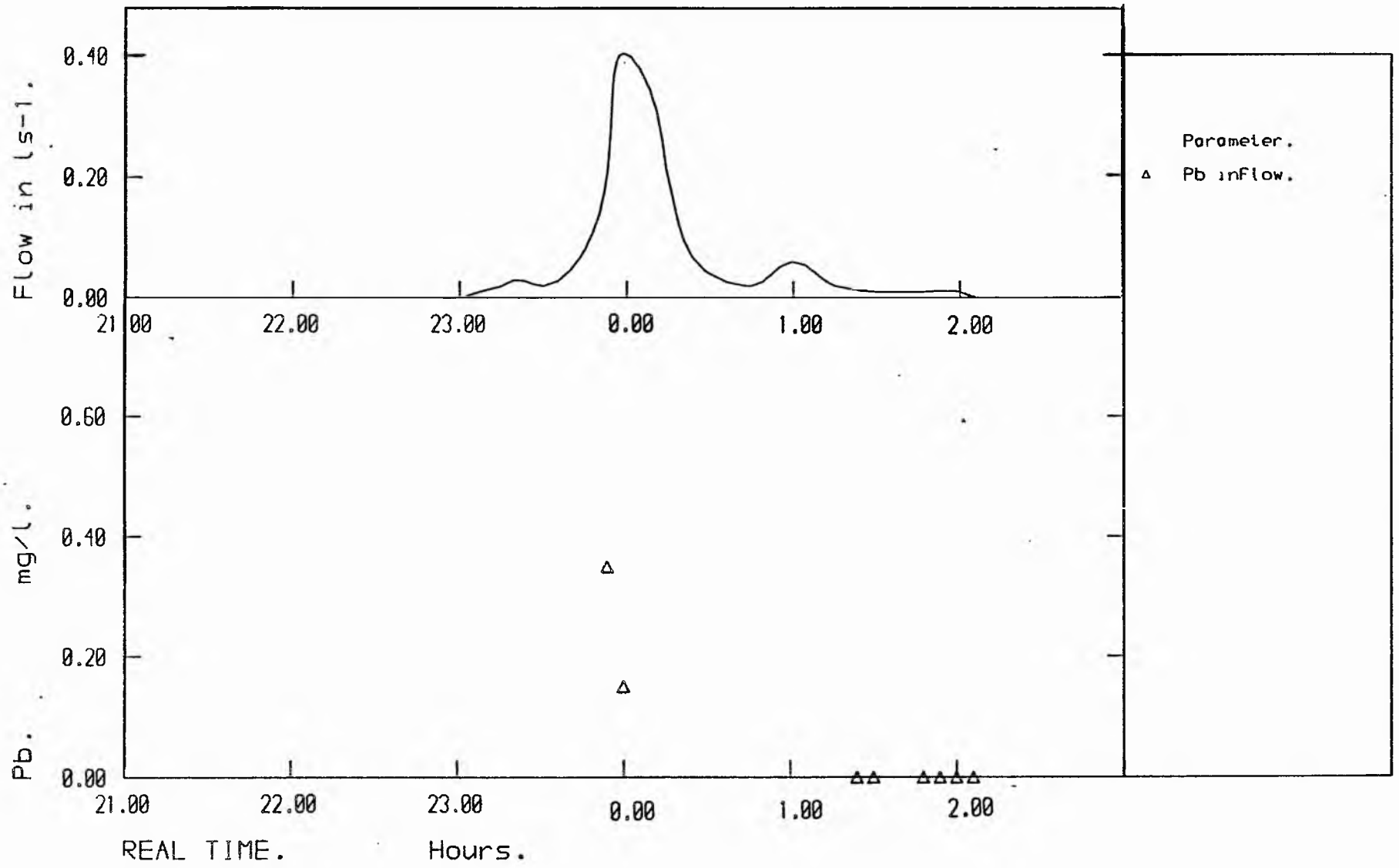
Graph of Zinc for Storm IV on TwyFord Gardens.
The graph shows inflow and outflow water quality data.



Graph of Manganese for Storm IV on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Iron for Storm IV on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Lead for Storm IV on Twyford Gardens.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
0117	102	16	22

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
0117	7	5	71
0129	7	5	98
0141	15	5	11
0153	0	8	66
0205	11	6	22
0217	4	5	33
0229	35	5	11
0241	4	4	66
0253	12	4	0
0305	13	0	38
0317	8	3	16
0329	22	2	33

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	pH pH units
0117	0.07	5.7

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	pH pH units
0117	0.12	6.0
0129	0.09	5.9
0141	0.09	5.9
0153	0.10	5.8
0205	0.10	6.0
0217	0.10	5.9
0229	0.10	6.1
0241	0.10	6.0
0253	0.10	5.9
0305	0.10	6.1
0317	0.10	6.1
0329	0.10	6.1

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close

DATE OF THE STORM EVENT : 8th. October 1984 (841008)

STORM NUMBER : V

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
0117	35.0	20.0	53	19.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close

DATE OF THE STORM EVENT : 8th. October 1984 (841008)

STORM NUMBER : V

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
0117	50.0	45.0	163	24.8
0129	45.0	35.0	159	17.7
0141	50.0	30.0	163	21.3
0153	45.0	35.0	274	23.0
0205	50.0	40.0	269	23.0
0217	50.0	40.0	317	21.3
0229	45.0	40.0	216	21.3
0241	50.0	40.0	317	21.3
0253	50.0	45.0	211	21.3
0305	45.0	40.0	206	24.8
0317	50.0	45.0	192	21.3
0329	50.0	45.0	317	23.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
0117	4.4	0.7	9.1	0.9

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
0117	3.7	1.0	9.3	0.8
0129	2.1	0.7	8.8	0.7
0141	3.7	1.0	11.1	1.0
0153	3.7	0.8	10.9	0.9
0205	3.3	0.8	10.9	0.9
0217	4.5	1.2	10.9	0.9
0229	2.9	0.9	11.1	0.9
0241	3.8	0.9	10.9	0.9
0253	3.4	0.9	11.8	0.9
0305	3.0	0.9	10.5	0.9
0317	3.4	1.0	10.9	0.9
0329	4.5	1.2	11.1	0.9

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Phosphate mgl-1
0117	0.2	3.5	1.4
0129	3.8	7.3	0.9
0141	0.1	8.4	1.1
0153	0.1	12.6	1.0
0205	0.2	8.4	0.9
0217	0.6	5.3	1.0
0229	0.2	1.9	0.9
0241	0.1	3.4	0.8
0253	0.2	7.0	1.2
0305	0.2	8.9	1.1
0317	0.3	5.5	0.5
0329	0.3	10.4	0.9

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF INFLOW WATER TO THE GULLY POT

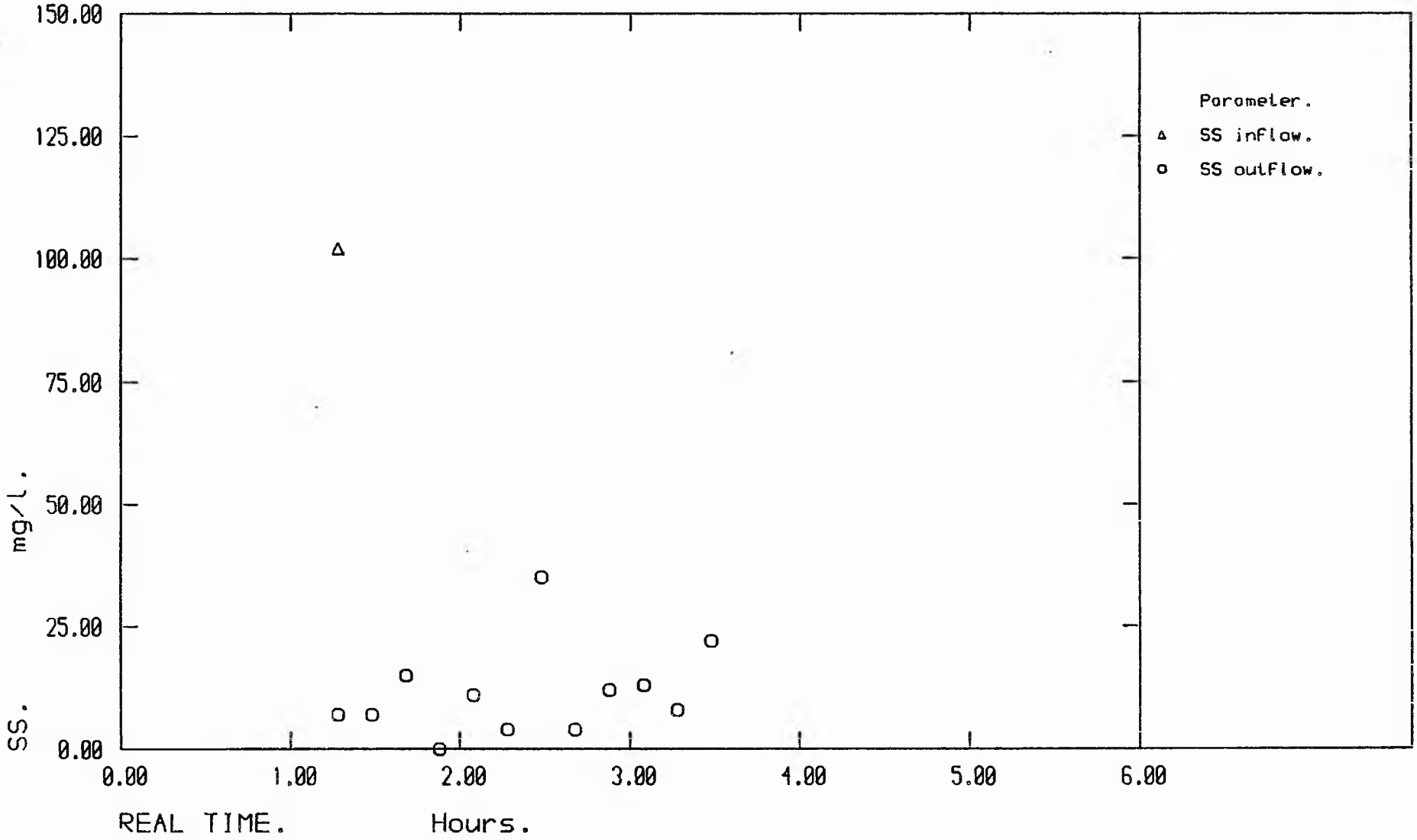
REAL TIME Hours	Zn mgl-1	Phosphate mgl-1
0117	0.1	0.7

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

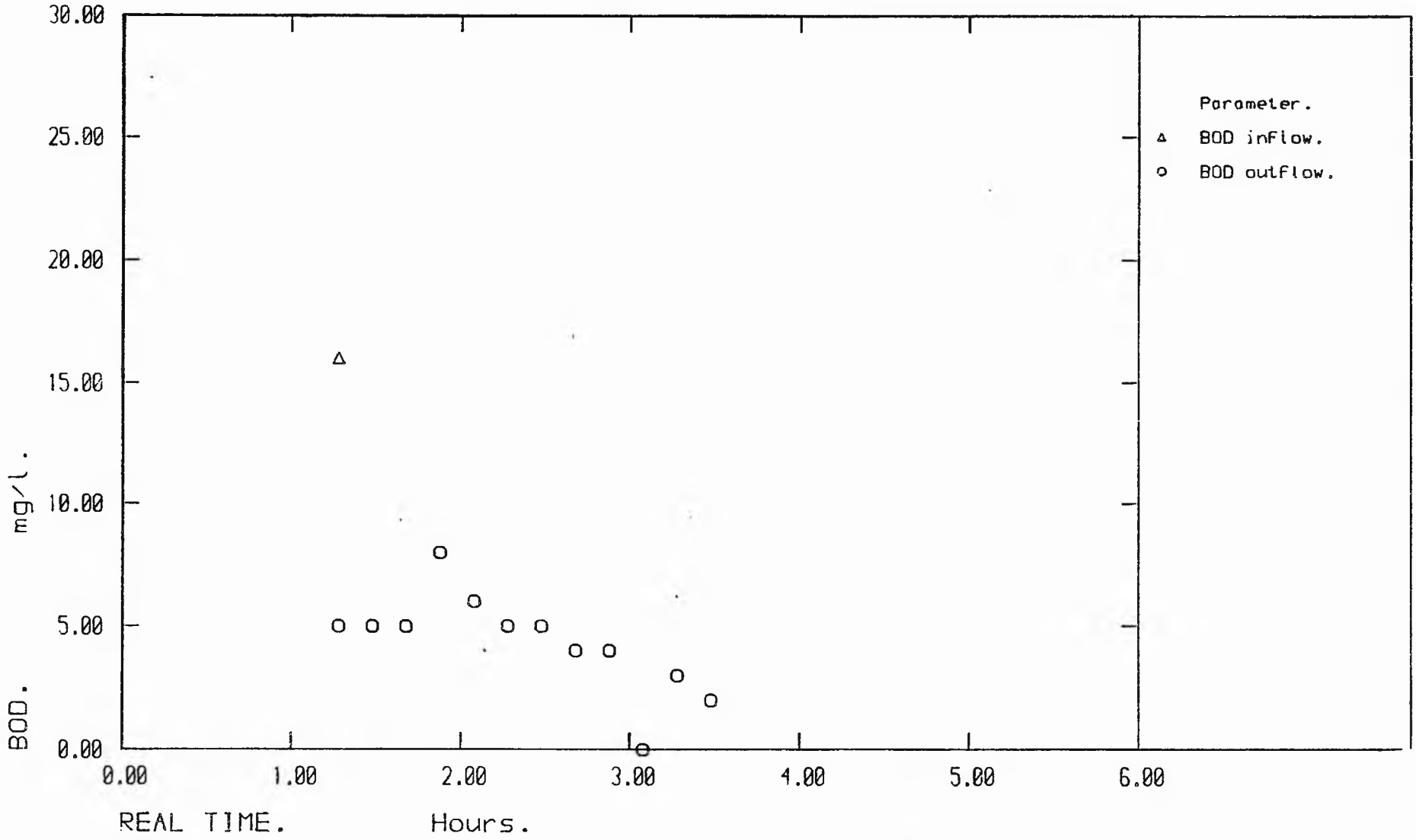
CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

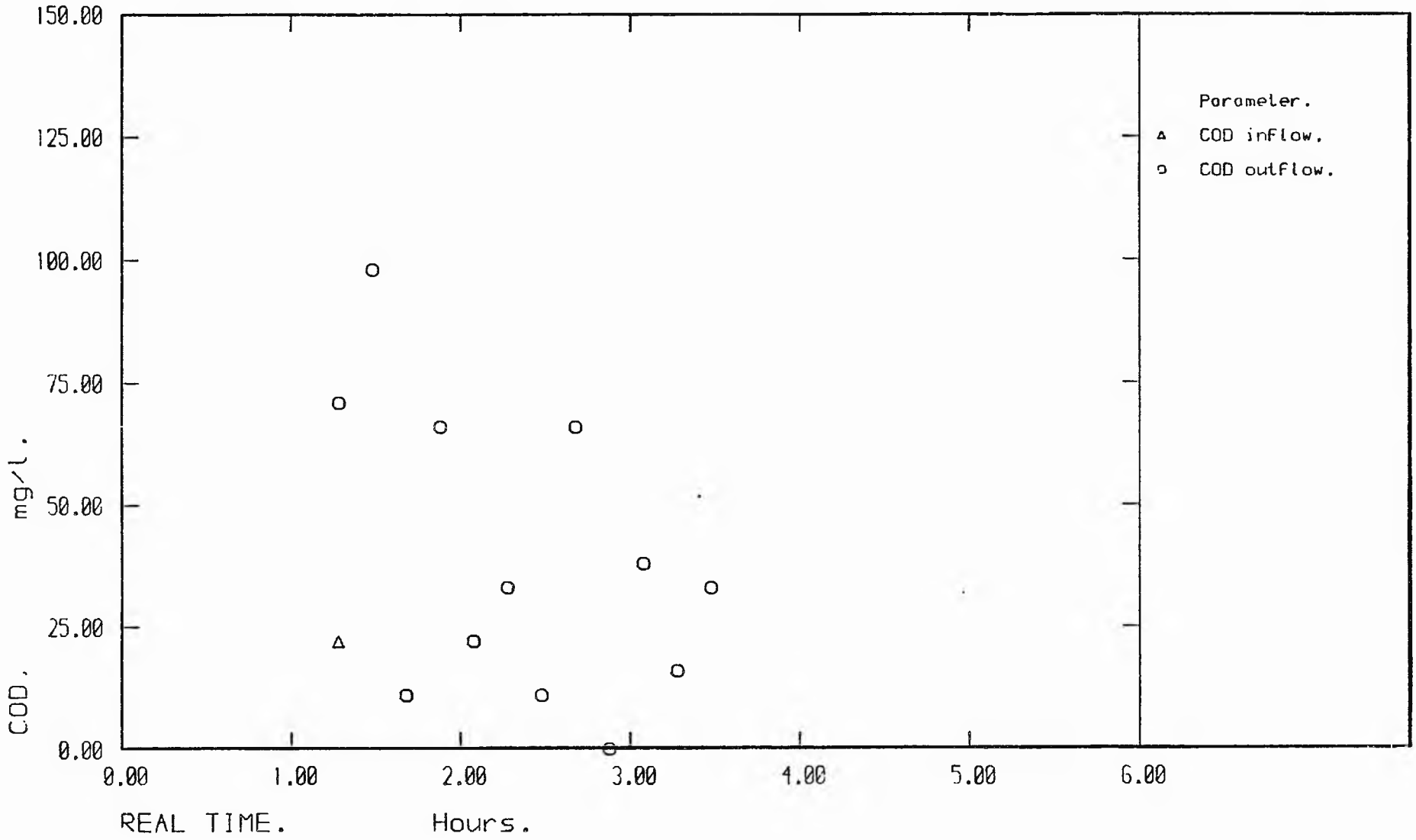
REAL TIME Hours	Zn mgl-1
0117	0.2
0129	0.3
0141	0.3
0153	0.1
0205	0.2
0217	0.2
0229	0.2
0241	0.1
0253	0.2
0305	0.2
0317	0.2
0329	0.2



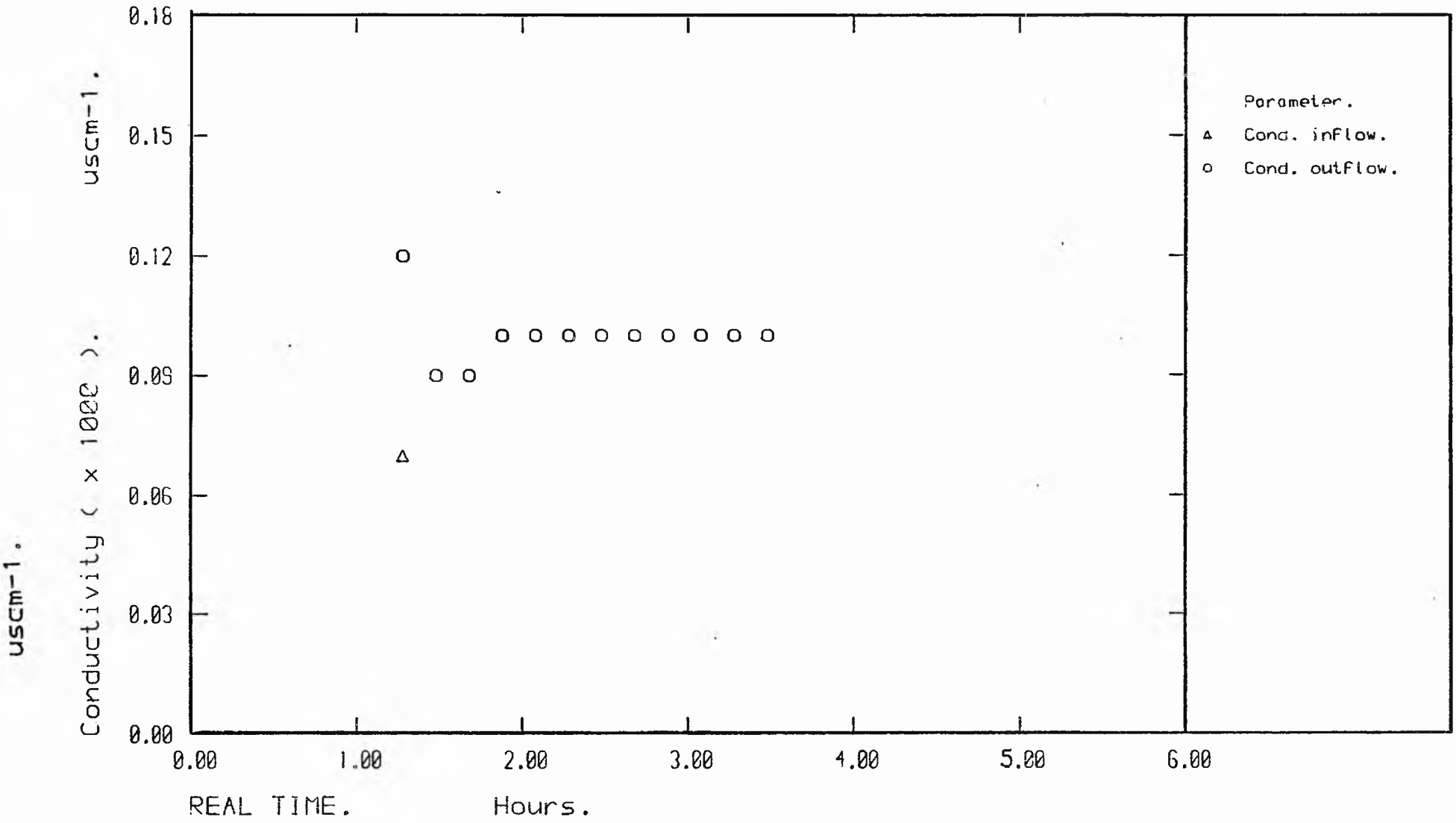
Graph of Suspended Solids for Storm V on Tame Close.
The graph shows inflow and outflow water quality data.



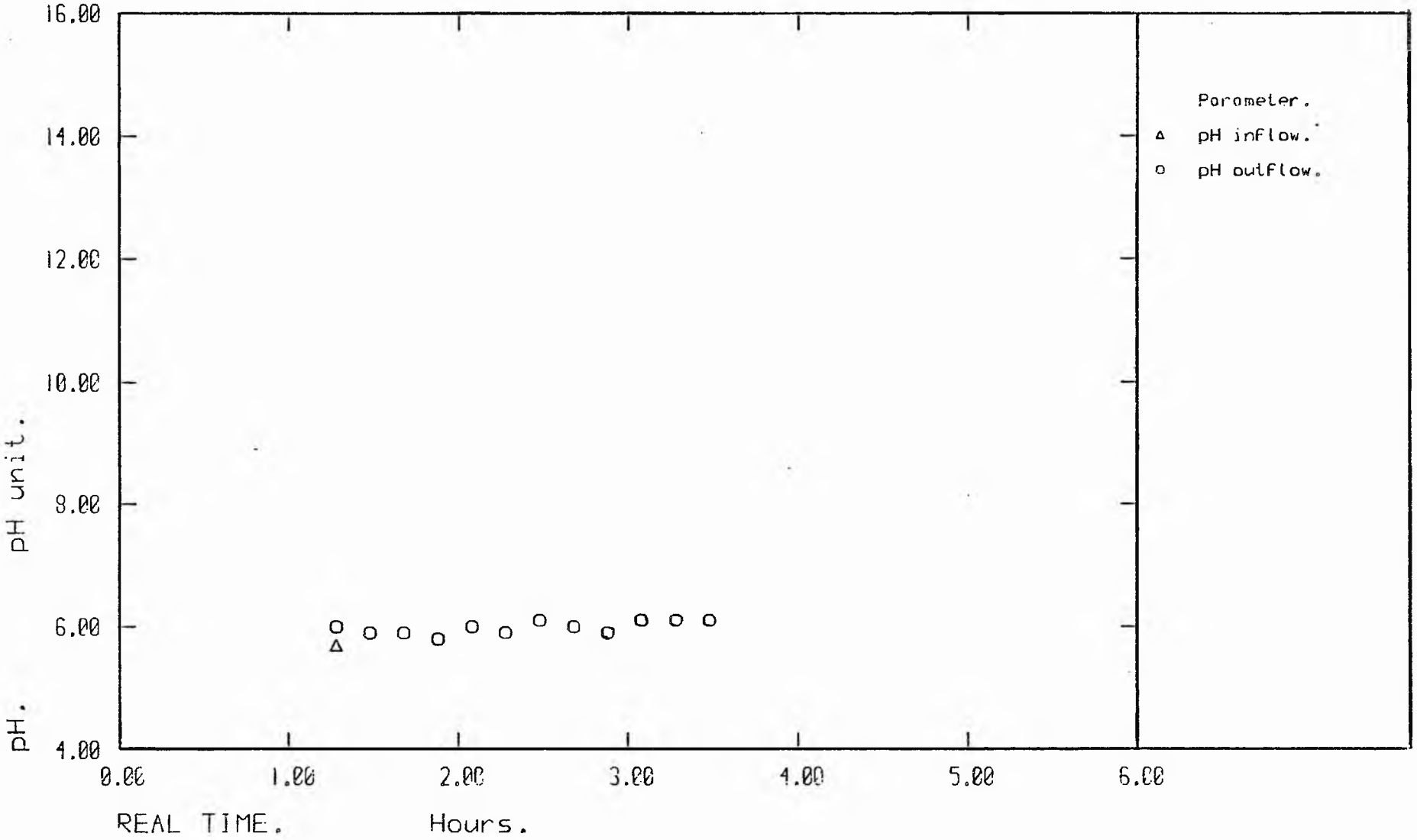
Graph of Biochemical Oxygen Demand for Storm V on Tame Close.
The graph shows inflow and outflow water quality data.



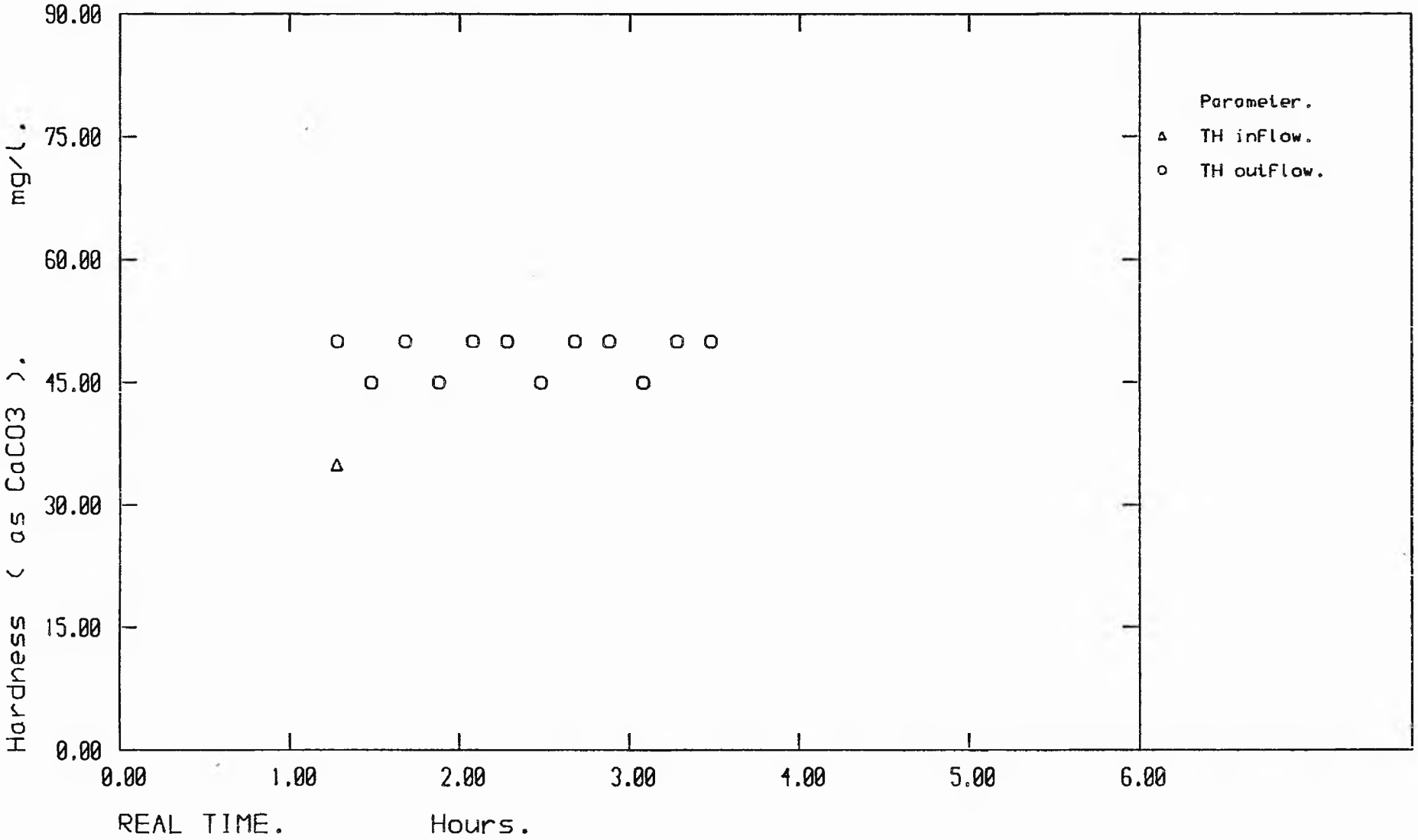
Graph of Chemical Oxygen Demand for Storm V on Tame Close.
The graph shows inflow and outflow water quality data.



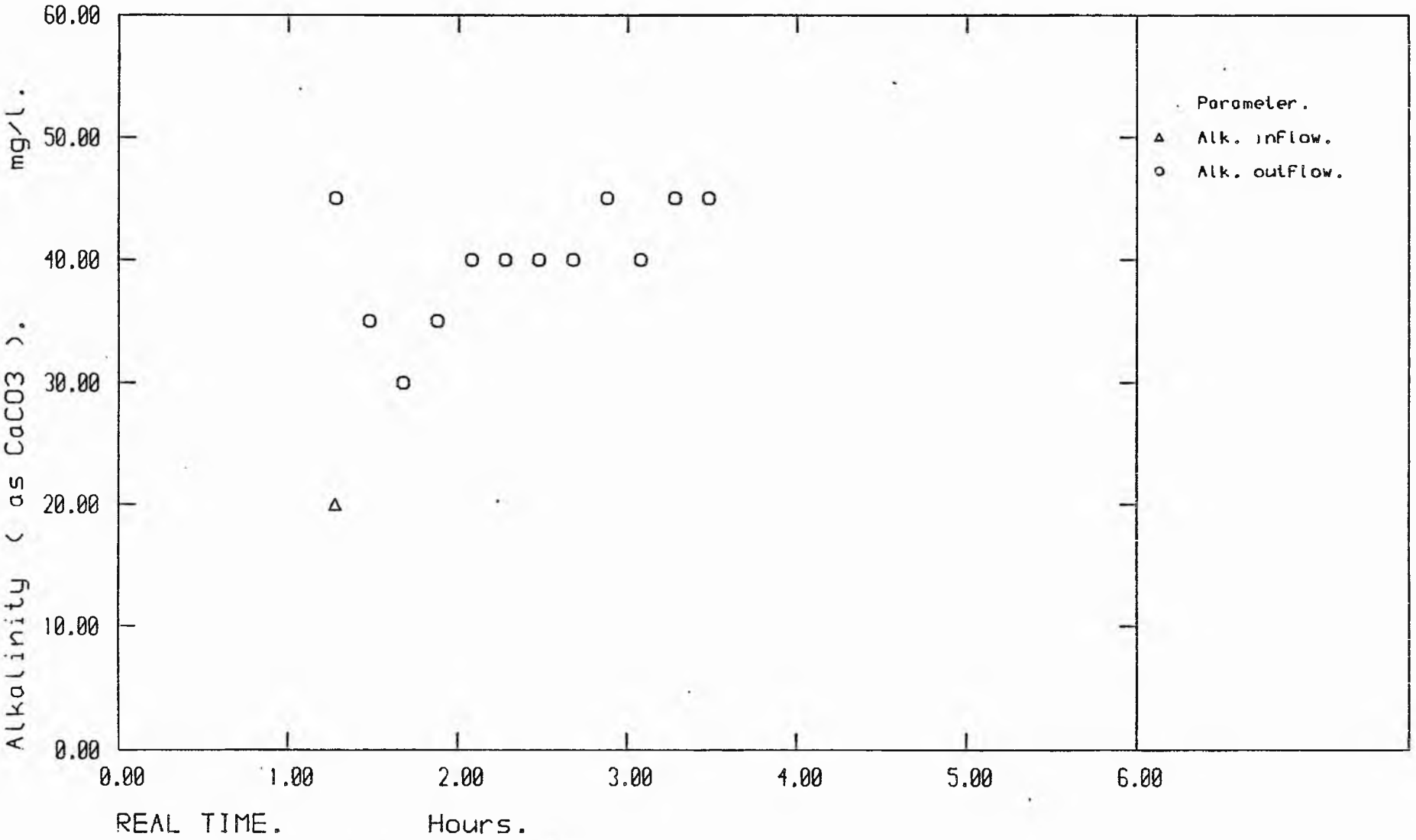
Graph of Conductivity for Storm V on Tame Close.
The graph shows inflow and outflow water quality data.



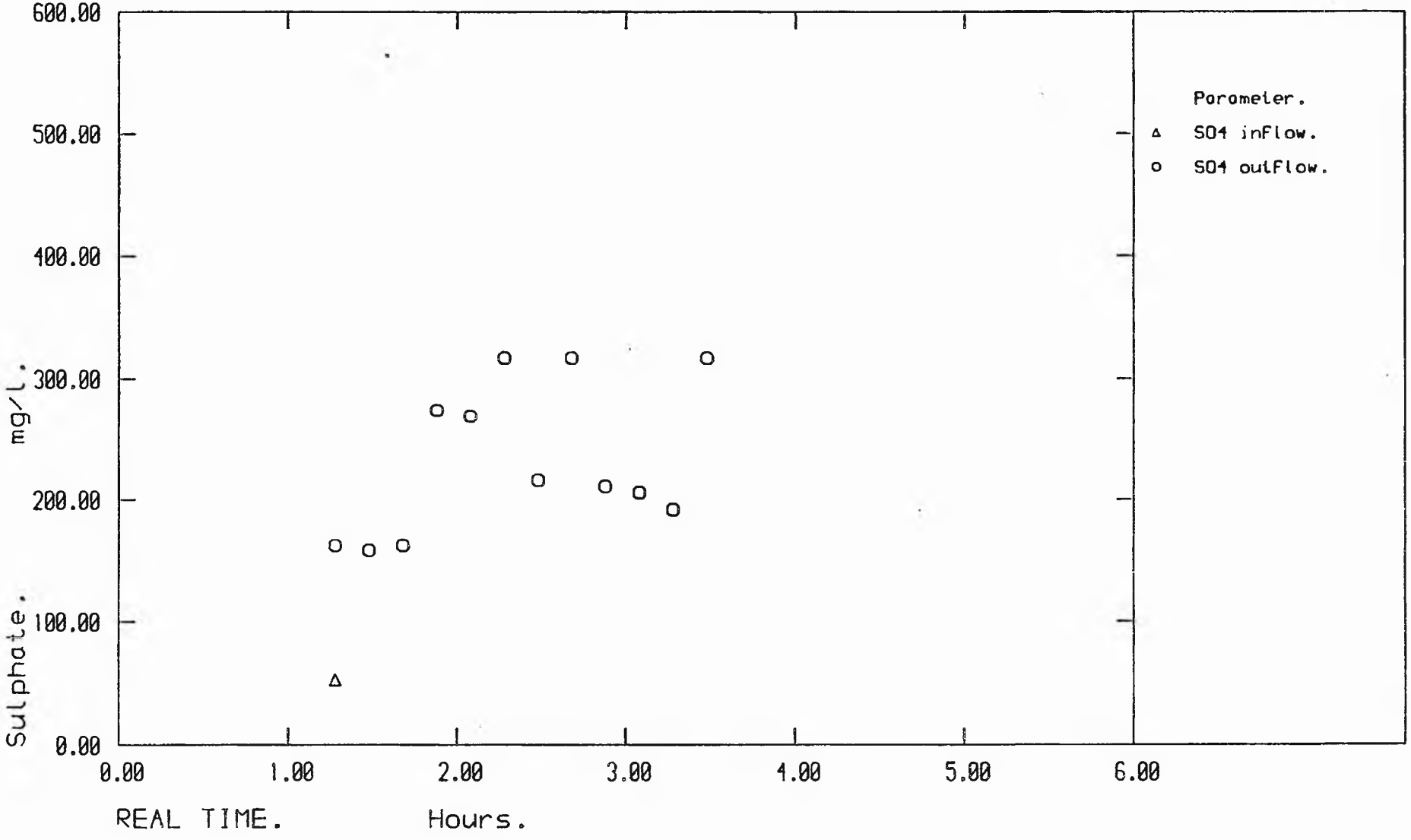
Graph of pH for Storm V on Tame Close.
The graph shows inflow and outflow water quality data.



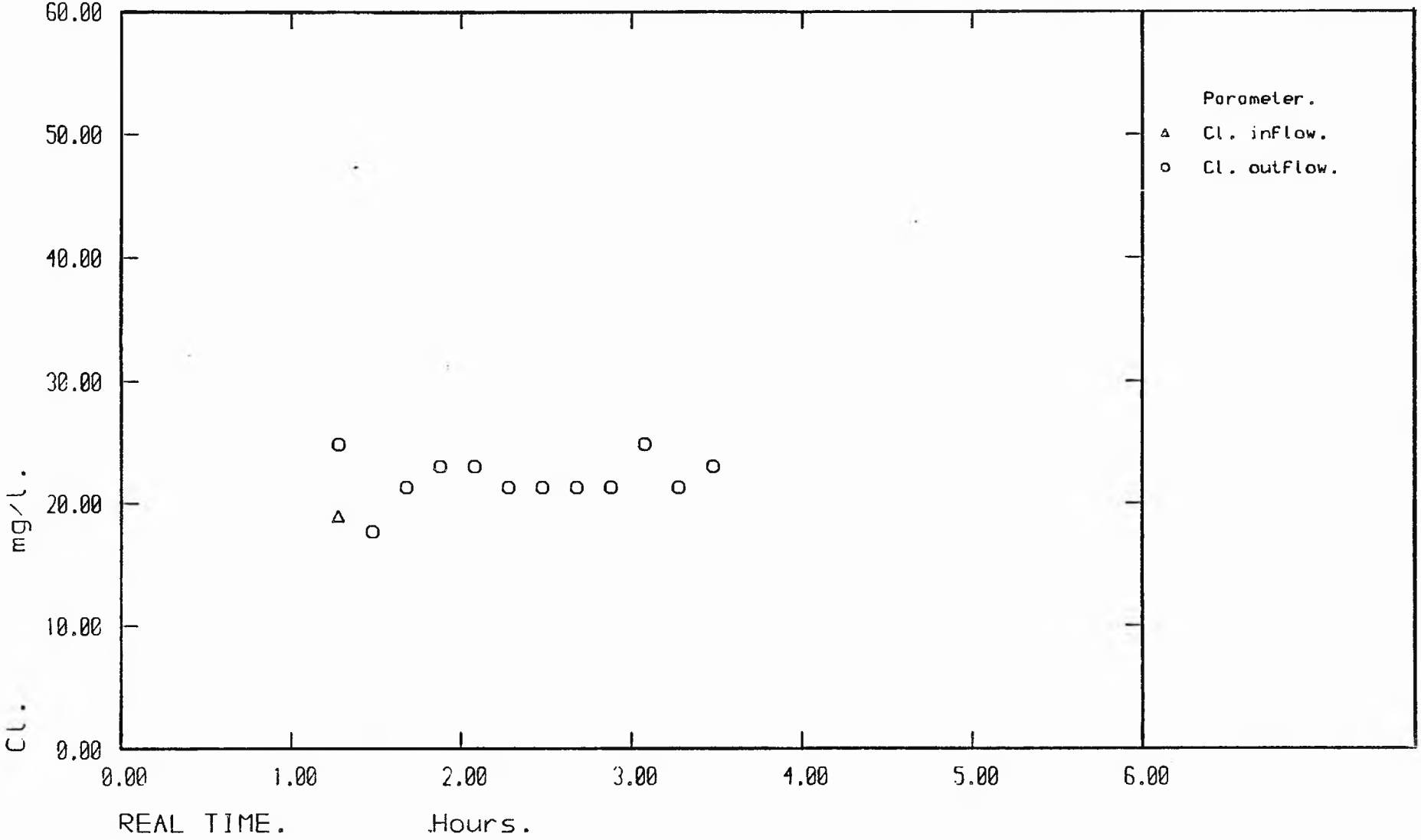
Graph of Total Hardness for Storm V on Tame Close.
The graph shows inflow and outflow water quality data.



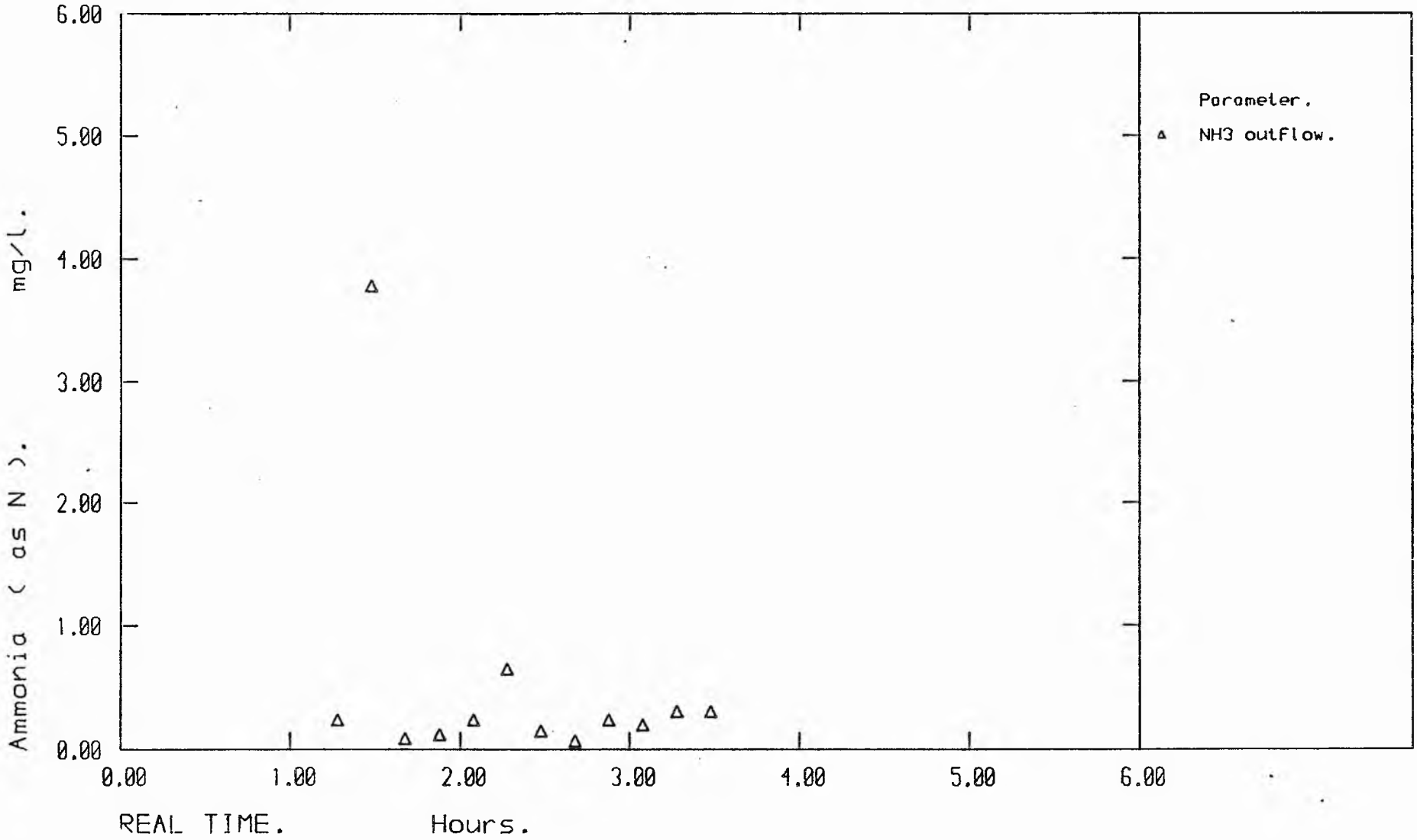
Graph of Total Alkalinity for Storm V on Tame Close.
The graph shows inflow and outflow water quality data.



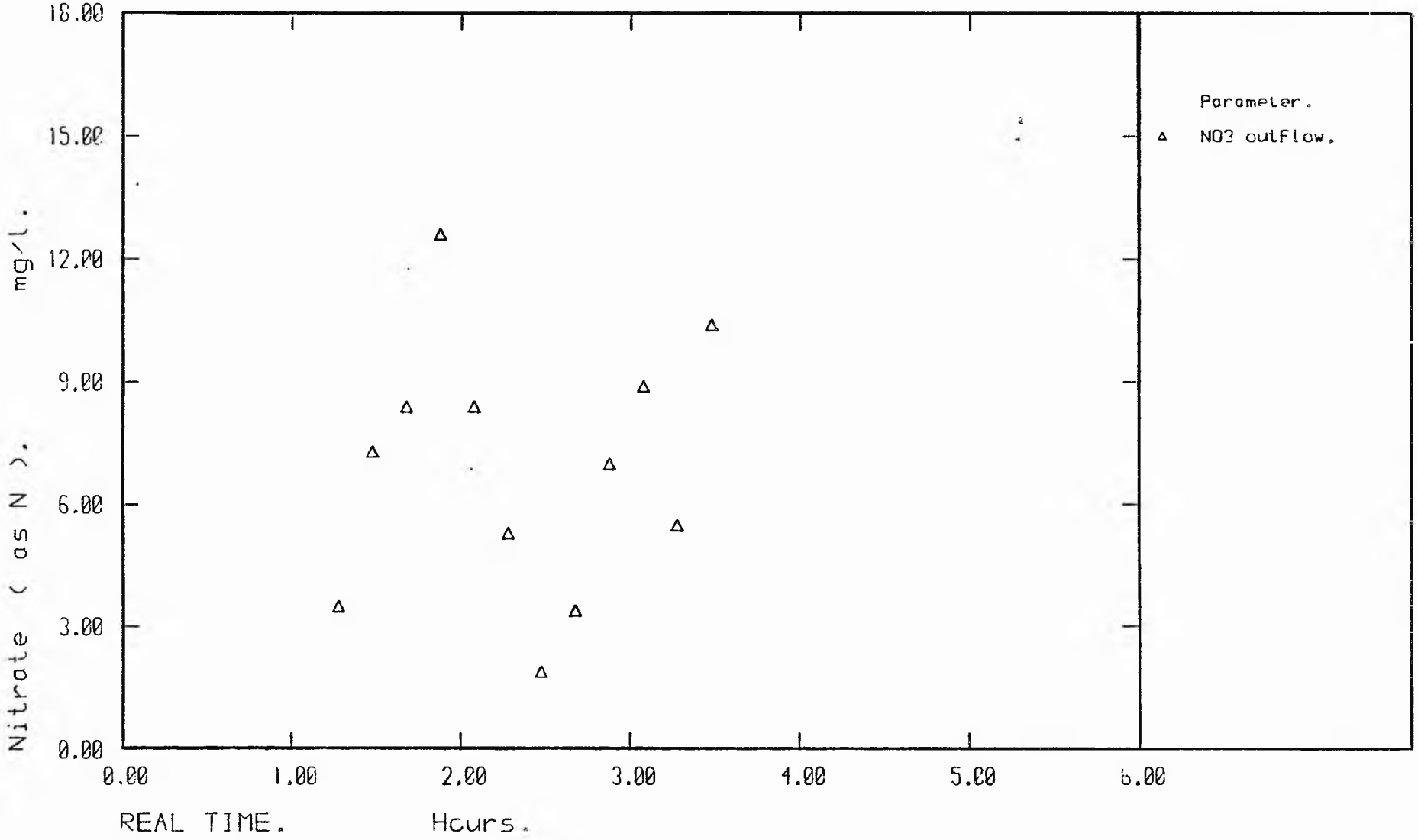
Graph of Sulphate for Storm V on Tame Close.
The graph shows inflow and outflow water quality data.



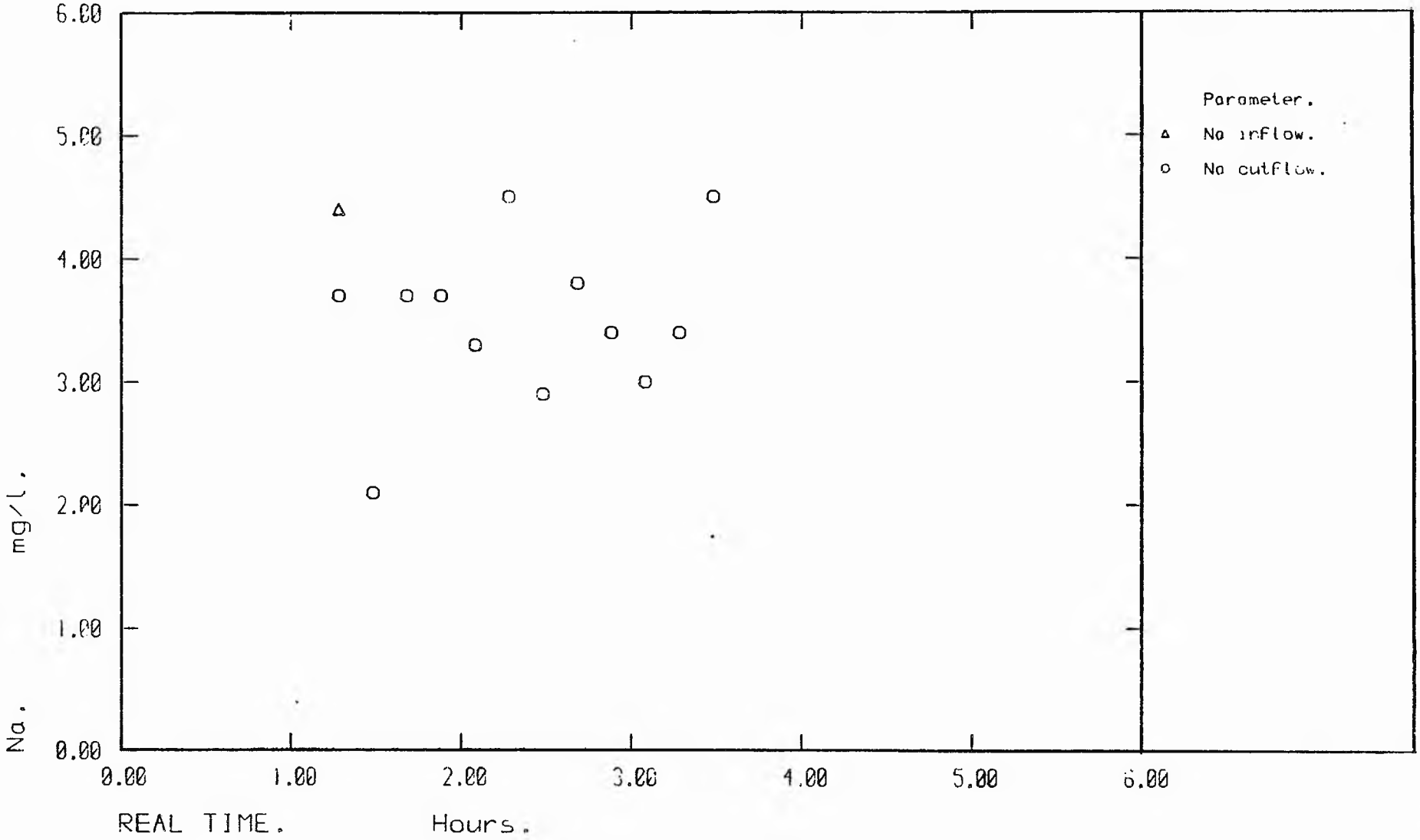
Graph of Chloride for Storm V on Tame Close.
The graph shows inflow and outflow water quality data.



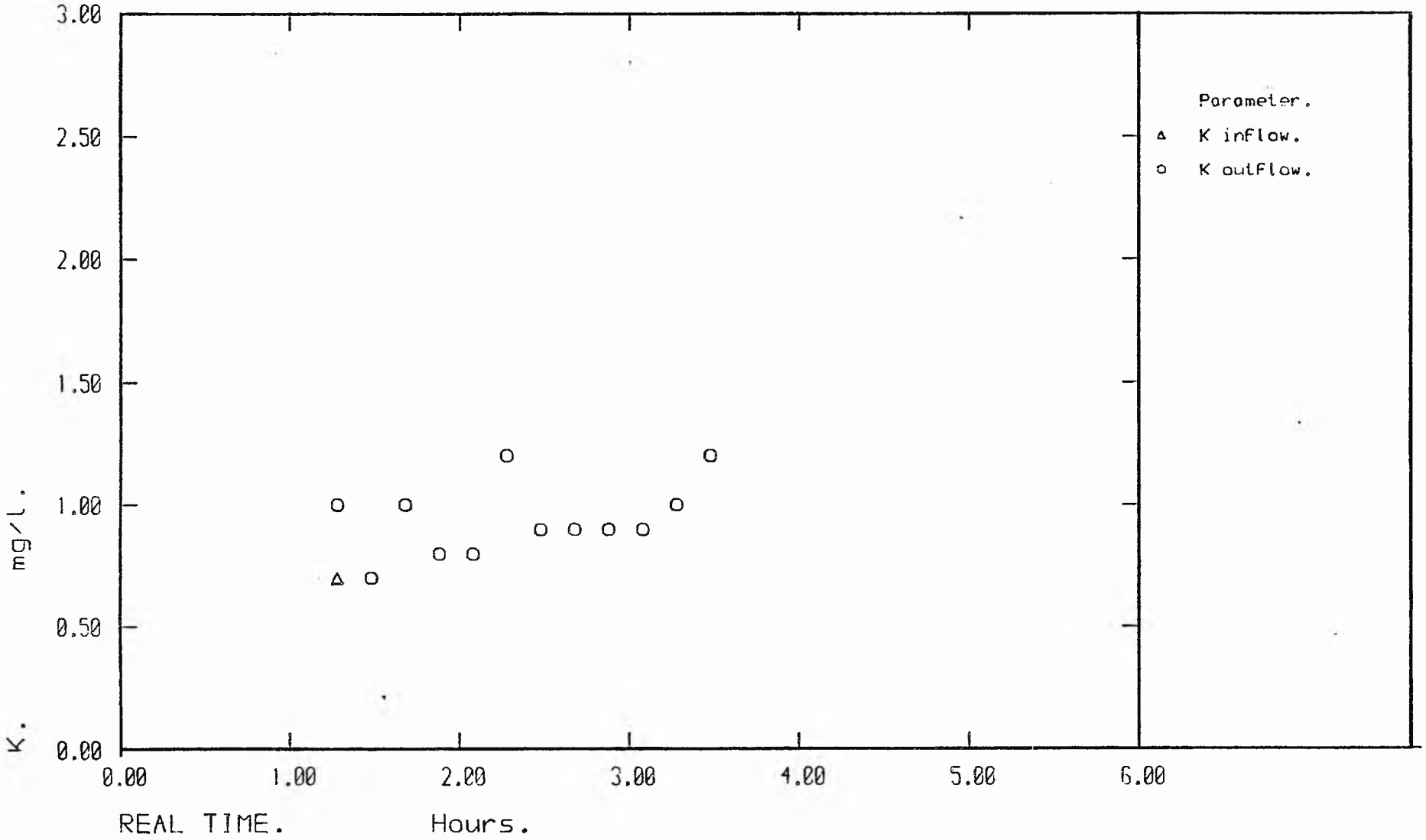
Graph of Ammonia for Storm V on Tame Close.
The graph shows inflow and outflow water quality data.



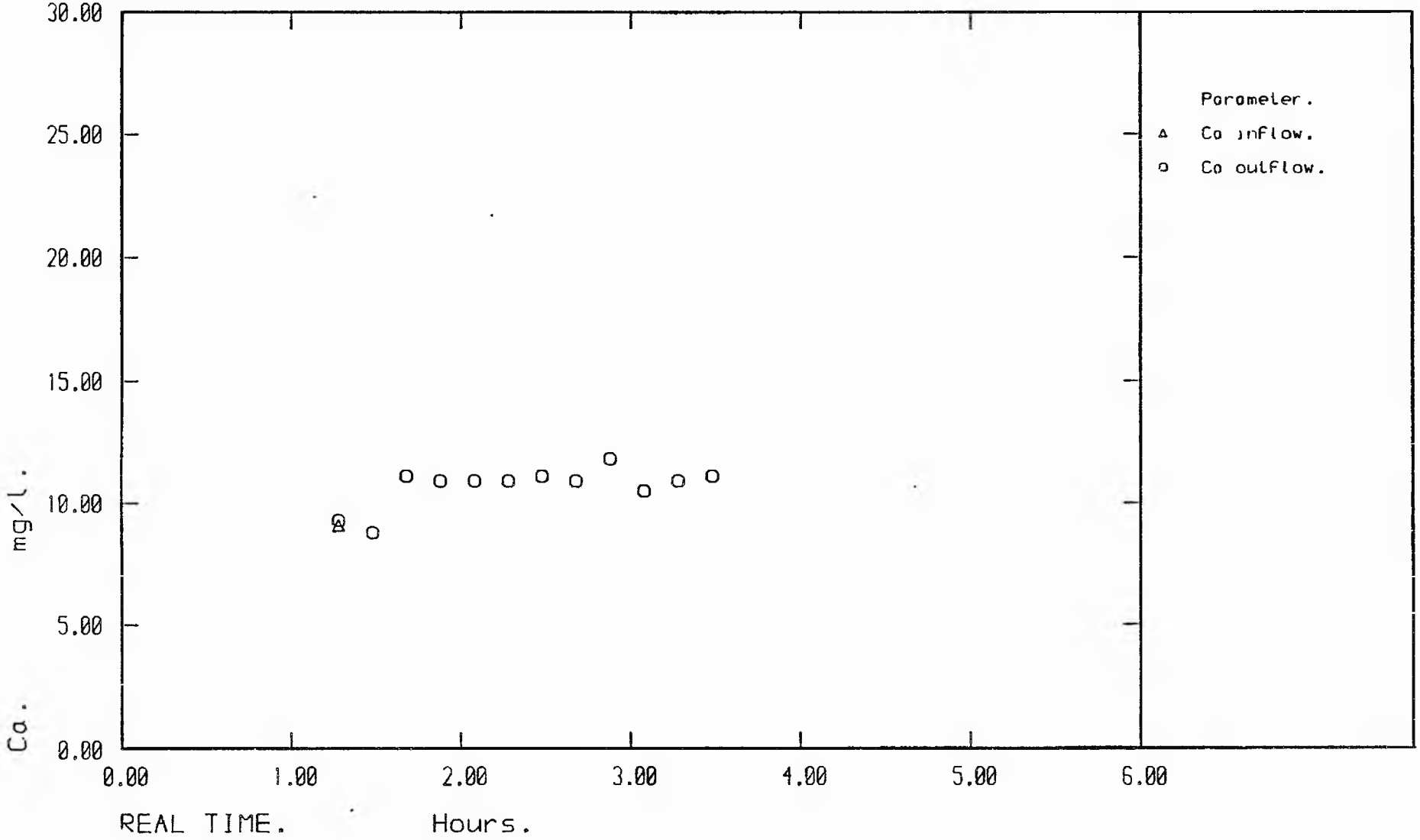
Graph of Nitrate for Storm V on Tame Close.
The graph shows inflow and outflow water quality data.



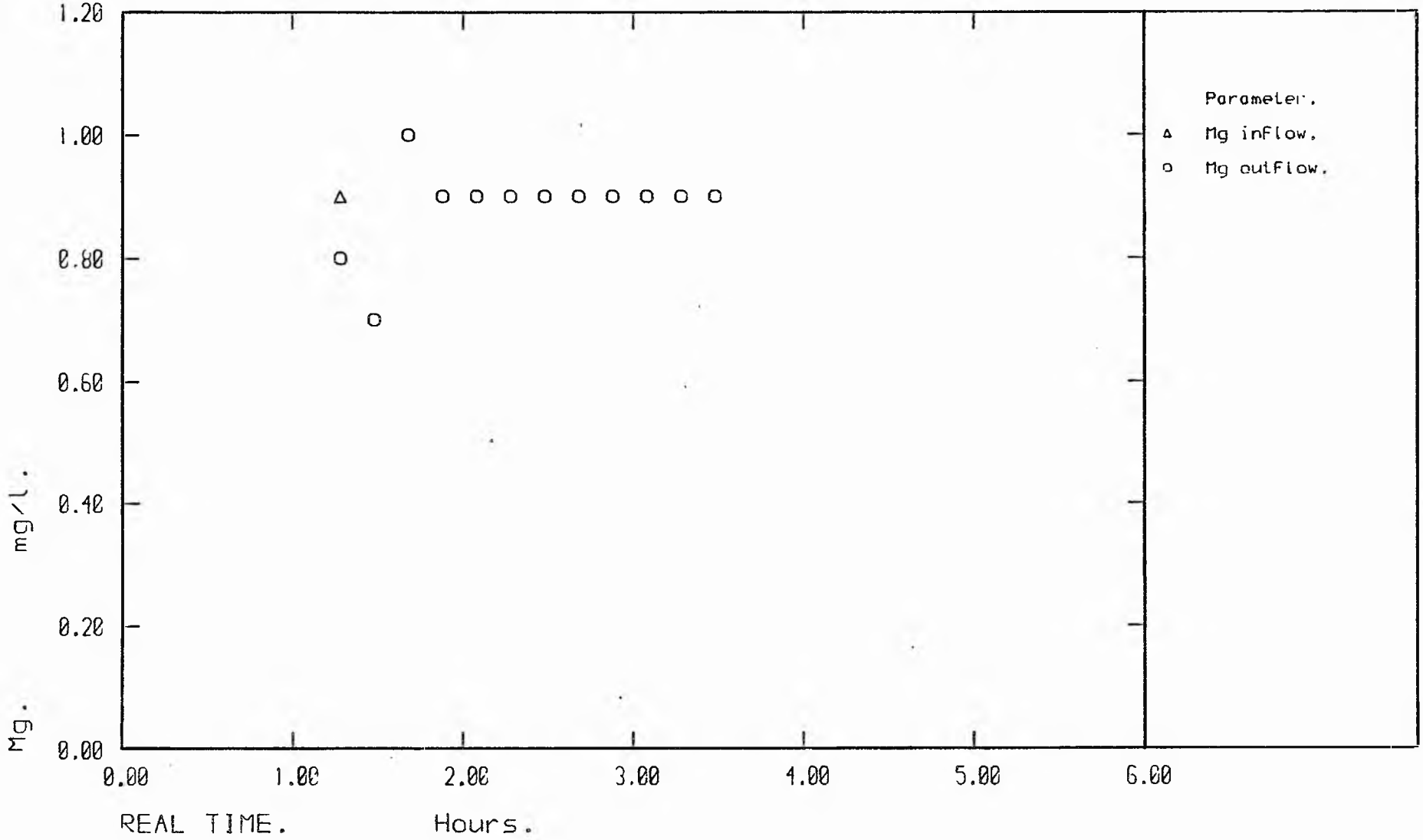
Graph of Sodium for Storm V on Tame Close.
The graph shows inflow and outflow water quality data.



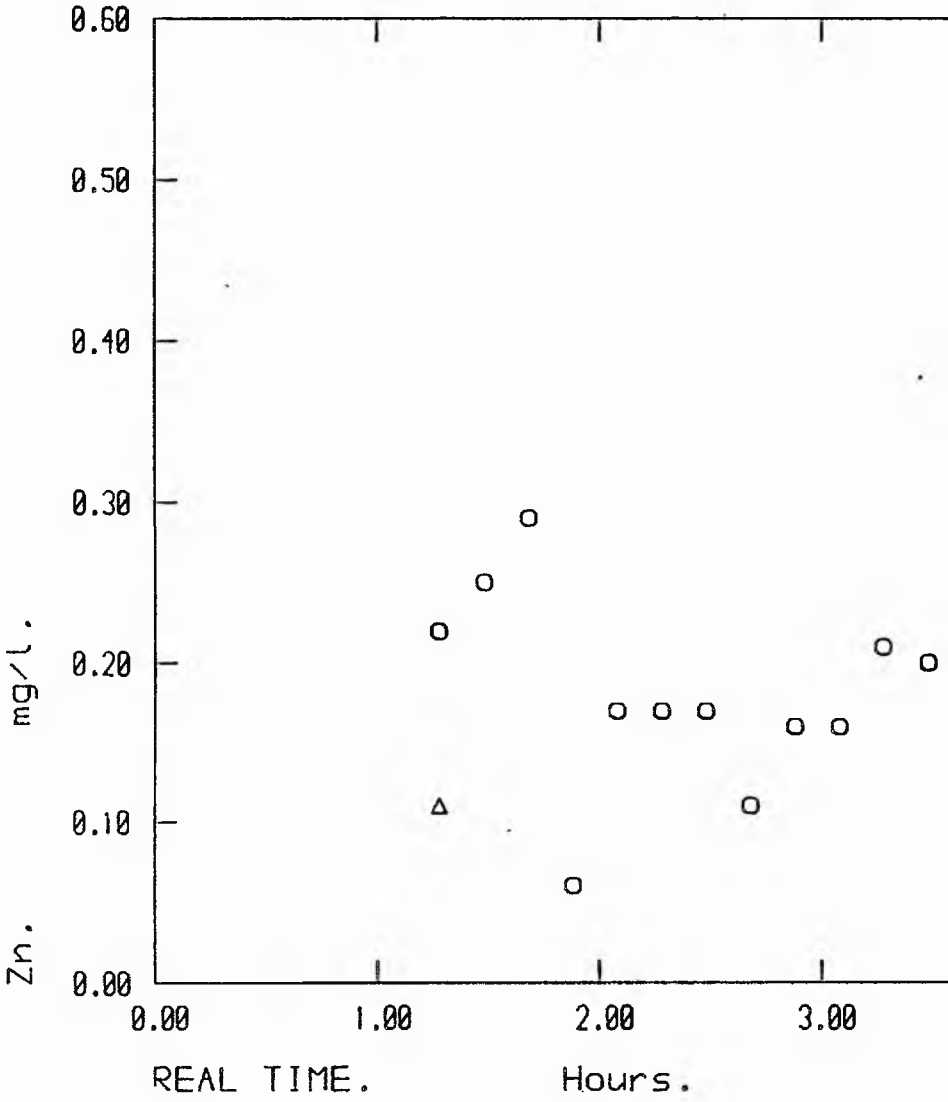
Graph of Potassium for Storm V on Tame Close.
The graph shows inflow and outflow water quality data.



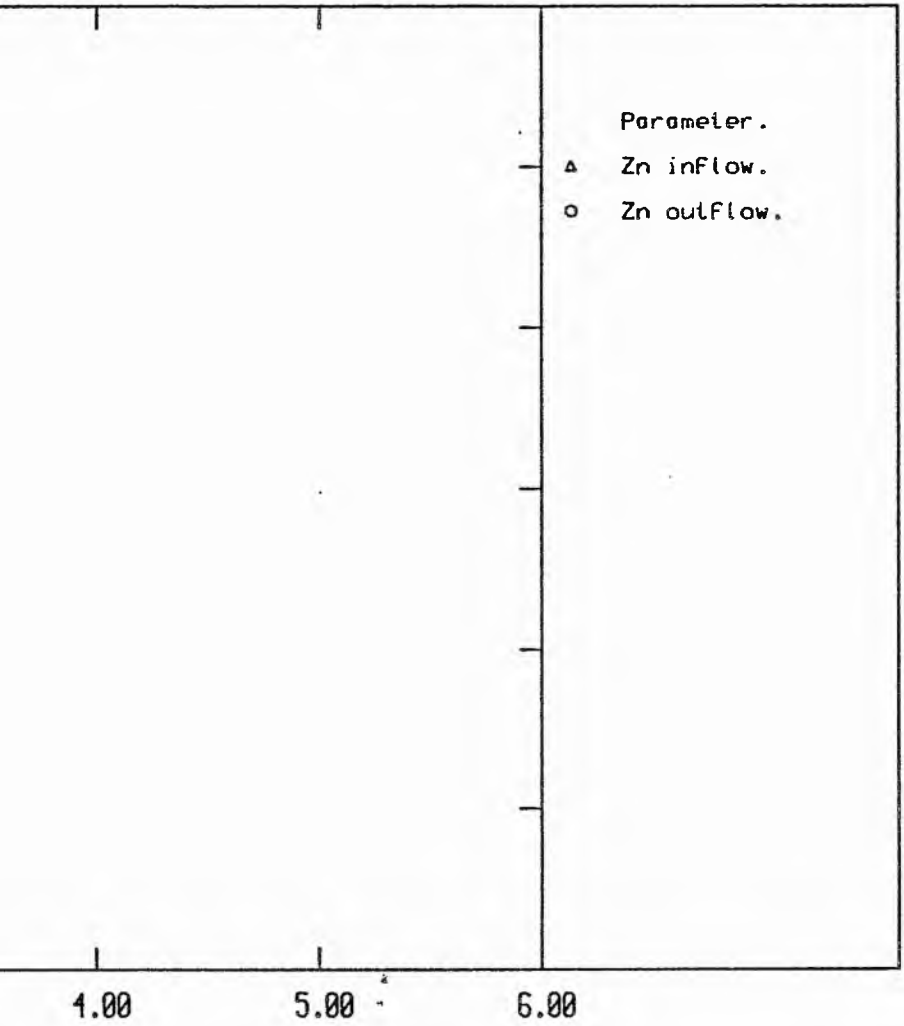
Graph of Calcium for Storm V on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Magnesium for Storm V on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc For Storm V on Tame Close.
The graph shows inflow and outflow water qu



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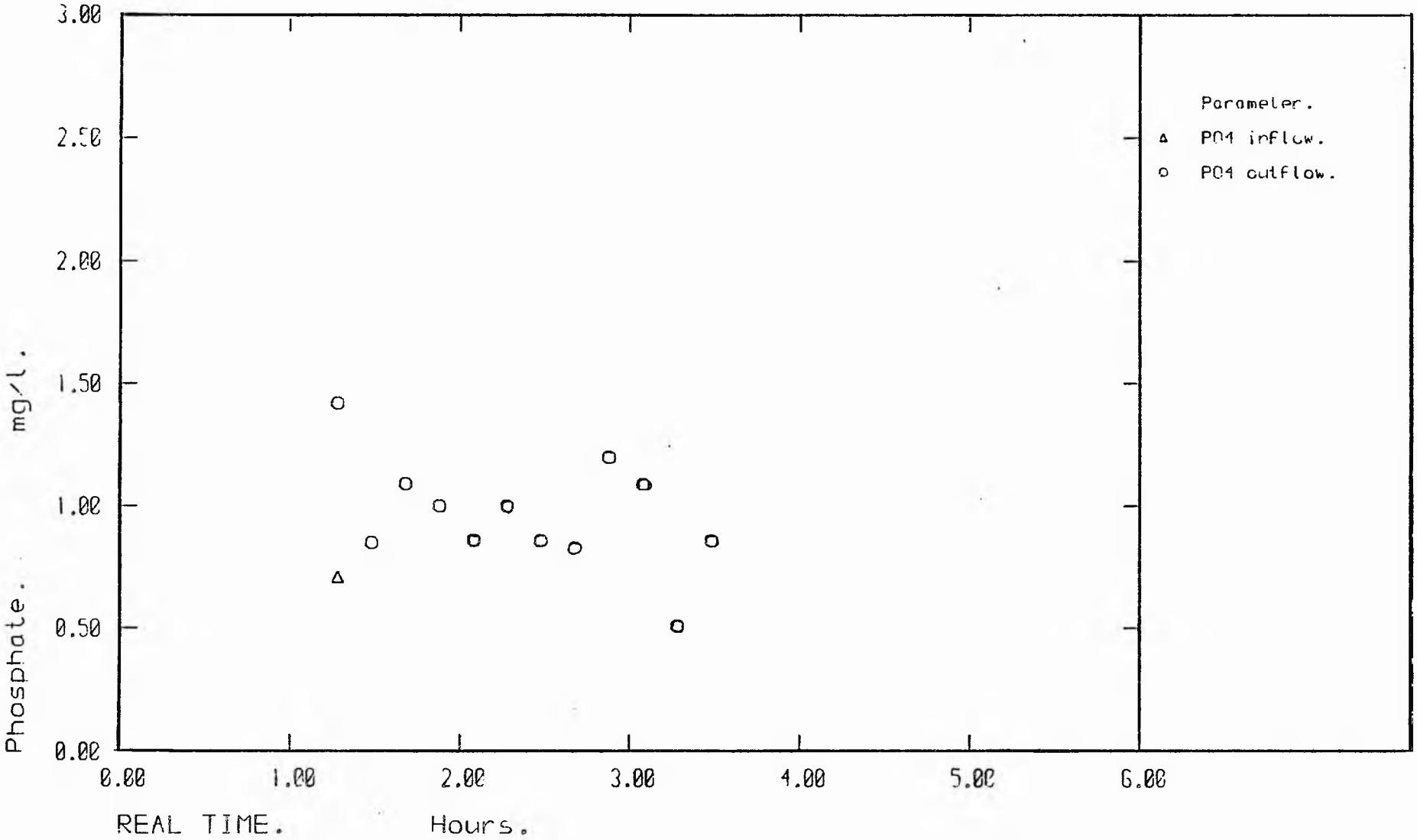

Graph of Phosphate for Storm V on Tame Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
0117	202	51	71
0123	23	21	0
0129	46	17	22
0135	6	23	38

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
0117	2	23	38
0129	6	18	5
0141	6	16	16
0153	10	17	16
0205	8	14	98
0217	25	10	87
0229	13	10	0
0241	20	13	104
0253	6	11	60
0305	16	10	49
0317	11	8	104
0329	4	7	38

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close

DATE OF THE STORM EVENT : 8th. October 1984 (841008)

STORM NUMBER : V

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	pH pH units
0117	0.11	5.3
0123	0.07	5.3
0129	0.07	5.2
0135	0.07	5.2

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close

DATE OF THE STORM EVENT : 8th. October 1984 (841008)

STORM NUMBER : V

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	pH pH units
0117	0.11	5.9
0129	0.07	5.8
0141	0.06	5.7
0153	0.08	5.7
0205	0.06	5.6
0217	0.06	5.7
0229	0.06	5.7
0241	0.06	6.0
0253	0.06	5.9
0305	0.06	5.9
0317	0.06	5.8
0329	0.06	5.7

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
0117	50.0	30.0	135	28.4
0123	30.0	25.0	86	21.3
0129	35.0	20.0	34	21.3
0135	40.0	25.0	19	21.3

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
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ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
0117	55.0	40.0	139	26.6
0129	35.0	25.0	62	19.5
0141	35.0	30.0	408	19.5
0153	40.0	30.0	240	21.2
0205	35.0	30.0	178	17.7
0217	35.0	30.0	149	17.7
0229	30.0	30.0	86	21.2
0241	35.0	30.0	72	23.0
0253	35.0	30.0	0	21.2
0305	35.0	30.0	130	17.7
0317	35.0	30.0	0	17.7
0329	40.0	30.0	29	19.5

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Phosphate mgl-1
0117	*	*	2.1
0123	*	*	1.3
0129	*	*	0.7
0135	0.0	*	0.8

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
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ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Phosphate mgl-1
0117	0.0	16.8	0.7
0129	0.3	10.1	0.6
0141	0.5	8.7	0.9
0153	0.0	*	0.7
0205	0.0	3.8	0.6
0217	0.0	15.4	0.7
0229	0.2	4.1	0.9
0241	0.1	12.6	0.7
0253	0.1	11.2	0.7
0305	0.2	12.6	0.3
0317	0.1	12.3	1.3
0329	0.0	16.8	0.8

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
0117	6.1	1.2	10.9	1.5
0123	7.2	0.8	9.1	1.5
0129	5.6	0.7	9.1	1.2
0135	5.0	0.6	8.9	1.5

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
0117	4.0	1.1	12.8	1.3
0129	2.9	1.0	7.7	0.7
0141	3.5	0.7	7.9	0.9
0153	2.8	0.8	7.4	0.8
0205	6.0	0.8	9.5	1.5
0217	8.6	0.8	9.5	1.5
0229	3.5	0.9	7.3	0.8
0241	2.4	0.7	5.9	0.6
0253	2.5	0.7	9.1	0.9
0305	2.6	0.8	8.8	1.0
0317	3.9	0.8	8.9	0.8
0329	3.1	0.8	11.0	0.8

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF INFLOW WATER TO THE GULLY POT

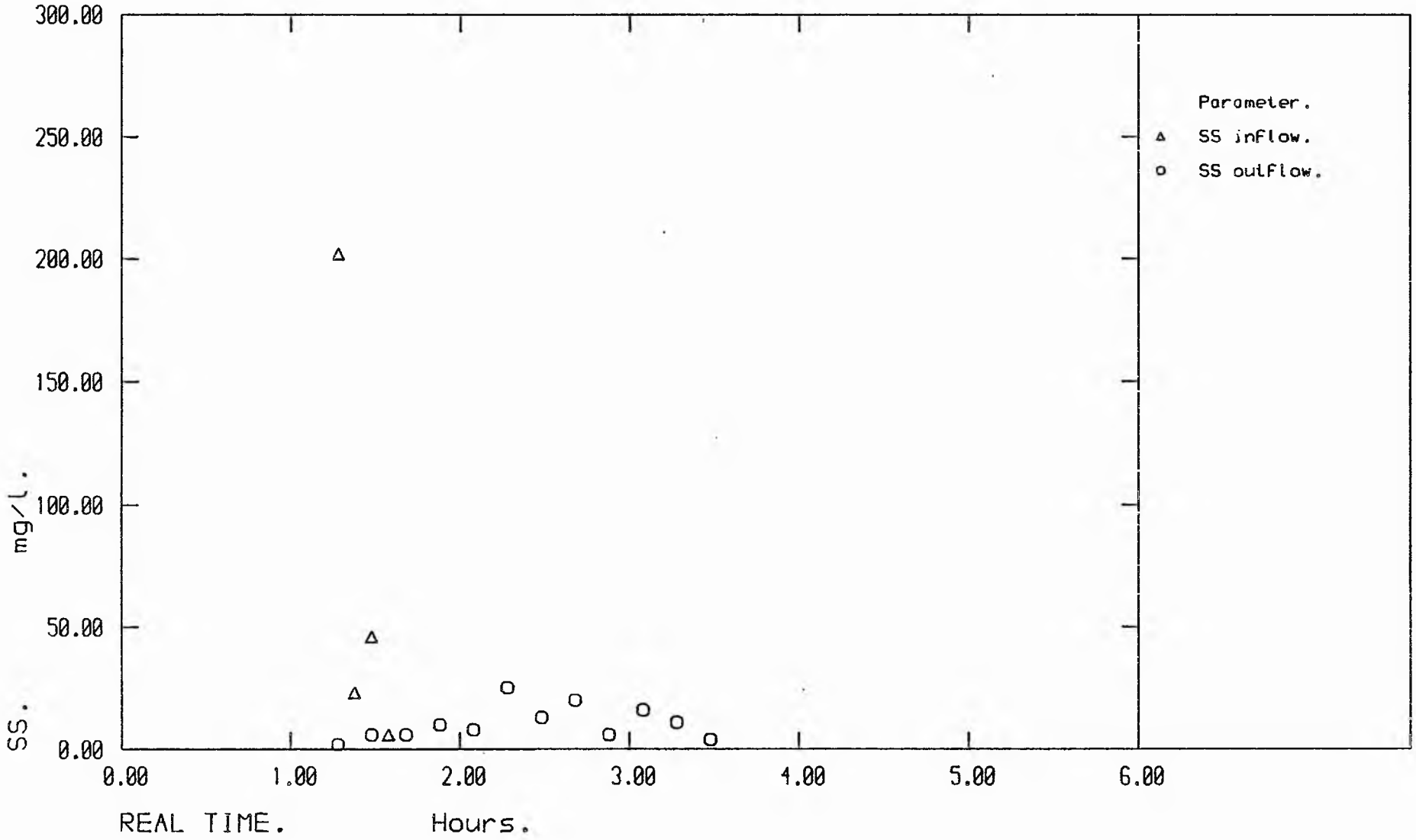
REAL TIME Hours	Zn mgl-1	Mn mgl-1
0117	0.4	0.2
0123	0.1	0.1
0129	0.2	0.2
0135	0.2	0.2

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

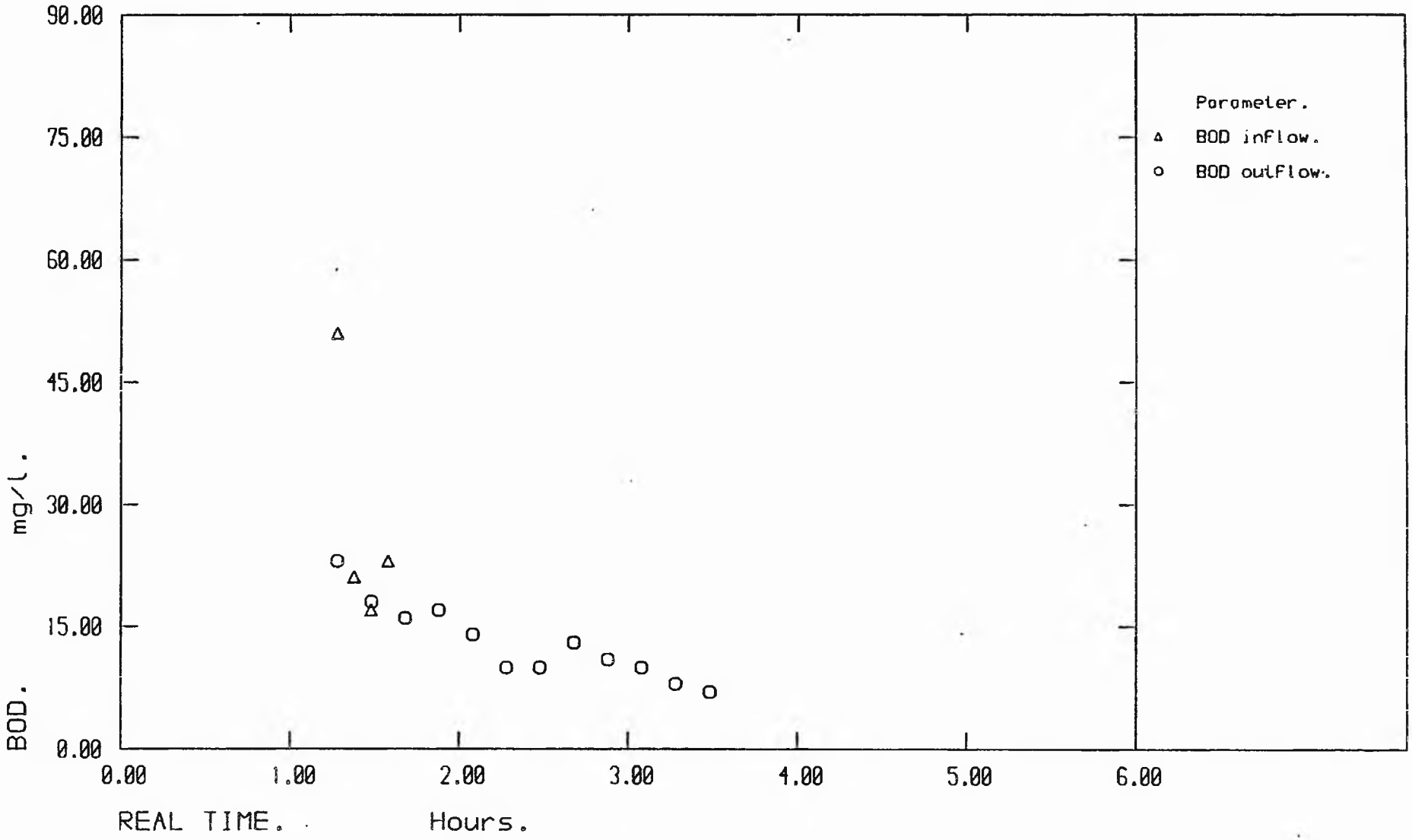
CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

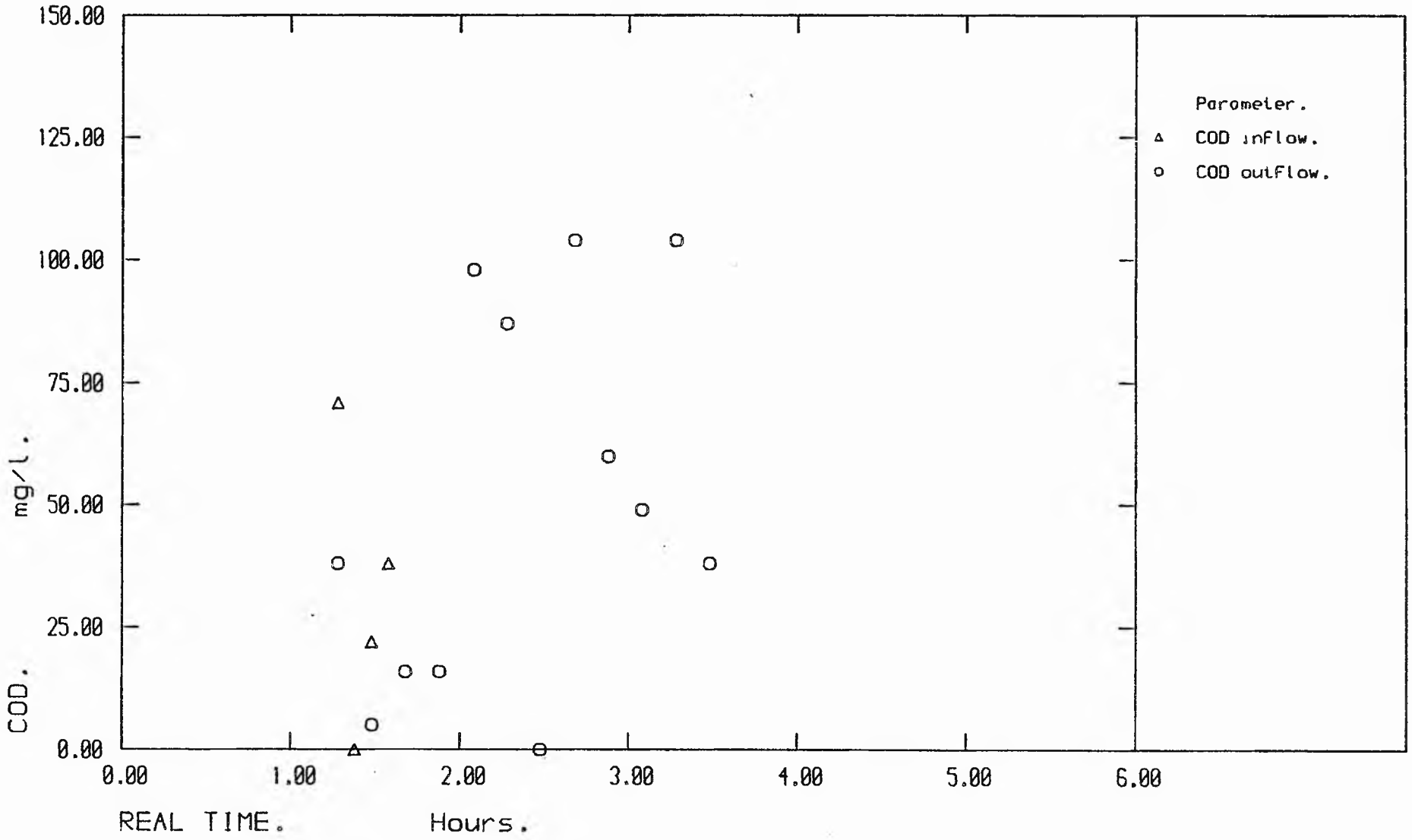
REAL TIME Hours	Zn mgl-1
0117	0.3
0129	0.2
0141	0.2
0153	0.2
0205	0.1
0217	0.2
0229	0.2
0241	0.1
0253	0.1
0305	0.1
0317	0.2
0329	0.1



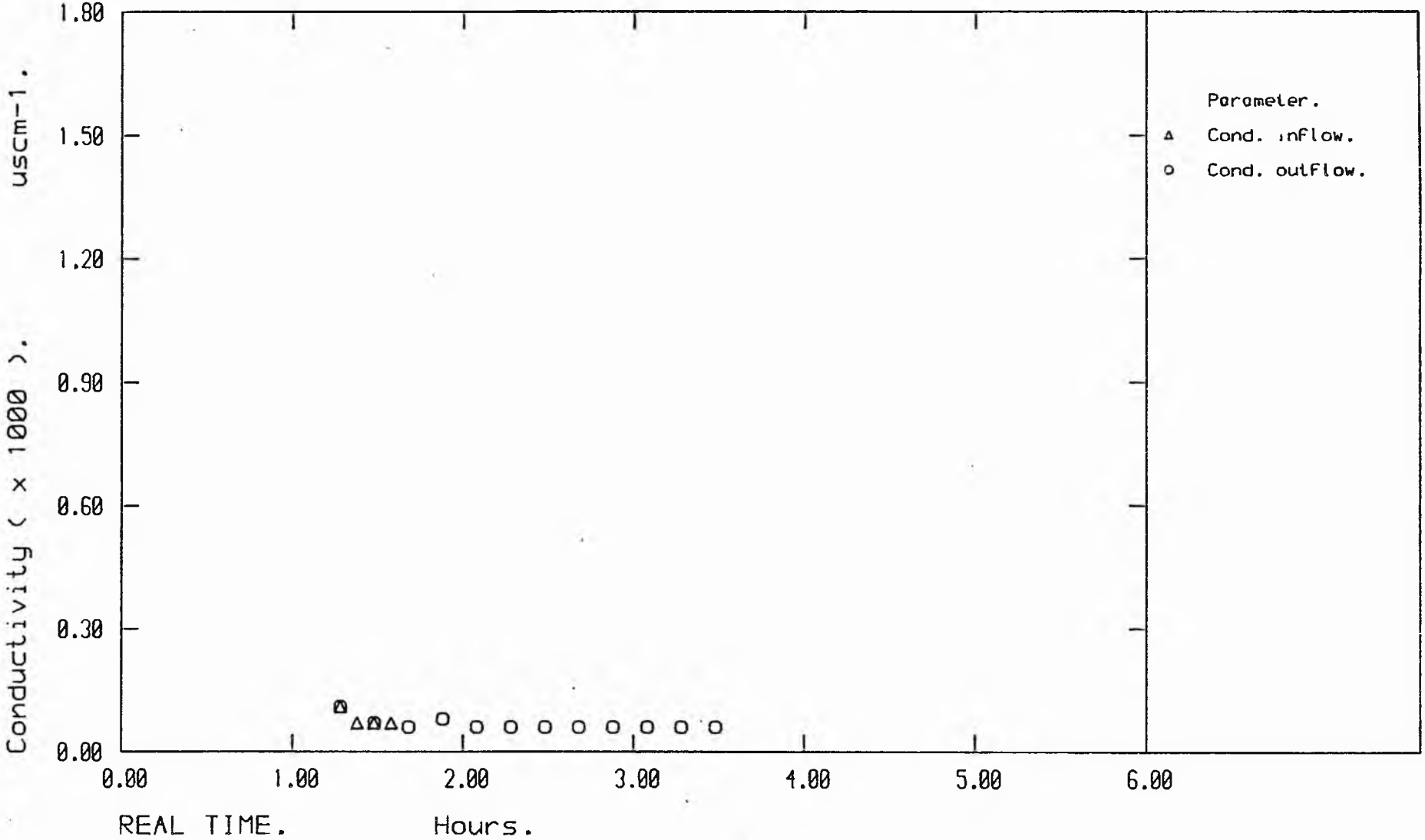
Graph of Suspended Solids for Storm V on Churnet Close.
The graph shows inflow and outflow water quality data.



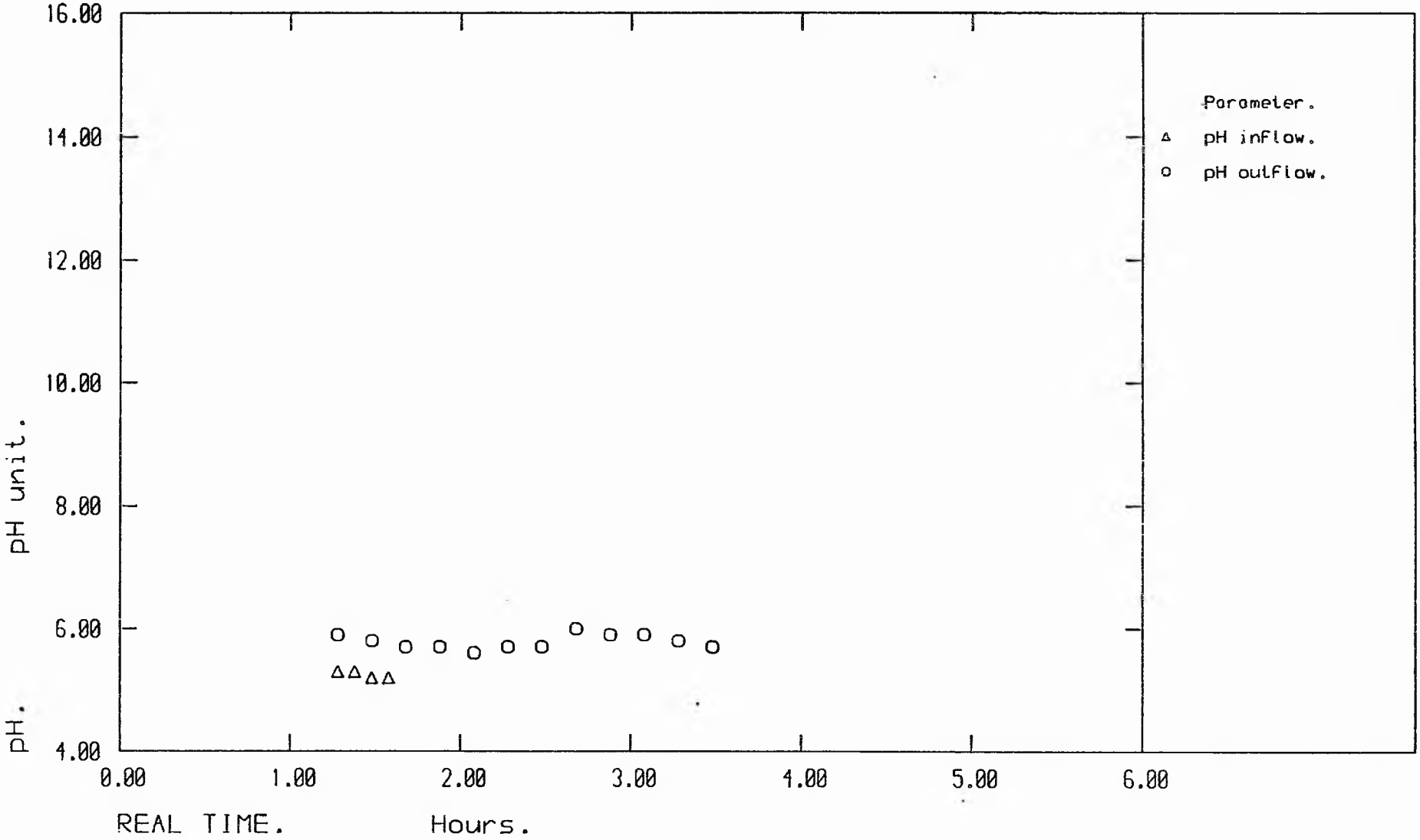
Graph of Biochemical Oxygen Demand For Storm V on Churnet Close.
The graph shows inflow and outflow water quality data.



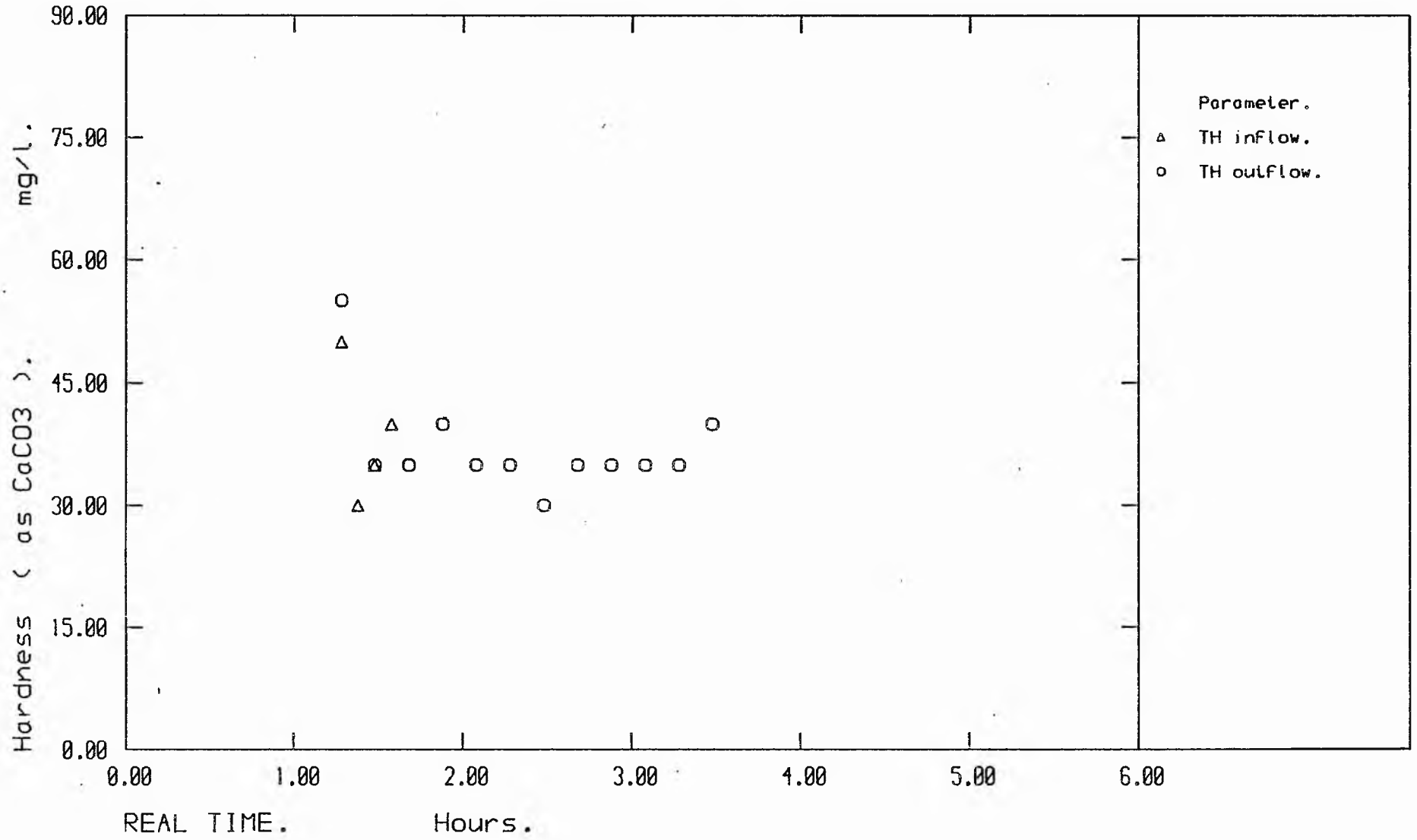
Graph of Chemical Oxygen Demand for Storm V on Churnet Close.
The graph shows inflow and outflow water quality data.



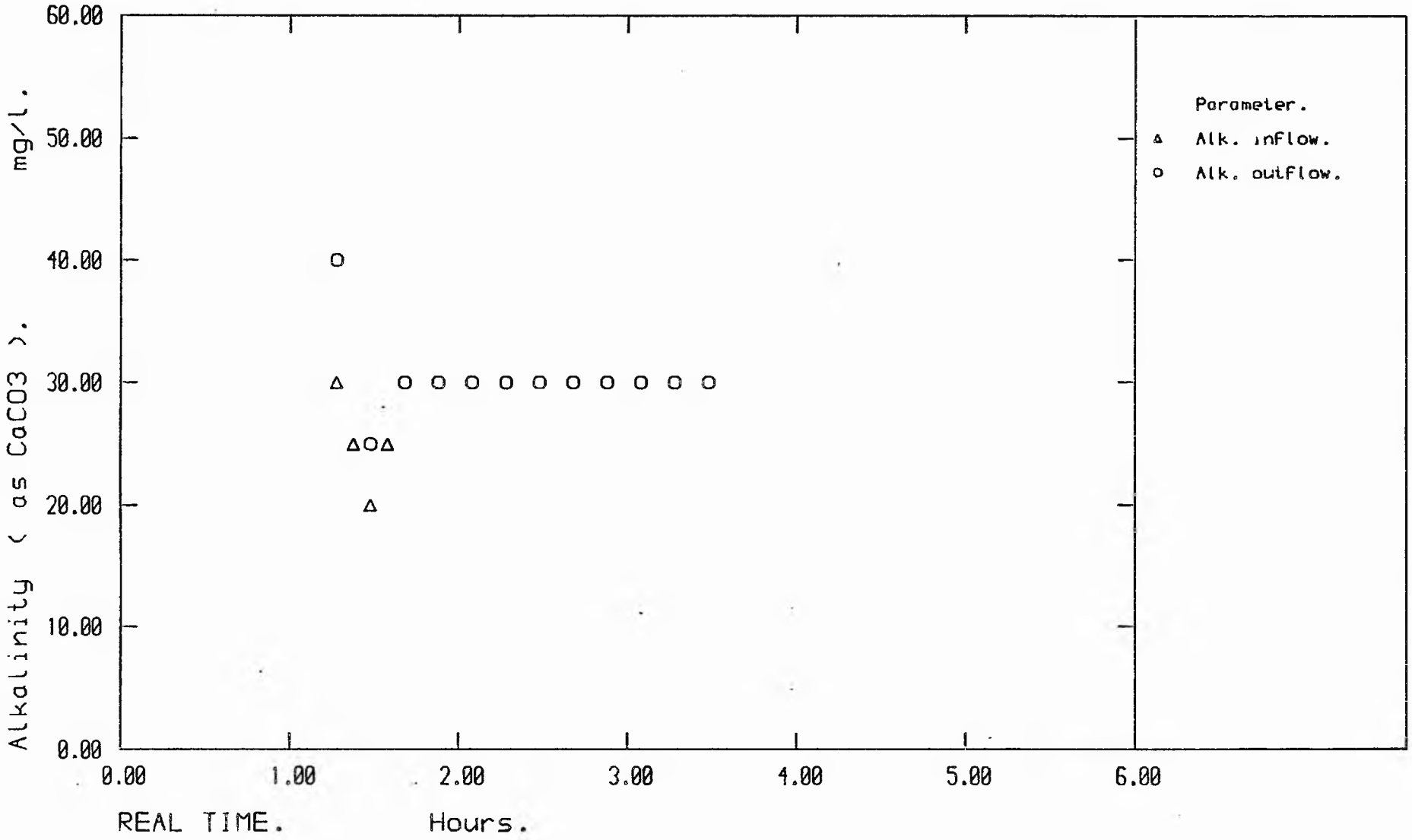
Graph of Conductivity For Storm V on Churnet Close.
The graph shows inflow and outflow water quality data.



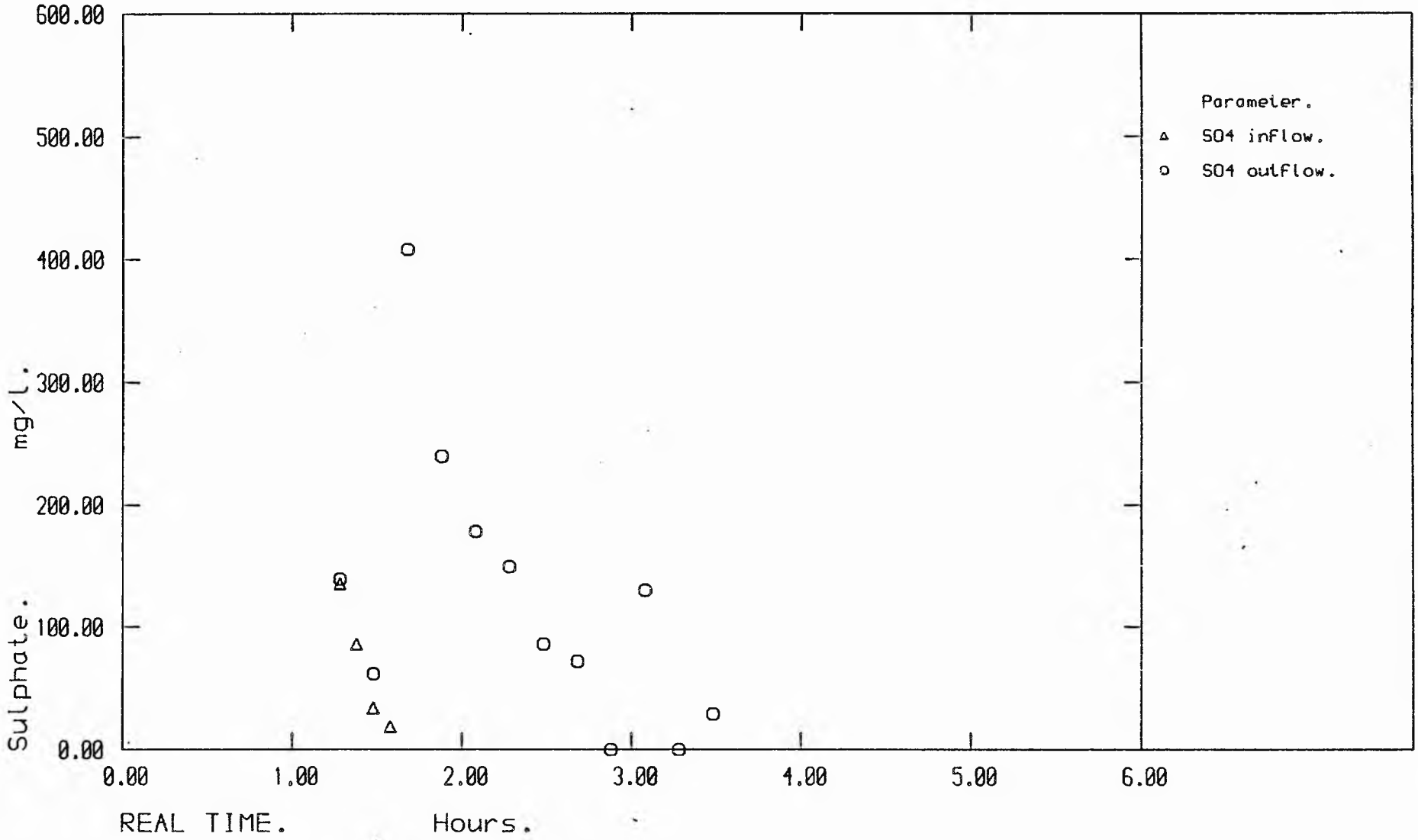
Graph of pH for Storm V on Churnet Close.
The graph shows inflow and outflow water quality data.



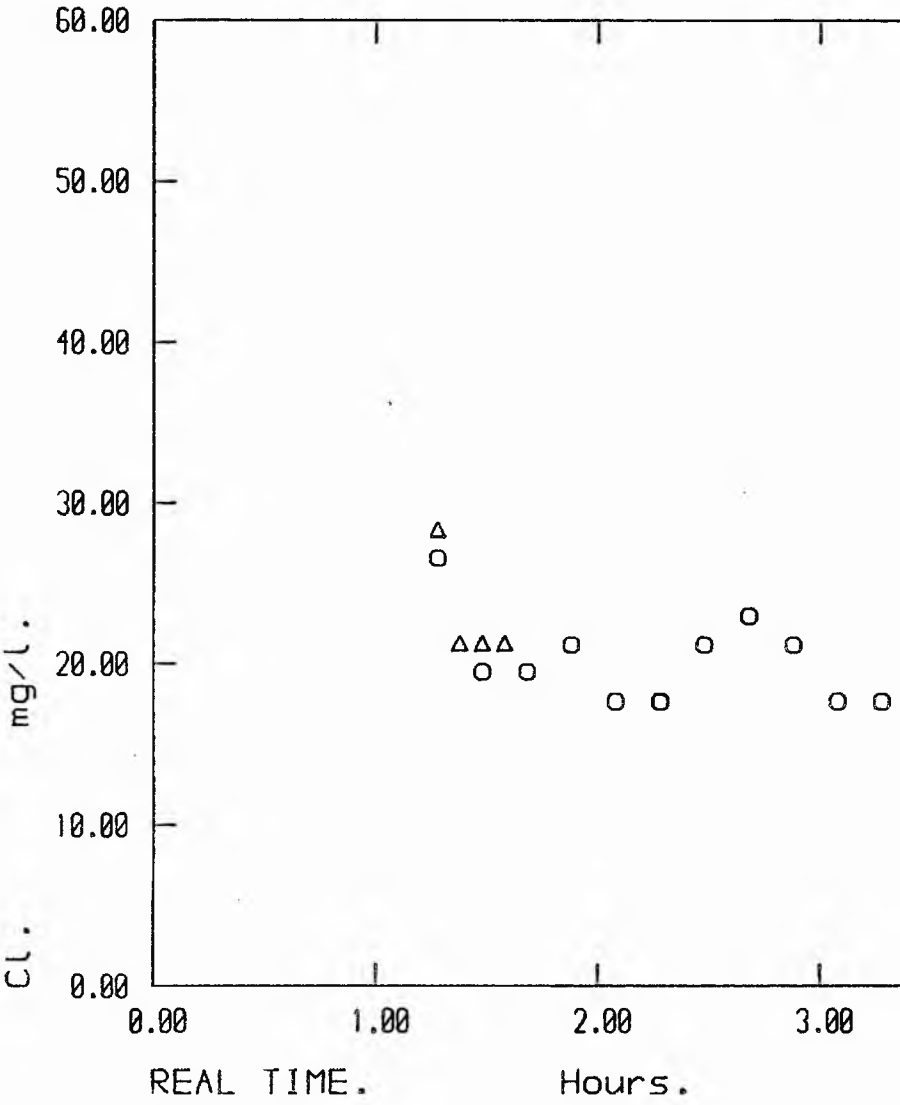
Graph of Total Hardness for Storm V on Churnet Close.
The graph shows inflow and outflow water quality data.



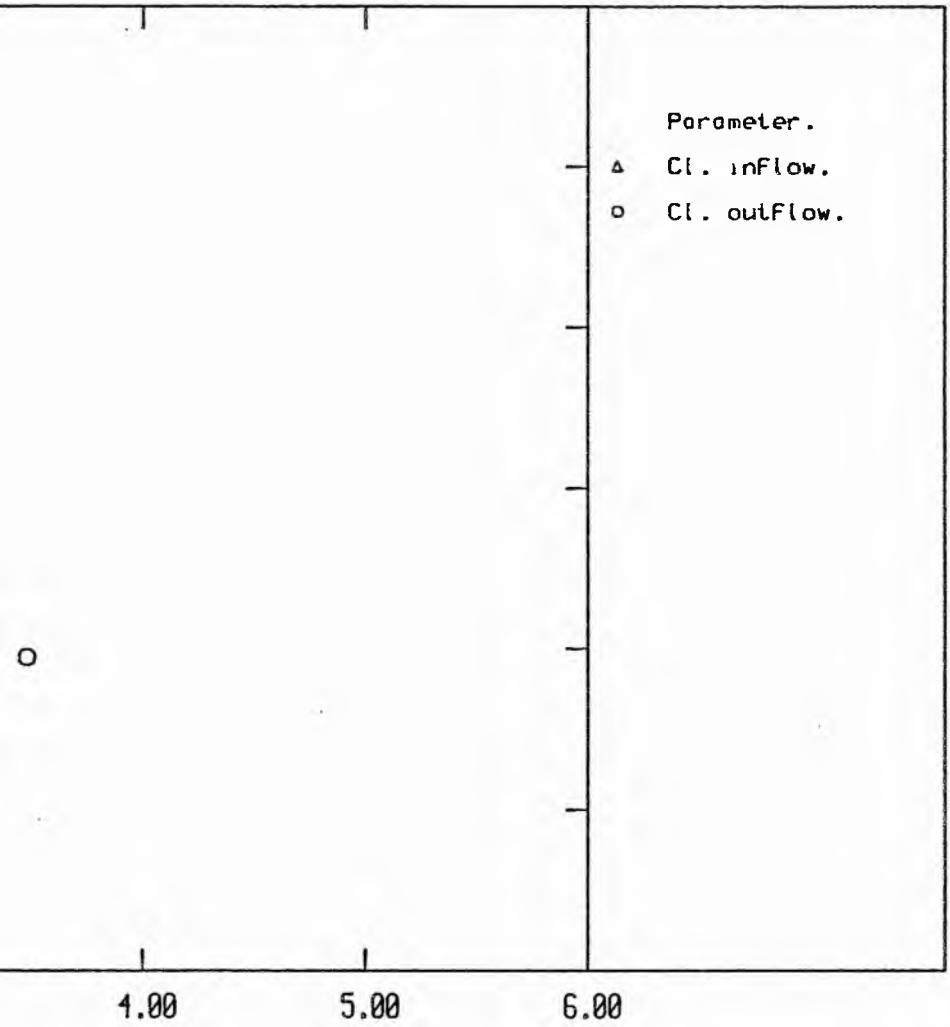
Graph of Total Alkalinity for Storm V on Churnet Close.
The graph shows inflow and outflow water quality data.



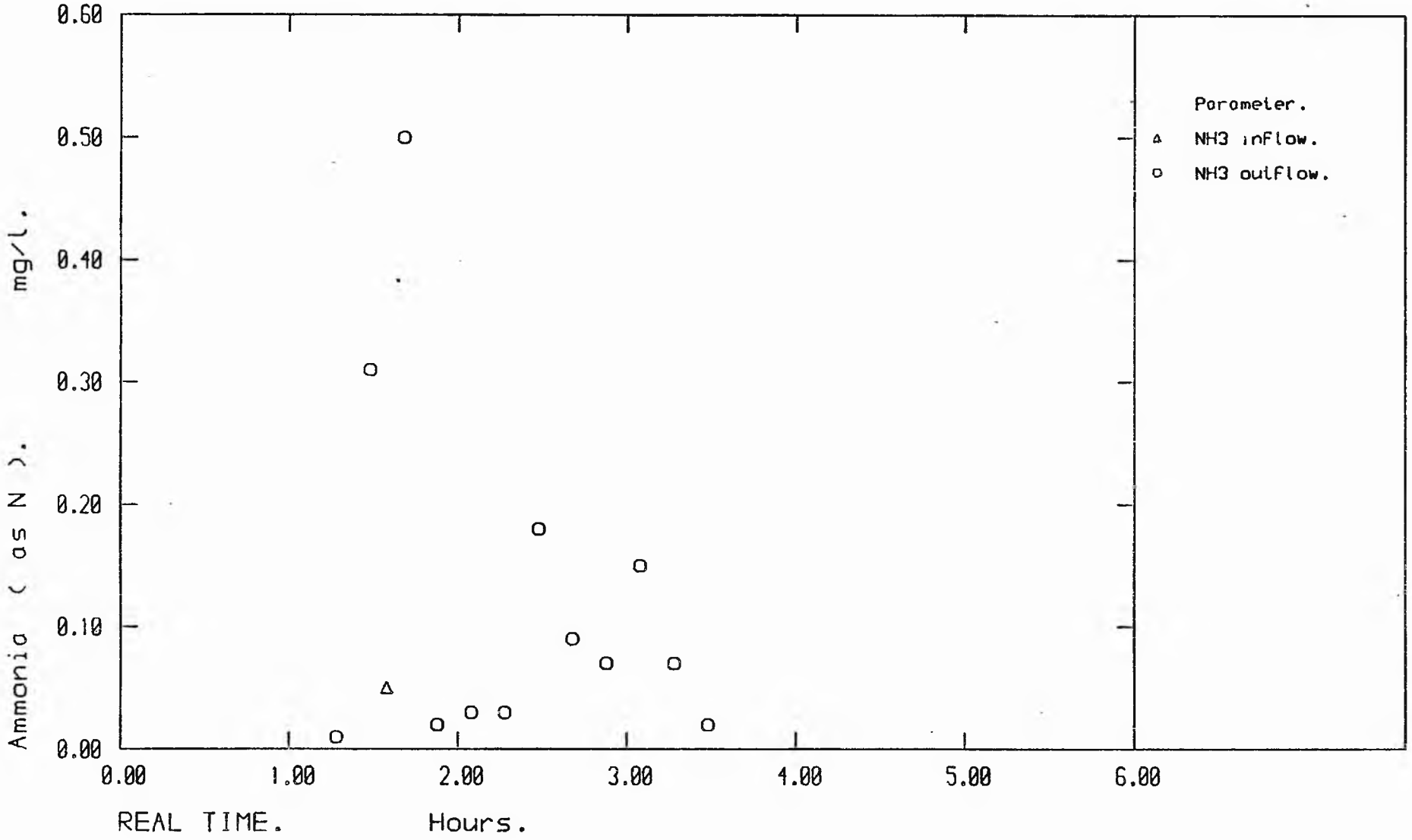
Graph of Sulphate for Storm V on Churnet Close.
The graph shows inflow and outflow water quality data.



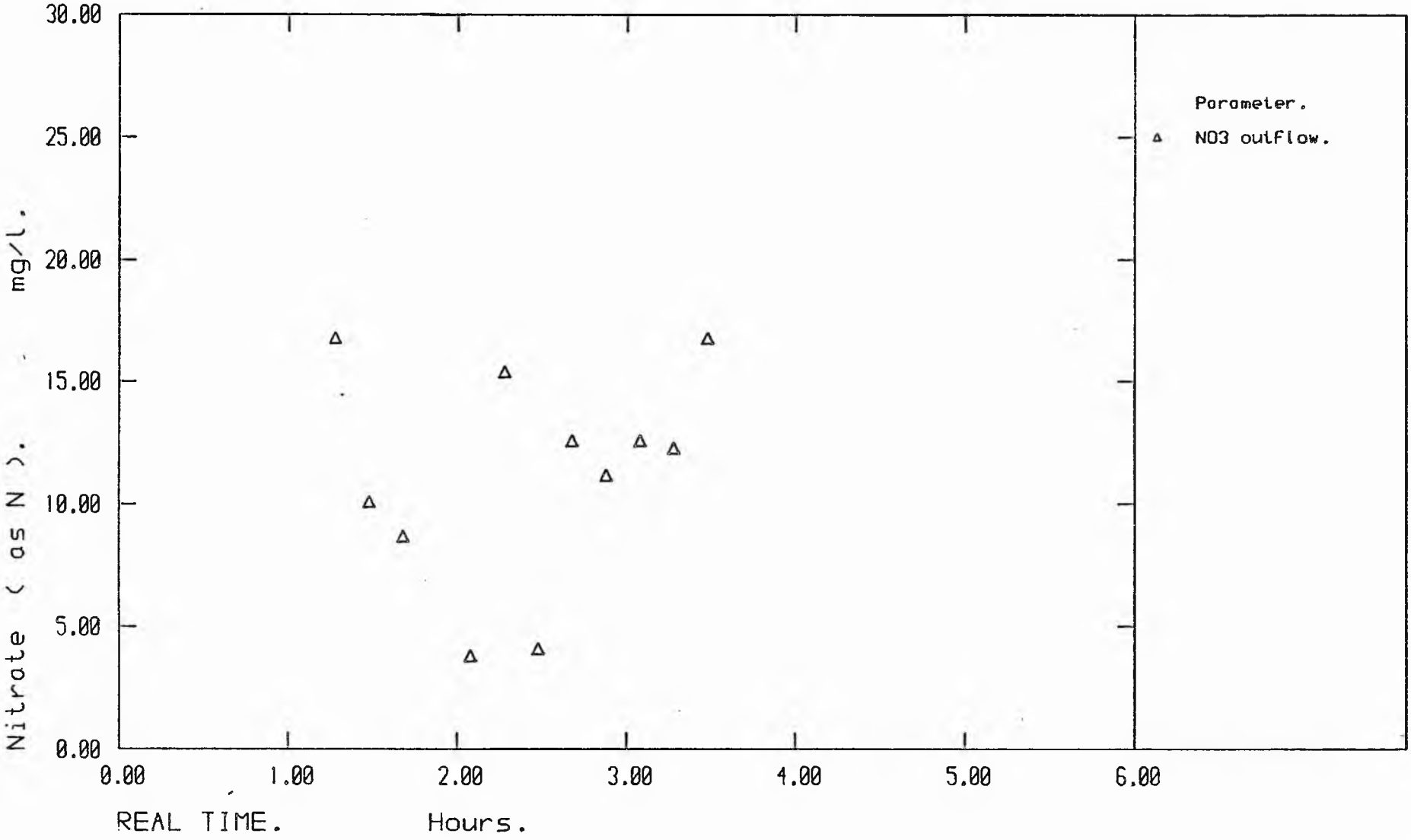
Graph of Chloride for Storm V on Churnet
The graph shows inflow and outflow water



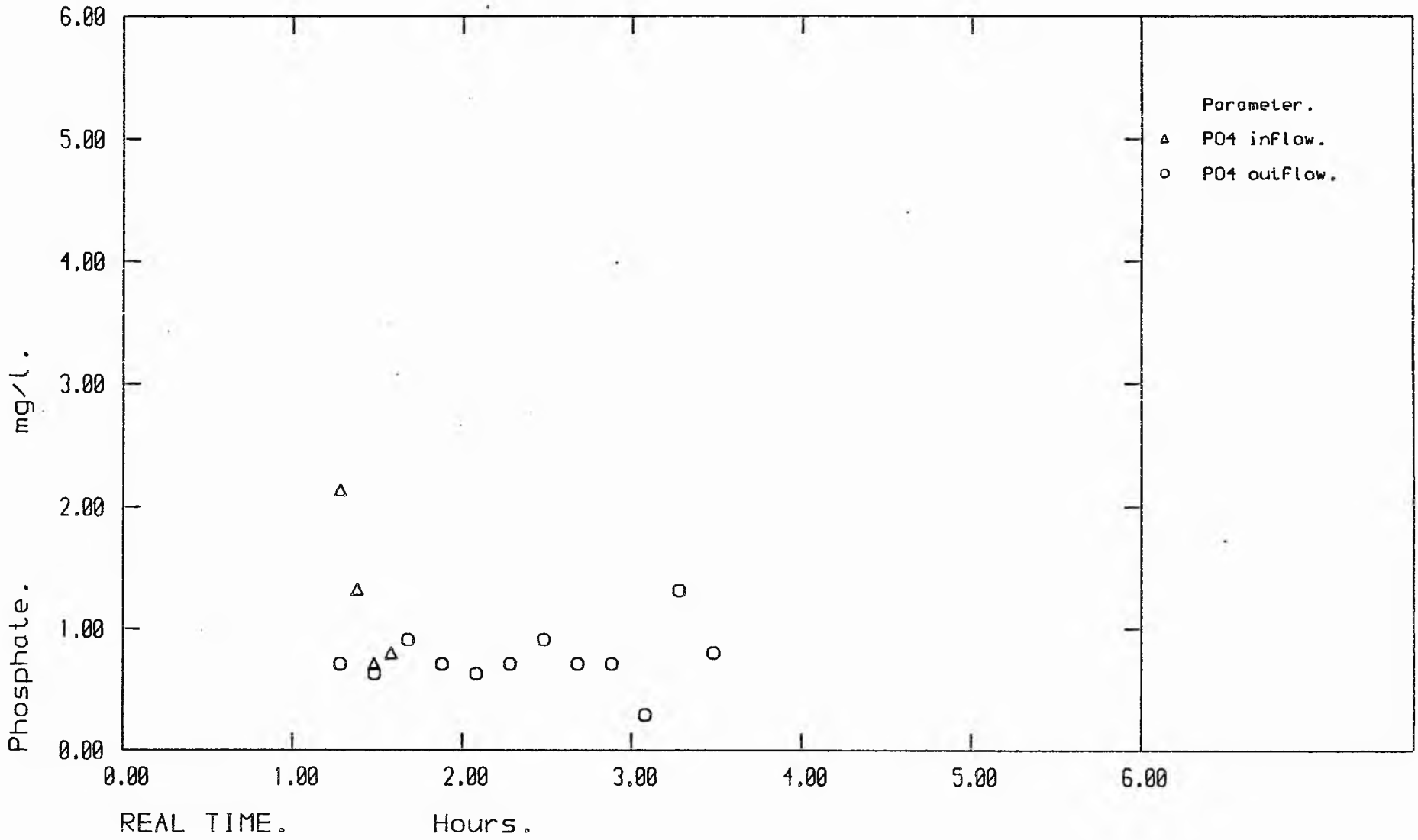
Close.
quality data.



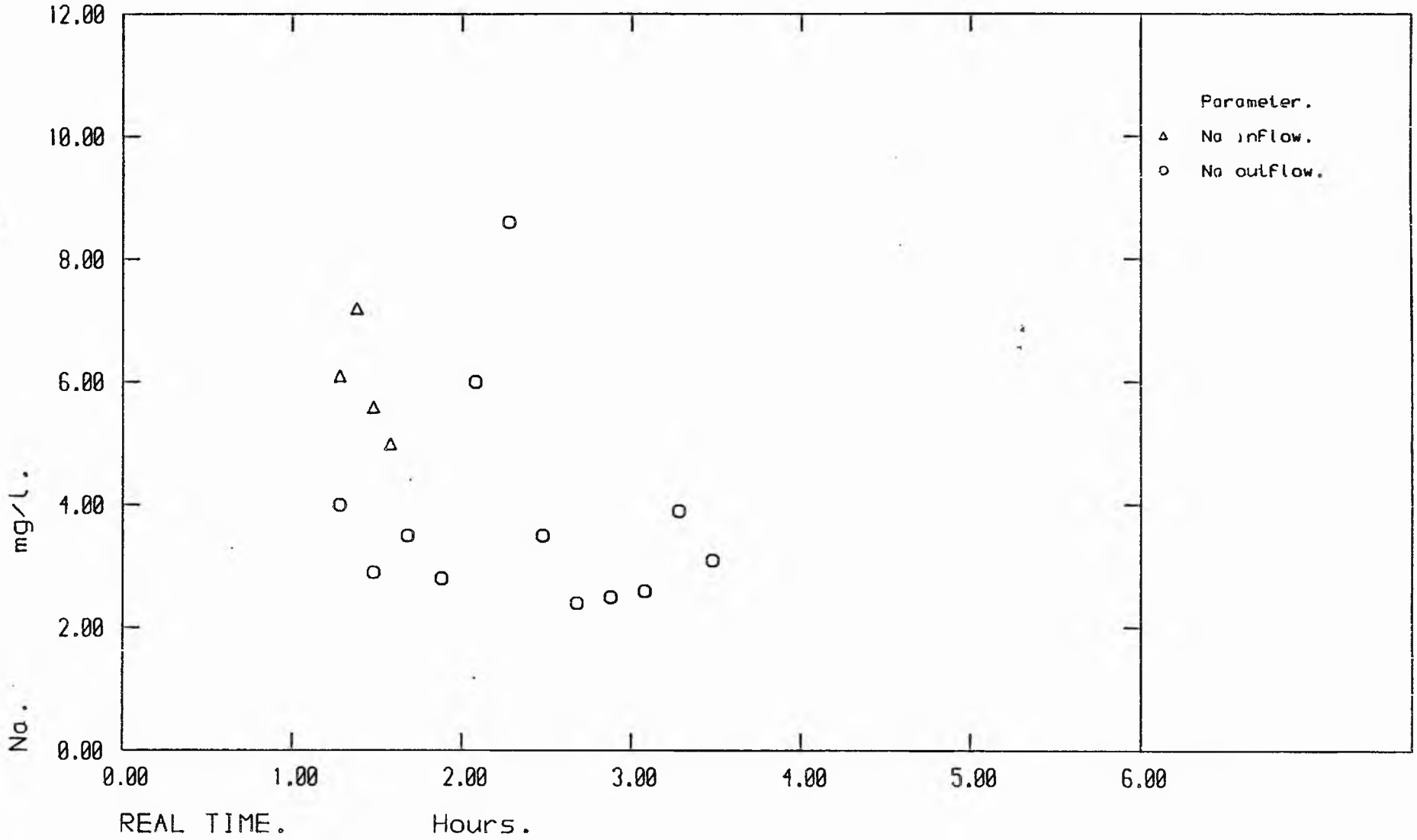
Graph of Ammonia For Storm V on Churnet Close.
The graph shows inflow and outflow water quality data.



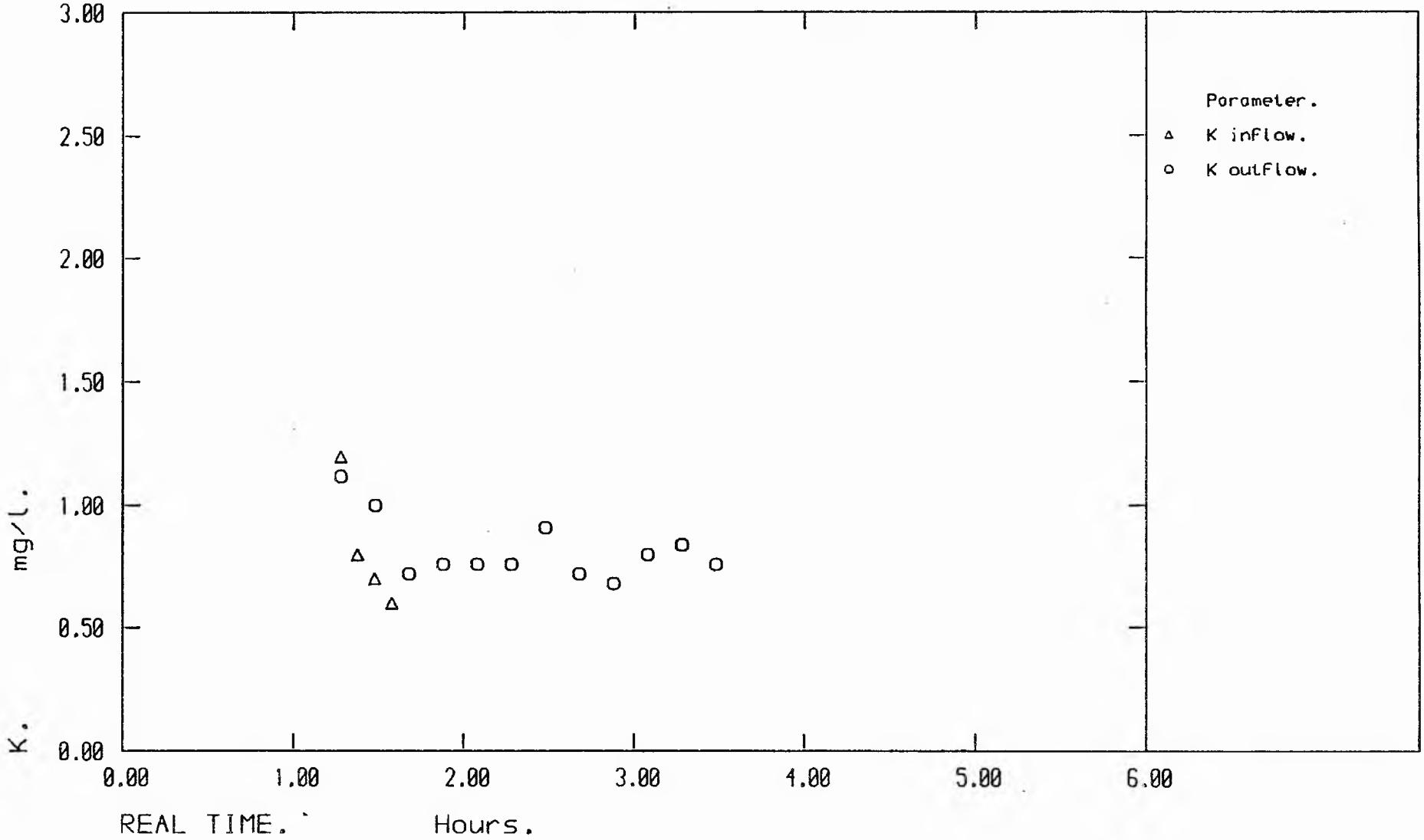
Graph of Nitrate for Storm V on Churnet Close.
The graph shows inflow and outflow water quality data.



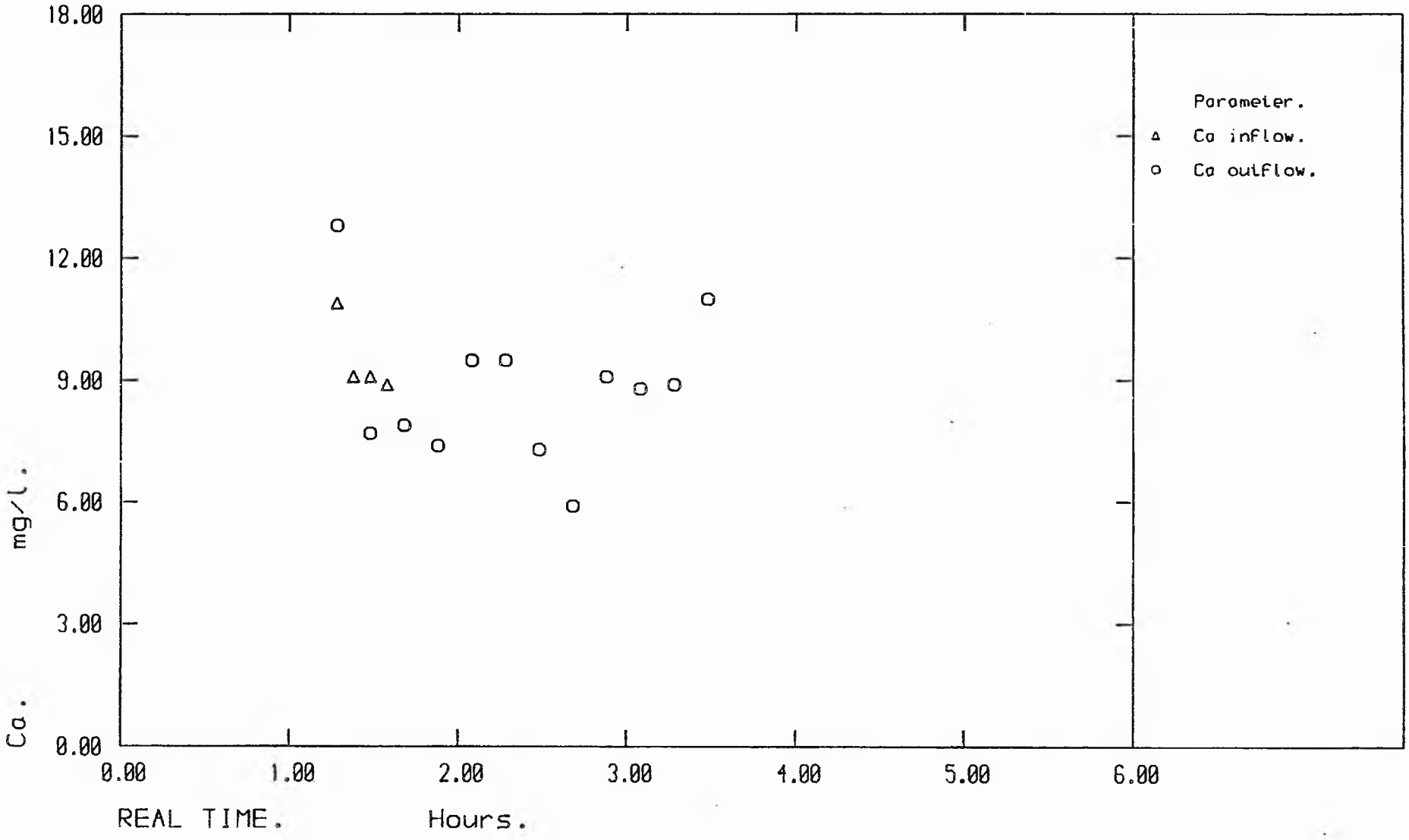
Graph of Phosphate for Storm V on Churnet Close.
The graph shows inflow and outflow water quality data.



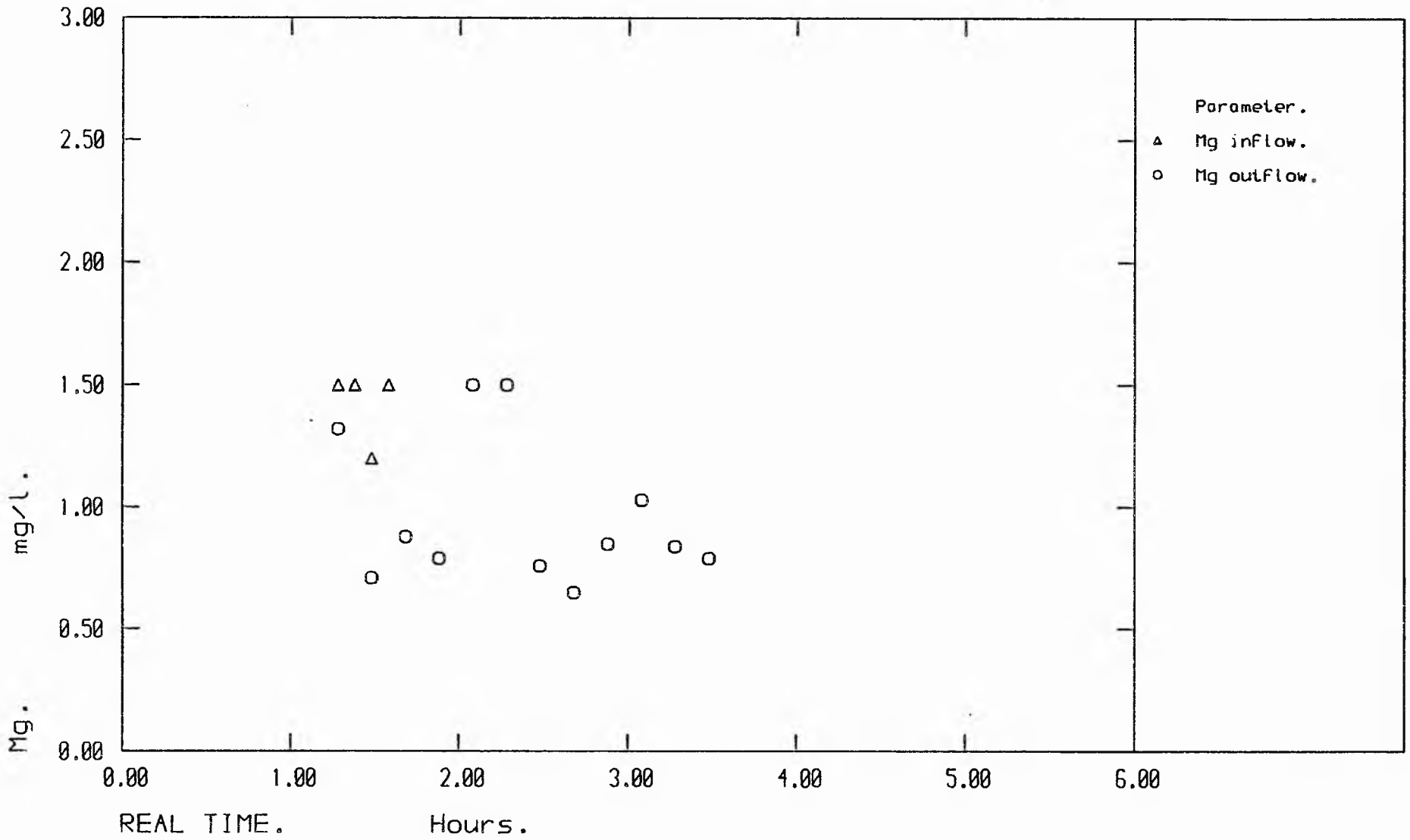
Graph of Sodium for Storm V on Churnet Close.
The graph shows inflow and outflow water quality data.



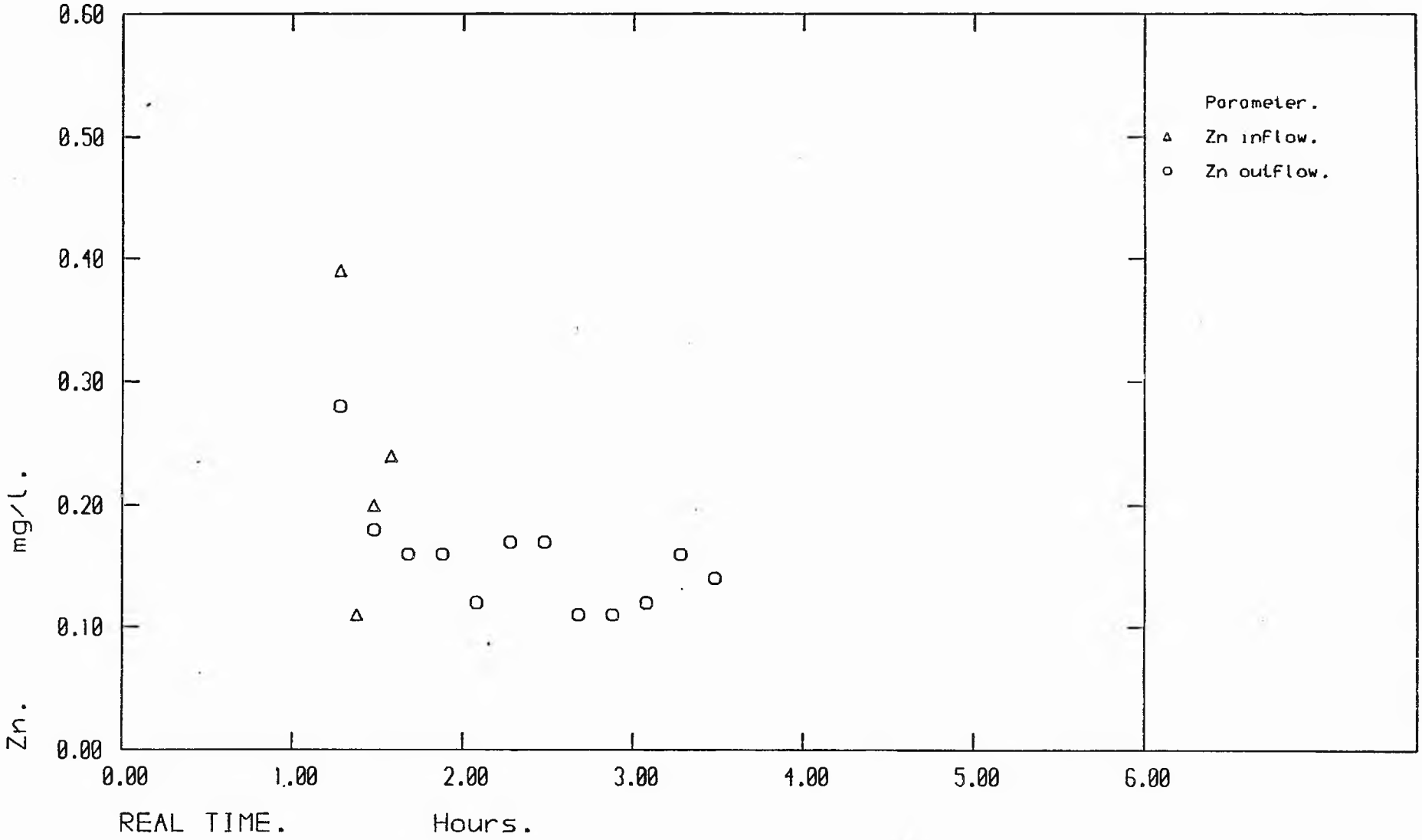
Graph of Potassium for Storm V on Churnet Close.
The graph shows inflow and outflow water quality data.



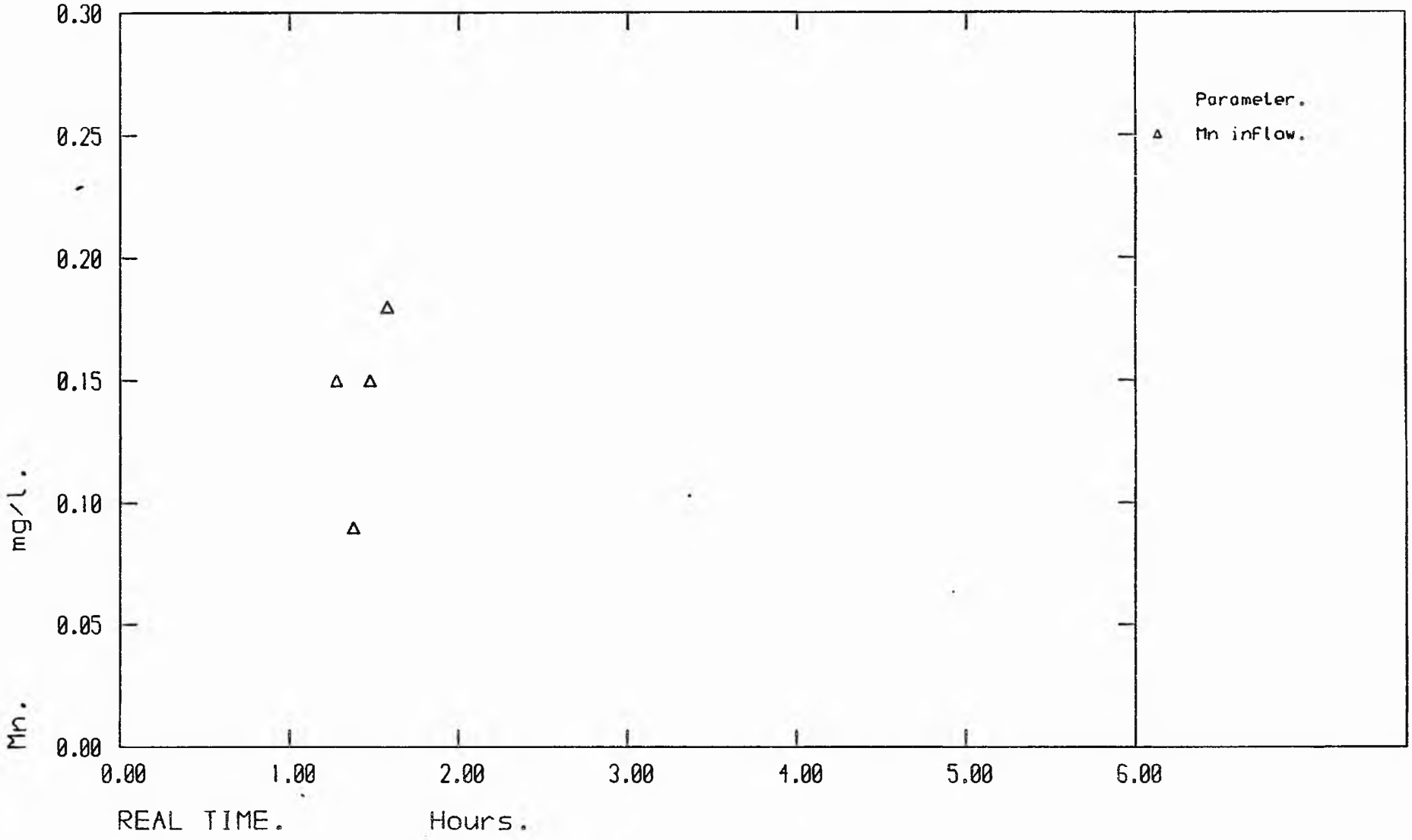
Graph of Calcium for Storm V on Churnet Close.
The graph shows inflow and outflow water quality data.



Graph of Magnesium for Storm V on Churnet Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm V on Churnet Close.
The graph shows inflow and outflow water quality data.



Graph of Manganese for Storm V on Churnet Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens

DATE OF THE STORM EVENT : 8th. October 1984 (841008)

STORM NUMBER : V

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
0117	23	11	82
0129	6	7	109
0141	5	3	27
0153	17	2	0
0205	15	4	27
0217	14	8	16
0229	11	5	158
0241	0	7	77
0253	9	5	87
0305	32	4	38
0317	10	0	60
0329	12	2	55

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
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STORM NUMBER : V

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	pH pH units
0117	0.19	6.4
0129	0.12	6.1
0141	0.11	6.0
0153	0.09	6.1
0205	0.09	5.8
0217	0.09	5.9
0229	0.09	5.8
0241	0.10	5.7
0253	0.09	6.1
0305	0.09	6.0
0317	0.09	6.0
0329	0.08	5.9

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
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ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
0117	60.0	70.0	0	26.6
0129	70.0	50.0	135	24.8
0141	40.0	40.0	0	21.3
0153	35.0	35.0	34	23.0
0205	40.0	35.0	86	23.0
0217	35.0	35.0	207	19.5
0229	35.0	35.0	24	24.8
0241	35.0	40.0	62	30.1
0253	45.0	30.0	24	23.0
0305	45.0	30.0	130	19.5
0317	40.0	30.0	106	21.3
0329	30.0	30.0	58	21.3

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
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STORM NUMBER : V

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Phosphate mgl-1
0117	10.5	26.6	1.5
0129	0.8	51.8	1.2
0141	0.3	32.2	1.1
0153	0.6	*	1.1
0205	1.2	18.2	0.9
0217	1.3	18.2	0.9
0229	2.4	19.6	0.9
0241	7.3	12.9	1.1
0253	0.5	25.2	2.1
0305	0.4	21.0	2.1
0317	0.7	18.2	2.7
0329	1.8	6.3	1.7

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

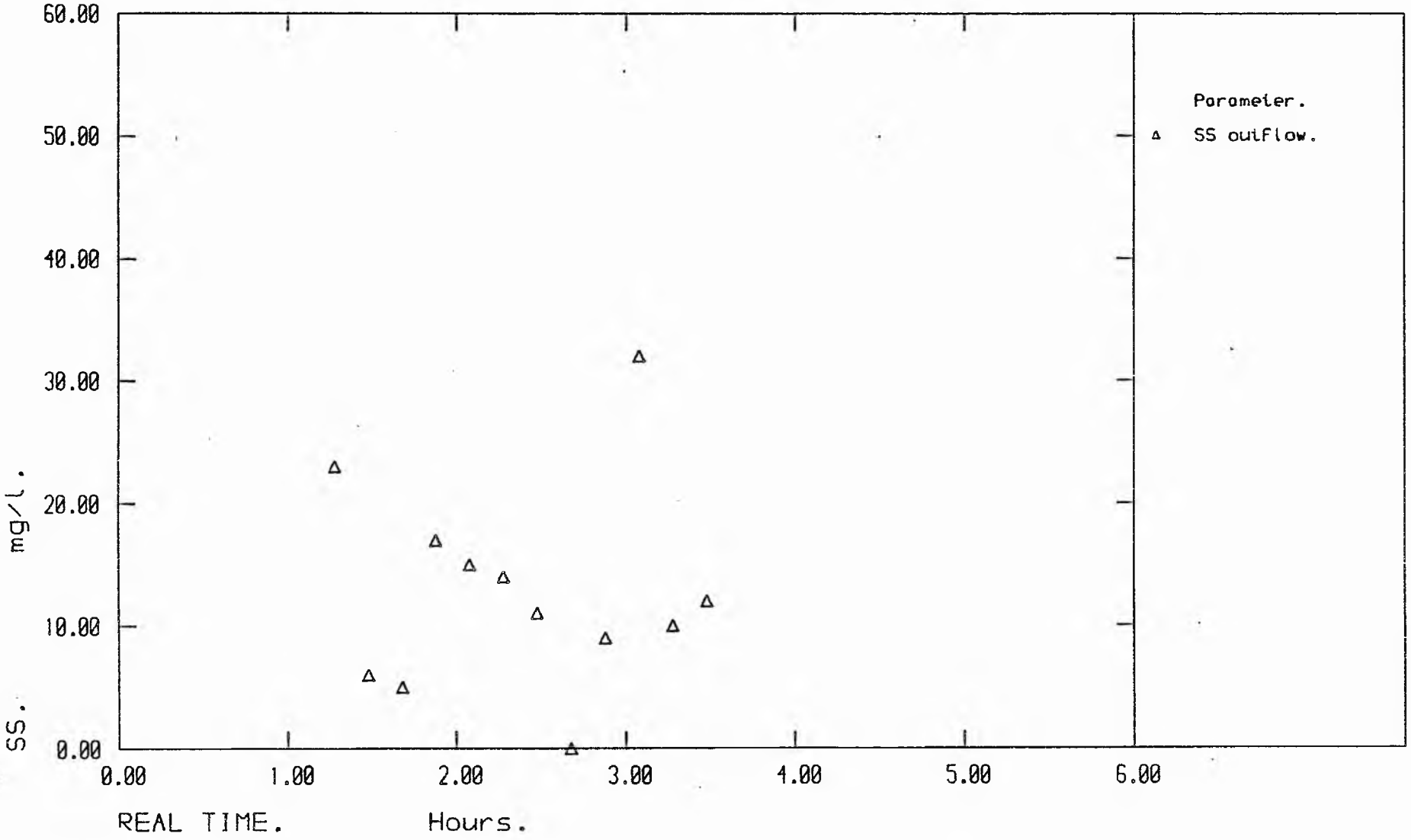
REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
0117	7.9	2.0	11.8	1.3
0129	6.1	1.4	10.0	1.1
0141	7.9	2.1	10.0	1.4
0153	6.3	1.2	10.9	1.3
0205	5.4	1.0	9.1	1.2
0217	6.1	1.1	9.1	1.2
0229	5.0	1.1	10.9	1.2
0241	6.5	0.9	10.0	1.3
0253	4.6	1.0	10.9	1.2
0305	7.9	1.1	9.1	1.4
0317	6.3	1.2	10.0	1.4
0329	6.1	1.0	9.1	1.2

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

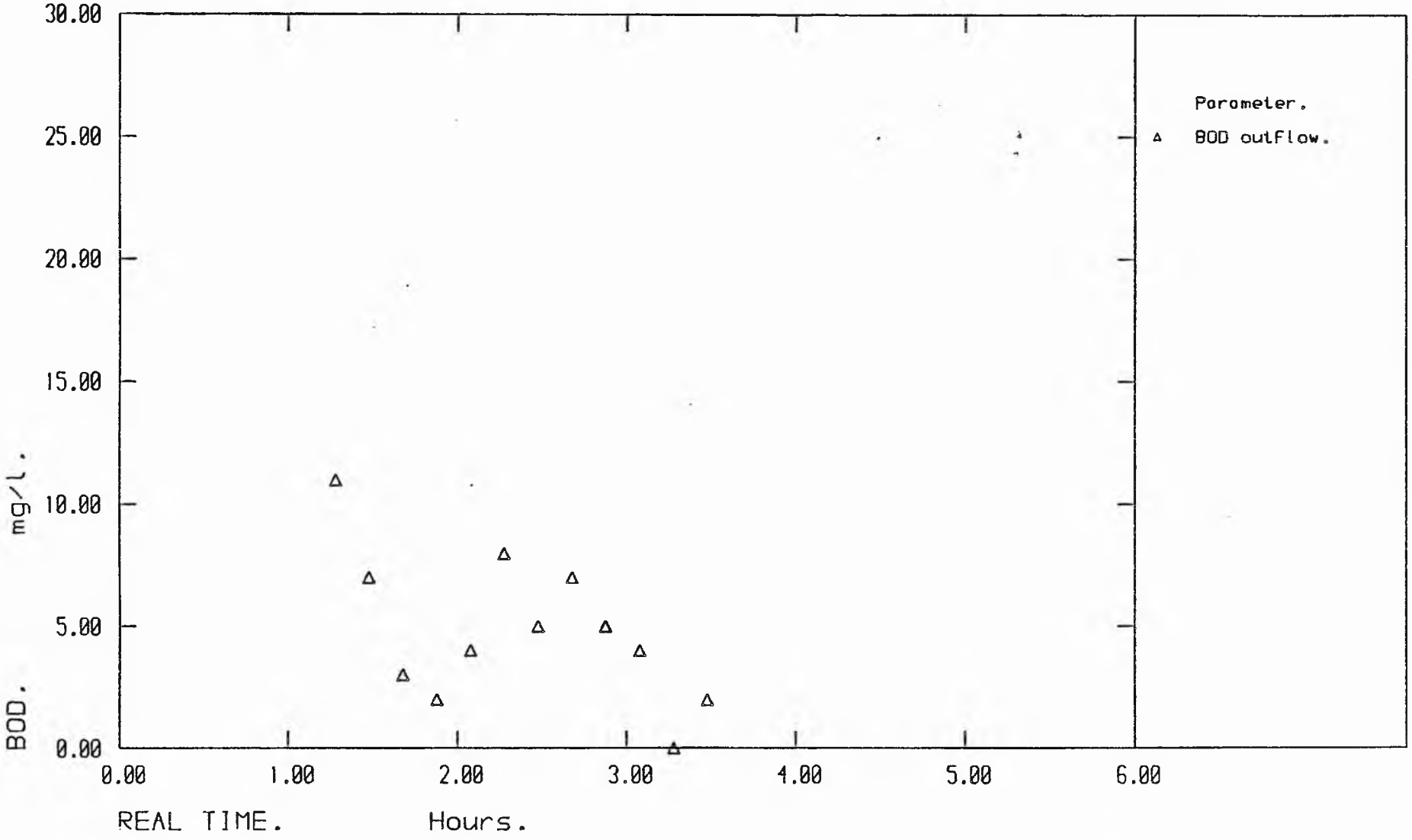
CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 8th. October 1984 (841008)
STORM NUMBER : V

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

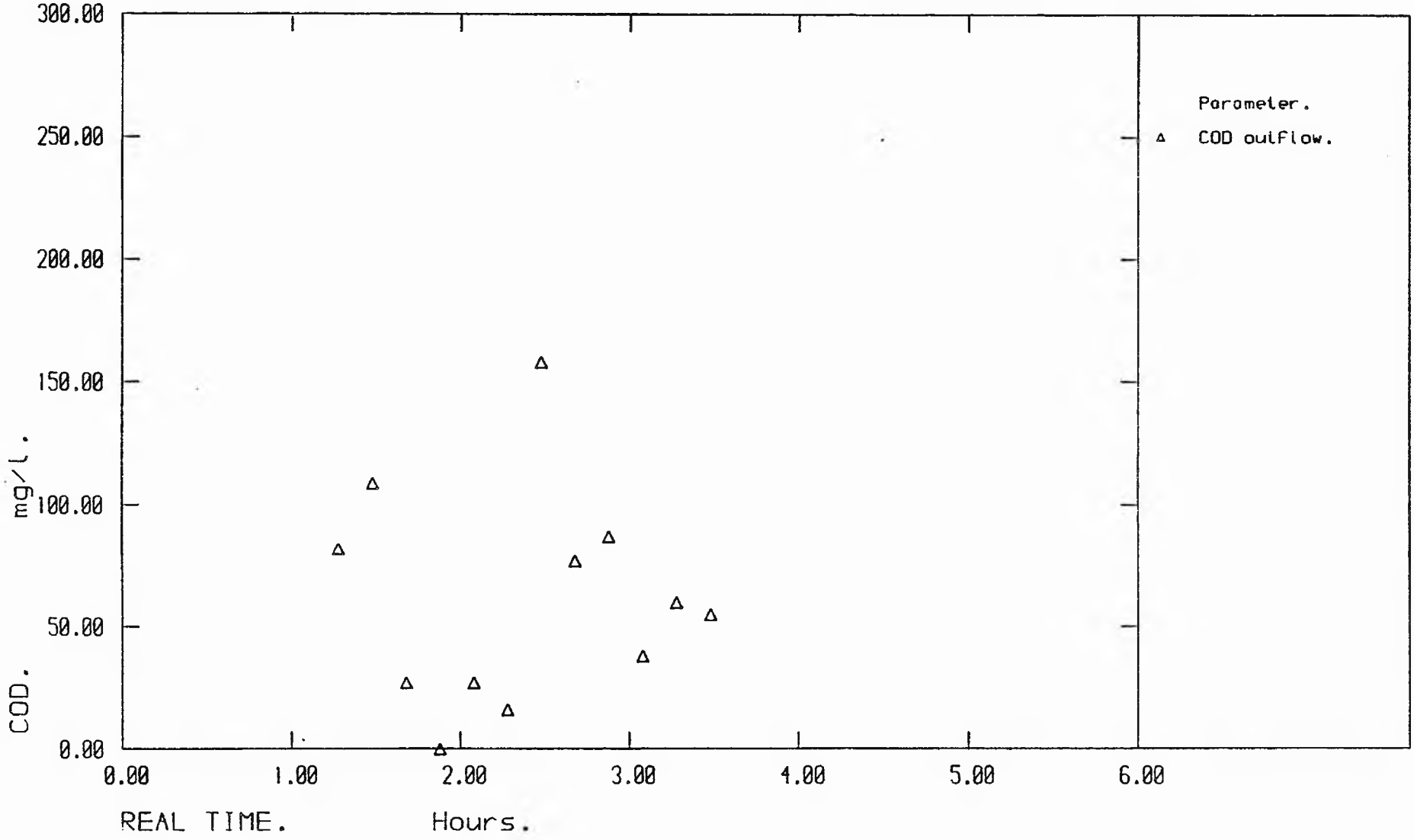
REAL TIME Hours	Zn mgl-1	Mn mgl-1
0117	0.3	0.2
0129	0.4	0.2
0141	0.4	0.2
0153	0.4	0.2
0205	0.2	0.2
0217	0.3	0.2
0229	0.3	0.2
0241	0.3	0.2
0253	0.3	0.2
0305	0.3	0.2
0317	0.2	0.2
0329	0.2	0.2



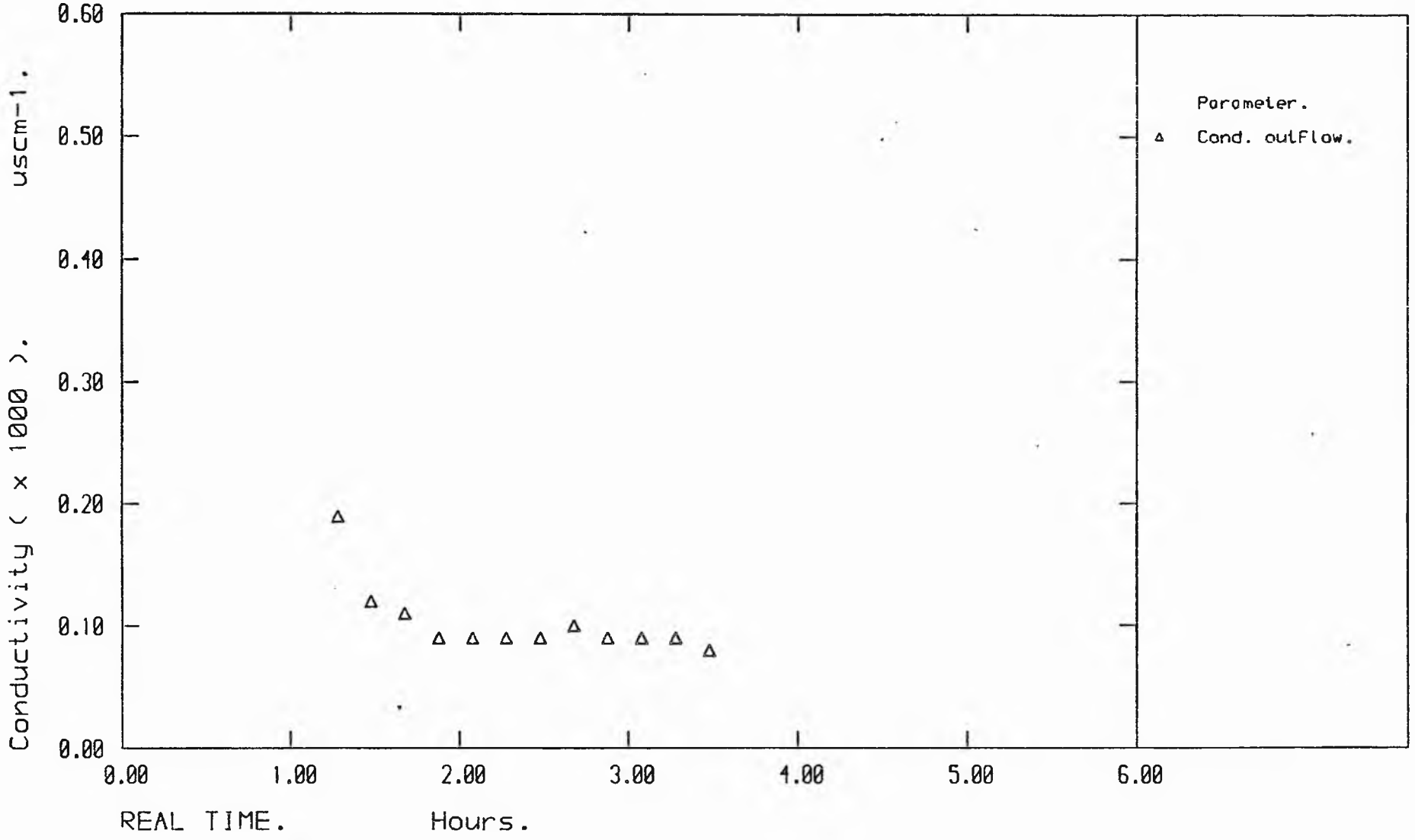
Graph of Suspended Solids for Storm V on Twyford Gardens.
The graph shows inflow and outflow water quality data.



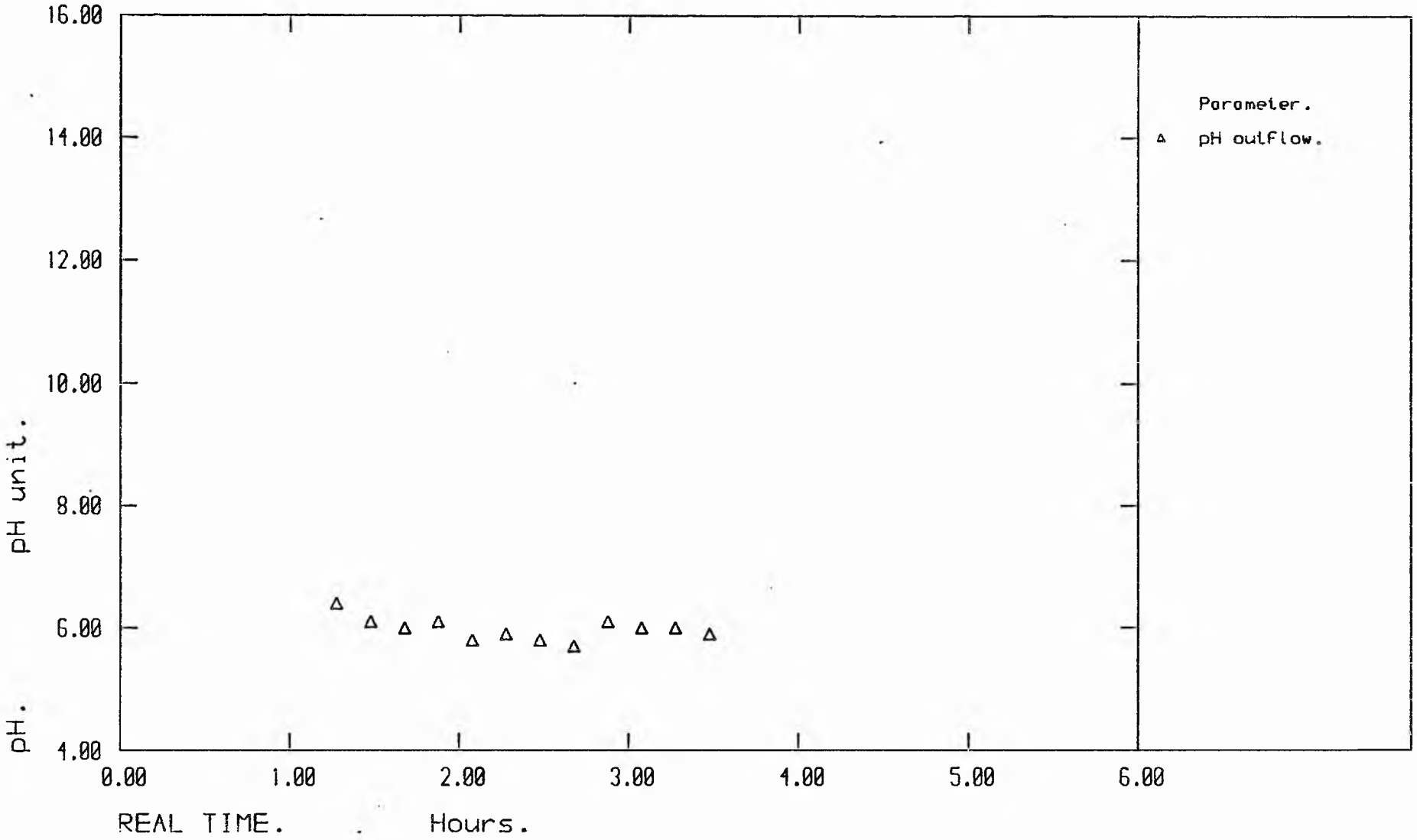
Graph of Biochemical Oxygen Demand for Storm V on Twyford Gardens.
The graph shows inflow and outflow water quality data.



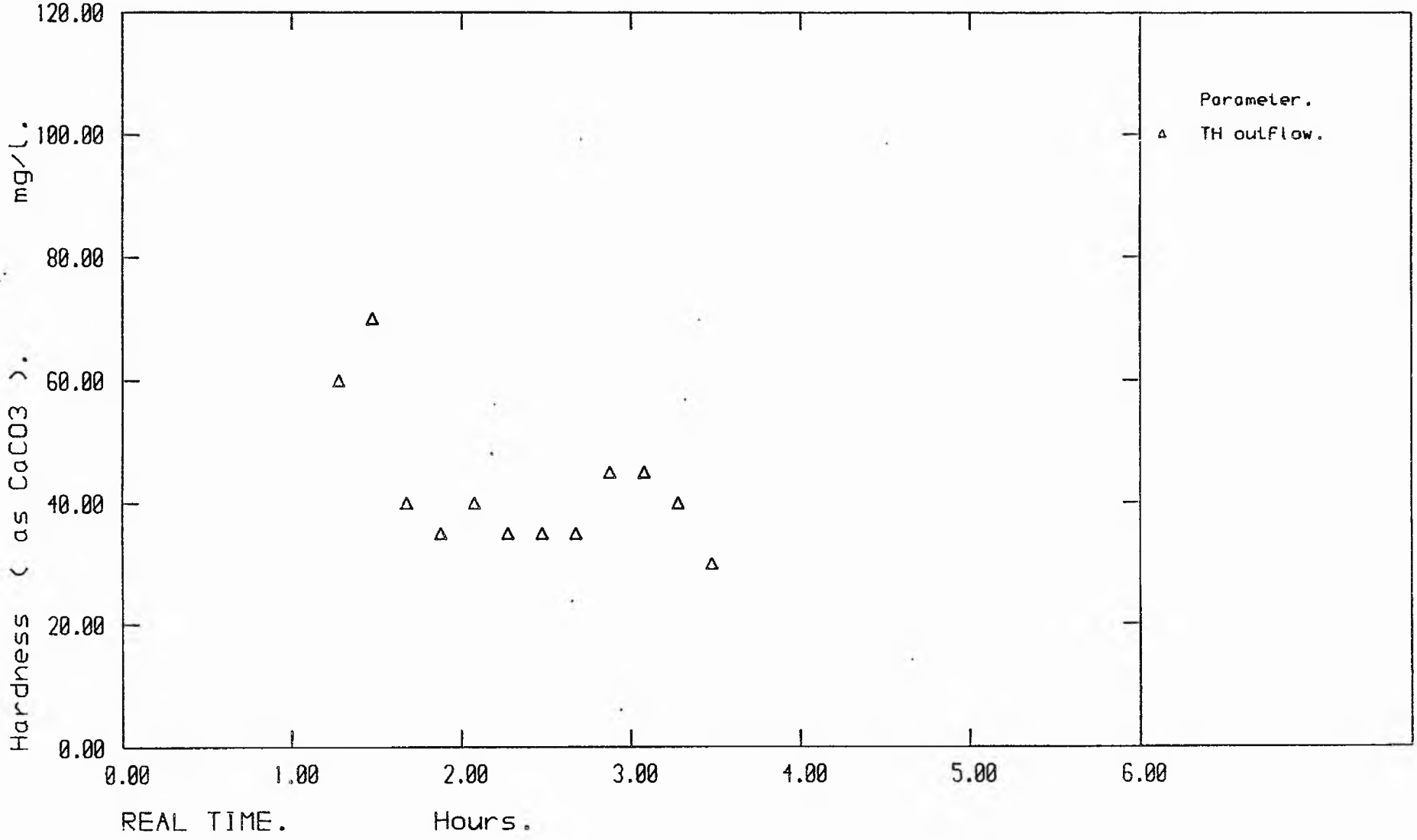
Graph of Chemical Oxygen Demand for Storm V on Twyford Gardens.
The graph shows inflow and outflow water quality data.



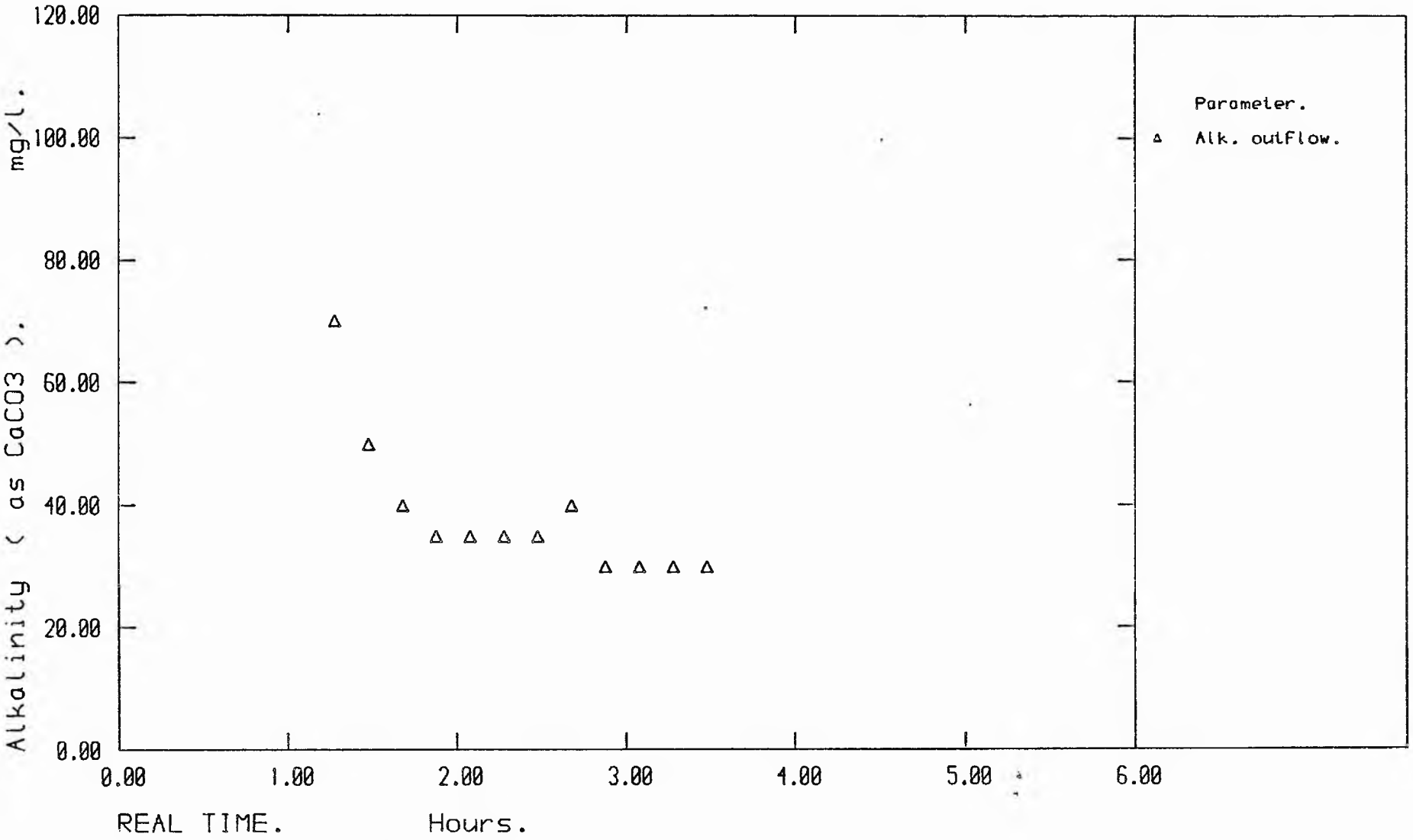
Graph of Conductivity for Storm V on Twyford Gardens.
The graph shows inflow and outflow water quality data.



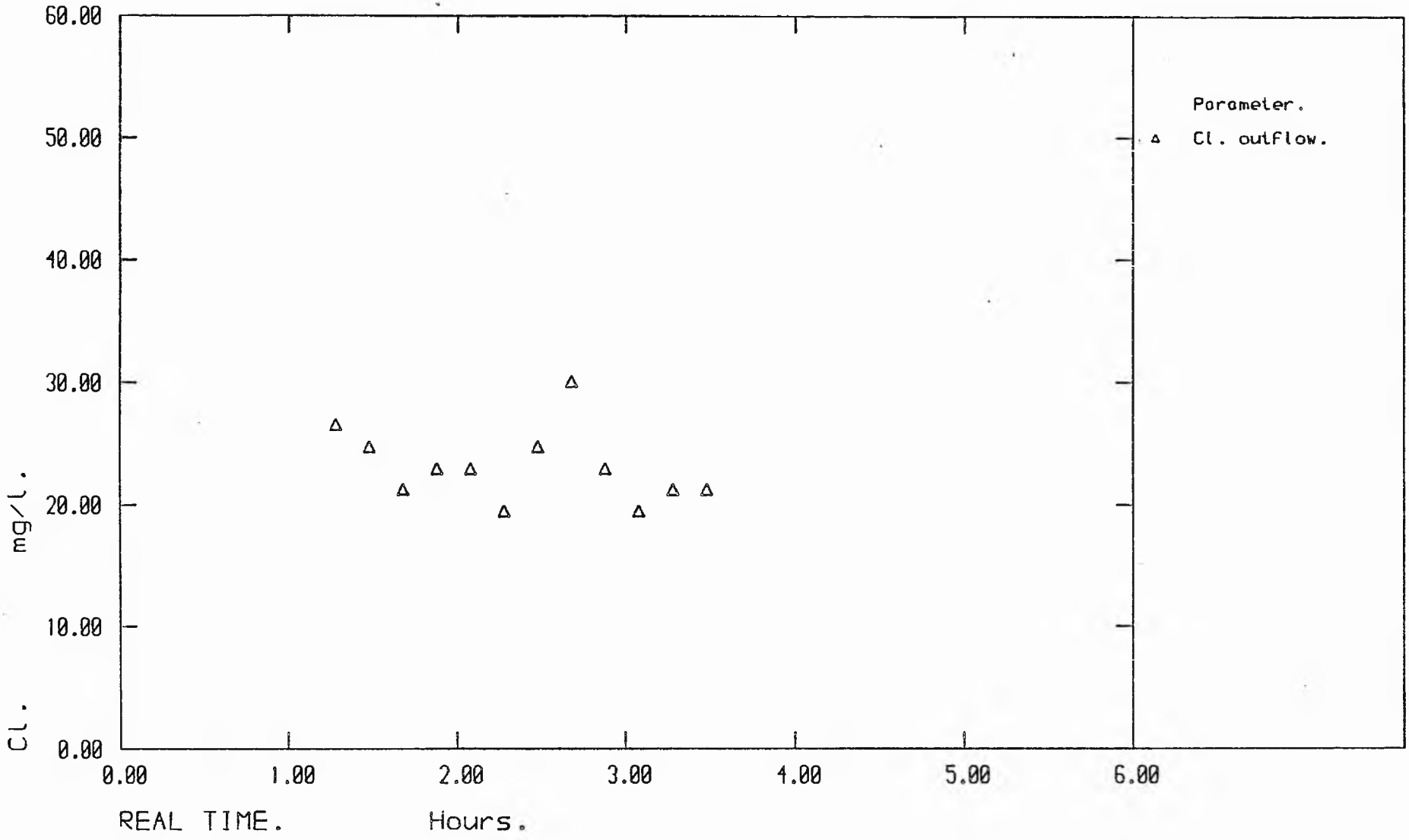
Graph of pH for Storm V on Twyford Gardens.
The graph shows inflow and outflow water quality data.



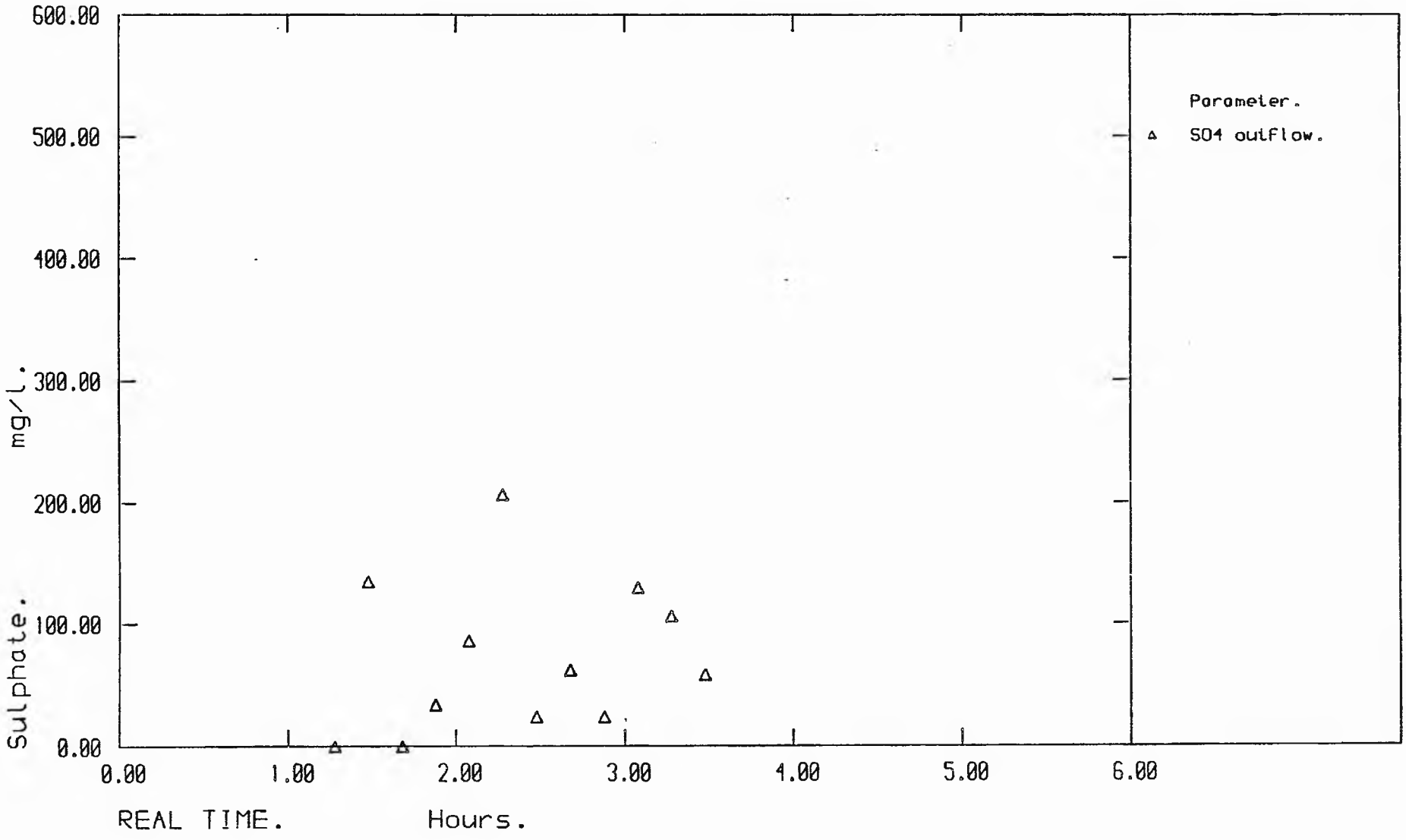
Graph of Total Hardness for Storm V on Twyford Gardens.
The graph shows inflow and outflow water quality data.



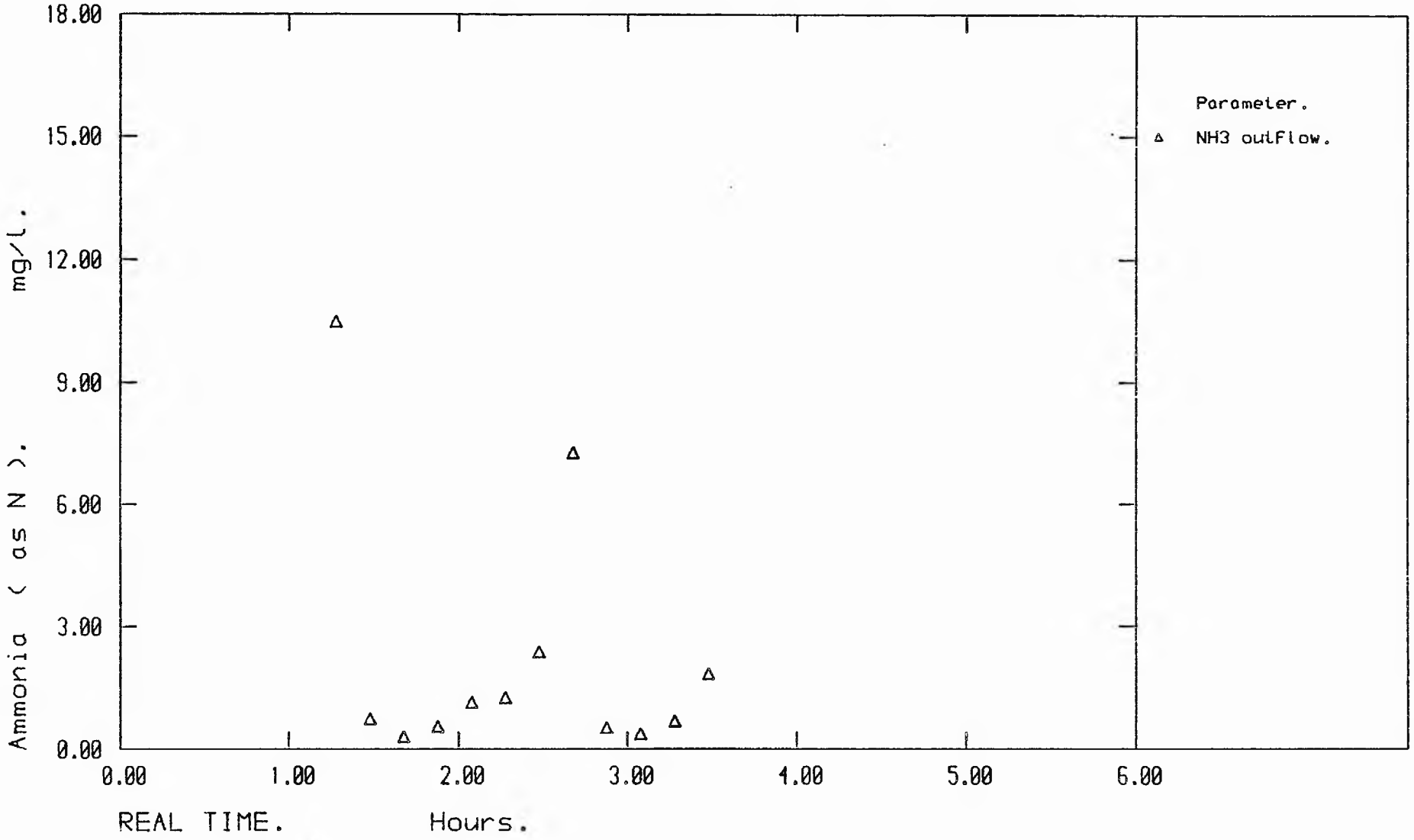
Graph of Total Alkalinity For Storm V on TwyFord Gardens.
The graph shows inflow and outflow water quality data.



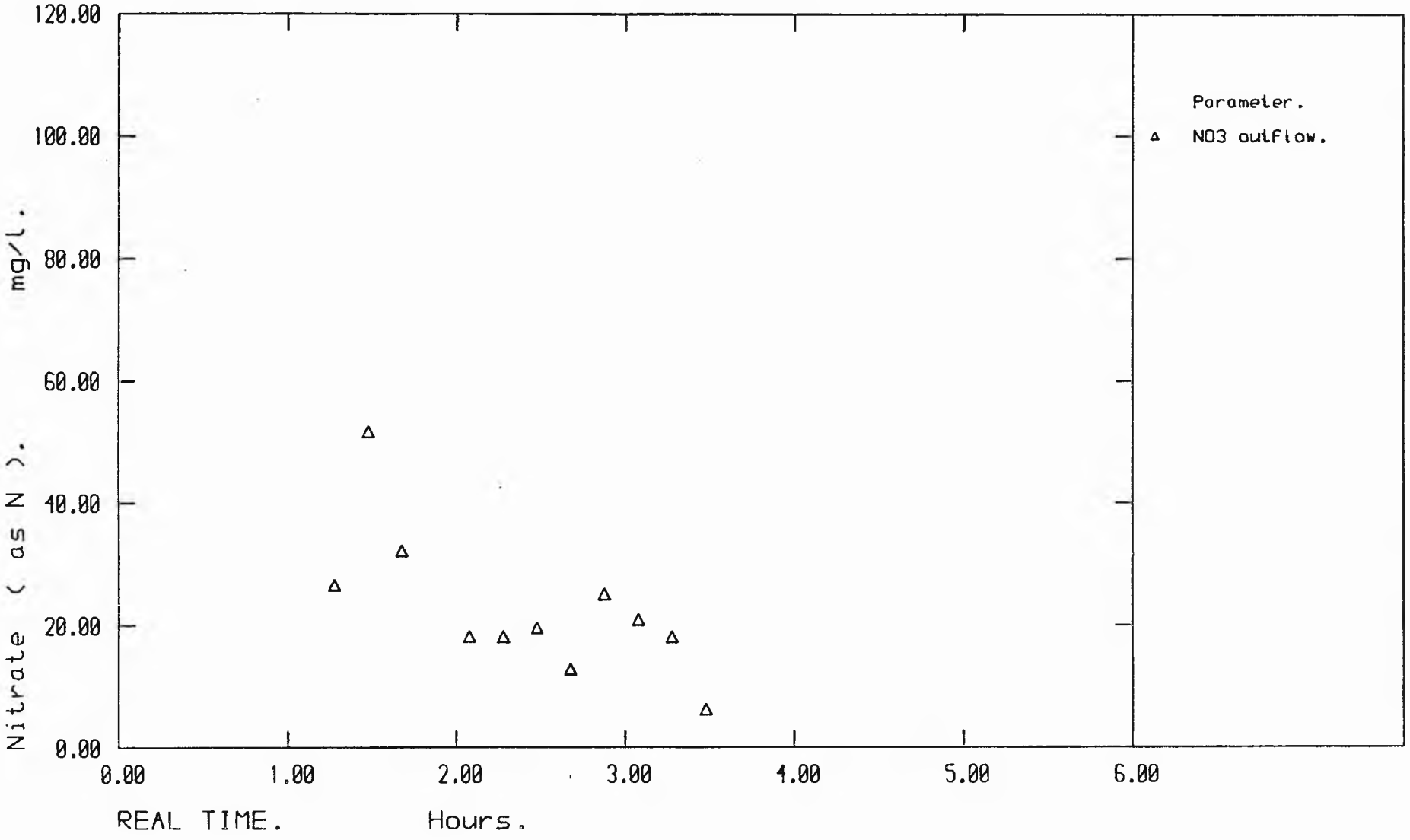
Graph of Chloride for Storm V on Twyford Gardens.
The graph shows inflow and outflow water quality data.



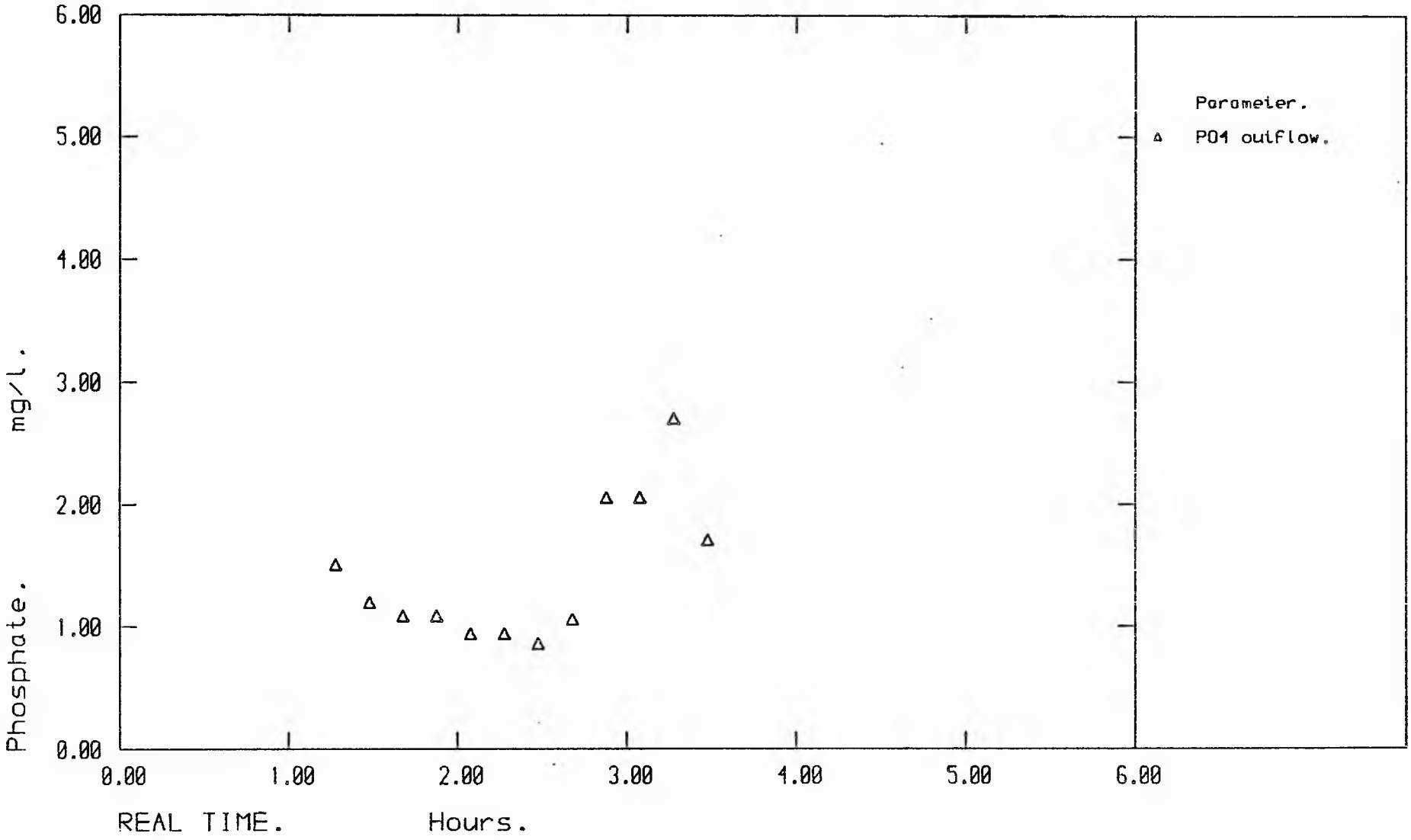
Graph of Sulphate for Storm V on Twyford Gardens.
The graph shows inflow and outflow water quality data.



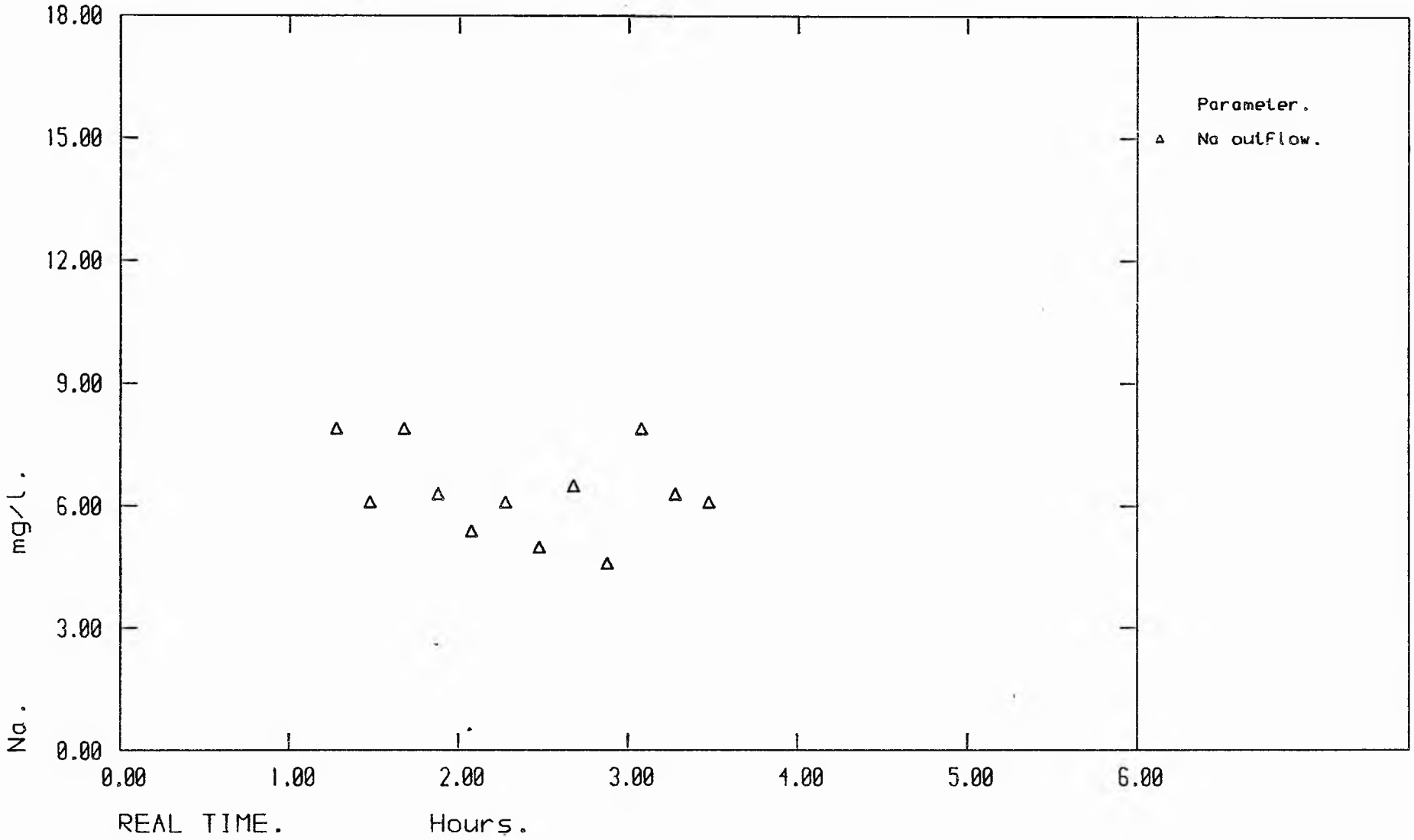
Graph of Ammonia for Storm V on Twyford Gardens.
The graph shows inflow and outflow water quality data.



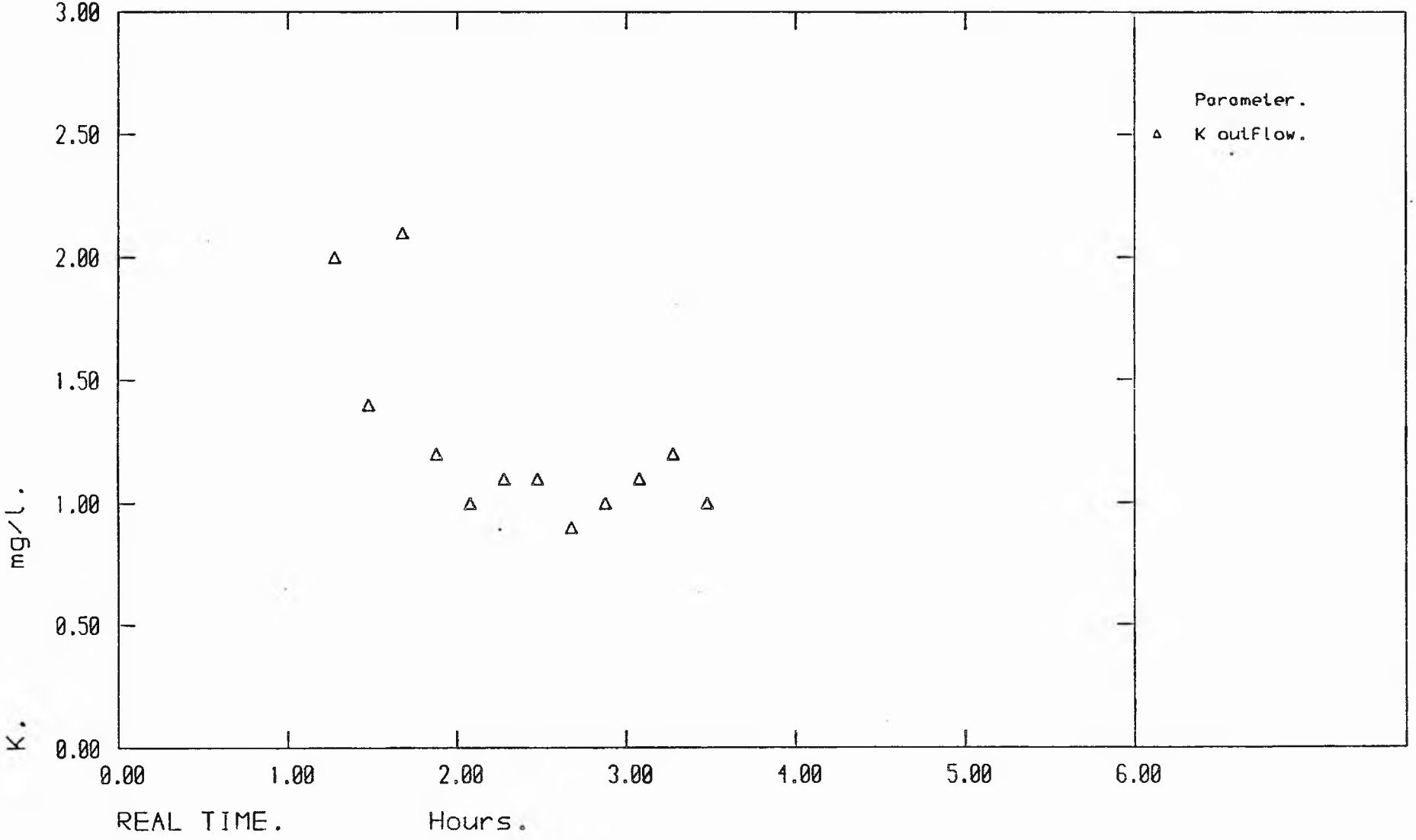
Graph of Nitrate for Storm V on Twyford Gardens.
The graph shows inflow and outflow water quality data.



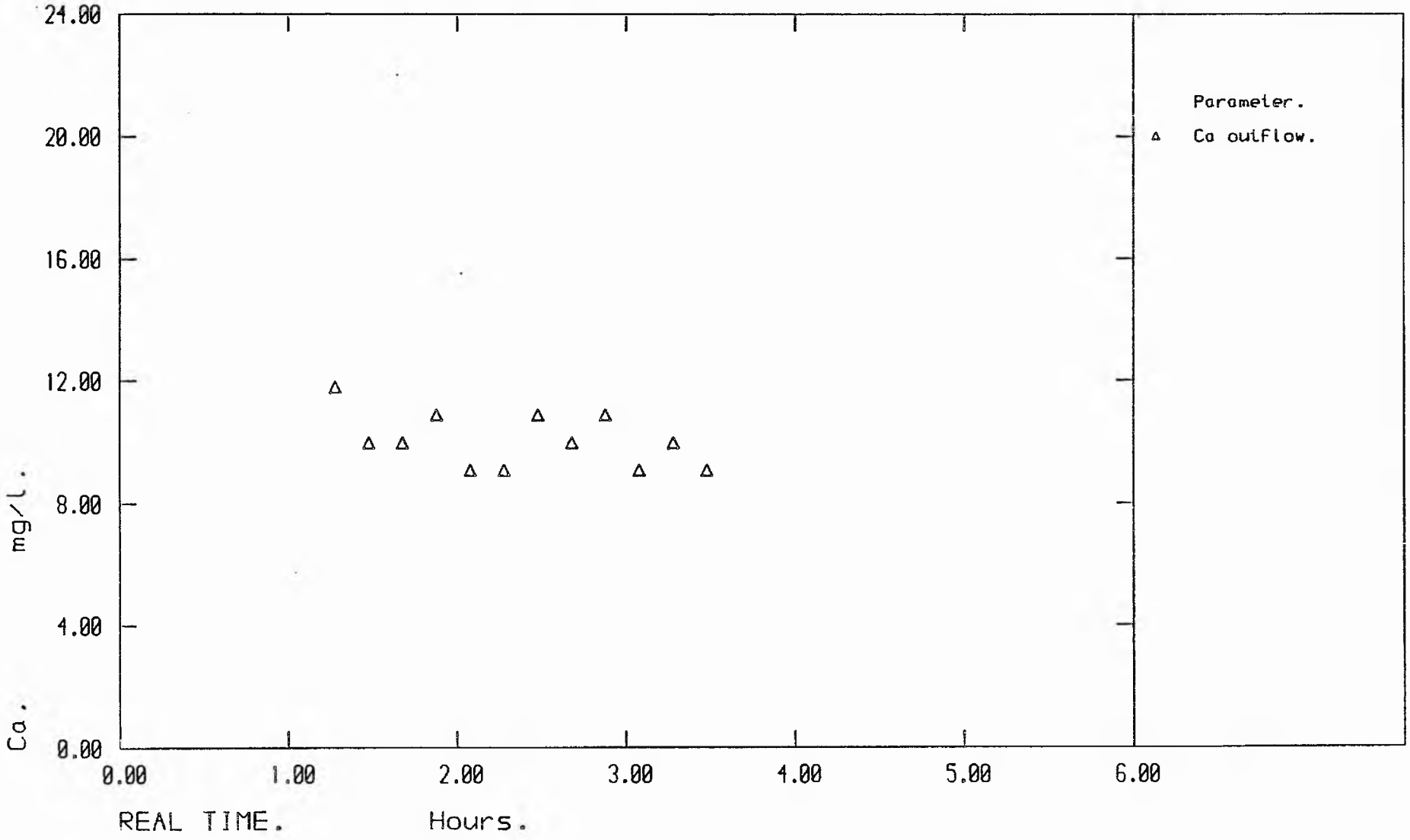
Graph of Phosphate for Storm V on TwyFord Gardens.
The graph shows inflow and outflow water quality data.



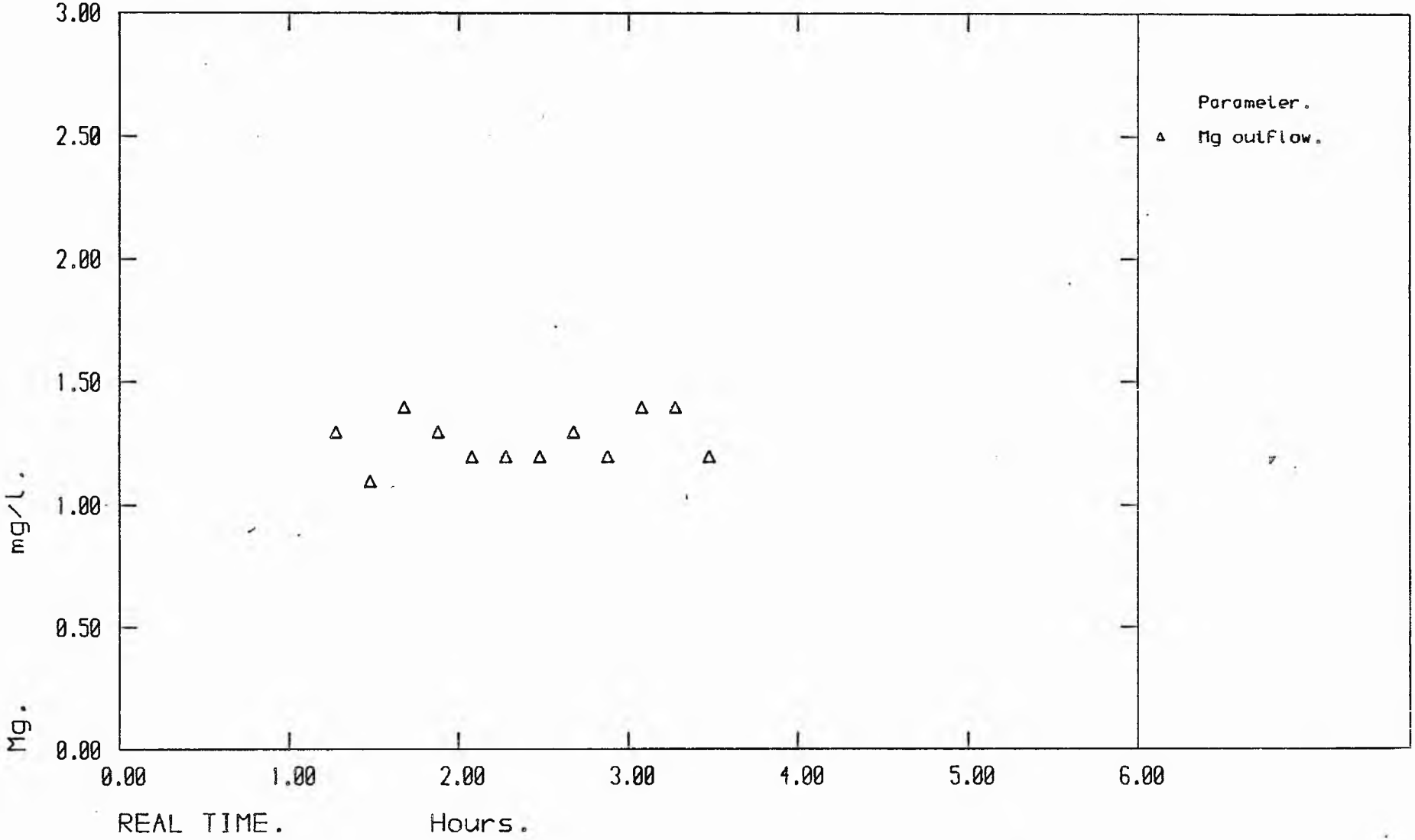
Graph of Sodium for Storm V on Twyford Gardens.
The graph shows inflow and outflow water quality data.



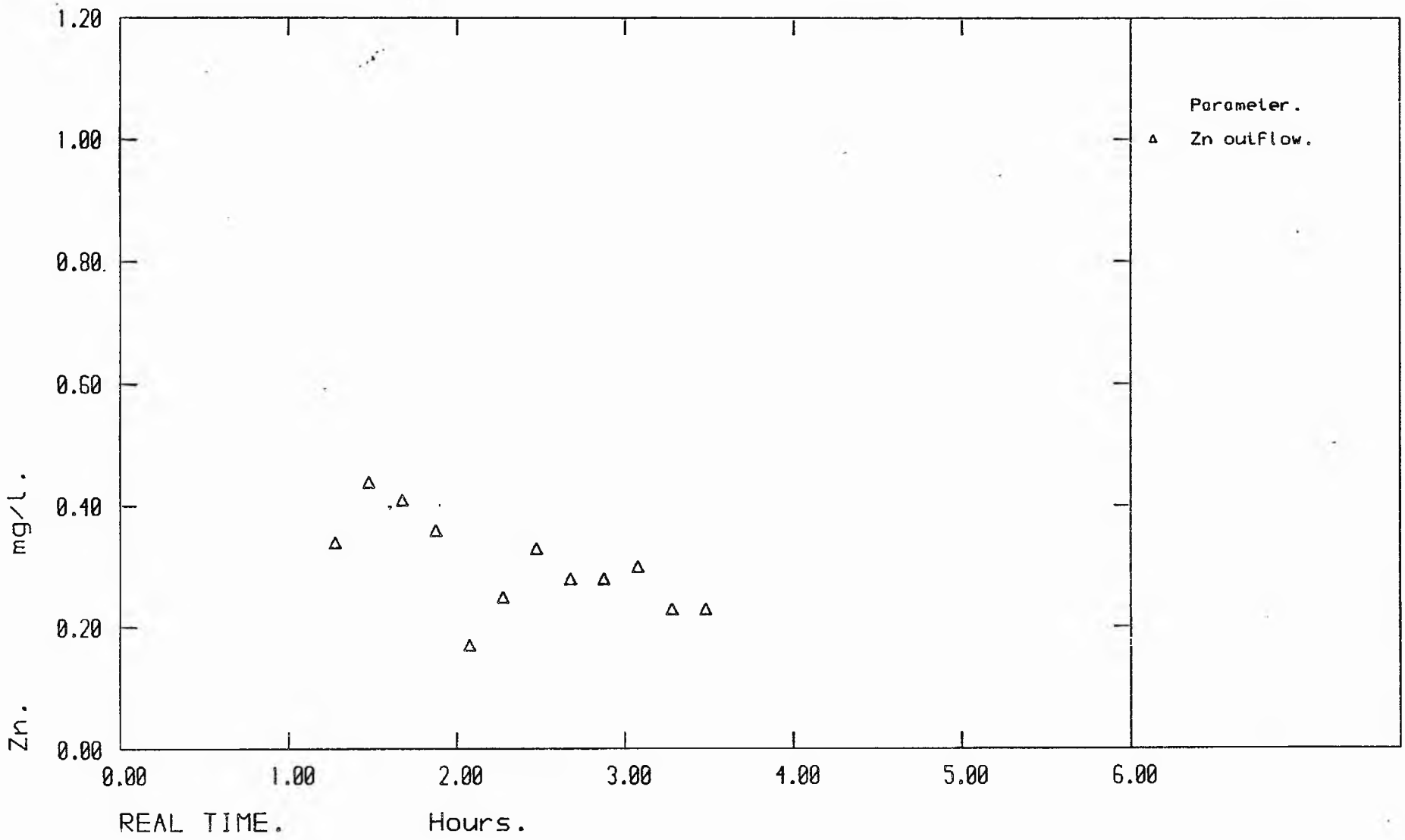
Graph of Potassium for Storm V on Twyford Gardens.
The graph shows inflow and outflow water quality data.



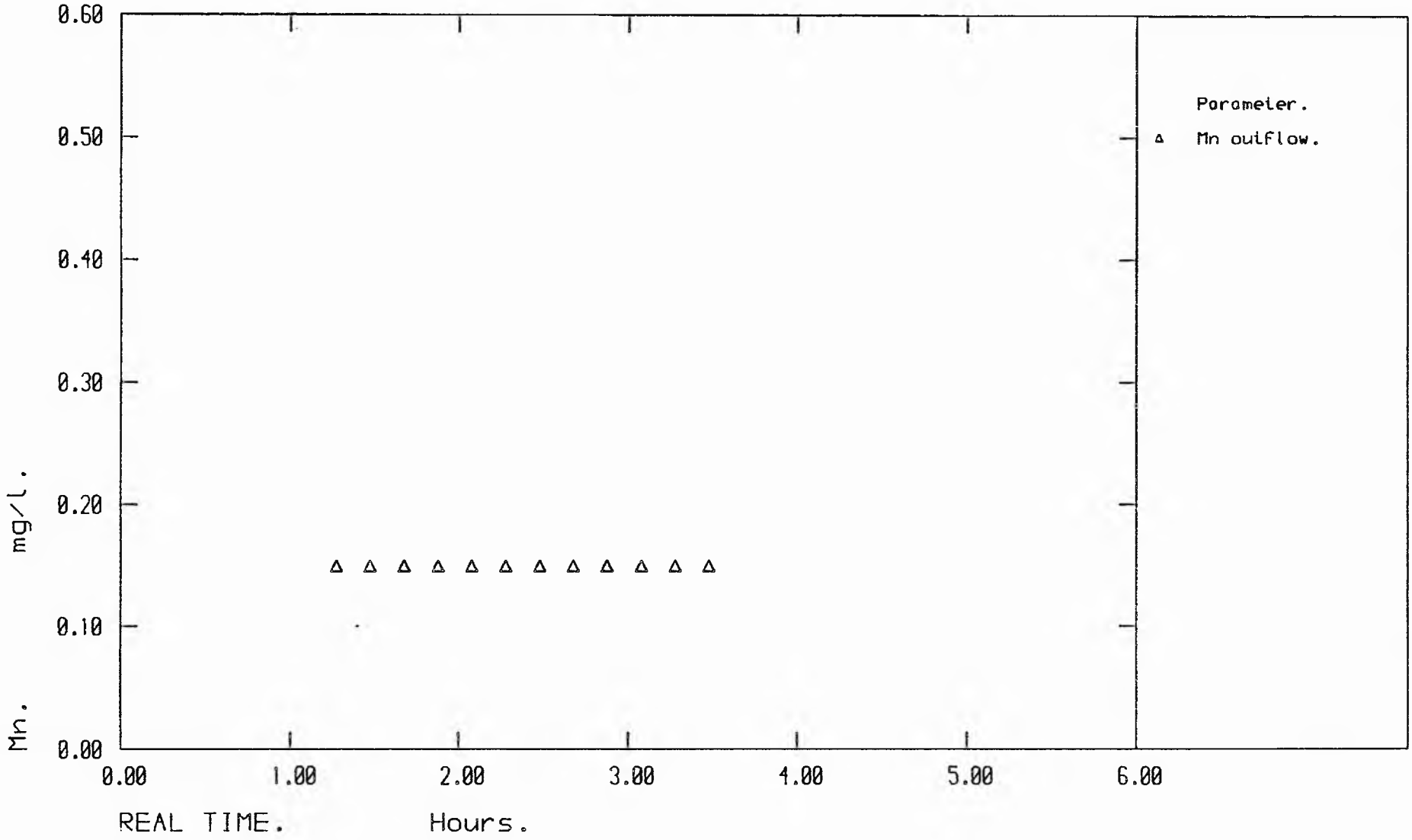
Graph of Calcium for Storm V on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Magnesium for Storm V on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Zinc For Storm V on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Manganese for Storm V on Twyford Gardens.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
1012	66	8	253
1018	117	60	222
1024	114	62	190
1030	60	7	169
1036	*	61	138
1042	87	62	180
1054	46	16	*
1118	154	61	275
1136	75	62	63
1154	97	15	153
1212	109	59	153
1230	87	63	201

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
1012	43	13	58
1024	50	*	85
1036	35	*	100
1048	28	13	122
1100	23	*	122
1112	19	*	100
1124	78	16	138
1136	56	*	127
1148	39	*	132
1200	30	7	122
1212	28	*	127
1224	30	12	90

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
1012	0.30	4.7	6.1
1018	0.21	4.7	6.2
1024	0.21	4.3	6.2
1030	0.11	4.7	6.2
1036	0.13	4.7	6.1
1042	0.11	4.7	6.1
1054	0.11	5.0	6.1
1118	0.12	5.5	6.1
1136	0.11	5.5	6.0
1154	0.11	5.3	6.0
1212	0.12	5.4	6.1
1230	0.11	5.4	6.1

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VT

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
1012	0.30	5.1	6.4
1024	0.22	5.3	6.6
1036	0.21	5.3	6.4
1048	0.25	5.3	6.4
1100	0.23	5.5	6.3
1112	0.25	5.3	6.3
1124	0.25	5.7	6.3
1136	0.21	5.7	6.1
1148	0.18	6.0	6.1
1200	0.20	6.0	6.0
1212	0.15	5.7	6.0
1224	0.15	5.7	6.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
1012	40.0	180.0	163	17.7
1018	30.0	190.0	29	21.3
1024	40.0	130.0	144	21.3
1030	30.0	170.0	106	17.7
1036	40.0	110.0	115	24.8
1042	30.0	140.0	125	21.3
1048	30.0	*	*	*
1112	50.0	140.0	106	24.8
1118	30.0	140.0	96	14.2
1124	30.0	*	*	*
1130	20.0	*	*	*
1136	20.0	140.0	86	21.3
1142	20.0	*	*	*
1148	20.0	*	*	*
1154	20.0	180.0	58	21.3
1200	20.0	*	*	*
1206	30.0	*	*	*
1212	30.0	150.0	58	24.8
1218	20.0	*	*	*
1224	30.0	*	*	*
1230	30.0	150.0	77	38.9

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
1012	50.0	120.0	327	21.3
1024	*	90.0	*	38.9
1036	*	180.0	*	21.3
1048	40.0	130.0	279	24.8
1100	*	70.0	*	28.4
1112	*	110.0	*	24.8
1124	*	130.0	*	42.5
1136	30.0	140.0	221	71.0
1148	*	200.0	*	24.8
1200	*	120.0	*	7.1
1212	*	120.0	*	28.4
1224	20.0	160.0	259	42.5

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Phosphate mgl-1
1012	2.9	21.7	1.3
1018	3.9	33.6	1.3
1024	2.4	30.8	1.1
1030	4.1	12.6	1.1
1036	2.8	19.9	*
1042	3.1	19.9	0.9
1054	4.2	18.9	1.1
1118	3.5	18.9	1.1
1136	2.4	21.7	0.9
1154	2.4	10.9	0.9
1212	2.8	10.9	0.9
1230	2.8	10.9	1.0

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Phosphate mgl-1
1012	3.4	21.7	0.7
1024	2.9	30.8	0.6
1036	4.2	36.4	0.7
1048	4.2	40.6	0.9
1100	3.5	35.0	0.9
1112	3.4	43.4	0.5
1124	2.9	44.8	0.5
1136	4.2	56.0	0.9
1148	7.1	28.0	0.5
1200	2.6	28.0	0.2
1212	1.8	19.9	0.2
1224	1.7	11.5	0.2

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
1012	2.3	0.6	10.0	0.9
1018	2.0	0.5	8.7	0.8
1024	1.9	0.5	8.7	0.8
1030	2.0	0.6	8.7	0.7
1036	*	*	*	*
1042	2.0	0.5	8.7	0.7
1054	2.0	0.5	8.7	0.7
1118	1.7	0.4	8.7	0.7
1136	1.3	0.2	0.9	0.7
1154	1.7	0.4	7.5	0.5
1212	1.5	0.4	8.7	0.5
1230	1.6	0.4	8.7	0.5

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
1012	2.5	0.9	13.8	1.0
1024	2.3	0.7	11.2	0.9
1036	2.5	0.6	10.0	0.9
1048	2.1	0.6	10.0	0.8
1100	2.3	0.6	10.0	0.8
1112	2.1	0.6	10.0	0.8
1124	2.1	0.5	8.7	0.7
1136	1.9	0.4	6.3	0.5
1148	2.1	0.4	6.3	0.5
1200	2.1	0.4	6.3	0.5
1212	3.2	0.4	6.3	0.6
1224	2.8	0.3	6.3	0.6

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Mn mgl-1	Zn mgl-1
1012	0.1	0.1
1018	0.2	0.1
1024	0.2	0.1
1030	0.0	0.2
1036	*	*
1042	0.2	0.1
1054	0.1	0.1
1118	0.1	0.1
1136	0.0	0.1
1154	0.0	0.1
1212	0.0	0.1
1230	0.0	0.1

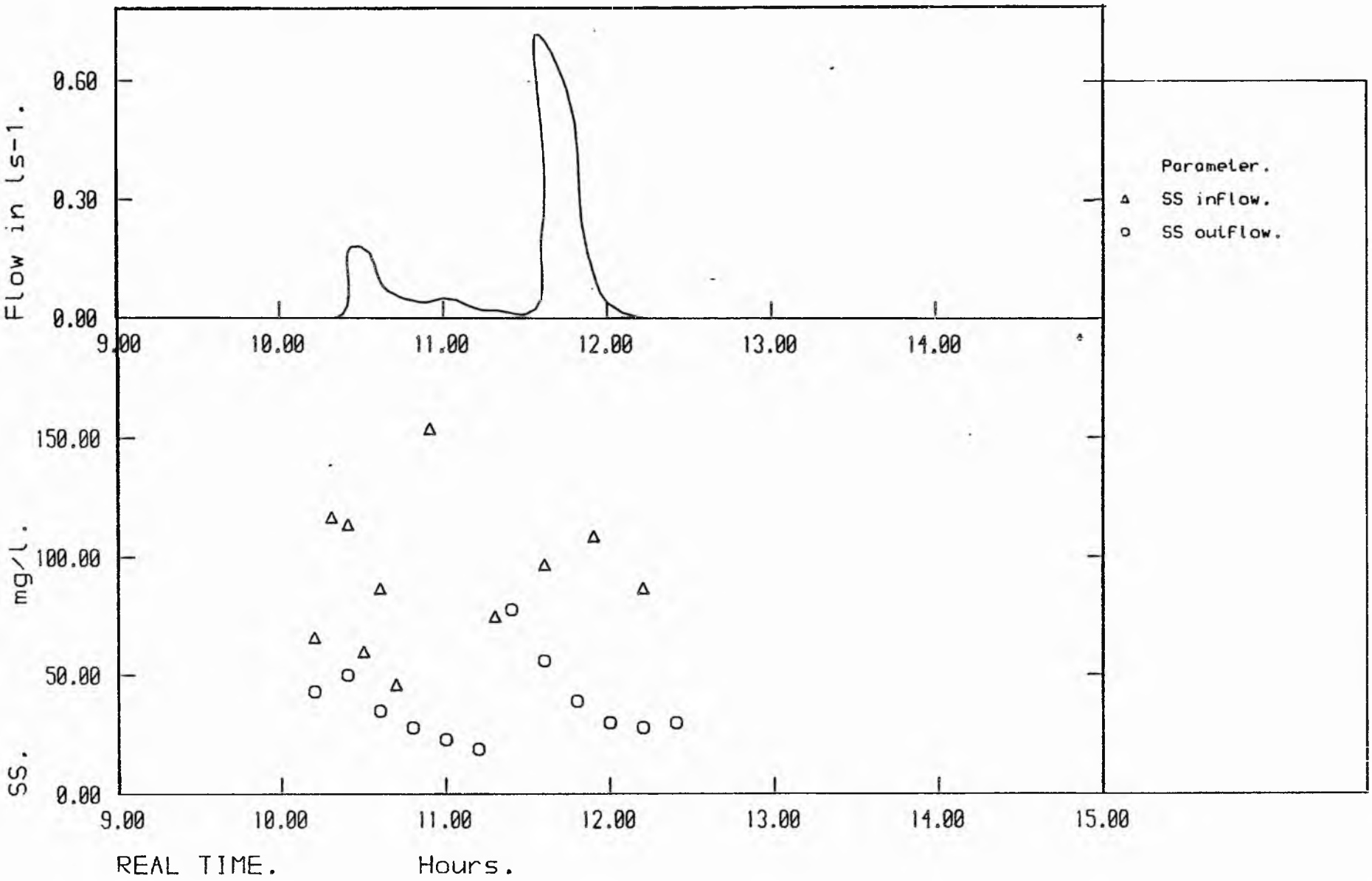
* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

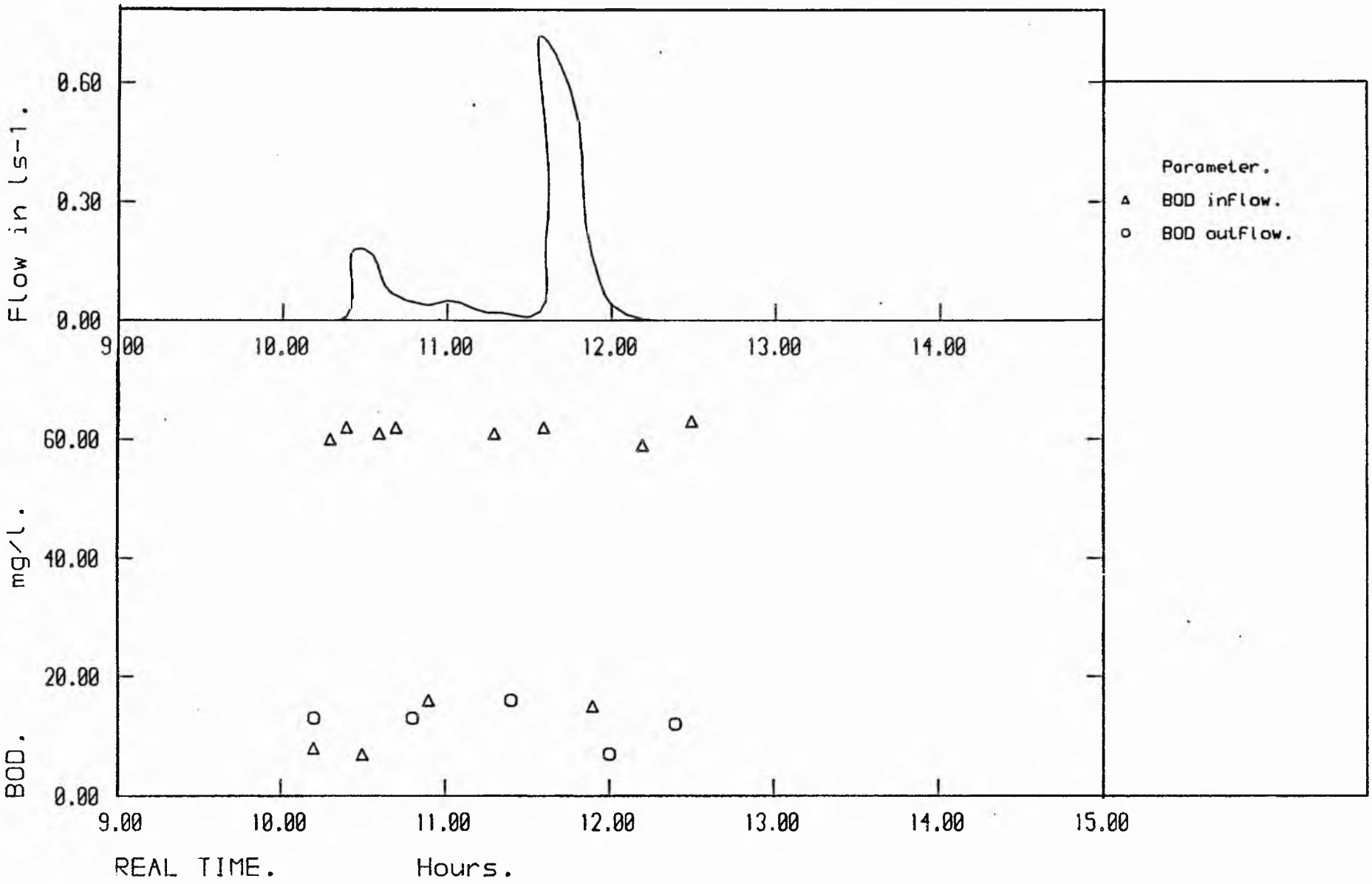
CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

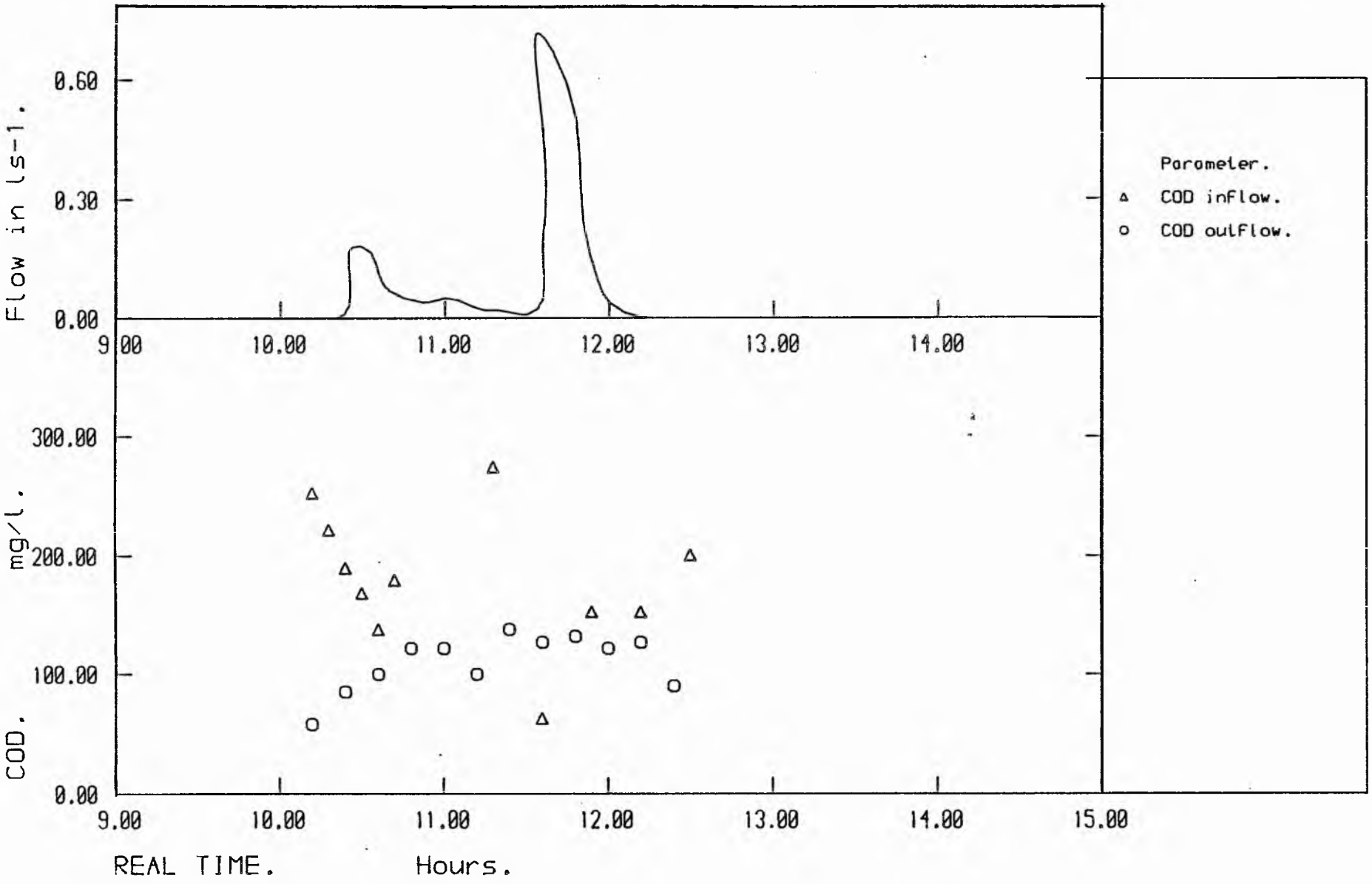
REAL TIME Hours	Mn mgl-1	Zn mgl-1
1012	0.0	0.1
1024	0.1	0.1
1036	0.0	0.1
1048	0.0	0.1
1100	0.0	0.1
1112	0.0	0.1
1124	0.0	0.1
1136	0.0	0.1
1148	0.0	0.1
1200	0.0	0.1
1212	0.0	0.1
1224	0.0	0.1



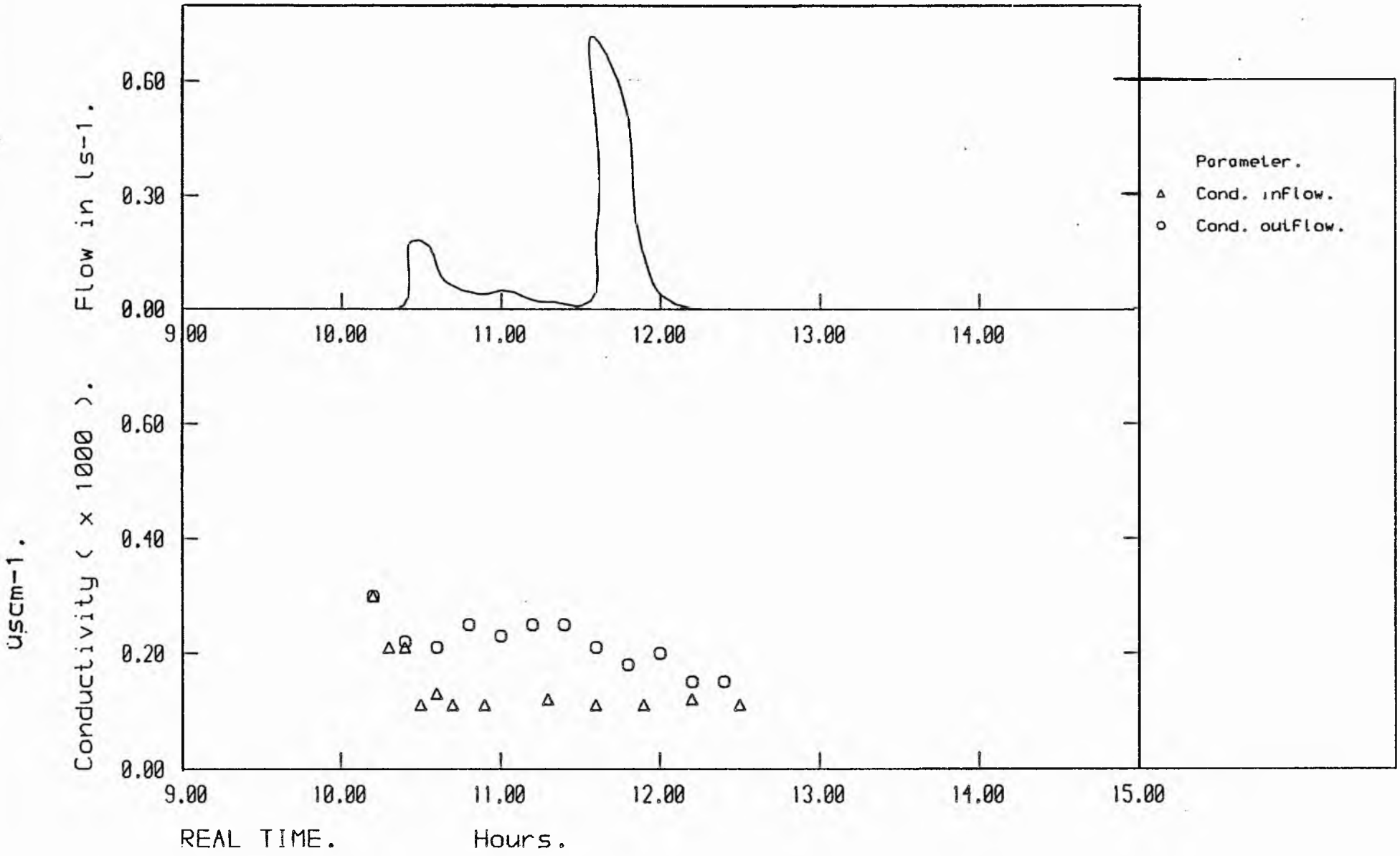
Graph of Suspended Solids for Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



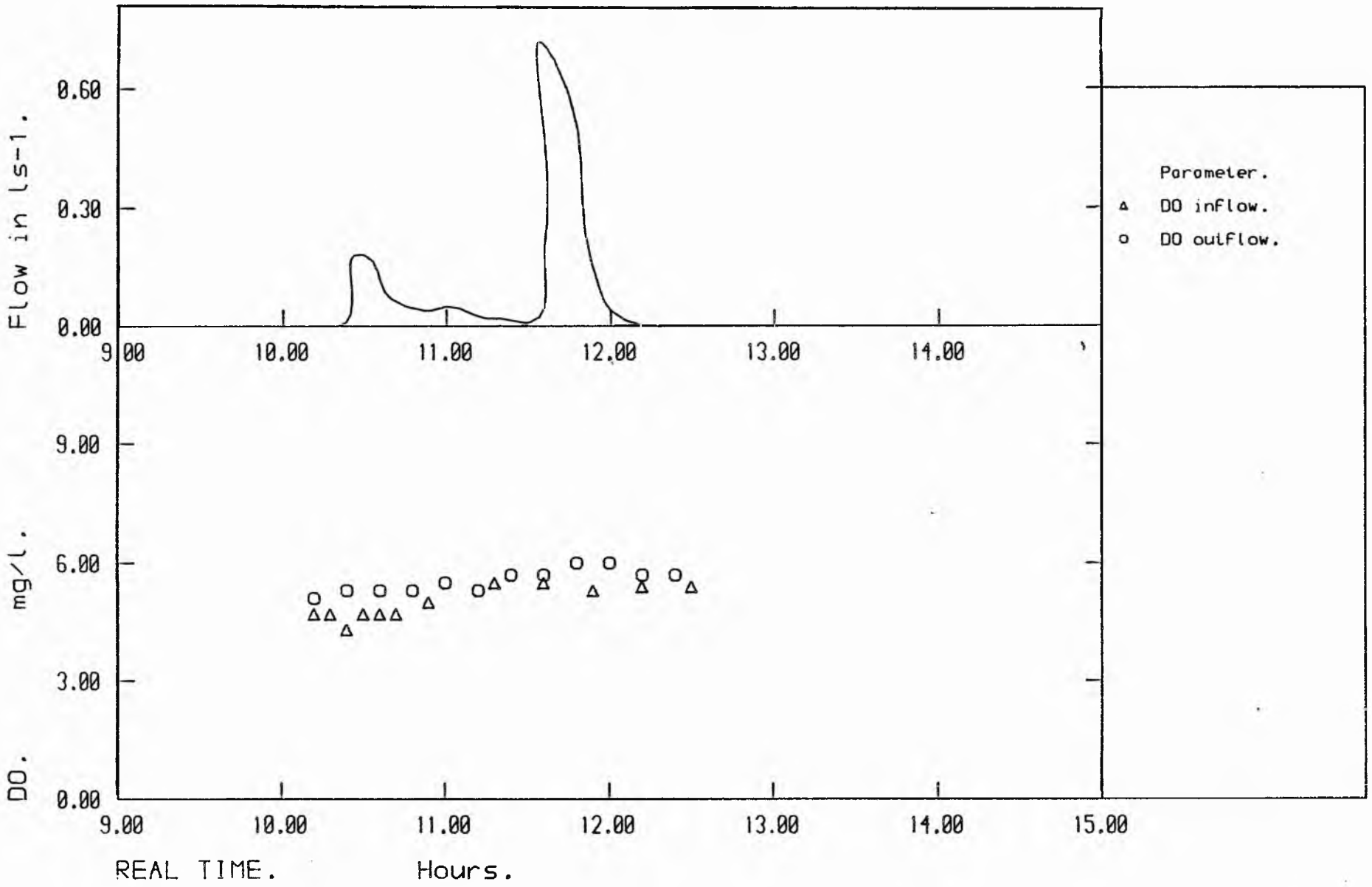
Graph of Biochemical Oxygen Demand for Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



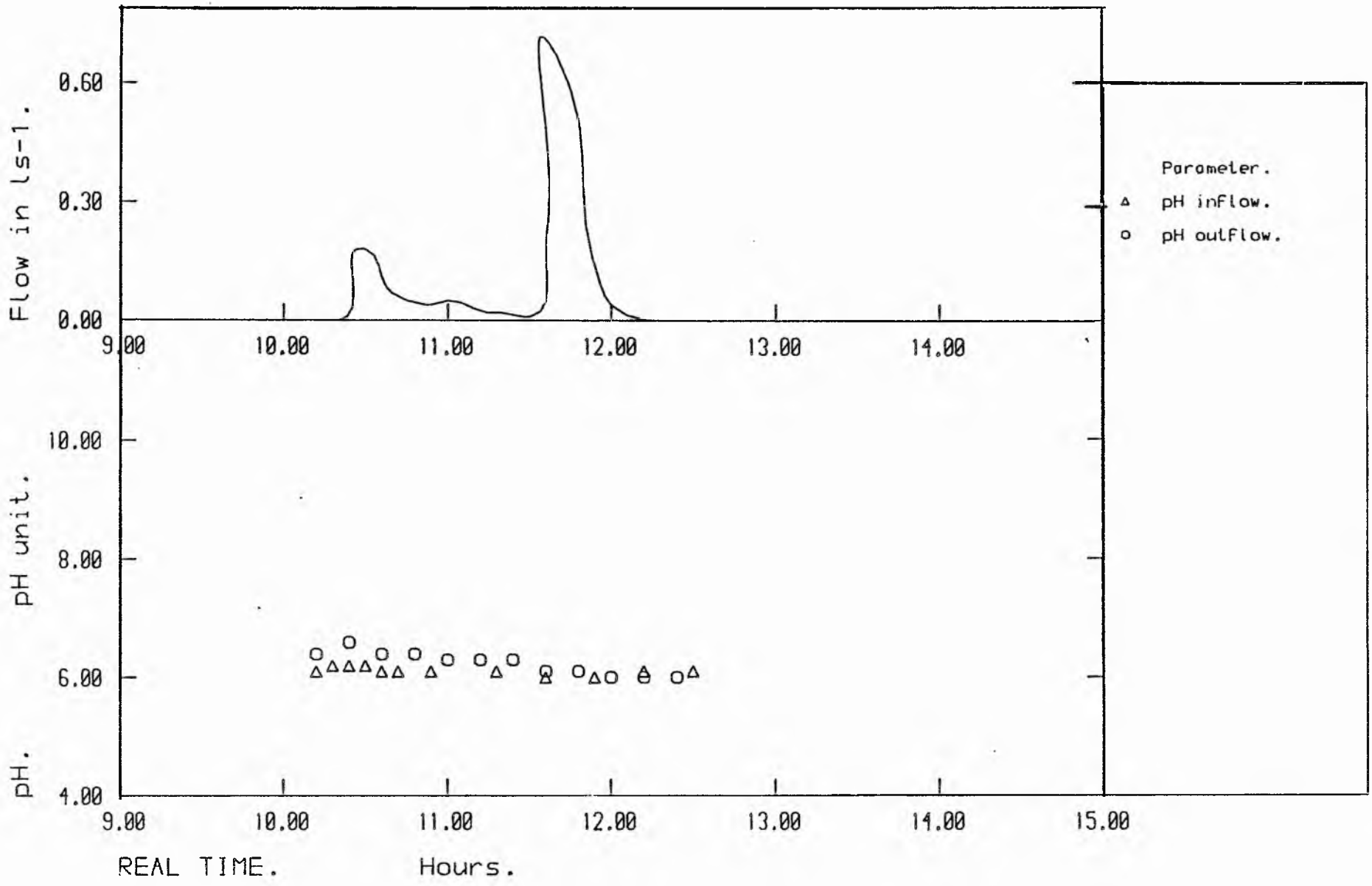
Graph of Chemical Oxygen Demand for Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



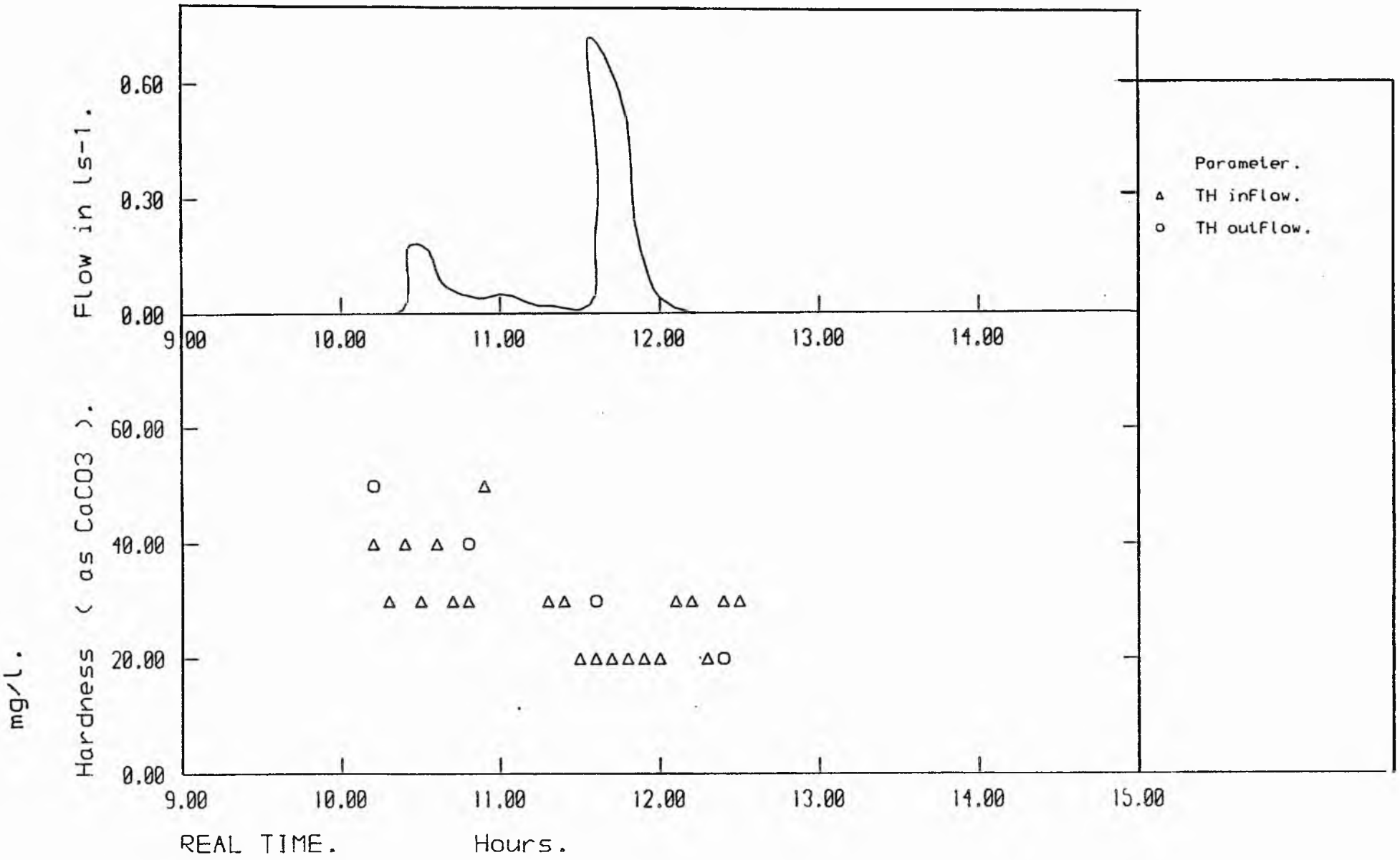
Graph of Conductivity for Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



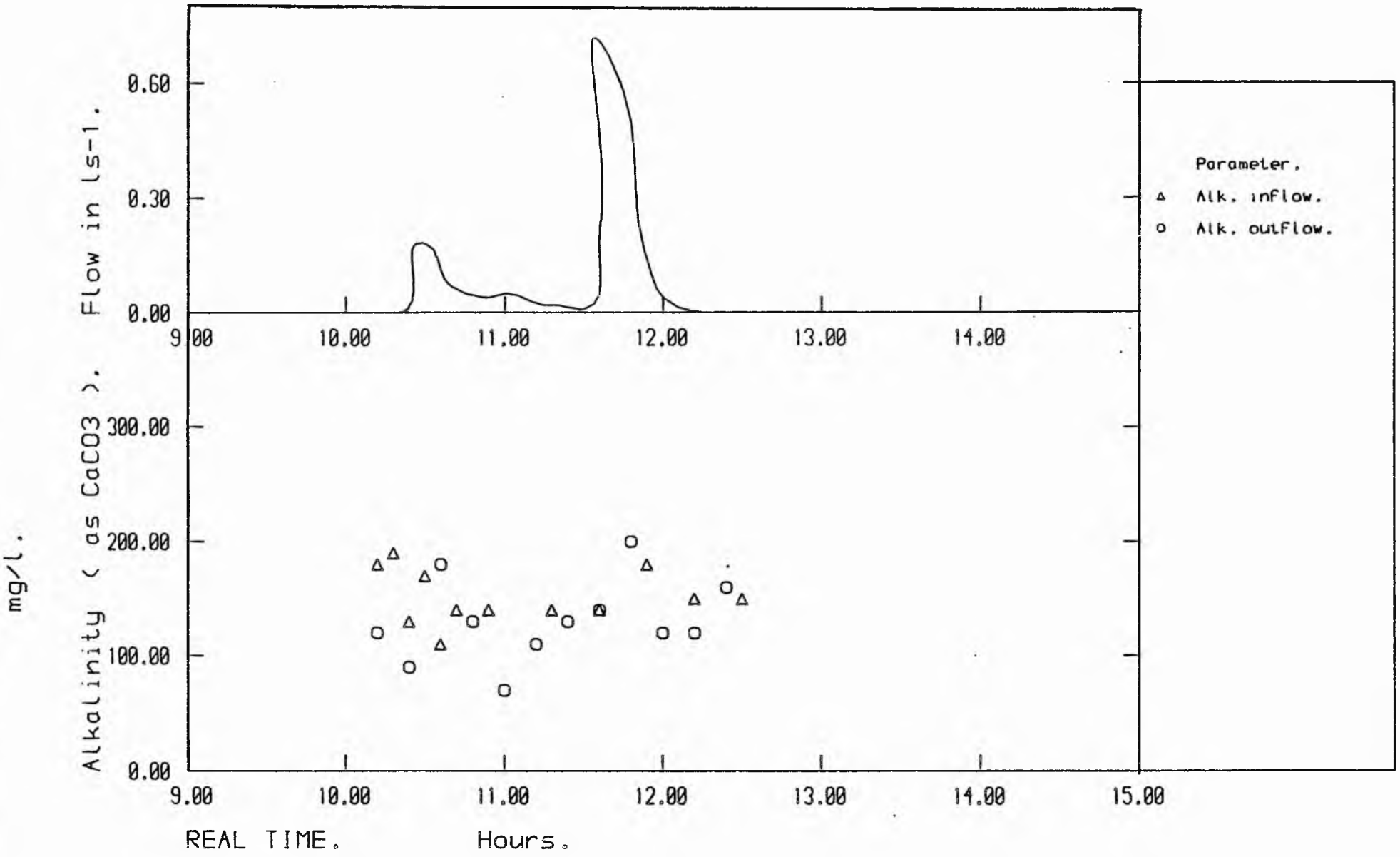
Graph of Dissolved Oxygen for Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



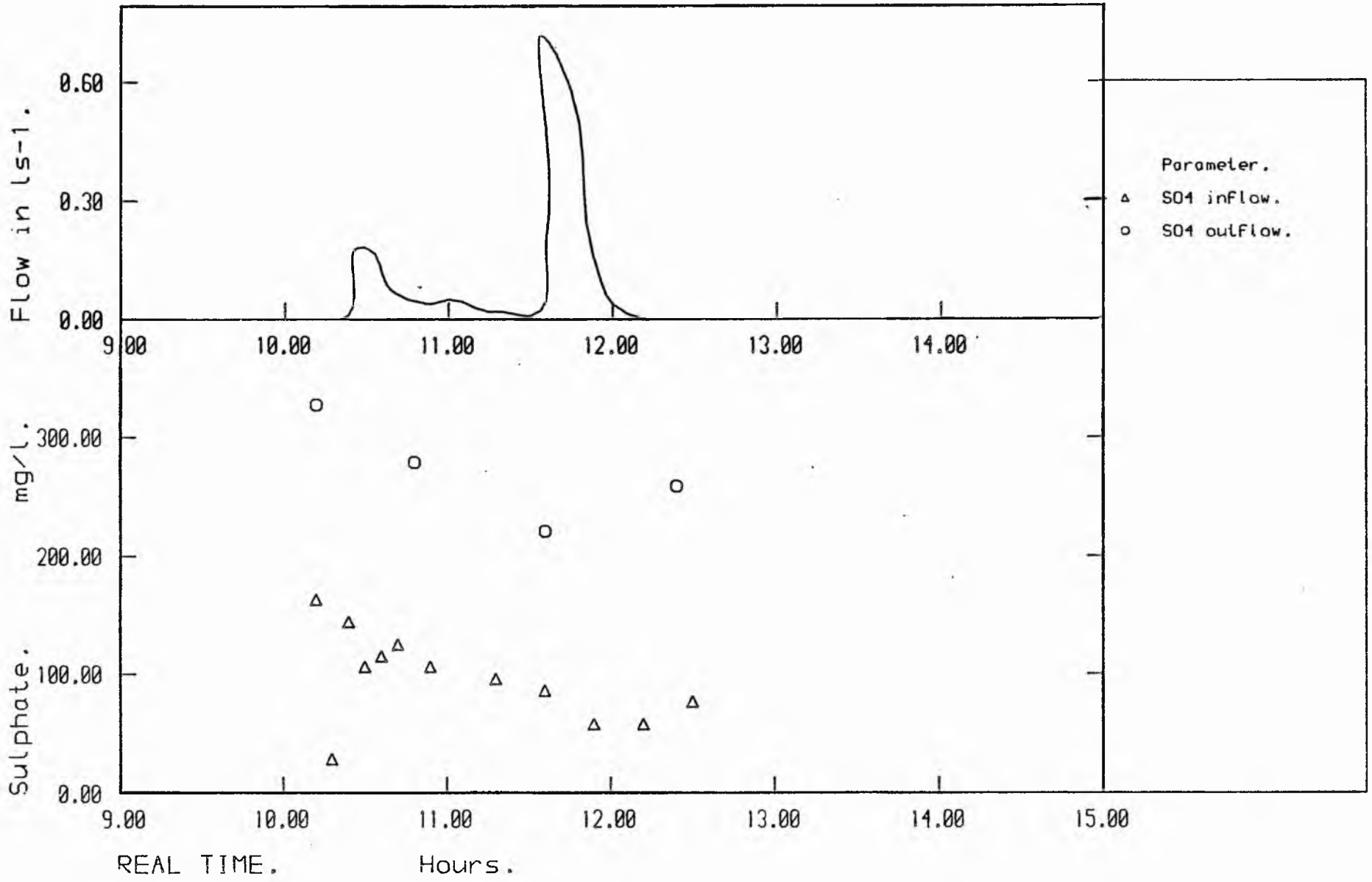
Graph of pH for Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



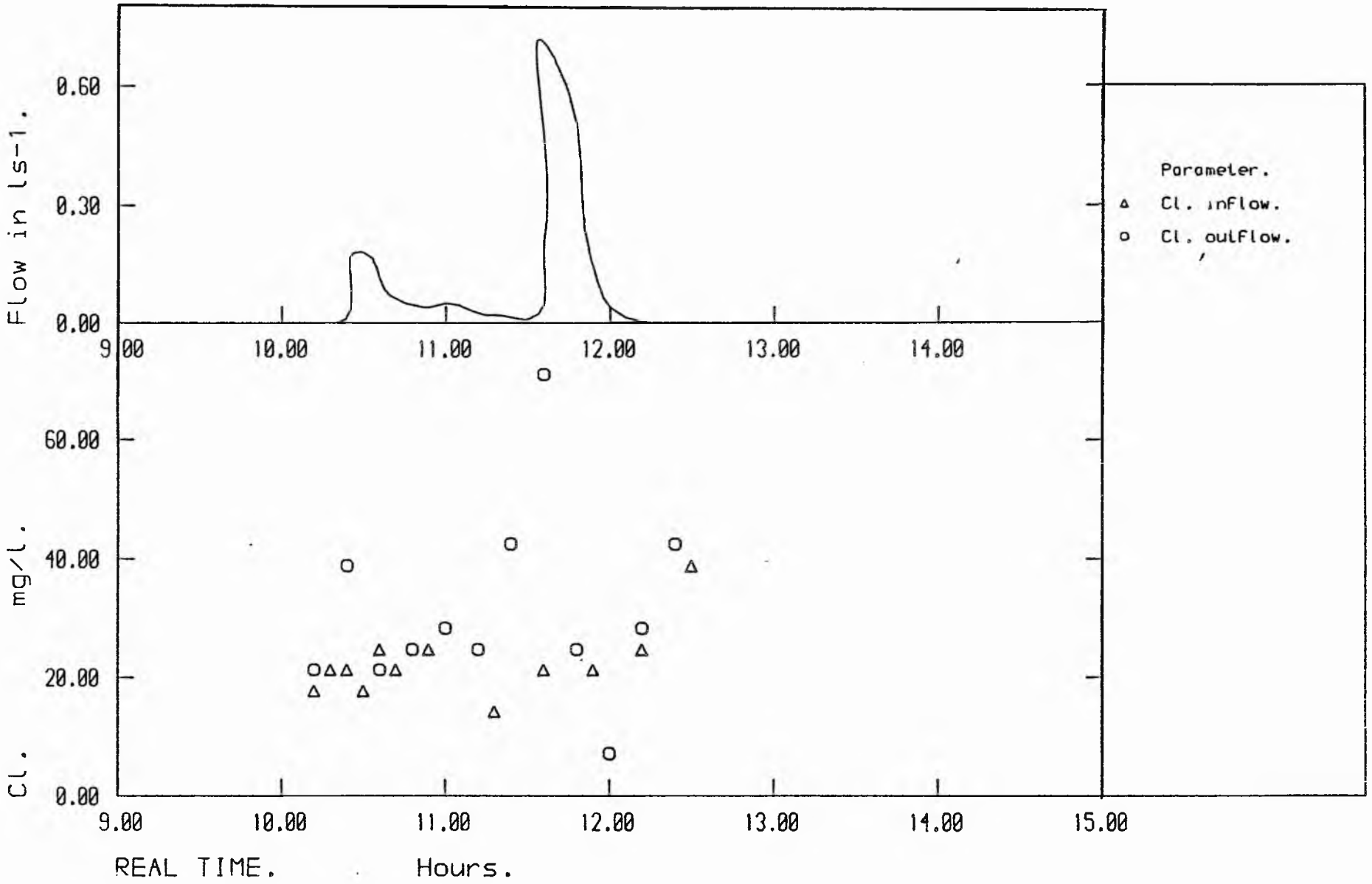
Graph of Total Hardness for Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



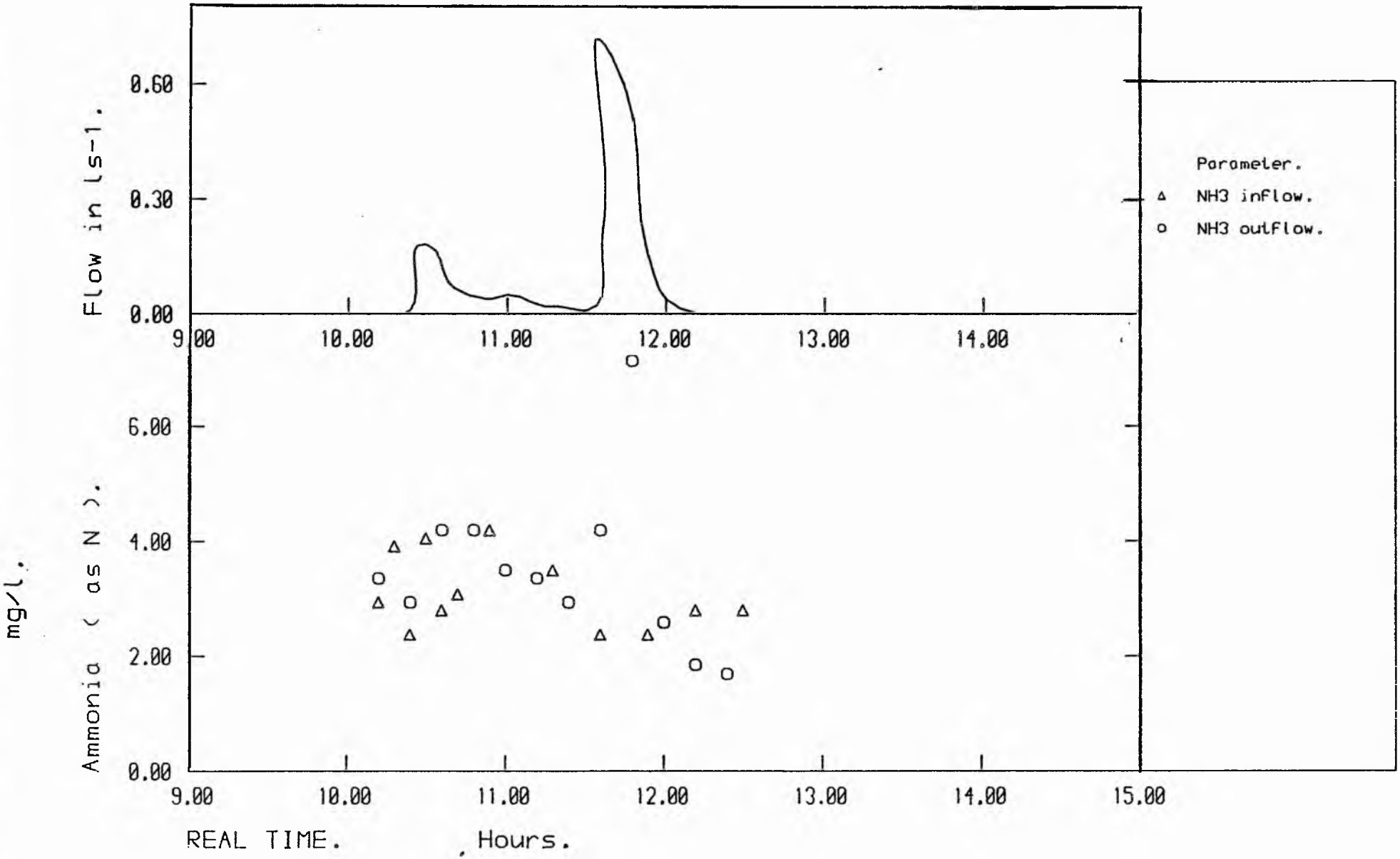
Graph of Total Alkalinity for Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



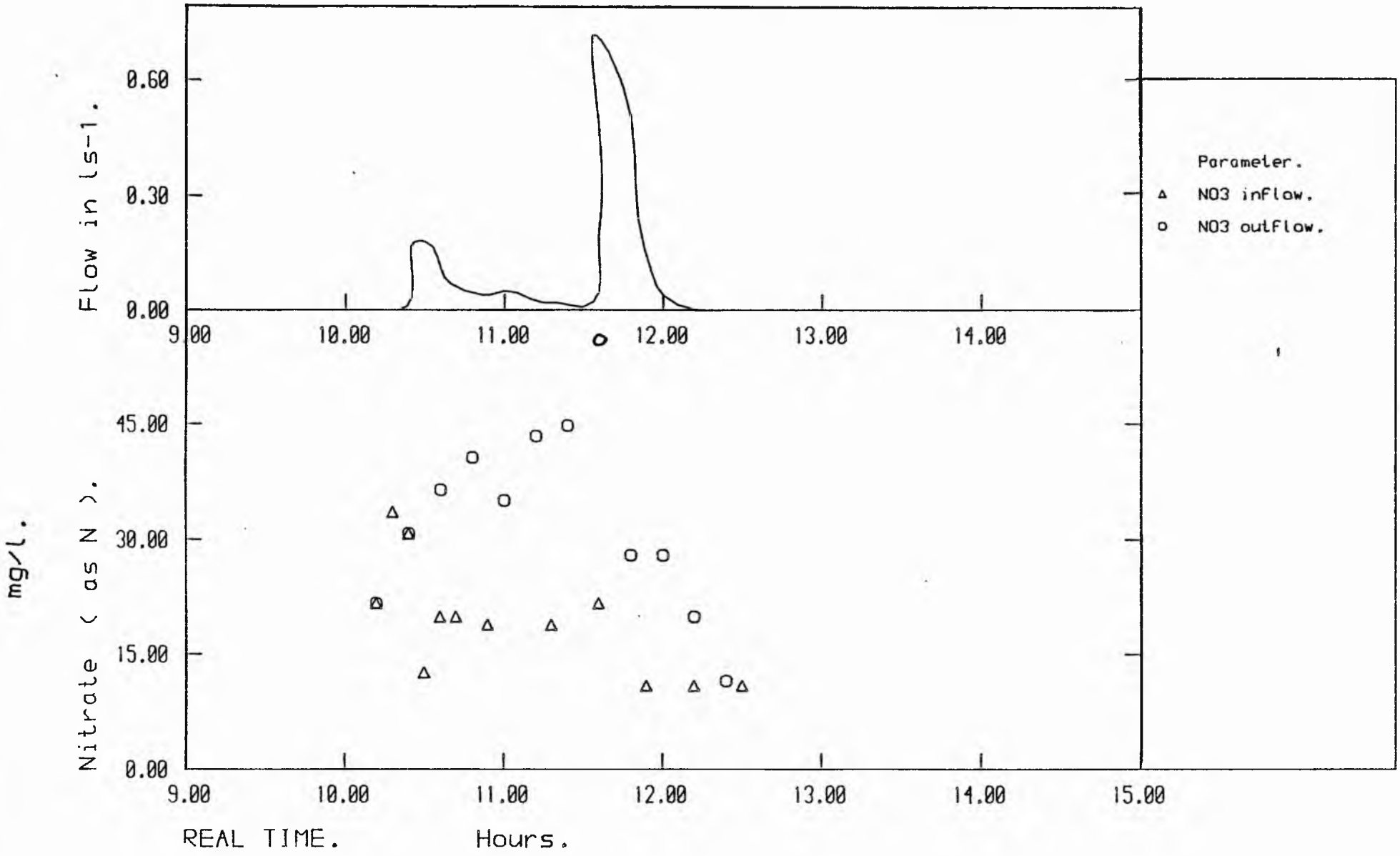
Graph of Sulphate for Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



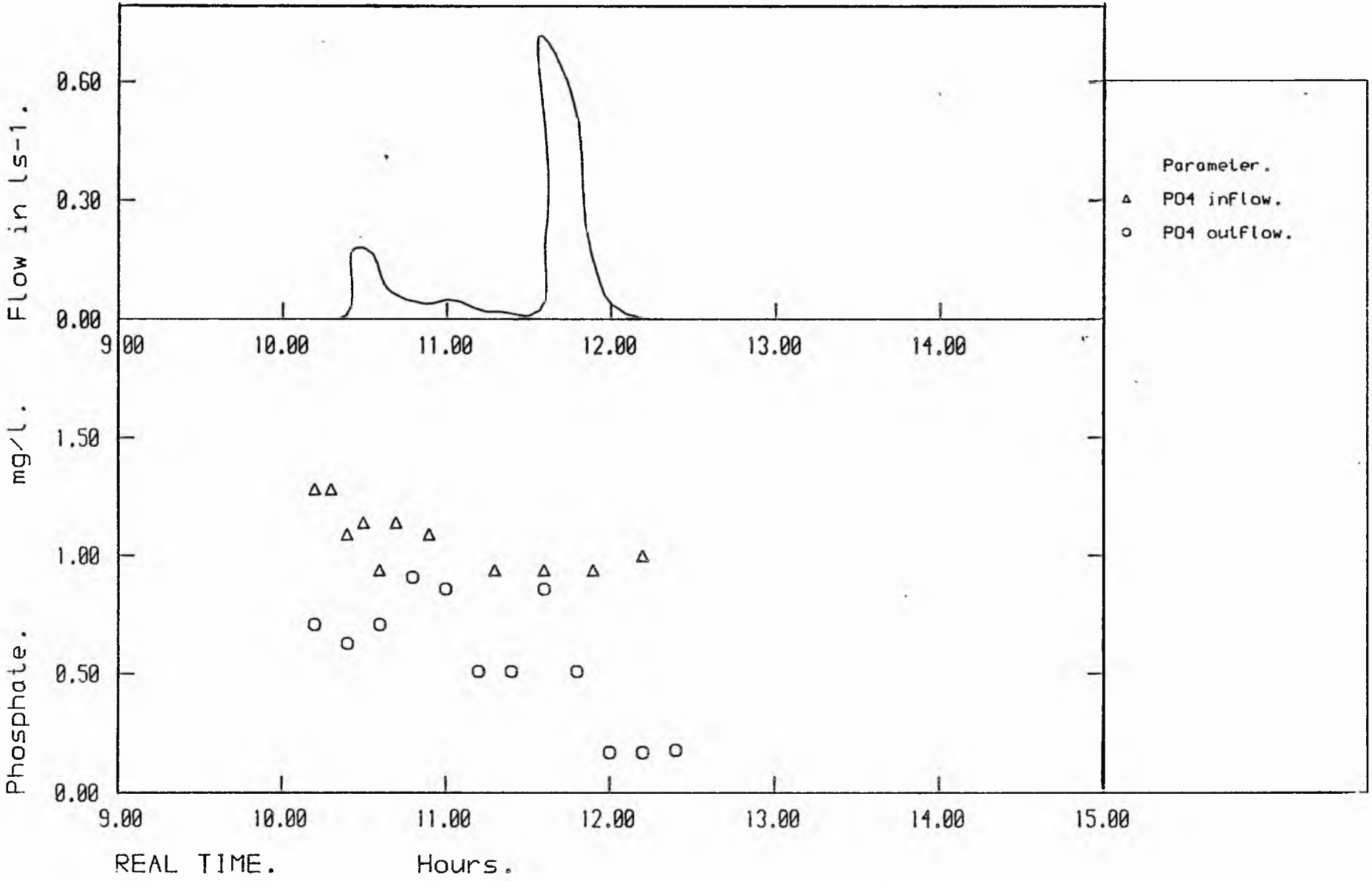
Graph of Chloride For Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



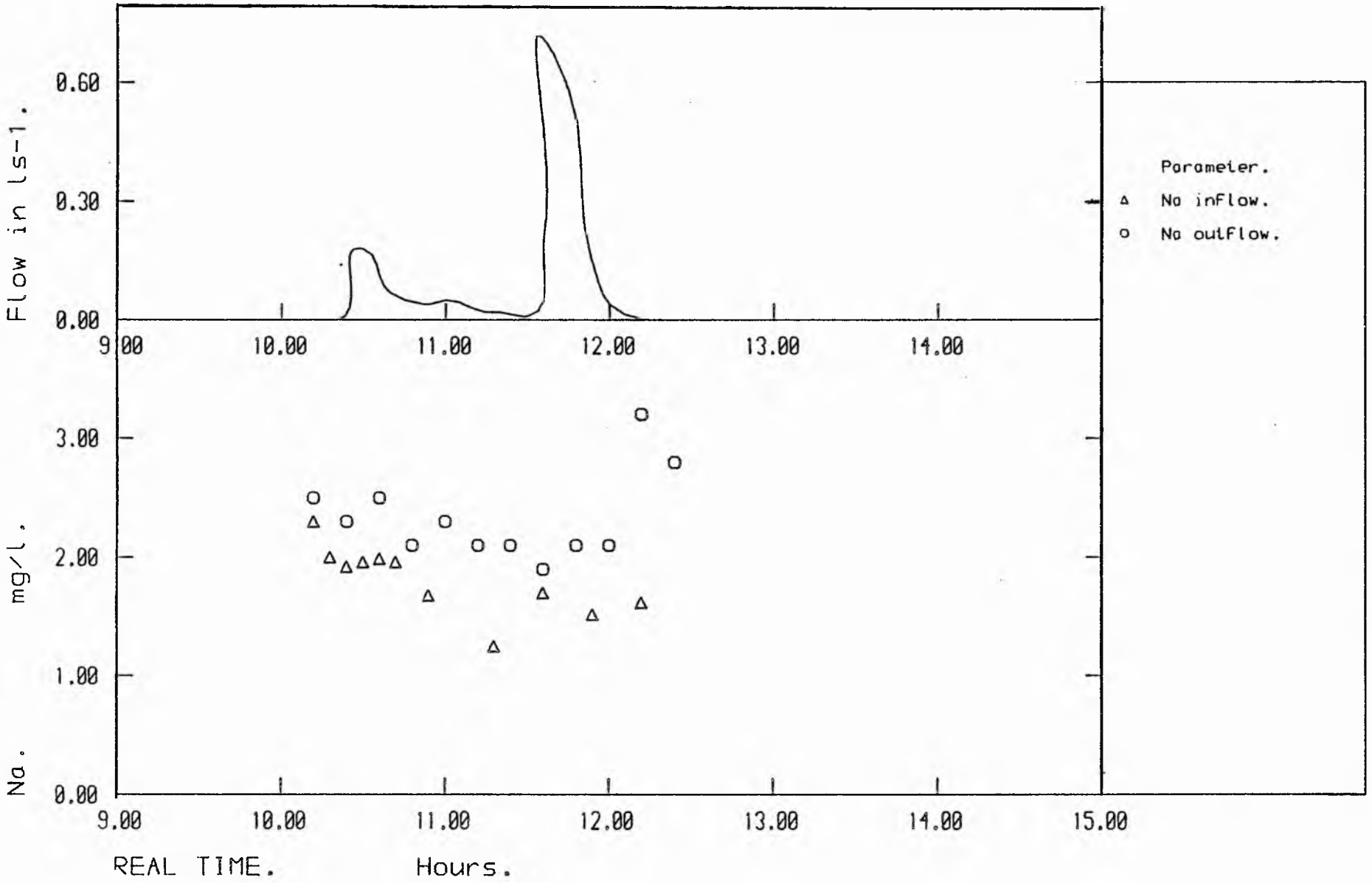
Graph of Ammonia For Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



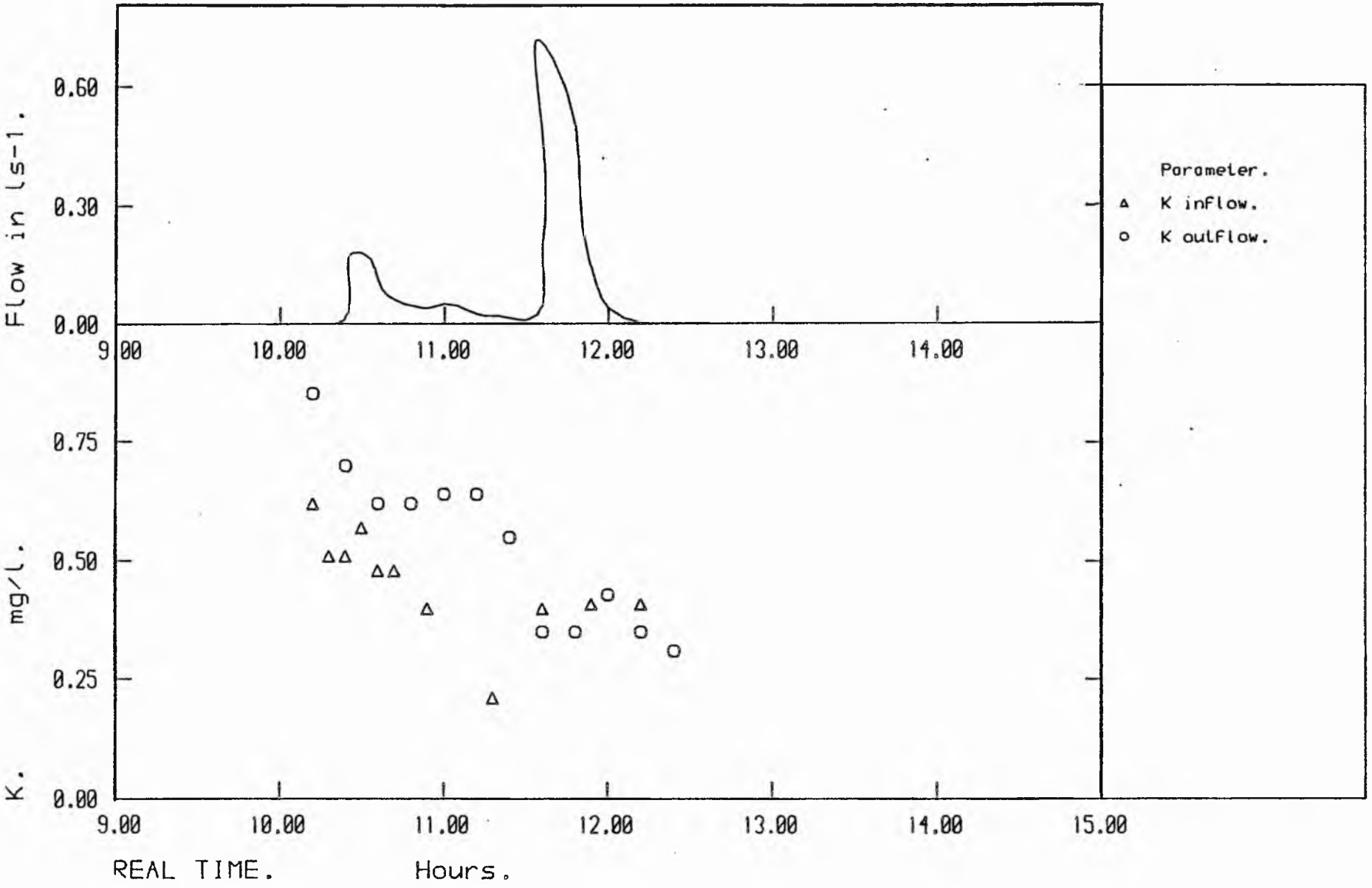
Graph of Nitrate for Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



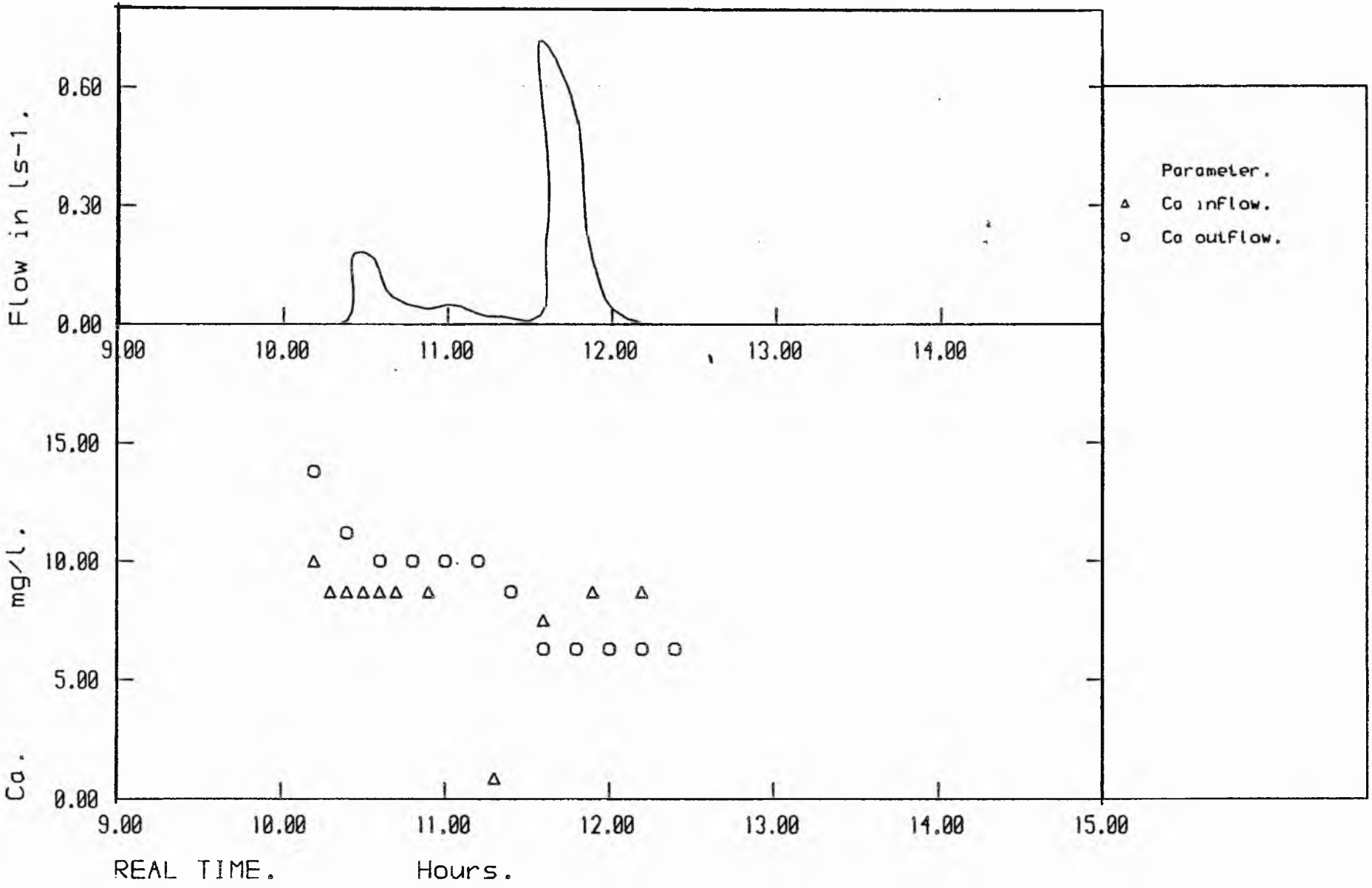
Graph of Phosphate for Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



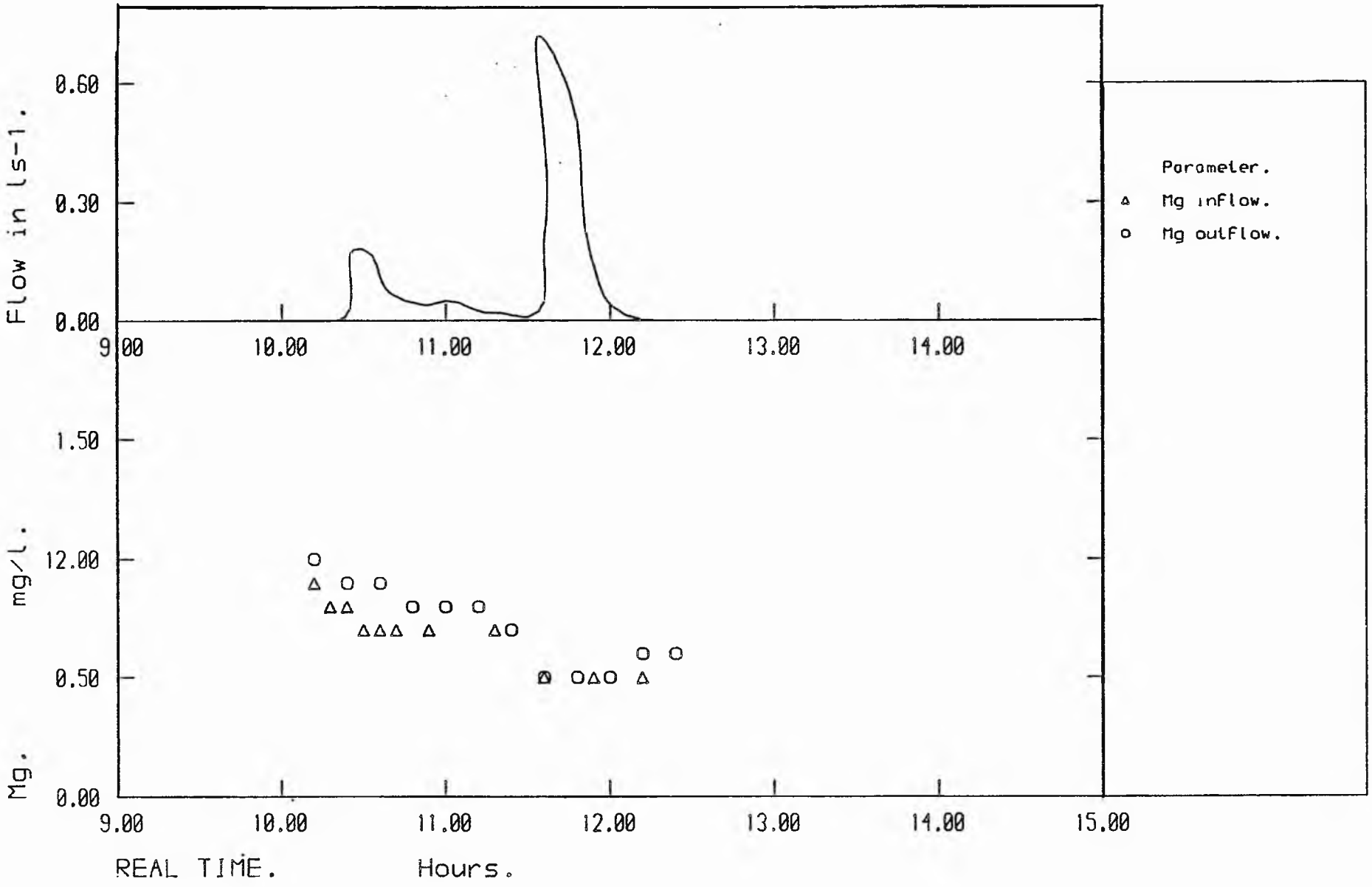
Graph of Sodium for Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



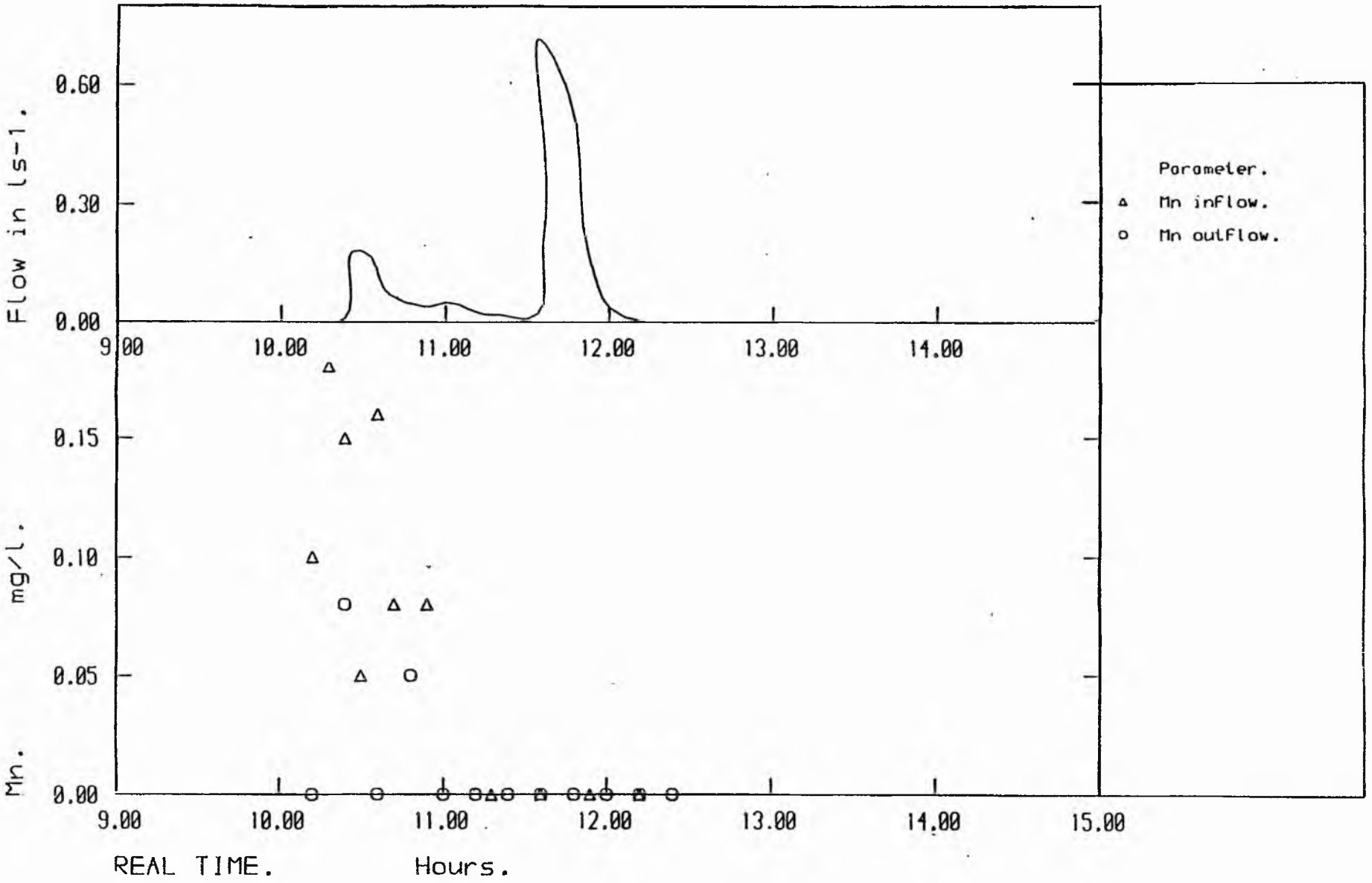
Graph of Potassium for Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



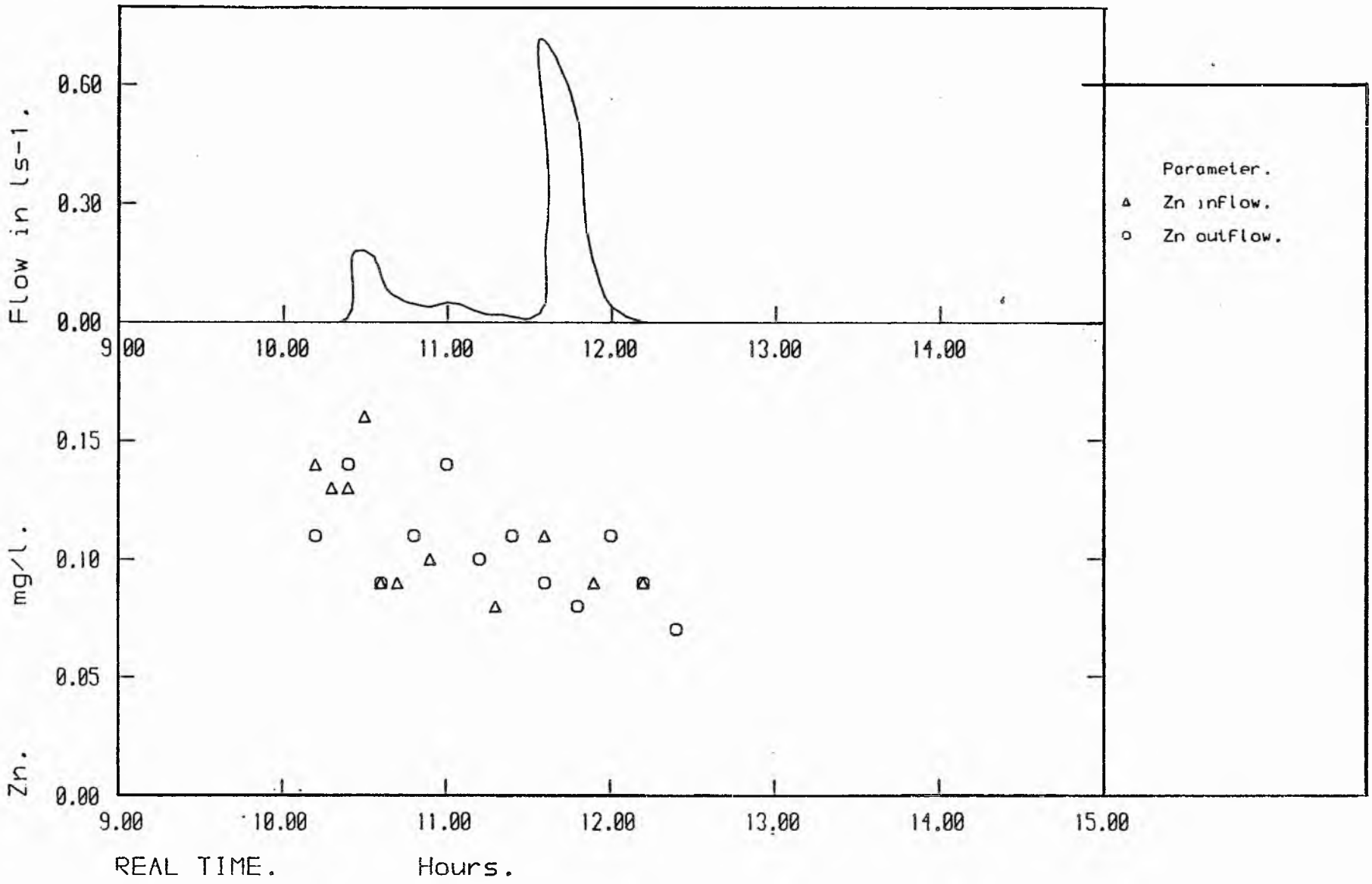
Graph of Calcium For Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Magnesium for Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Manganese for Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm VI on Tame Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	[illegible] mgl-1	[illegible] mgl-1	[illegible] mgl-1
1020	19	13	94
1032	35	*	50
1044	12	*	64
1056	22	14	15
1108	15	*	0
1120	10	*	243
1132	23	13	50
1144	20	*	20
1156	5	*	25
1208	2	11	59
1220	9	*	40
1232	20	0	5

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close

DATE OF THE STORM EVENT : 2nd. November 1984 (841102)

STORM NUMBER : VI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
1020	0.23	6.8	6.5
1032	0.08	6.7	6.0
1044	0.07	6.2	6.6
1056	0.07	6.5	6.6
1108	0.07	6.0	6.2
1120	0.08	5.8	6.0
1132	0.06	5.2	5.5
1144	0.03	6.0	6.2
1156	0.03	6.1	6.1
1208	0.03	6.0	5.8
1220	0.03	5.9	6.0
1232	0.03	5.9	6.3

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
1020	50.0	110.0	394	31.9
1032	*	120.0	*	17.7
1044	*	140.0	*	17.7
1056	40.0	80.0	423	28.4
1108	*	80.0	*	14.2
1120	*	130.0	*	28.4
1132	*	110.0	*	0.0
1144	30.0	120.0	519	28.4
1156	*	80.0	*	17.7
1208	*	100.0	*	24.8
1220	*	120.0	*	21.3
1232	20.0	120.0	481	21.3

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Phosphate mgl-1
1020	2.7	21.7	0.9
1032	2.0	37.8	0.9
1044	1.7	21.0	0.6
1056	1.7	21.7	0.4
1108	1.5	21.7	0.6
1120	1.7	21.7	0.6
1132	1.7	39.2	0.5
1144	1.8	37.8	0.1
1156	1.5	46.2	0.3
1208	1.3	46.2	0.6
1220	1.5	46.2	0.3
1232	1.5	56.0	0.9

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

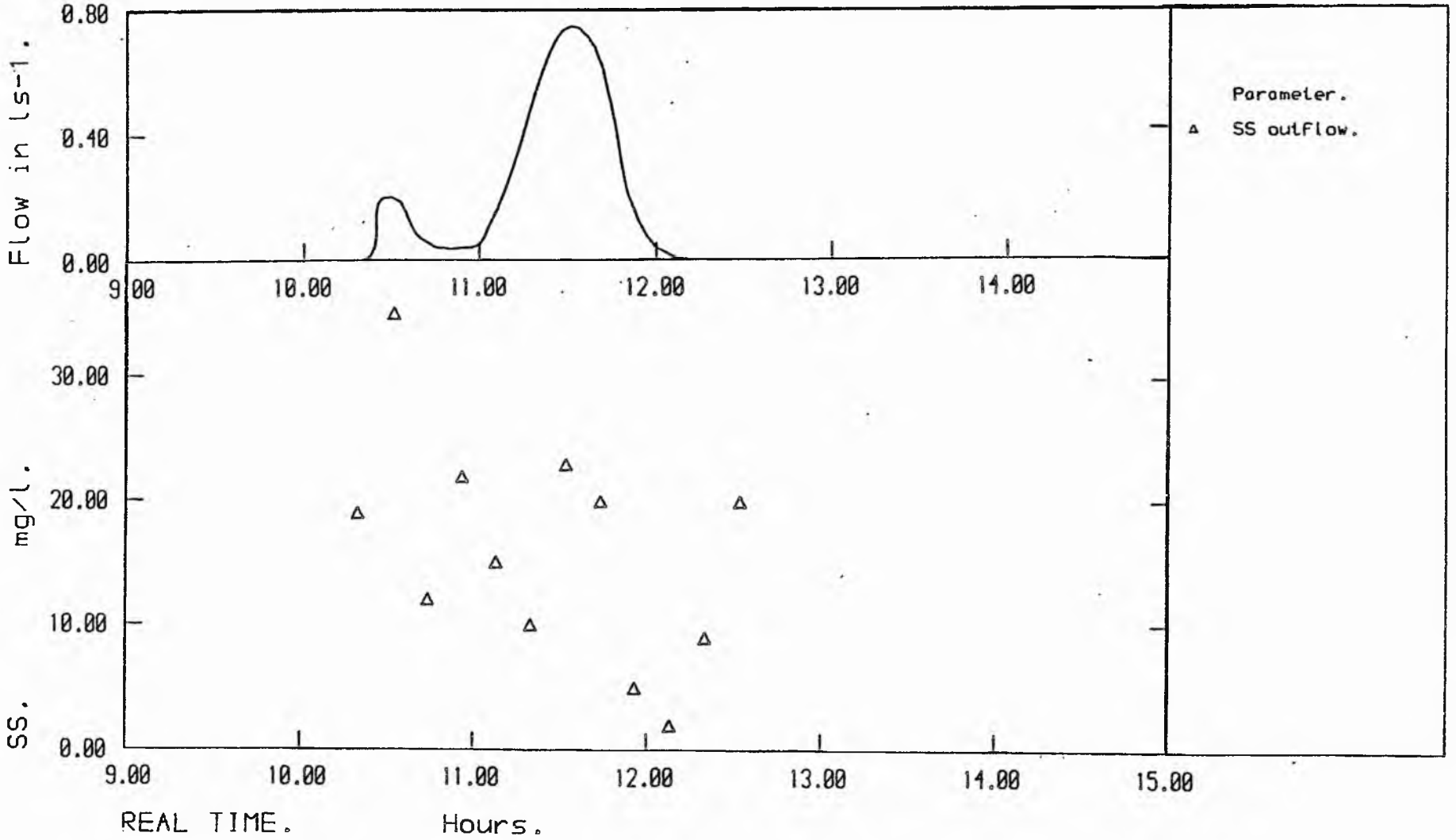
REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
1020	5.0	1.8	10.5	1.3
1032	3.0	1.1	9.0	0.8
1044	3.0	0.9	7.5	0.5
1056	3.0	1.0	9.0	0.5
1108	2.5	0.9	9.0	0.5
1120	2.2	1.0	9.0	0.5
1132	2.5	1.0	9.0	0.5
1144	2.2	0.6	6.0	0.3
1156	1.9	0.9	6.0	0.3
1208	1.2	0.6	6.0	0.3
1220	1.2	0.6	6.0	0.3
1232	1.2	0.6	6.0	0.3

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

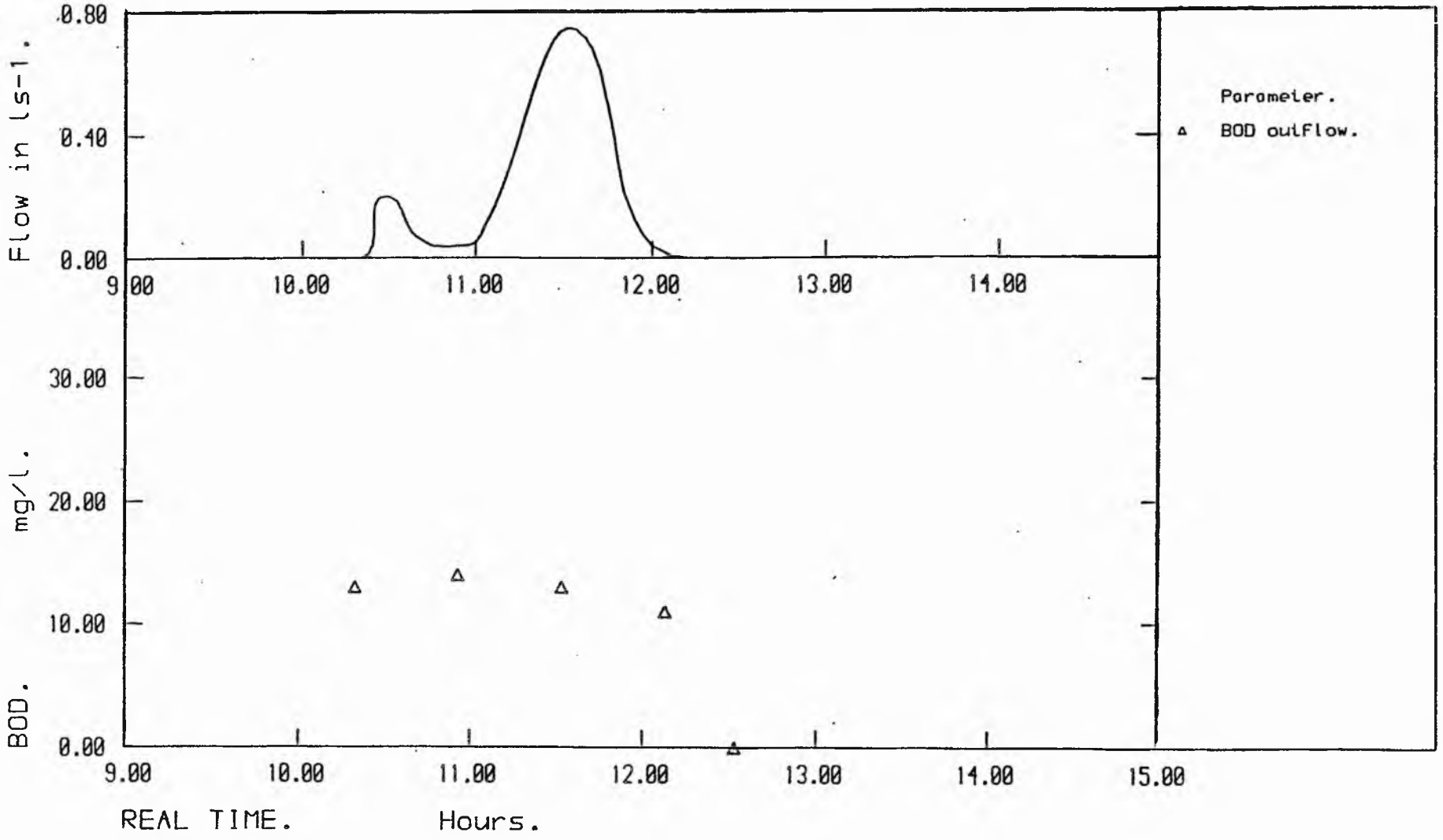
CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

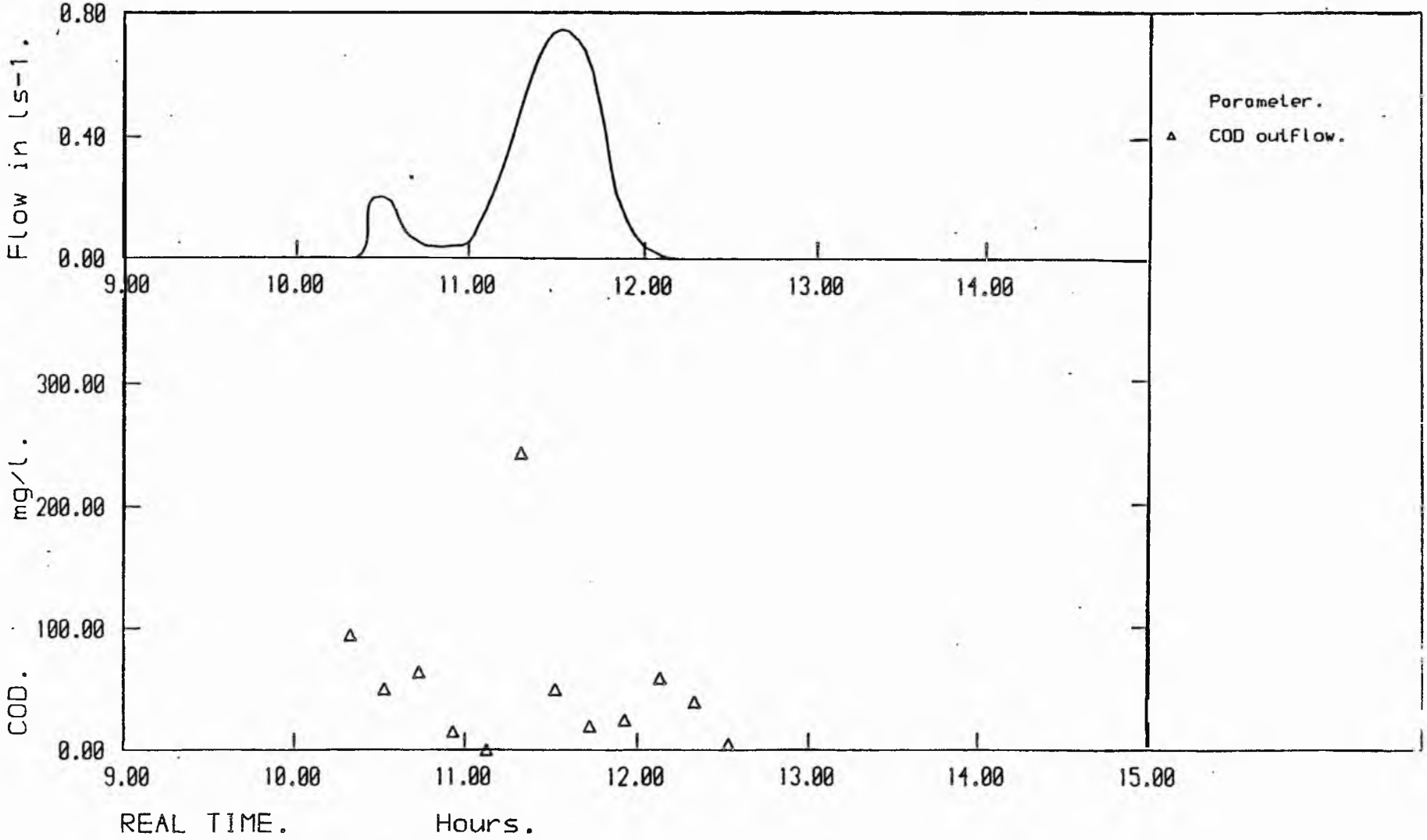
REAL TIME Hours	Mn mgl-1	Zn mgl-1
1020	0.0	0.1
1032	0.0	0.1
1044	0.1	0.1
1056	0.0	0.1
1108	0.0	0.1
1120	0.0	0.1
1132	0.0	0.1
1144	0.0	0.1
1156	0.0	0.1
1208	0.0	0.1
1220	0.0	0.1
1232	0.0	0.1



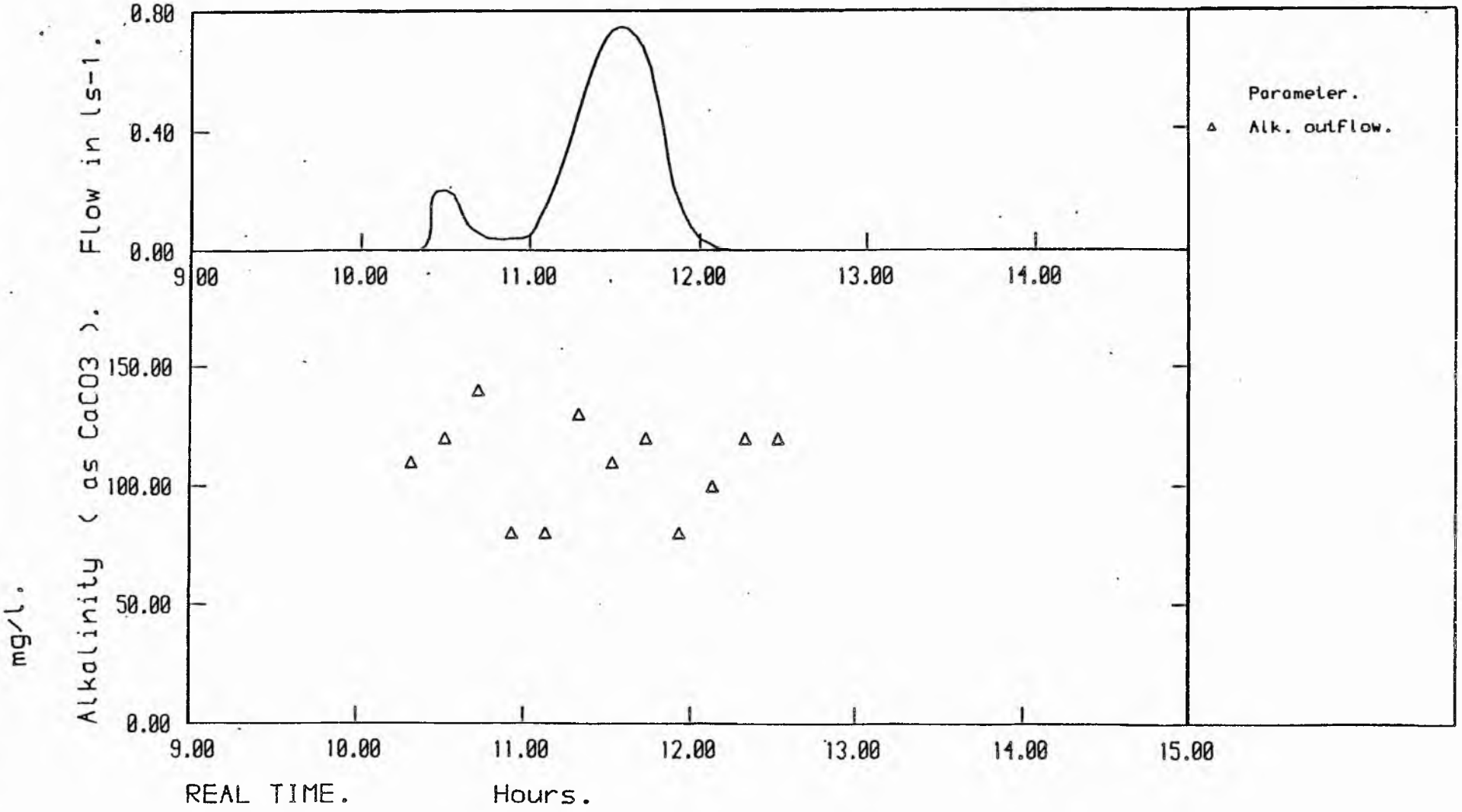
Graph of Suspended Solids for Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



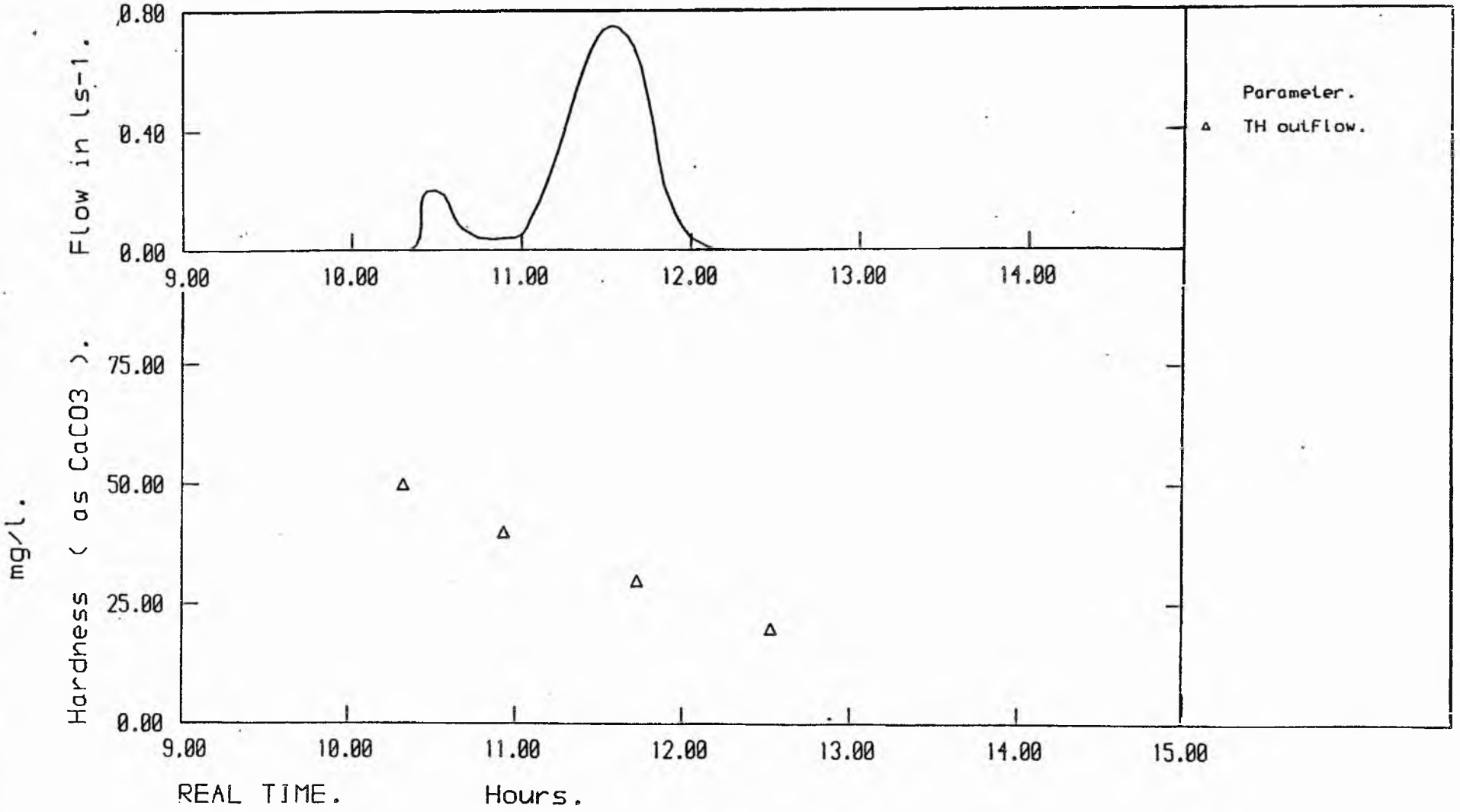
Graph of Biochemical Oxygen Demand for Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



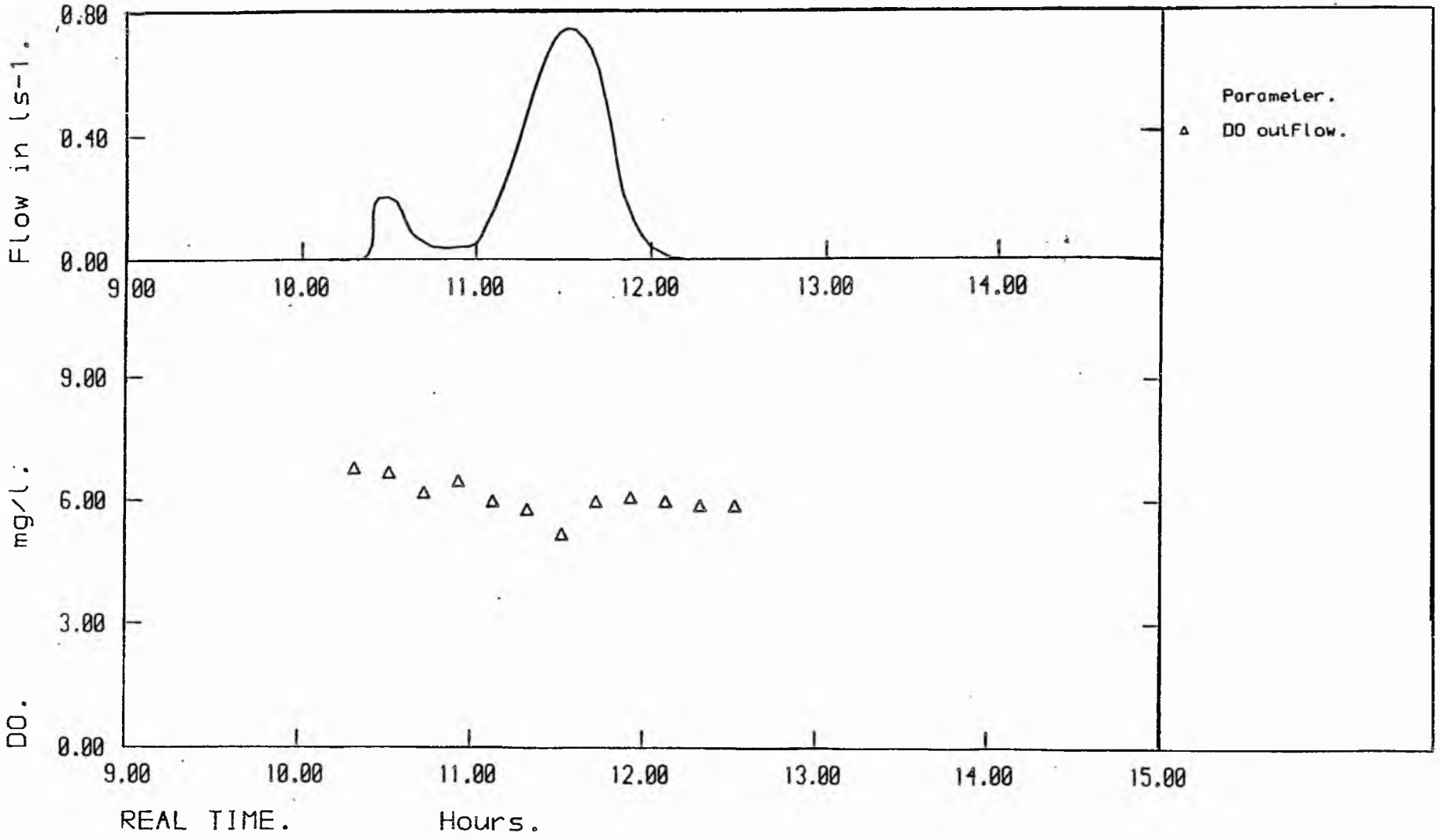
Graph of Chemical Oxygen Demand for Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



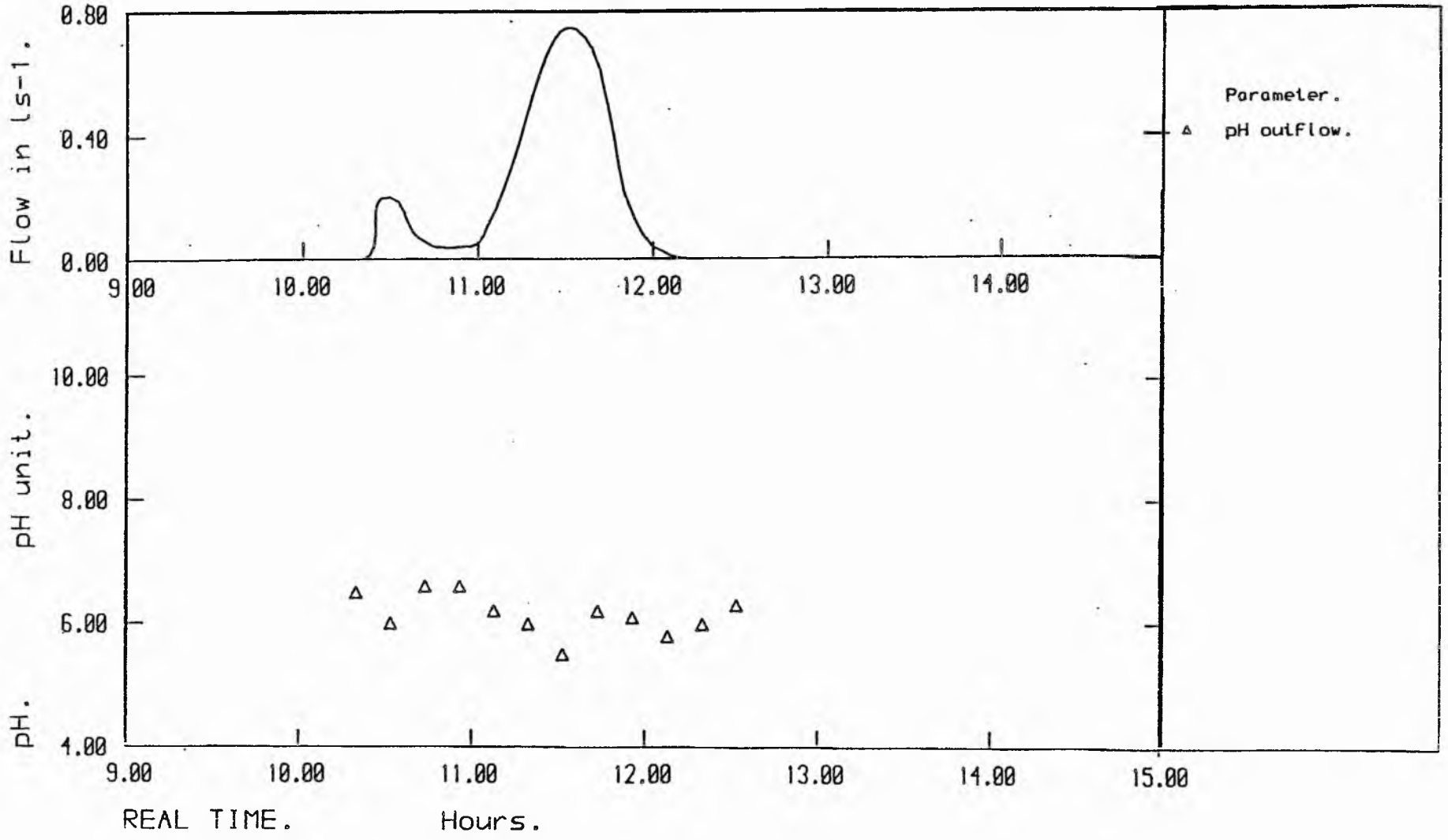
Graph of Total Alkalinity for Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



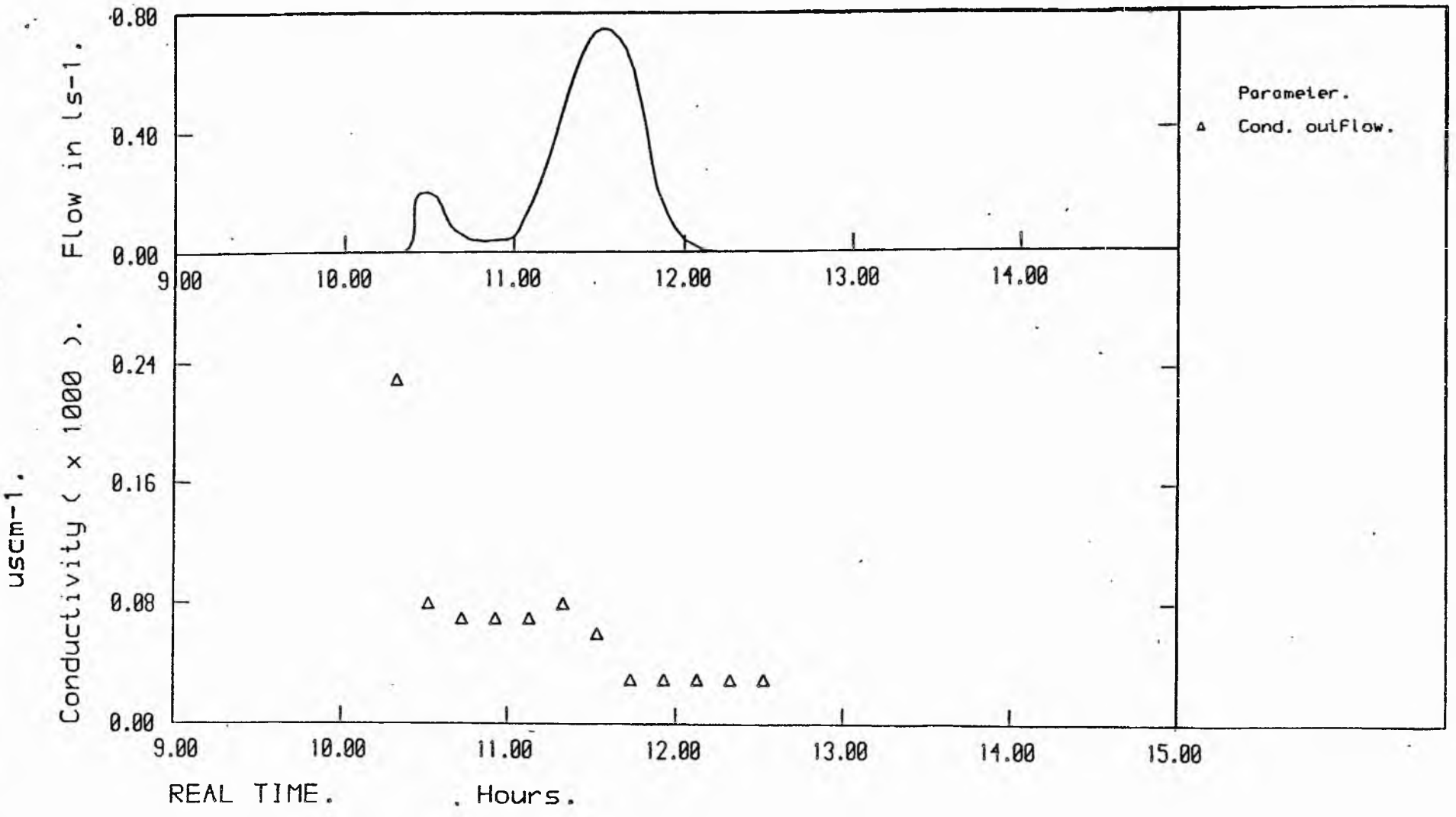
Graph of Total Hardness for Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



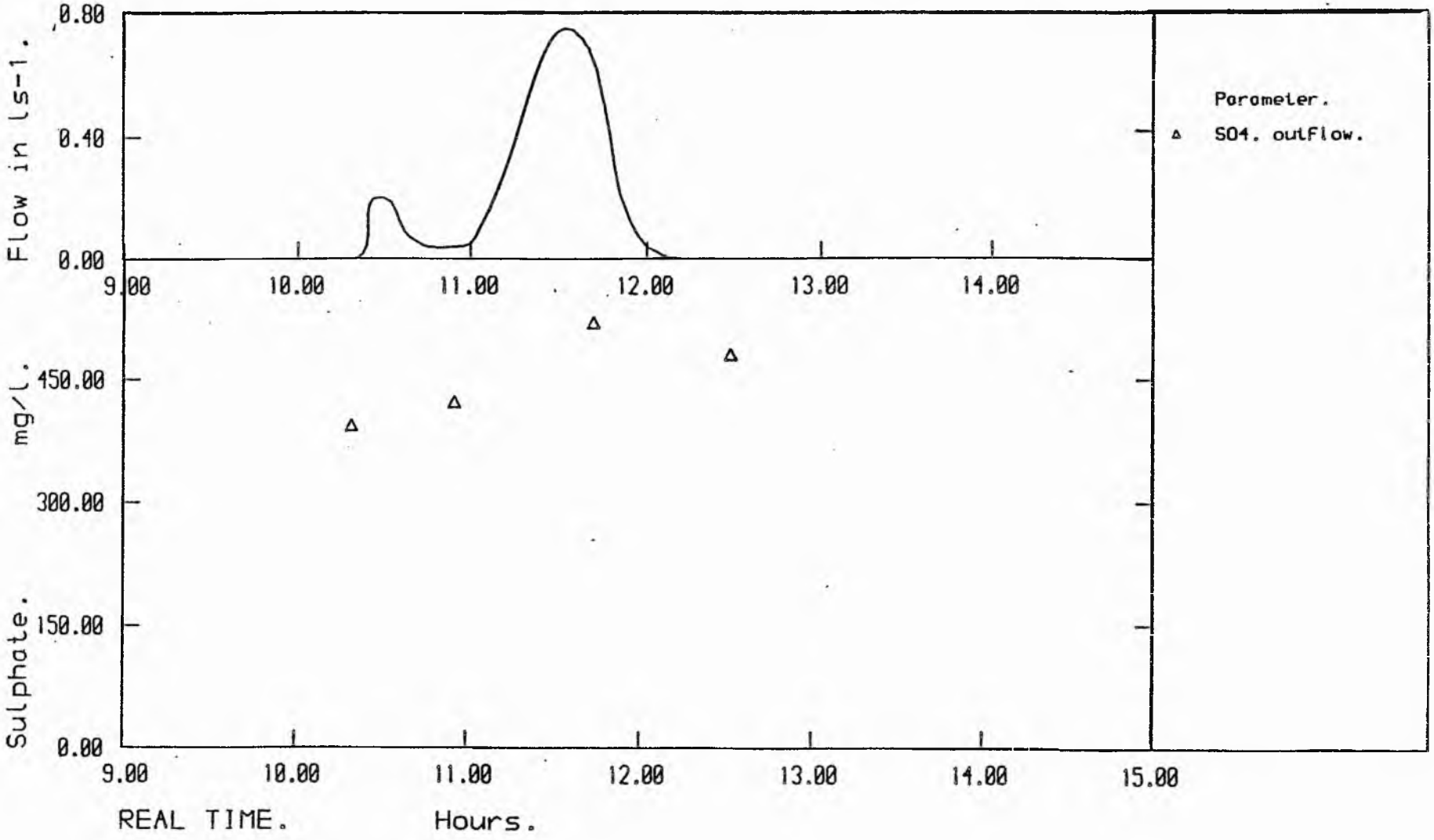
Graph of Dissolved Oxygen For Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



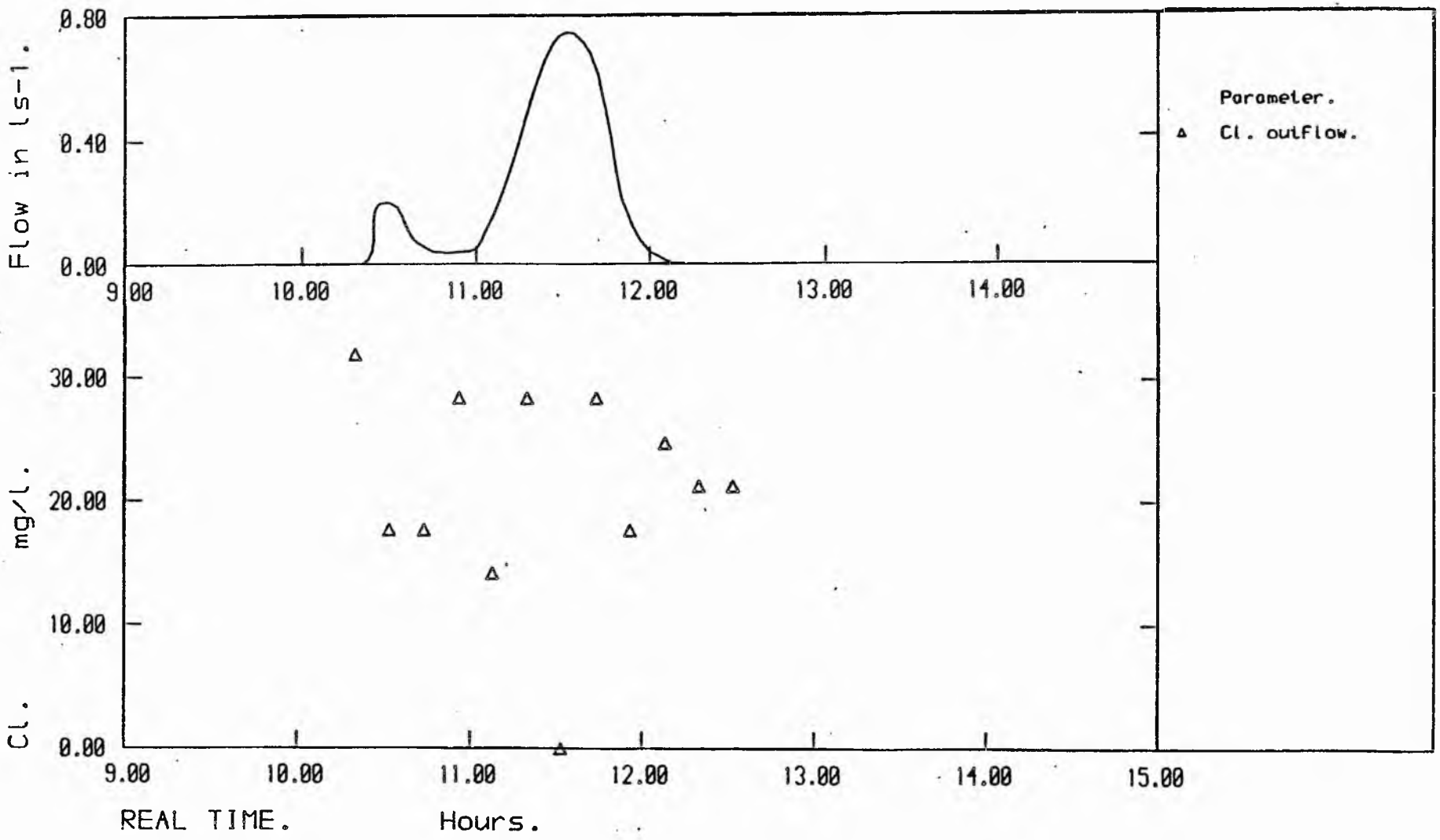
Graph of pH for Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



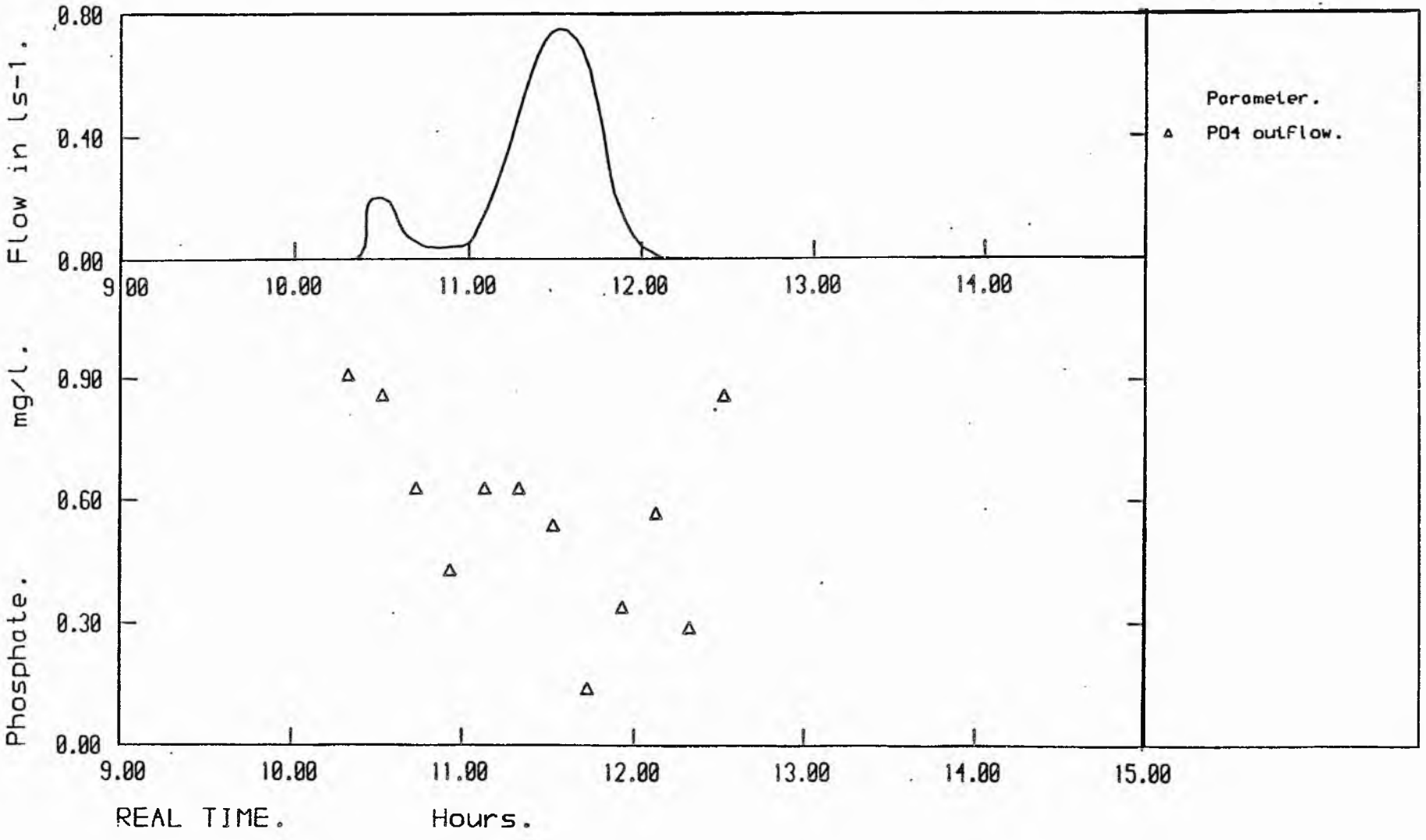
Graph of Conductivity for Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



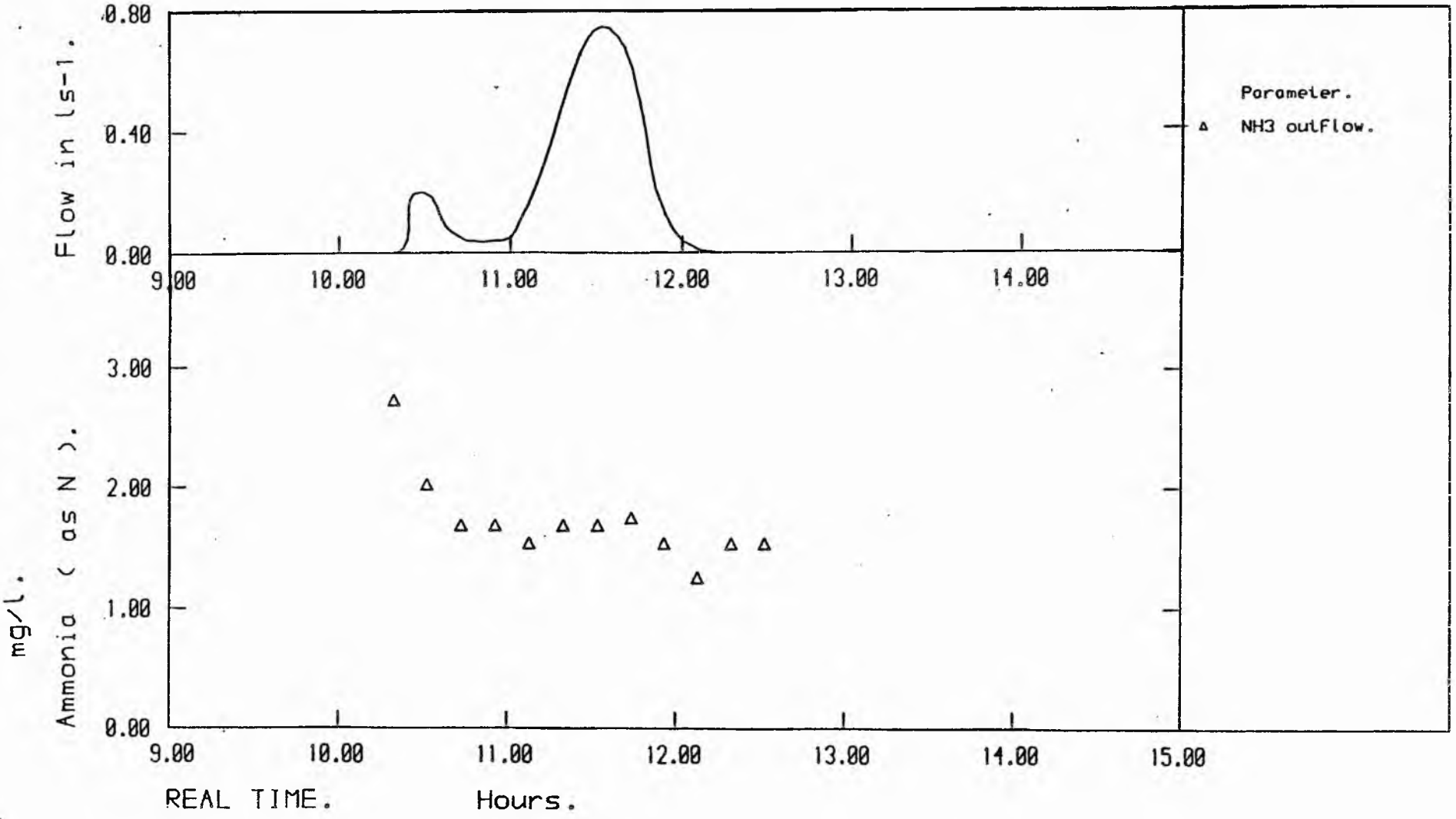
Graph of Sulphate for Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



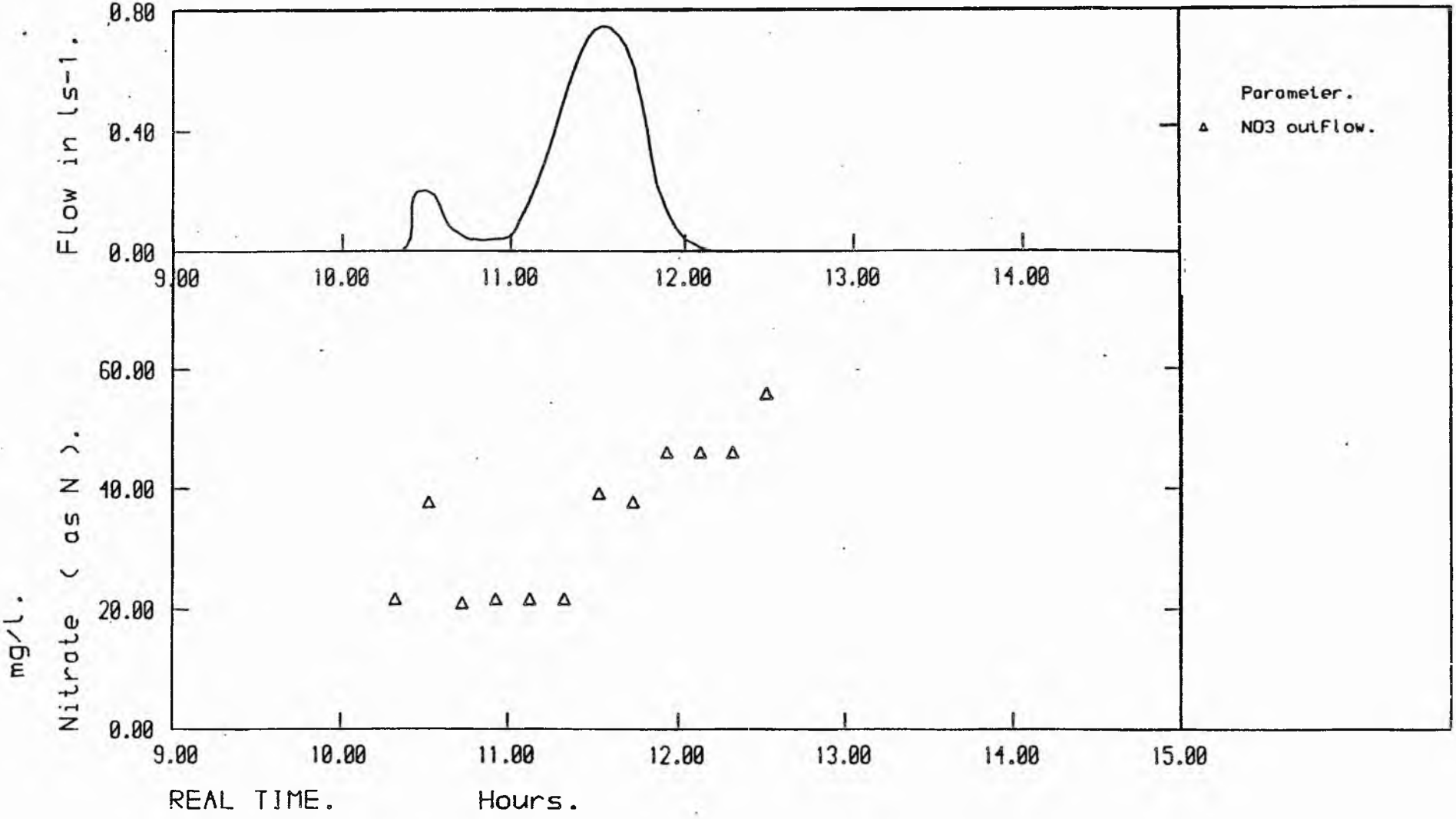
Graph of Chloride For Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



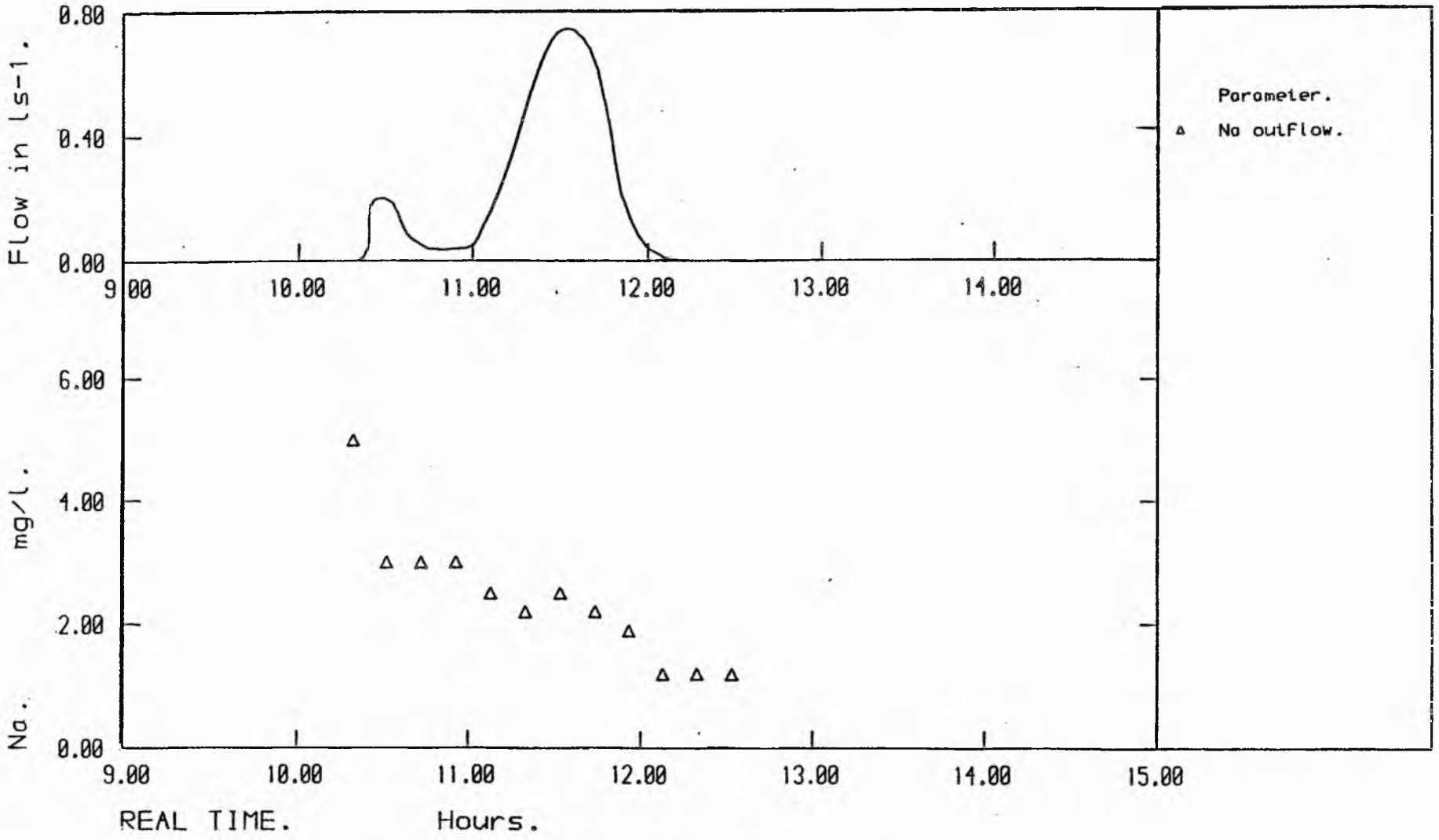
Graph of Phosphate for Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



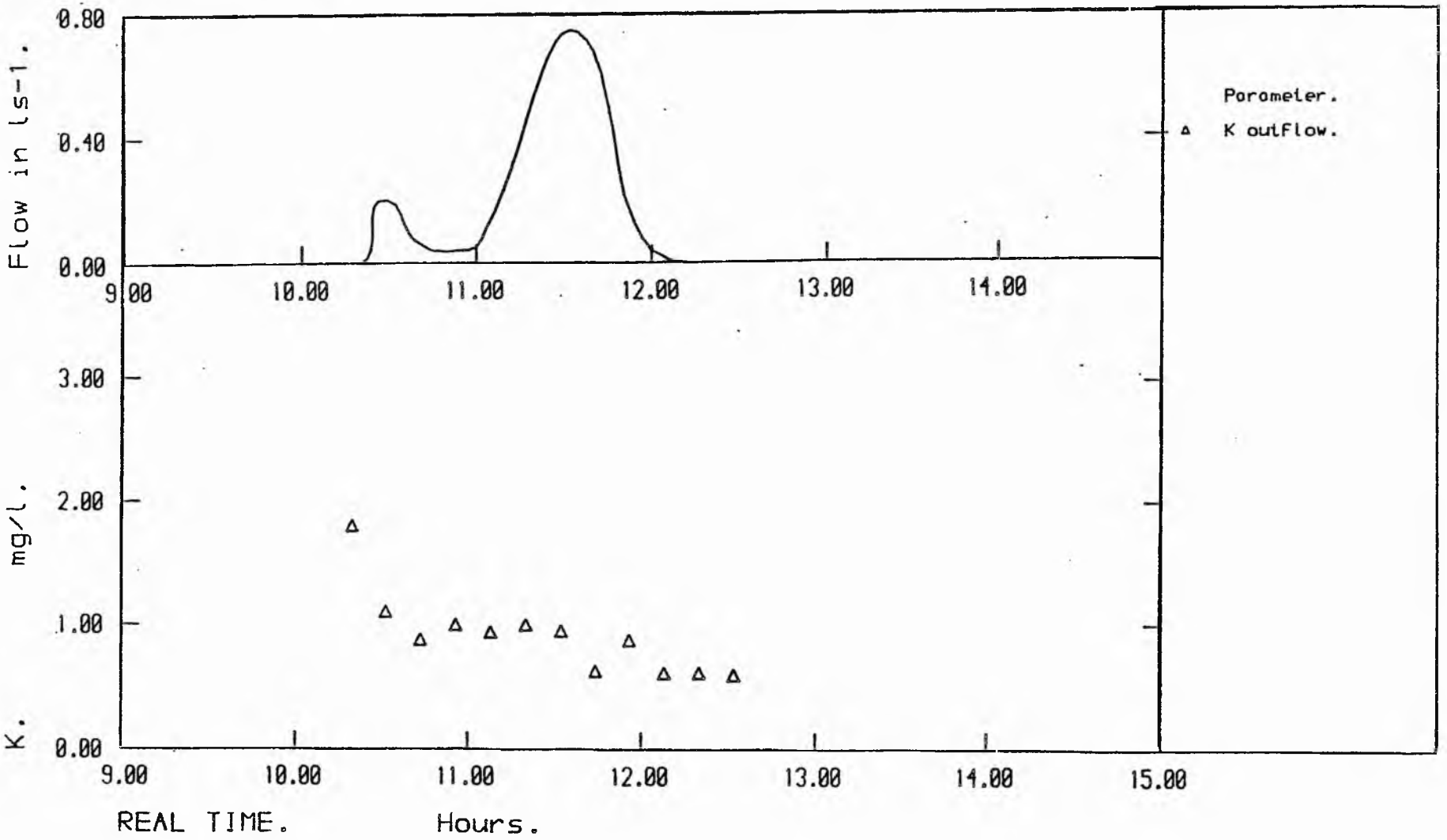
Graph of Ammonia for Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



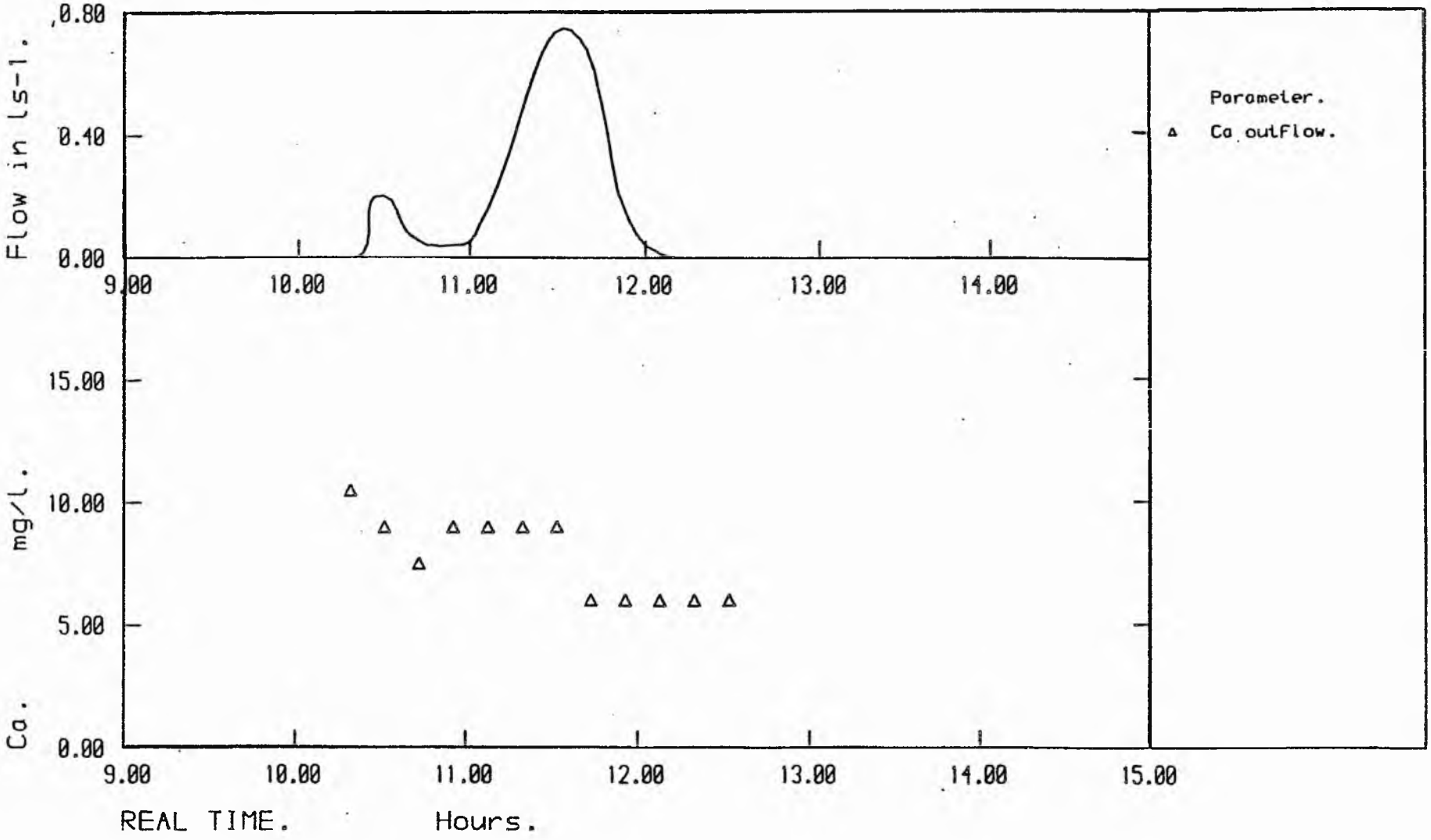
Graph of Nitrate for Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



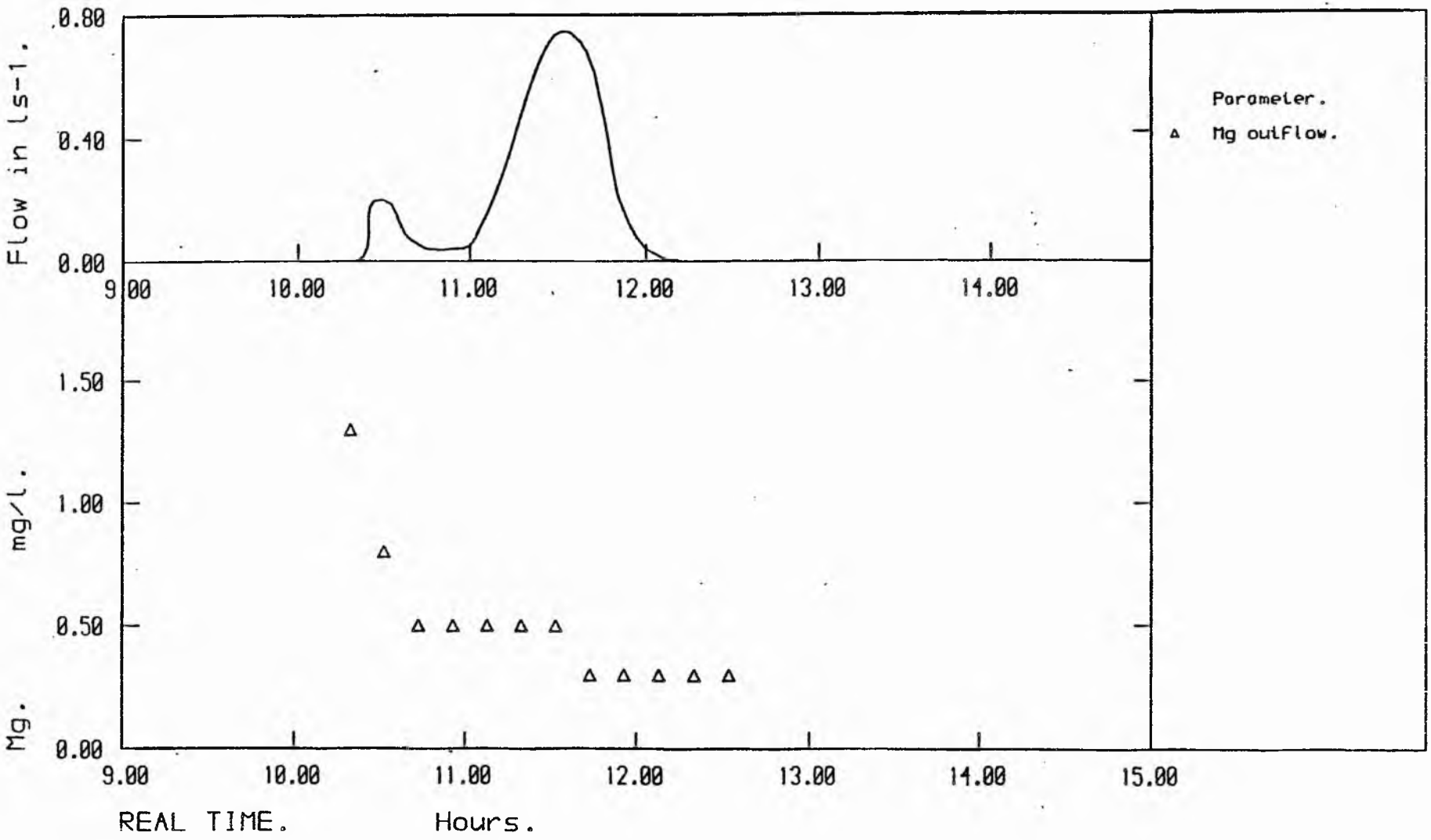
Graph of Sodium for Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



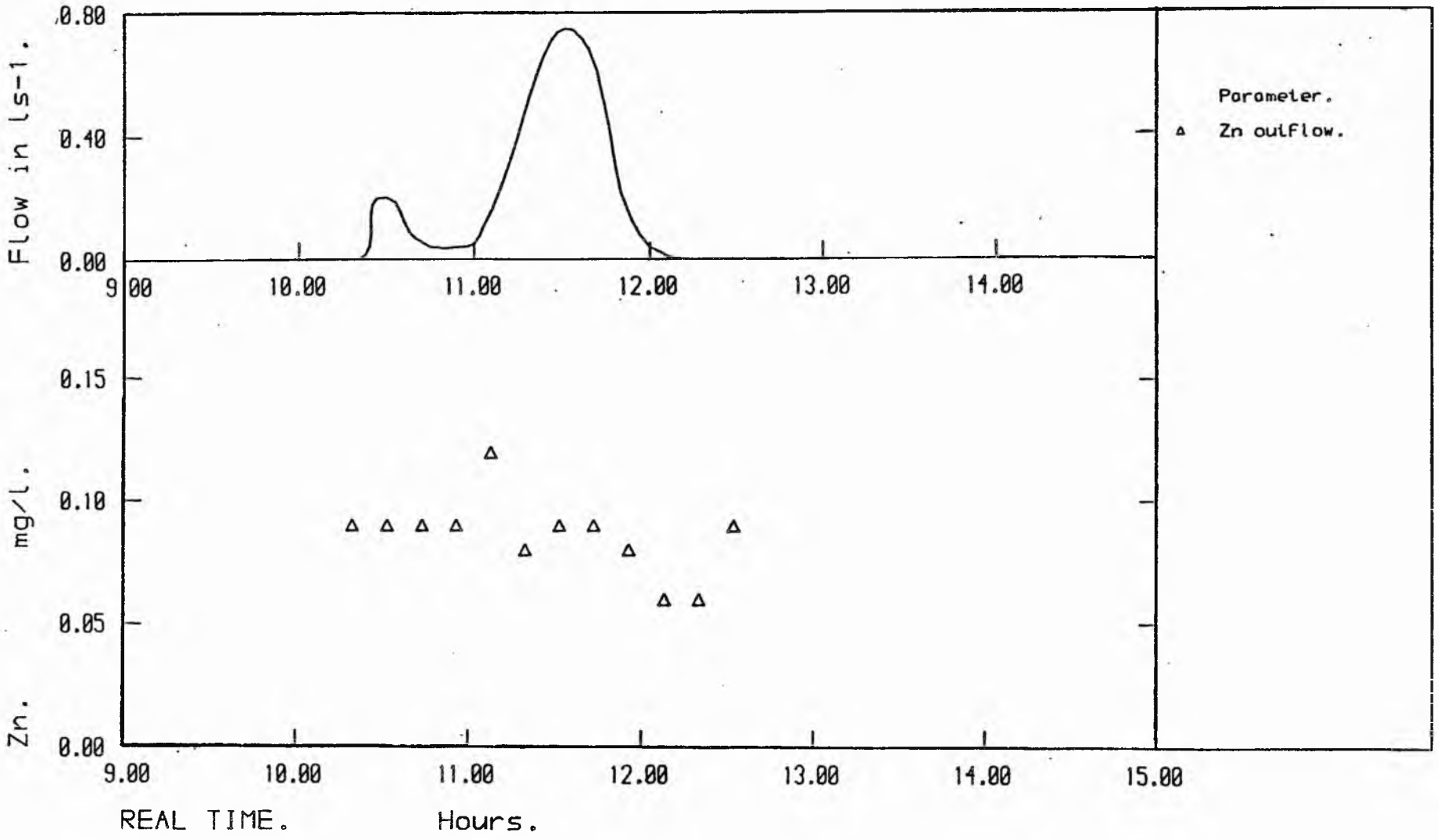
Graph of Potassium for Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



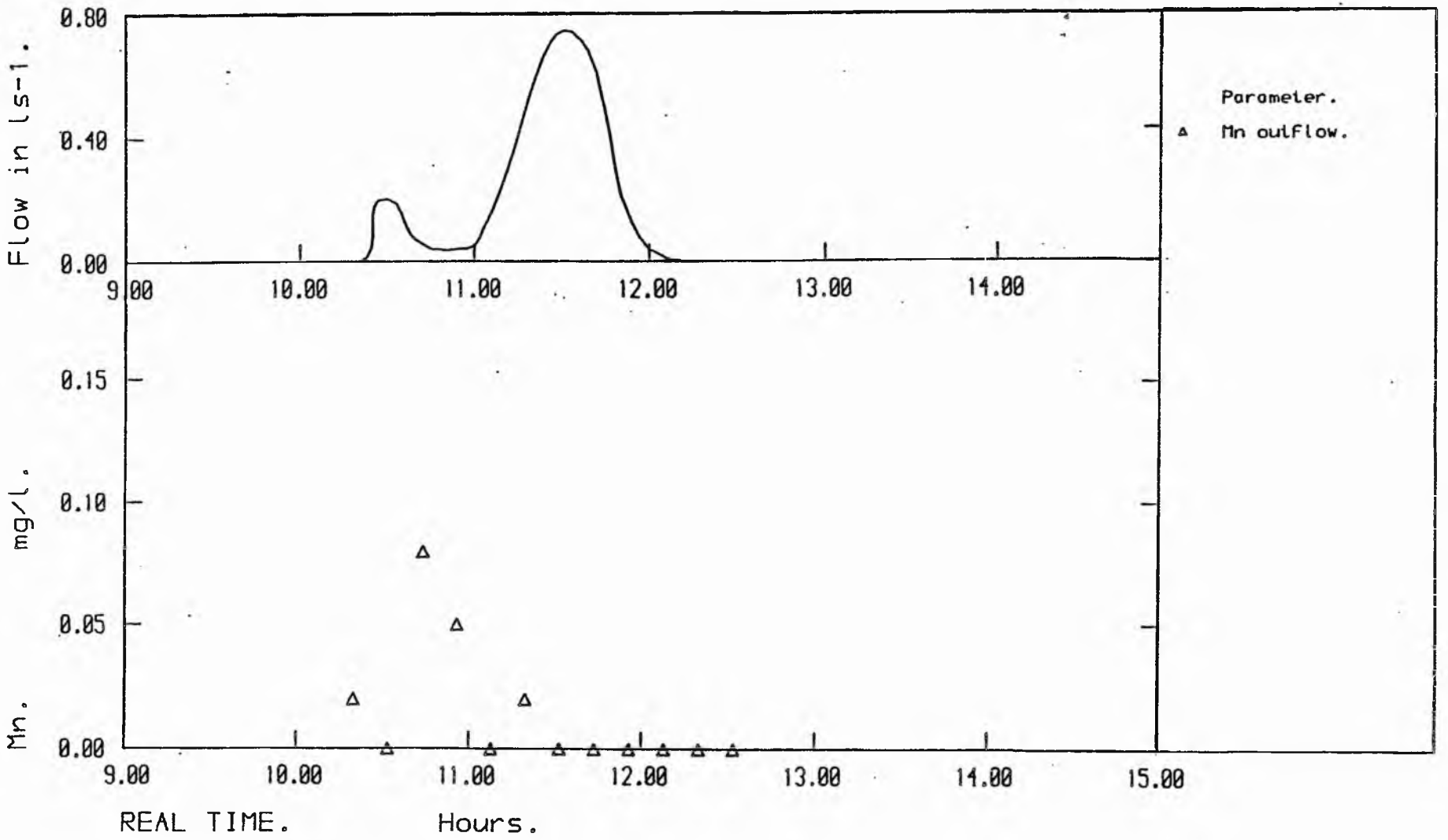
Graph of Calcium for Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



Graph of Magnesium for Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.



Graph of Manganese for Storm VI on Churnet Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
1027	71	5	153
1033	50	0	127
1039	57	0	122
1045	43	0	159
1051	26	0	148
1057	36	7	106
1115	92	4	111
1133	49	2	233
1151	28	0	175
1209	45	0	143

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
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STORM NUMBER : VI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
1027	29	5	59
1039	21	*	35
1051	19	*	54
1103	18	6	0
1115	22	*	40
1127	15	*	10
1139	39	5	45
1151	25	*	30
1203	16	*	20
1215	12	2	5
1227	*	*	20
1239	20	4	0

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
1027	0.21	4.5	6.3
1033	0.27	5.2	6.5
1039	0.25	5.2	6.4
1045	0.25	5.2	6.2
1051	0.21	5.1	6.2
1057	0.27	5.2	6.1
1115	0.21	5.5	6.1
1133	0.21	5.5	6.3
1151	0.17	5.4	6.3
1209	0.12	5.5	6.3

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

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STORM NUMBER : VI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
1027	0.21	4.7	6.0
1039	0.20	4.9	6.1
1051	0.18	5.2	6.3
1103	0.17	5.3	6.4
1115	0.18	5.3	6.3
1127	0.18	5.7	6.3
1139	0.11	6.2	6.3
1151	0.13	6.0	6.4
1203	0.13	5.7	6.3
1215	0.14	5.7	6.3
1227	0.12	6.0	6.2
1239	0.14	6.2	6.4

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
1027	40.0	70.0	125	17.7
1033	40.0	110.0	135	56.7
1039	40.0	100.0	106	31.9
1045	40.0	40.0	135	21.3
1051	40.0	80.0	135	31.9
1057	40.0	110.0	135	28.4
1103	30.0	*	*	*
1109	40.0	*	*	*
1115	40.0	90.0	163	31.9
1127	40.0	*	*	*
1133	30.0	100.0	125	17.7
1139	20.0	*	*	*
1145	10.0	*	*	*
1151	10.0	60.0	86	21.3
1157	20.0	*	*	*
1203	20.0	*	*	*
1209	20.0	90.0	96	24.8
1215	20.0	*	*	*

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
1027	40.0	130.0	279	31.9
1039	*	120.0	*	21.3
1051	*	140.0	*	21.3
1103	50.0	60.0	336	28.4
1115	*	140.0	*	0.0
1127	*	100.0	*	31.9
1139	*	90.0	*	24.8
1151	20.0	120.0	202	35.5
1203	*	120.0	*	49.6
1215	*	70.0	*	38.9
1227	*	110.0	*	17.7
1239	20.0	80.0	202	21.3

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Phosphate mgl-1
1027	5.5	19.9	1.0
1033	5.6	11.9	0.9
1039	5.9	8.7	0.7
1045	5.5	21.7	0.7
1051	6.3	16.8	0.7
1057	5.6	17.5	0.6
1109	5.9	7.6	0.6
1133	6.7	26.6	0.6
1151	6.7	31.5	0.3
1209	6.7	31.5	0.3

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Phosphate mgl-1
1027	5.9	26.6	1.2
1039	5.5	46.2	0.6
1051	6.7	56.0	0.4
1103	7.1	61.6	0.3
1115	6.7	56.0	0.9
1127	6.3	58.8	0.5
1139	6.3	67.2	0.7
1151	5.9	75.6	0.3
1203	5.5	67.2	0.2
1215	8.4	58.8	0.5
1227	8.7	67.2	0.3
1239	8.7	67.2	0.6

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
1027	3.0	0.8	10.5	1.4
1033	2.3	0.6	8.7	1.4
1039	2.2	0.5	10.5	1.4
1045	2.5	1.0	8.7	1.3
1051	1.9	0.6	8.7	1.3
1057	3.0	0.6	10.5	1.4
1109	3.2	0.6	10.5	1.4
1133	1.5	0.4	3.4	0.8
1151	1.7	0.2	2.1	0.5
1209	1.8	0.3	2.4	0.5

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
1027	2.5	1.0	11.8	0.8
1039	3.0	0.8	10.5	0.9
1051	2.8	0.7	10.5	0.9
1103	2.8	0.8	10.5	1.1
1115	2.2	0.6	9.0	0.9
1127	2.3	0.6	9.0	0.9
1139	2.0	0.5	6.0	0.5
1151	1.7	0.4	4.5	0.2
1203	2.0	0.4	4.5	0.4
1215	2.0	0.3	4.5	0.2
1239	1.6	0.3	4.5	0.2

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens

DATE OF THE STORM EVENT : 2nd. November 1984 (841102)

STORM NUMBER : VT

ANALYSIS OF INFLOW WATER TO THE GULLY POT

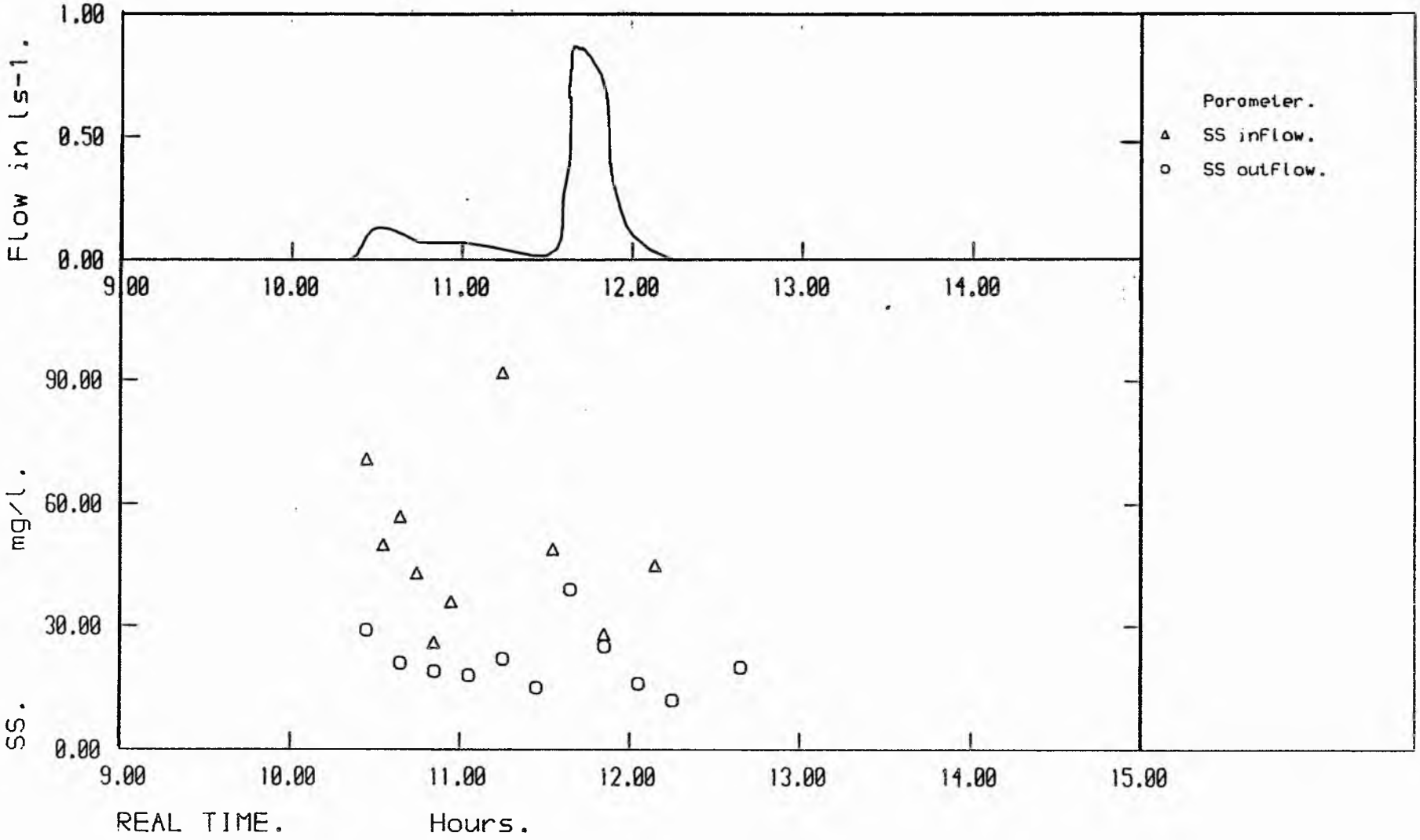
REAL TIME Hours	Mn mgl-1	Zn mgl-1
1027	0.2	0.2
1033	0.3	0.2
1039	0.2	0.2
1045	0.2	0.2
1051	0.0	0.1
1057	0.1	0.1
1109	0.1	0.1
1133	0.0	0.1
1151	0.0	0.1
1209	0.0	0.1

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

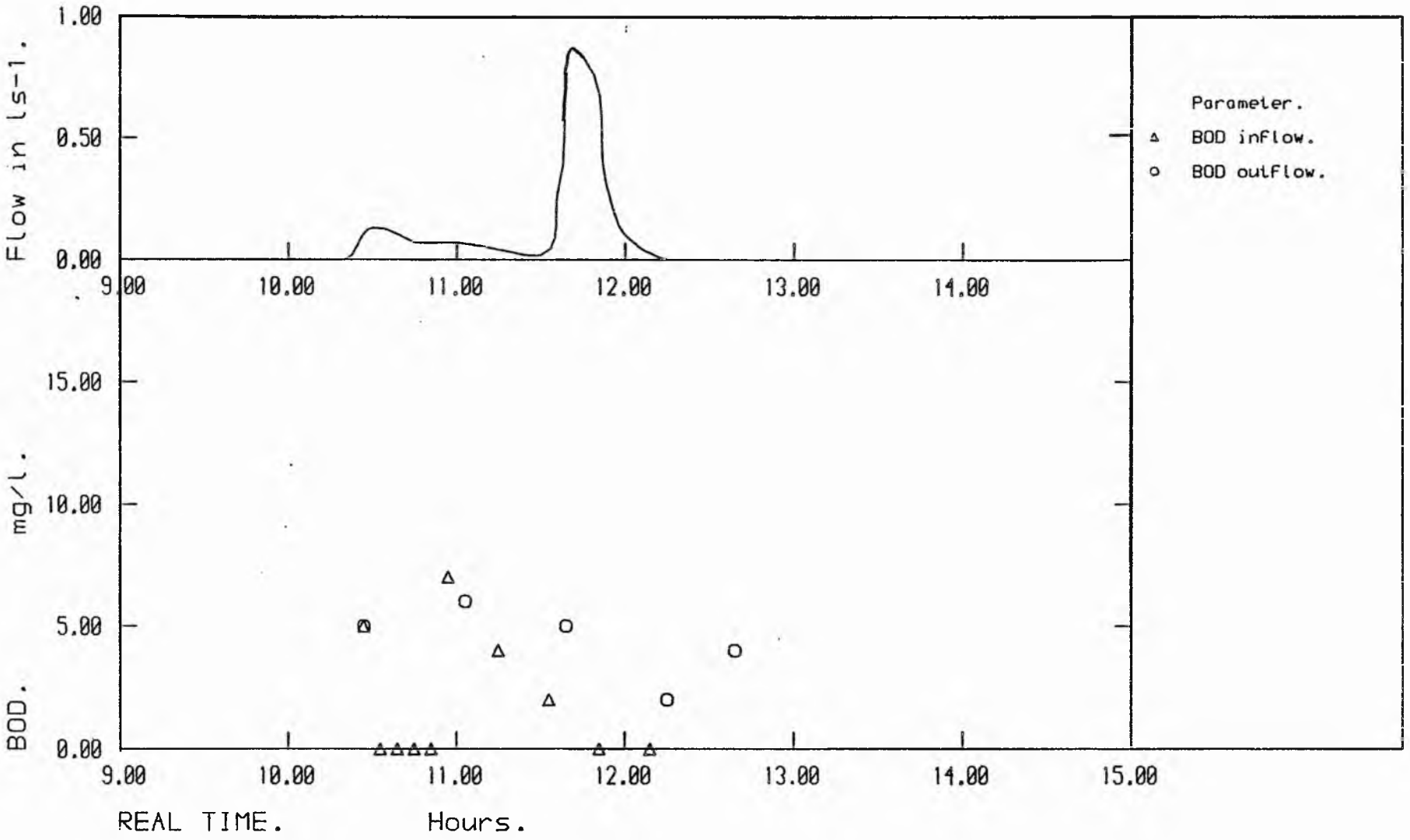
CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 2nd. November 1984 (841102)
STORM NUMBER : VI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

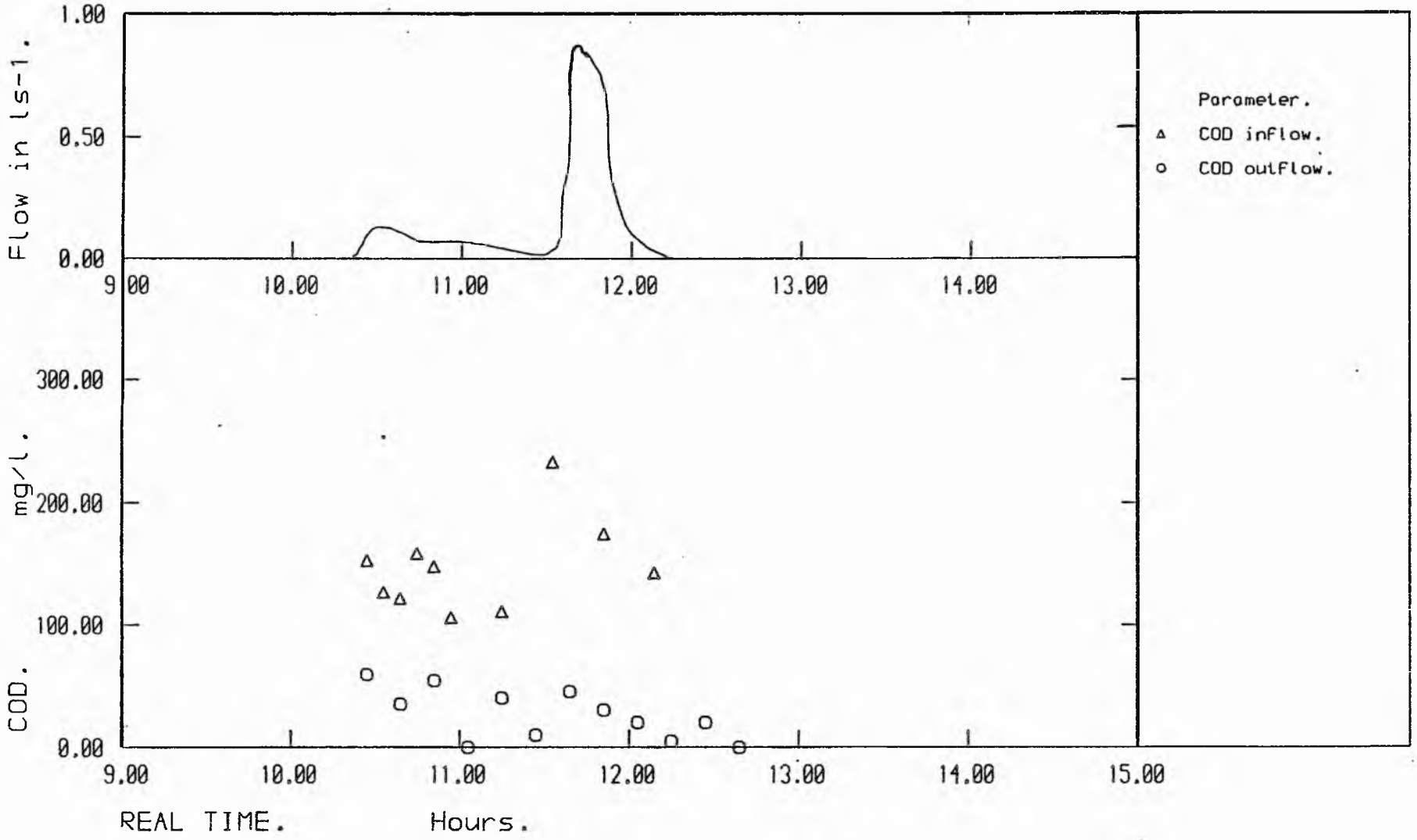
REAL TIME Hours	Mn mgl-1	Zn mgl-1
1027	0.1	0.2
1039	0.2	0.2
1051	0.1	0.1
1103	0.2	0.1
1115	0.1	0.2
1127	0.2	0.1
1139	0.2	0.1
1151	0.0	0.1
1203	0.0	0.0
1215	0.0	0.1
1239	0.0	0.1



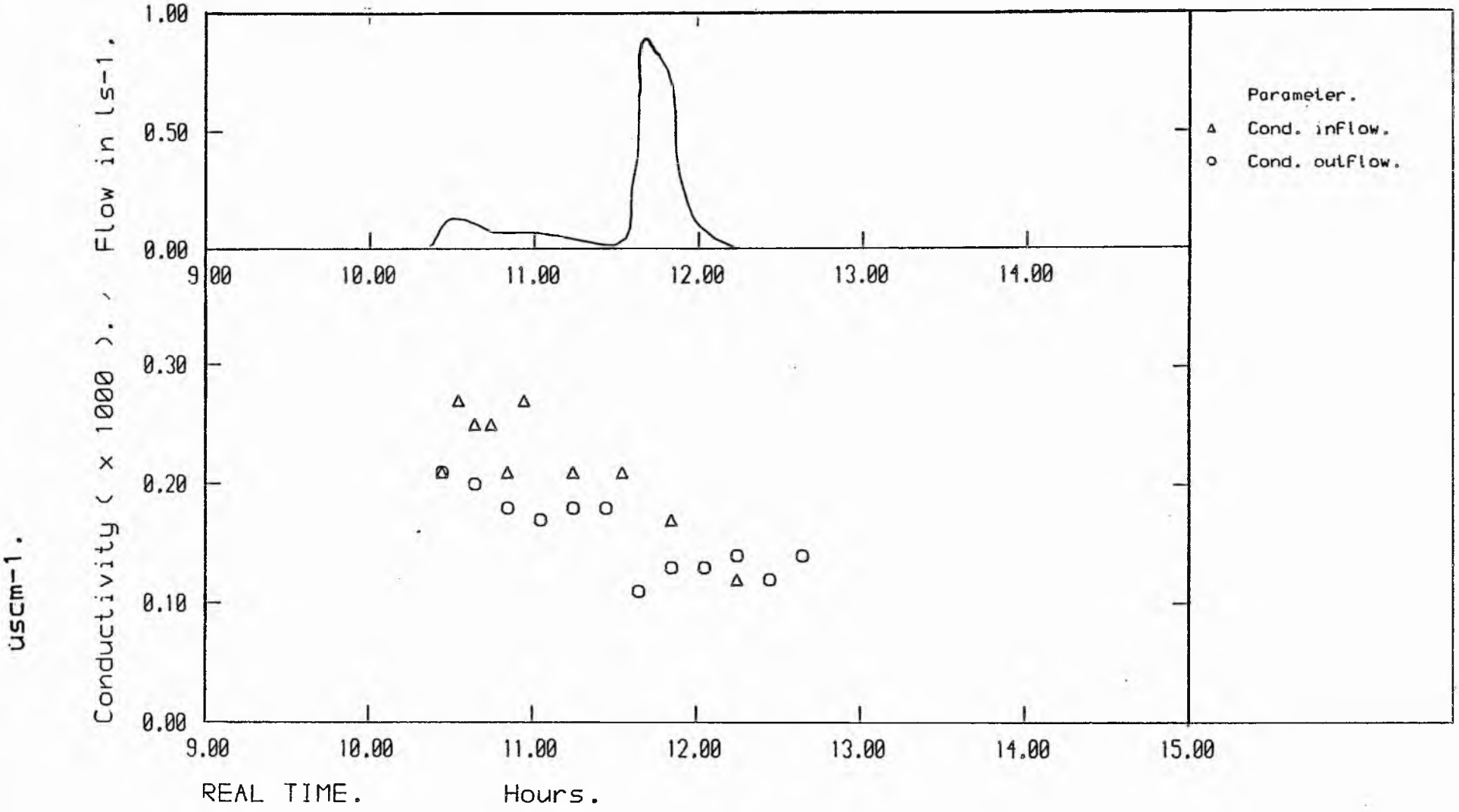
Graph of Suspended Solids for Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



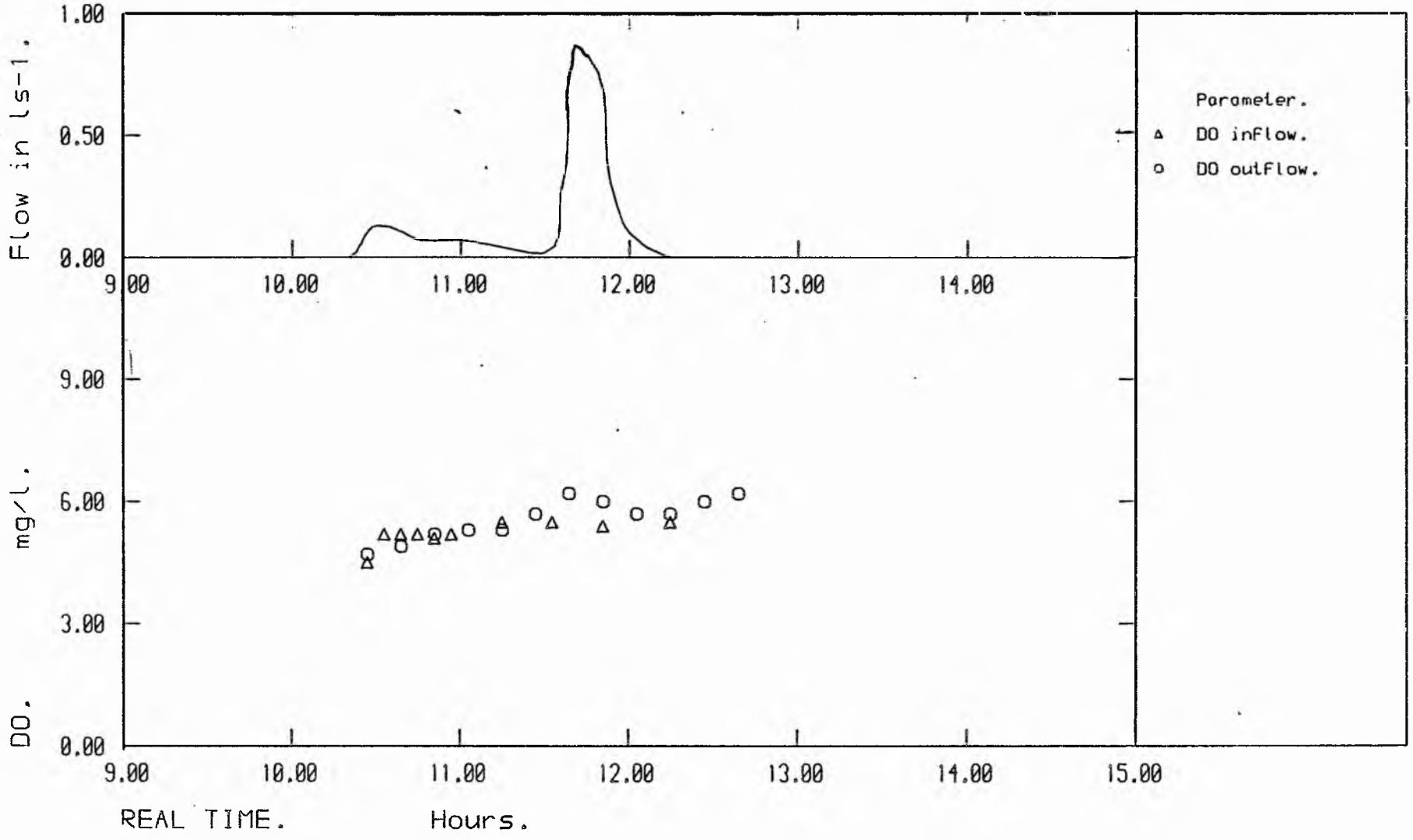
Graph of Biochemical Oxygen Demand For Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



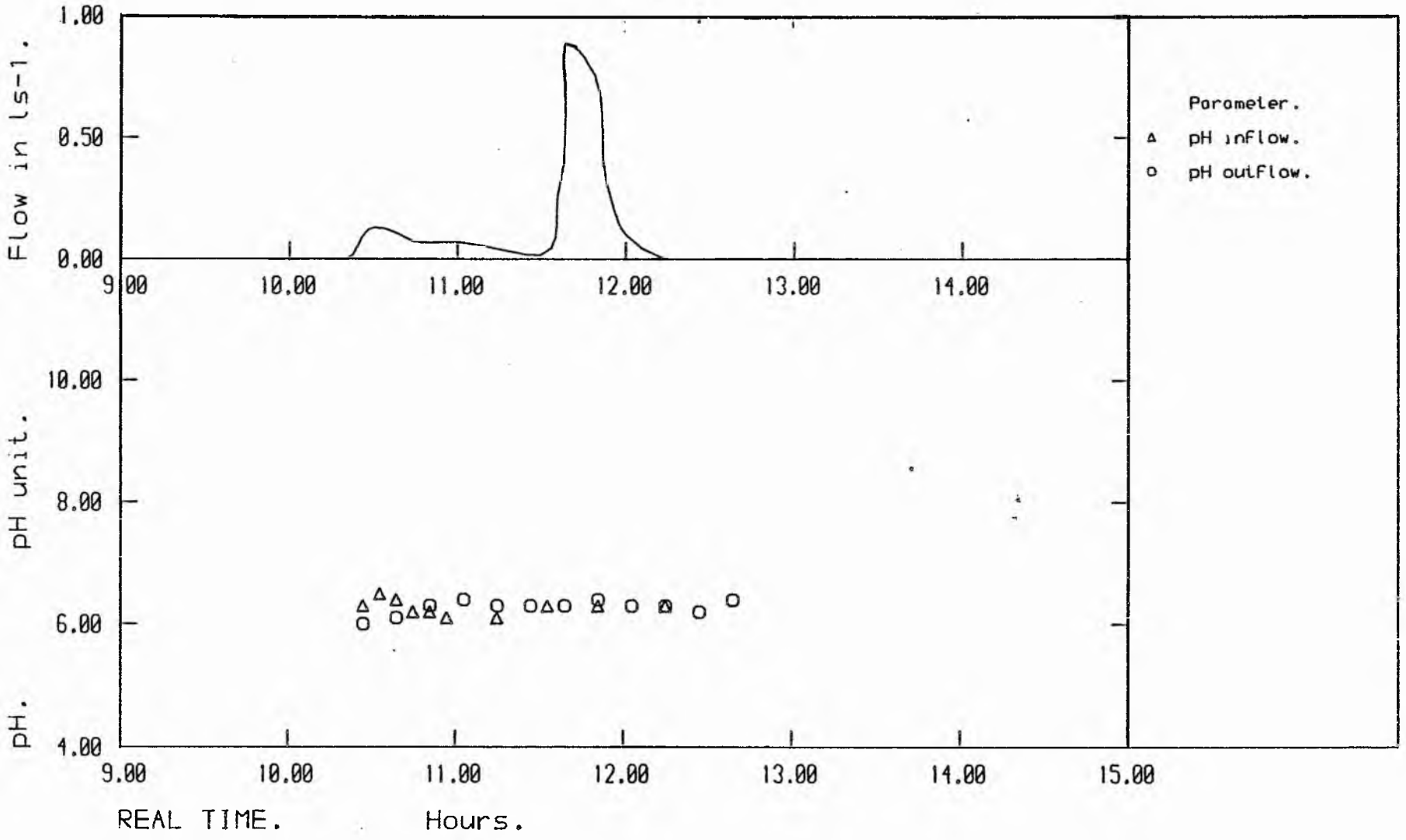
Graph of Chemical Oxygen Demand for Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



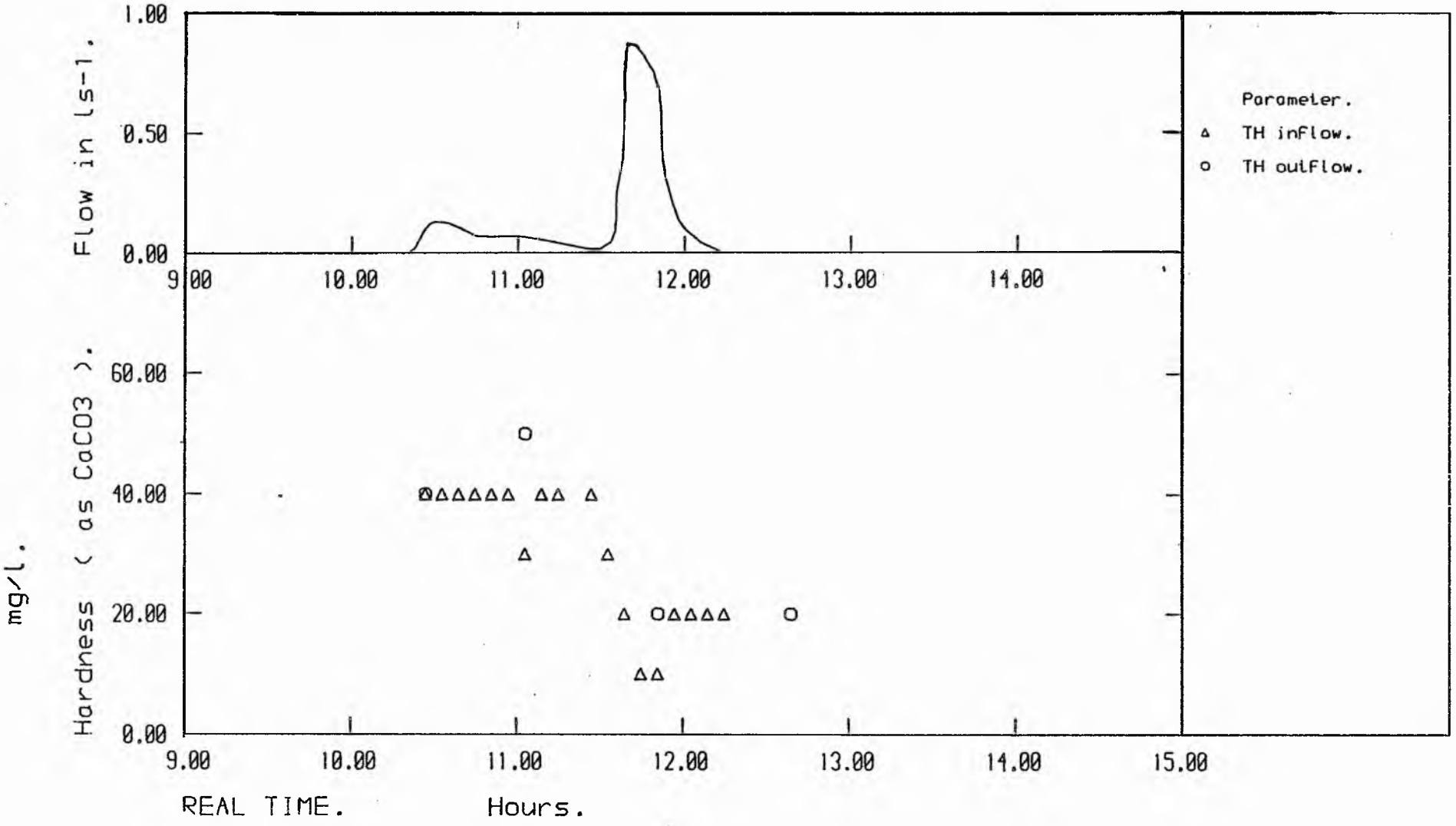
Graph of Conductivity for Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



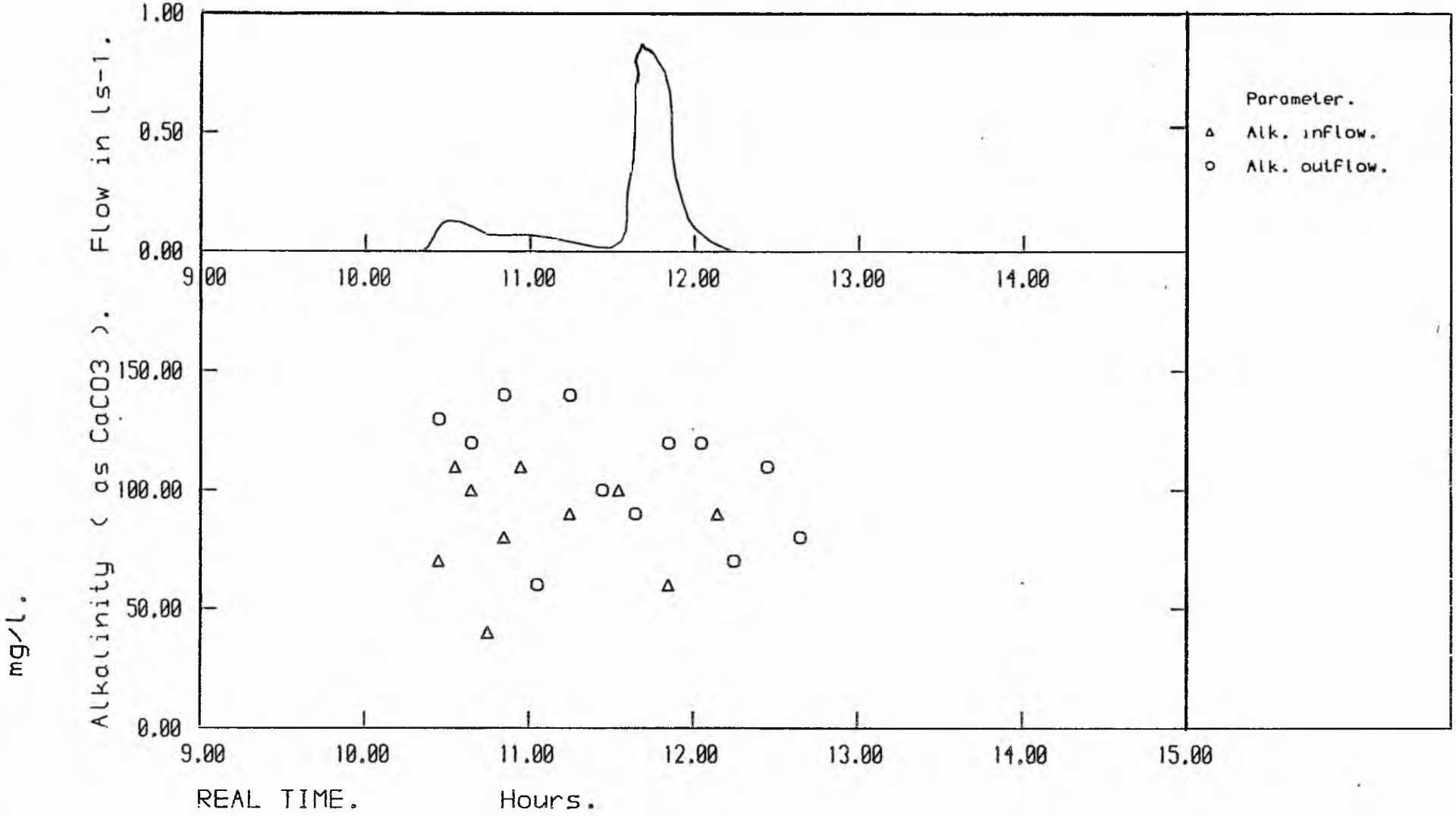
Graph of Dissolved Oxygen for Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



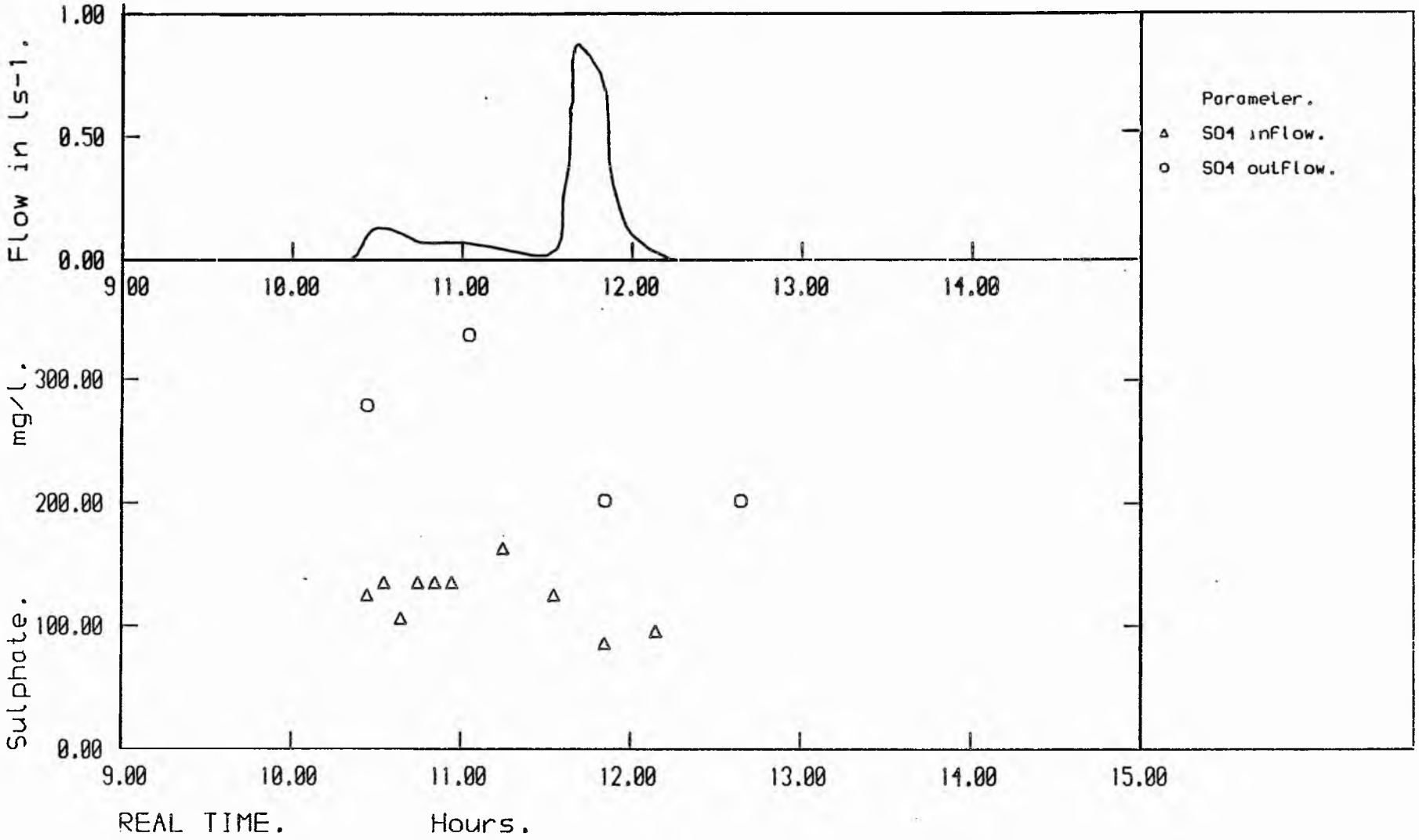
Graph of pH for Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



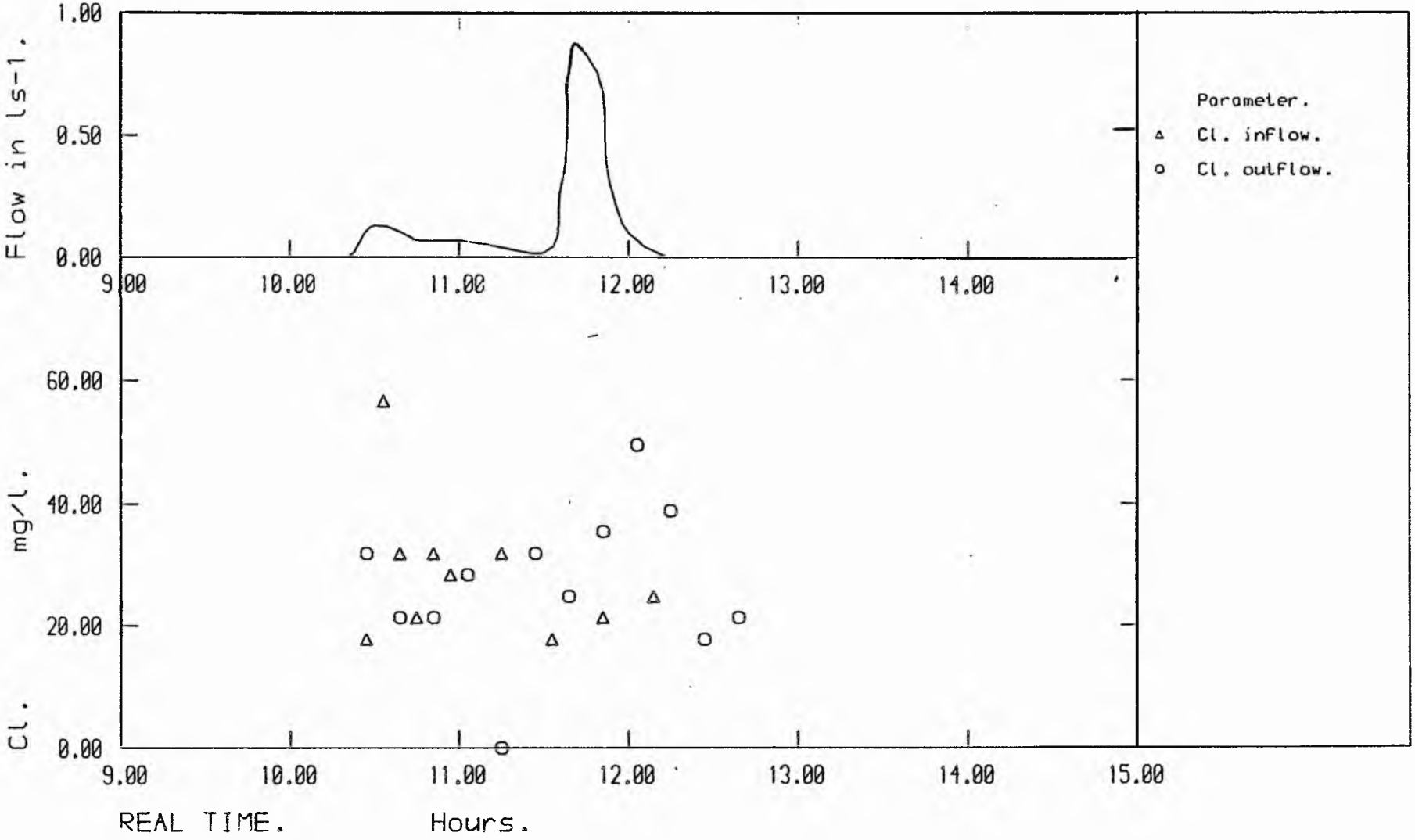
Graph of Total Hardness for Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



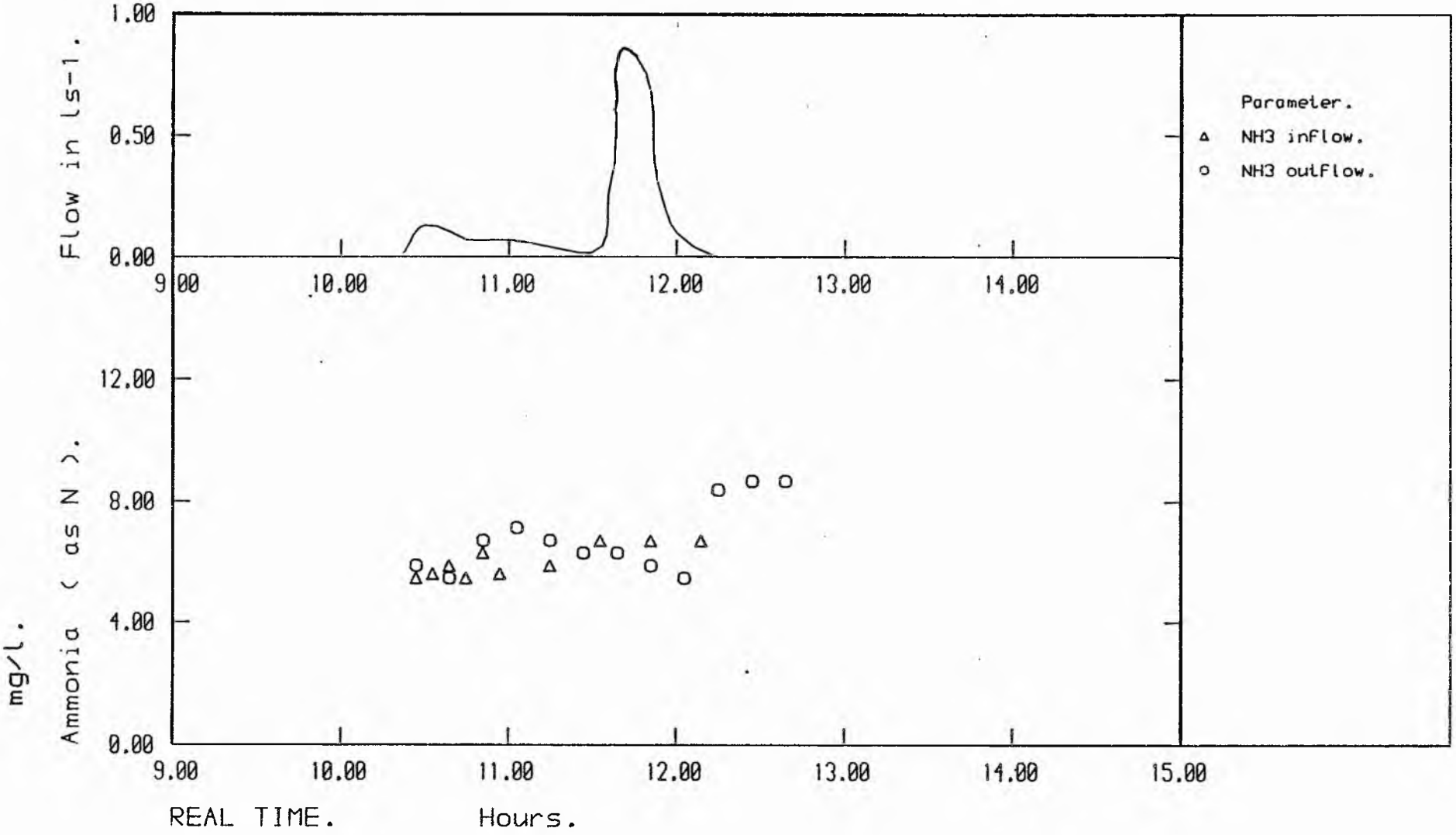
Graph of Total Alkalinity For Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



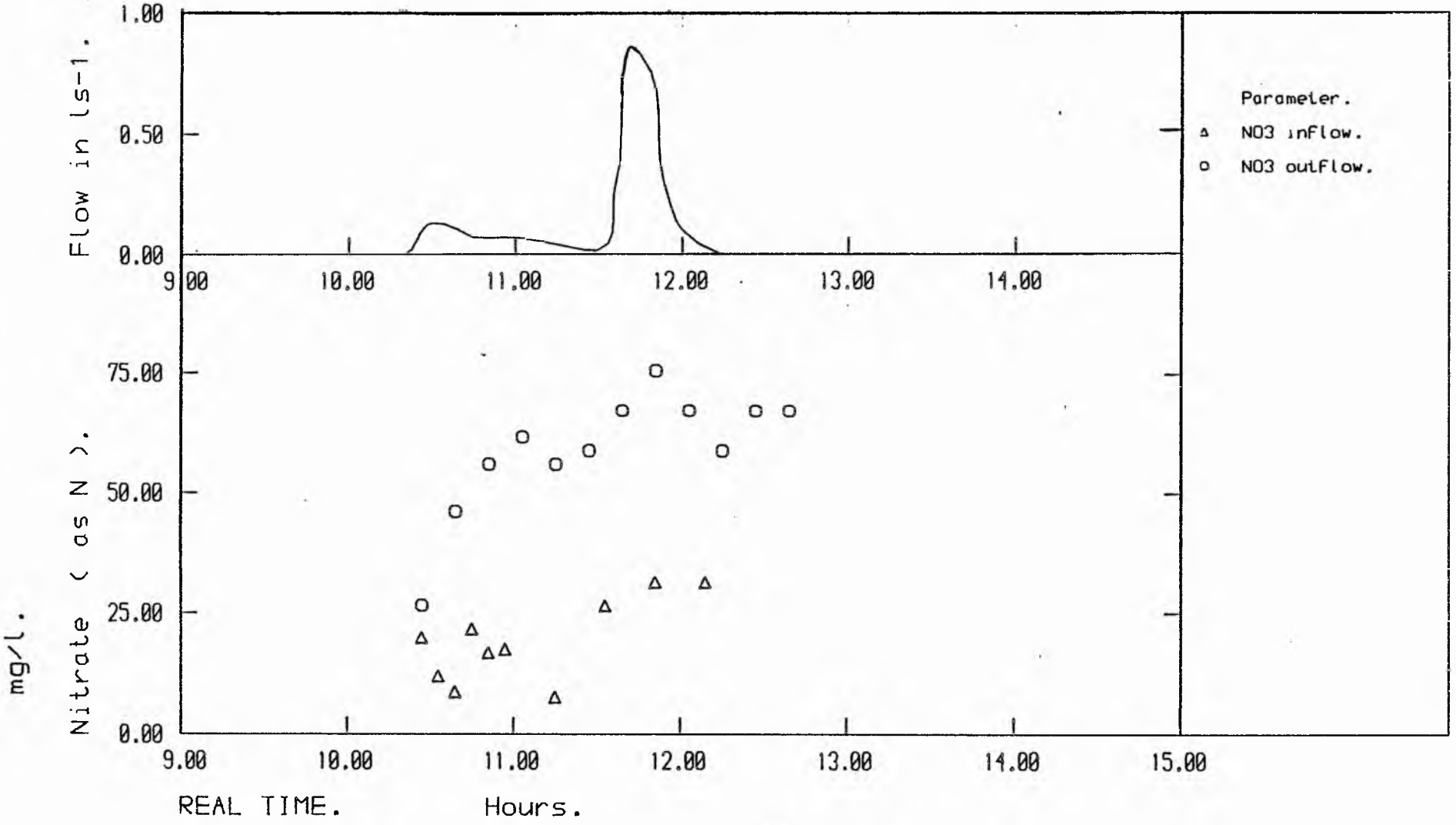
Graph of Sulphate For Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



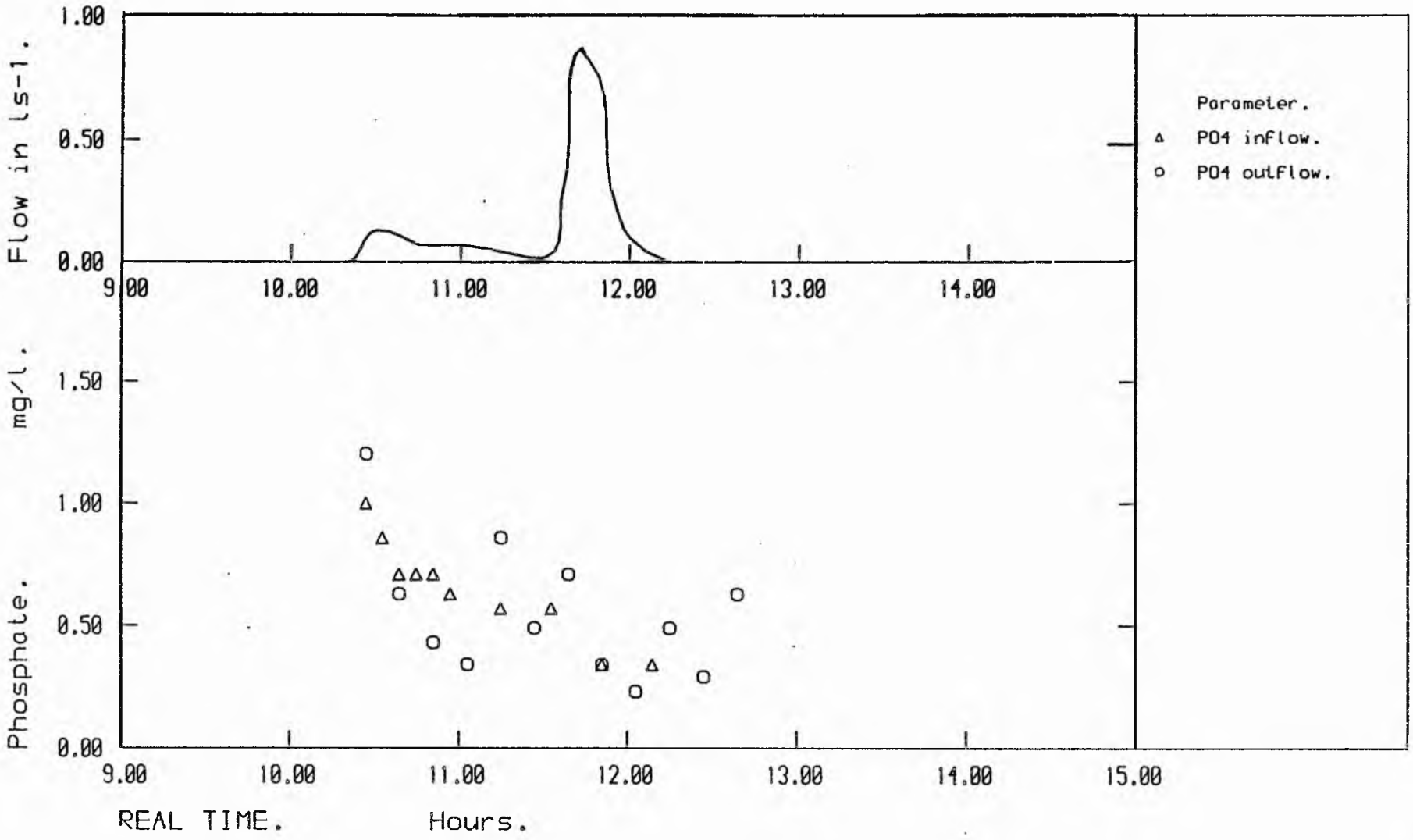
Graph of Chloride for Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



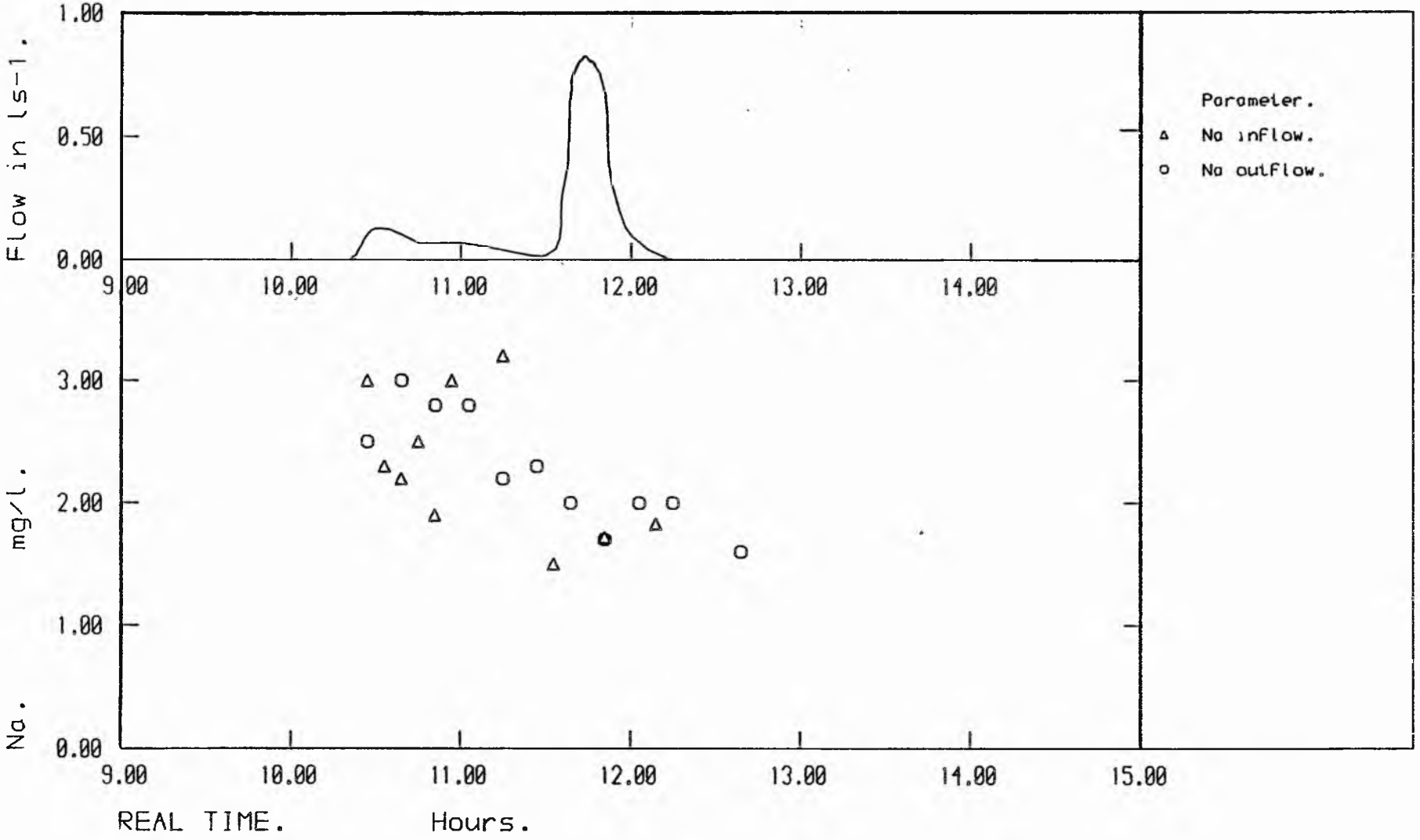
Graph of Ammonia for Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



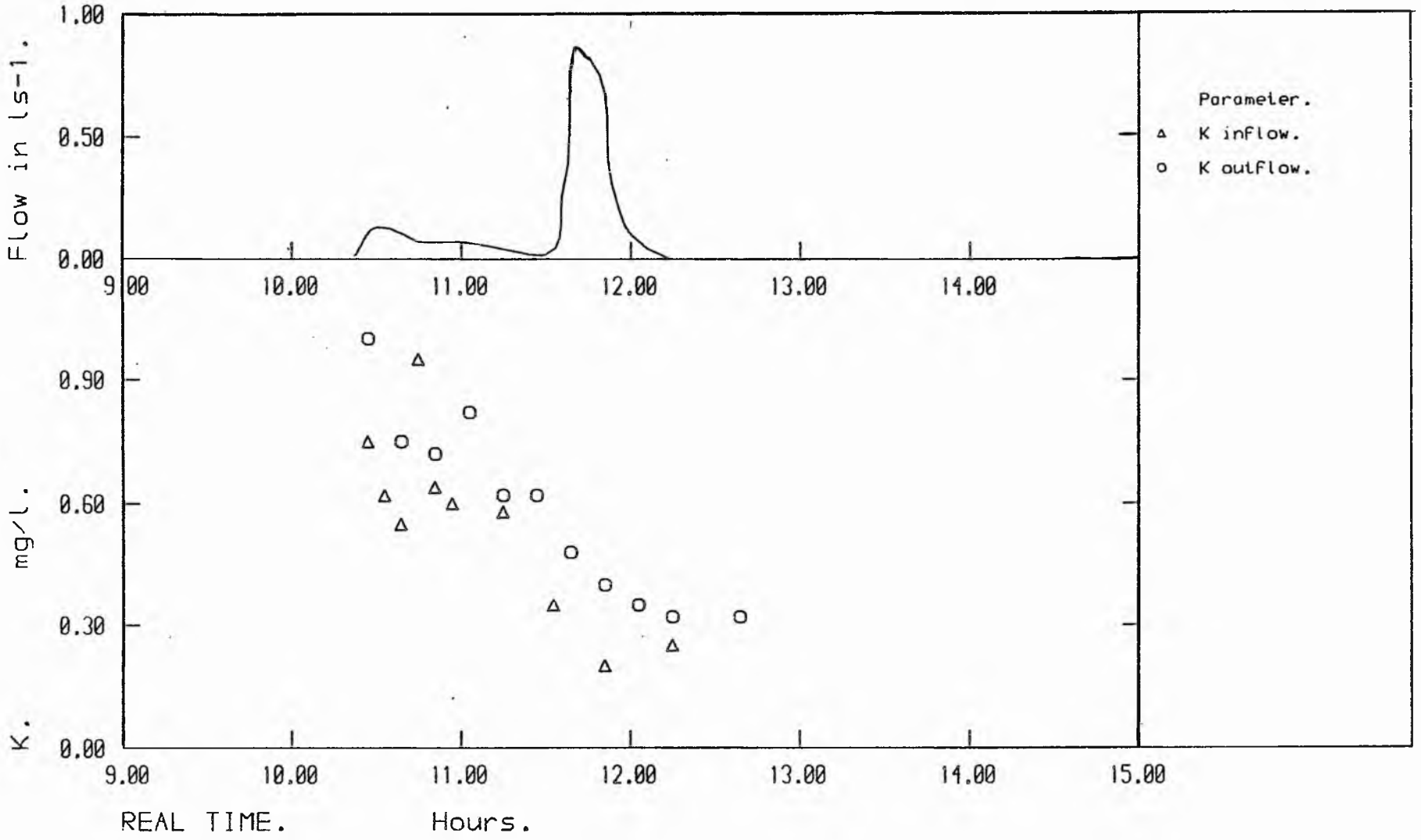
Graph of Nitrate for Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



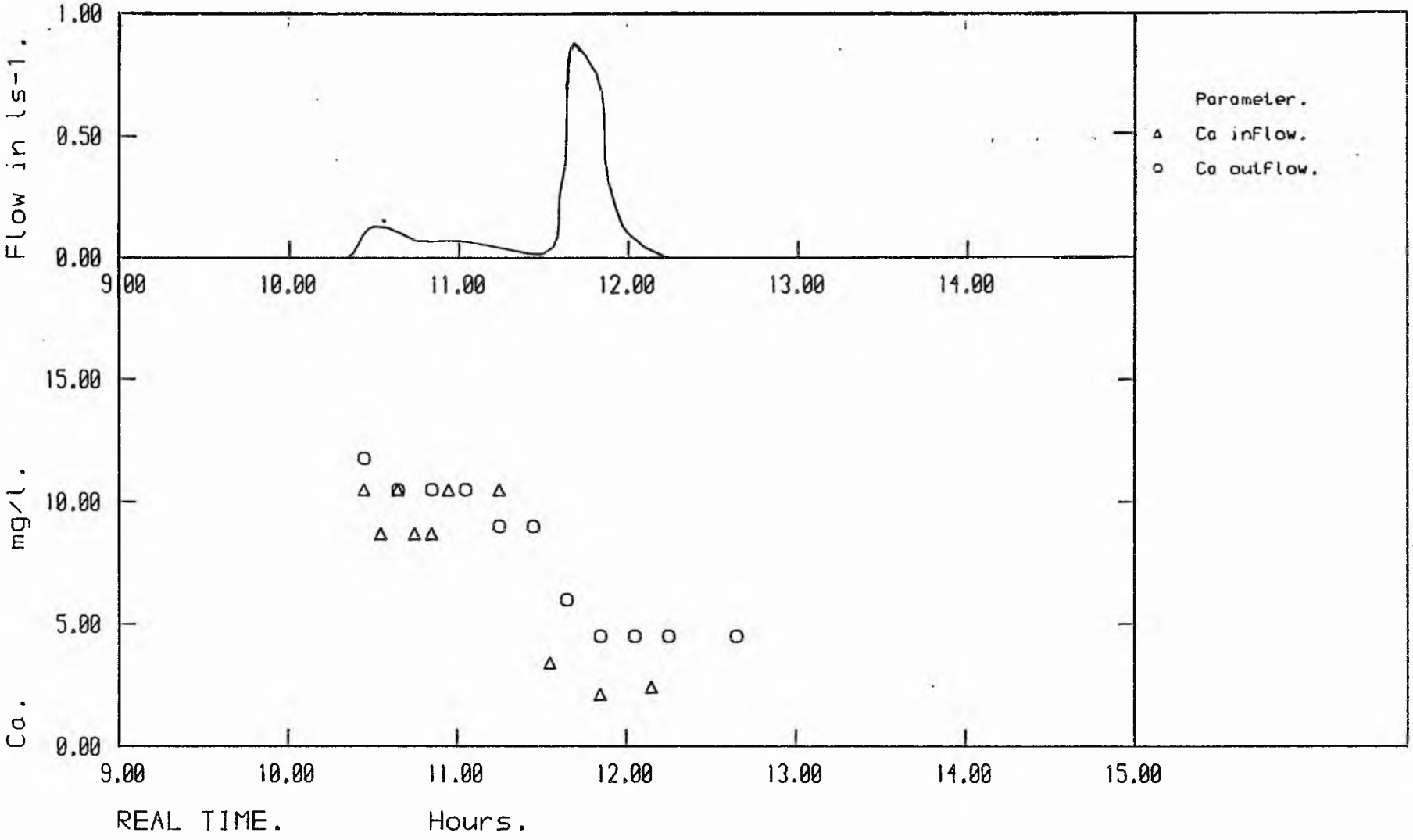
Graph of Phosphate for Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



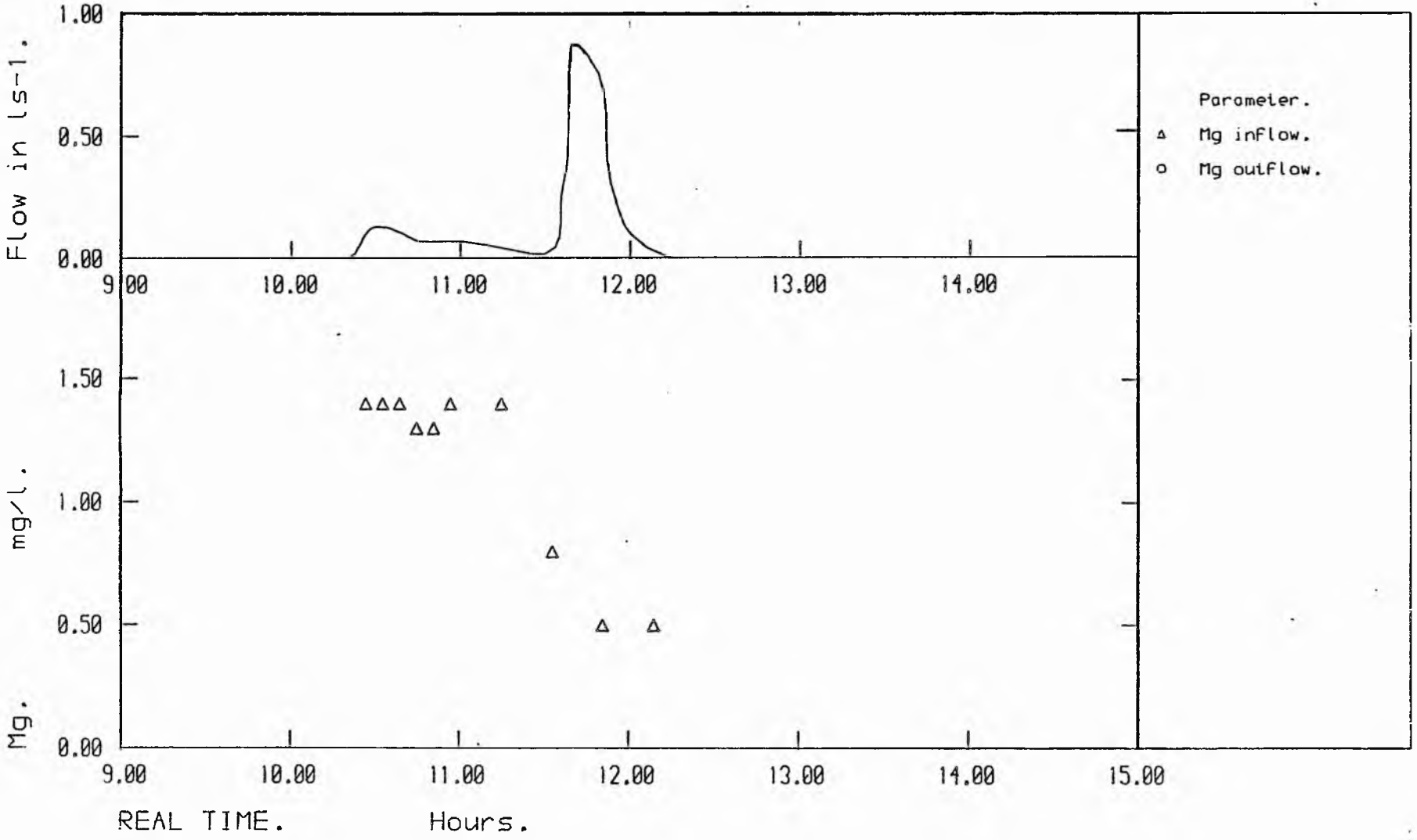
Graph of Sodium for Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



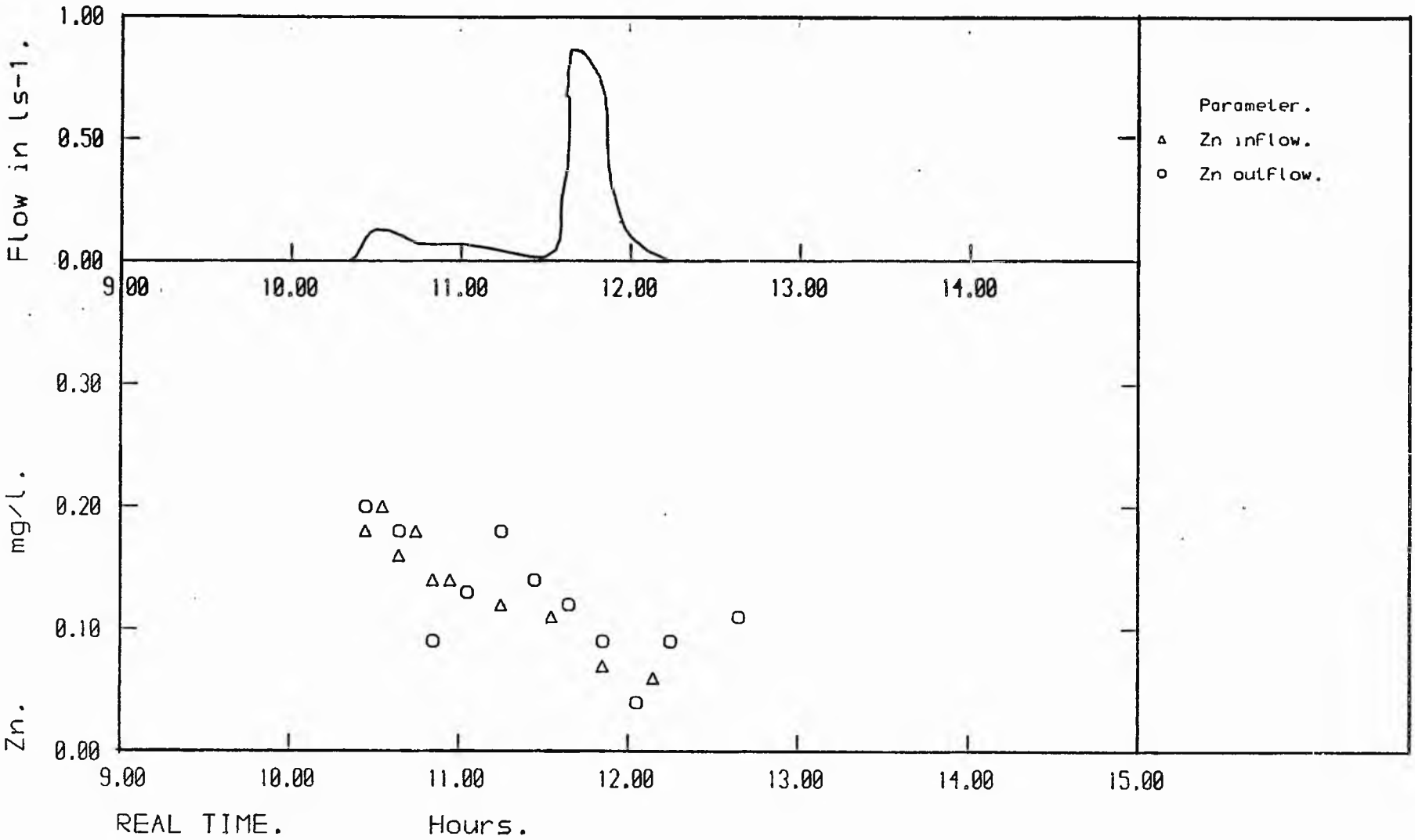
Graph of Potassium for Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



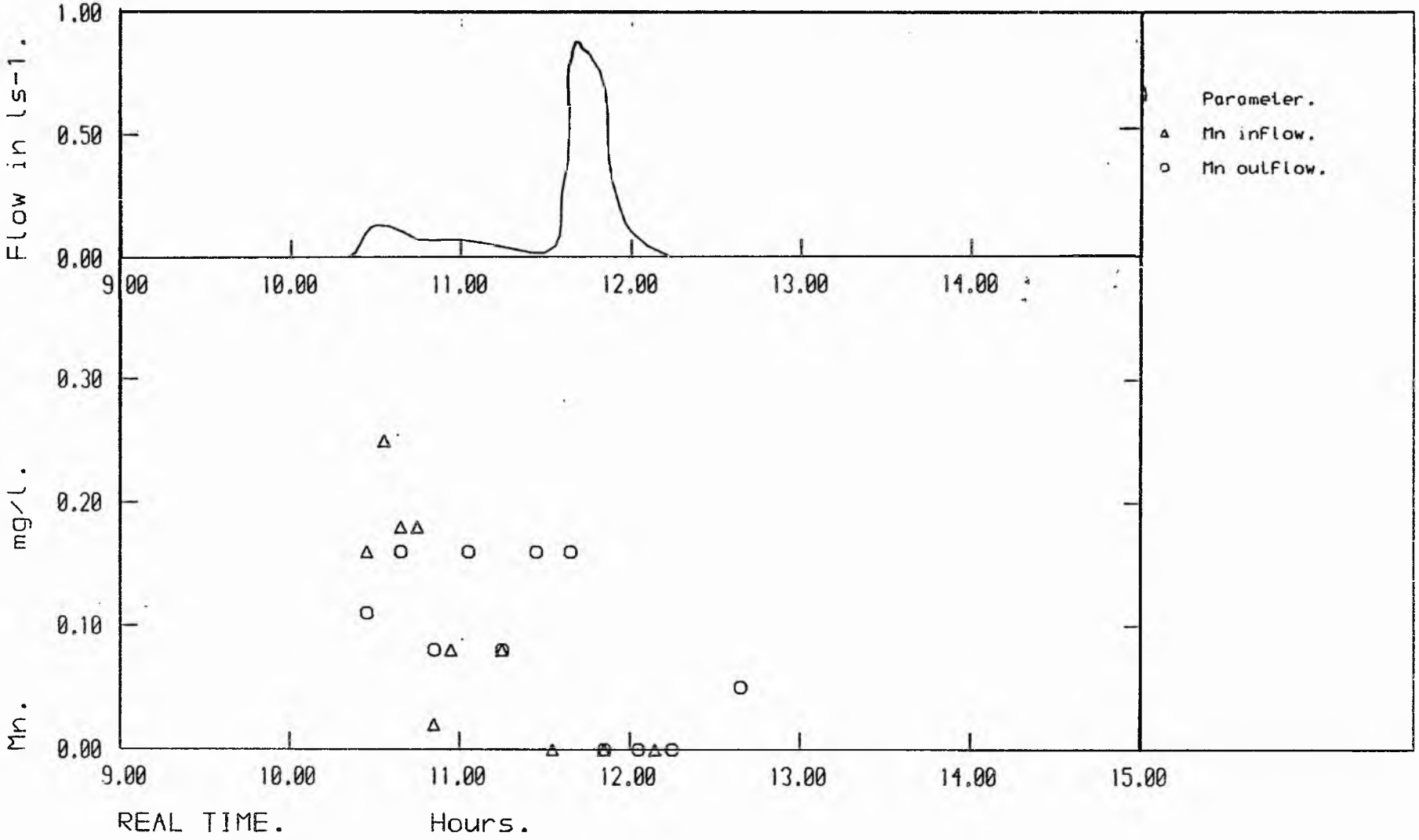
Graph of Calcium for Storm VI on TwyFord Gardens.
The graph shows inflow and outflow water quality data.



Graph of Magnesium for Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Zinc For Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Manganese for Storm VI on Twyford Gardens.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 26th. July 1985 (850726)
STORM NUMBER : VII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	COD mgl-1
1407	160	101
1413	87	65

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 26th. July 1985 (850726)
STORM NUMBER : VII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
1407	0.06	8.7	6.7
1413	0.02	8.7	6.8

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 26th. July 1985 (850726)
STORM NUMBER : VII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

REAL TIME Hours	TH mgl-1	ALK mgl-1	SO4 mgl-1	Cl mgl-1
1407	350.0	140.0	875	46.1
1413	370.0	100.0	1384	39.0

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close

DATE OF THE STORM EVENT : 26th. July 1985 (850726)

STORM NUMBER : VII

ANALYSIS OF INFLOW WATER TO THE GULLY POT

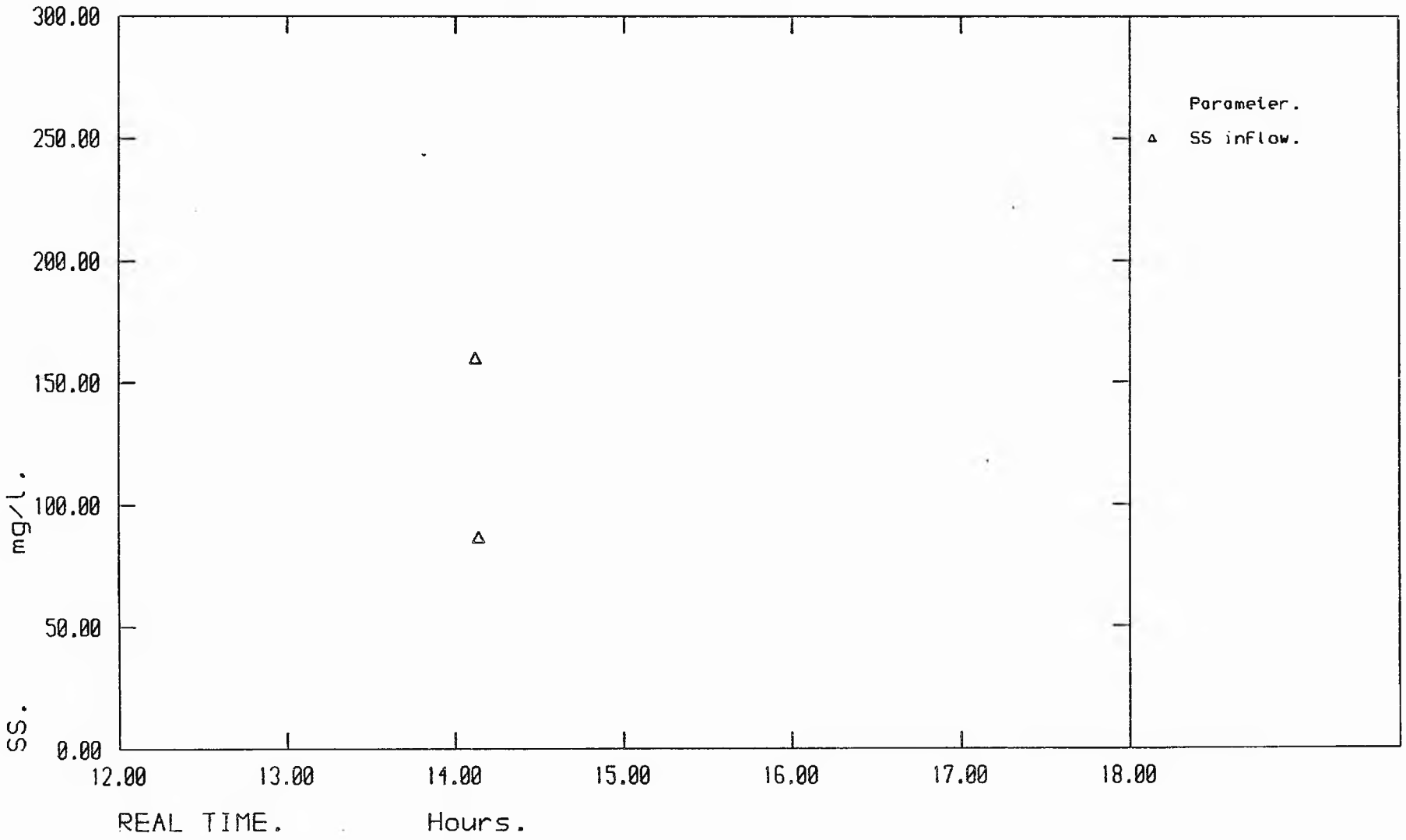
REAL TIME Hours	Calcium mgl-1	Phosphate mgl-1
1407	9.2	0.6
1413	8.7	*

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

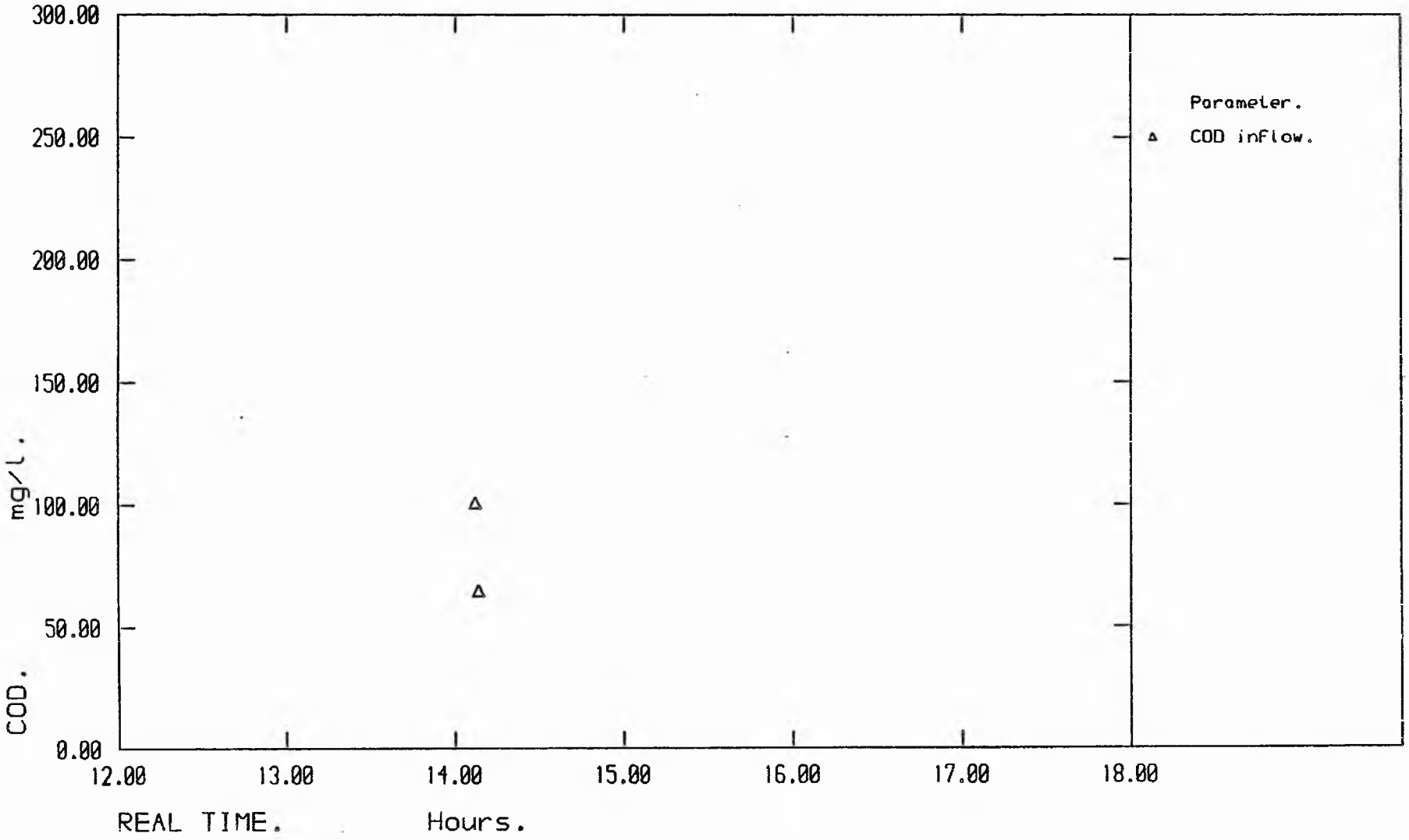
CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 26th. July 1985 (850726)
STORM NUMBER : VII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

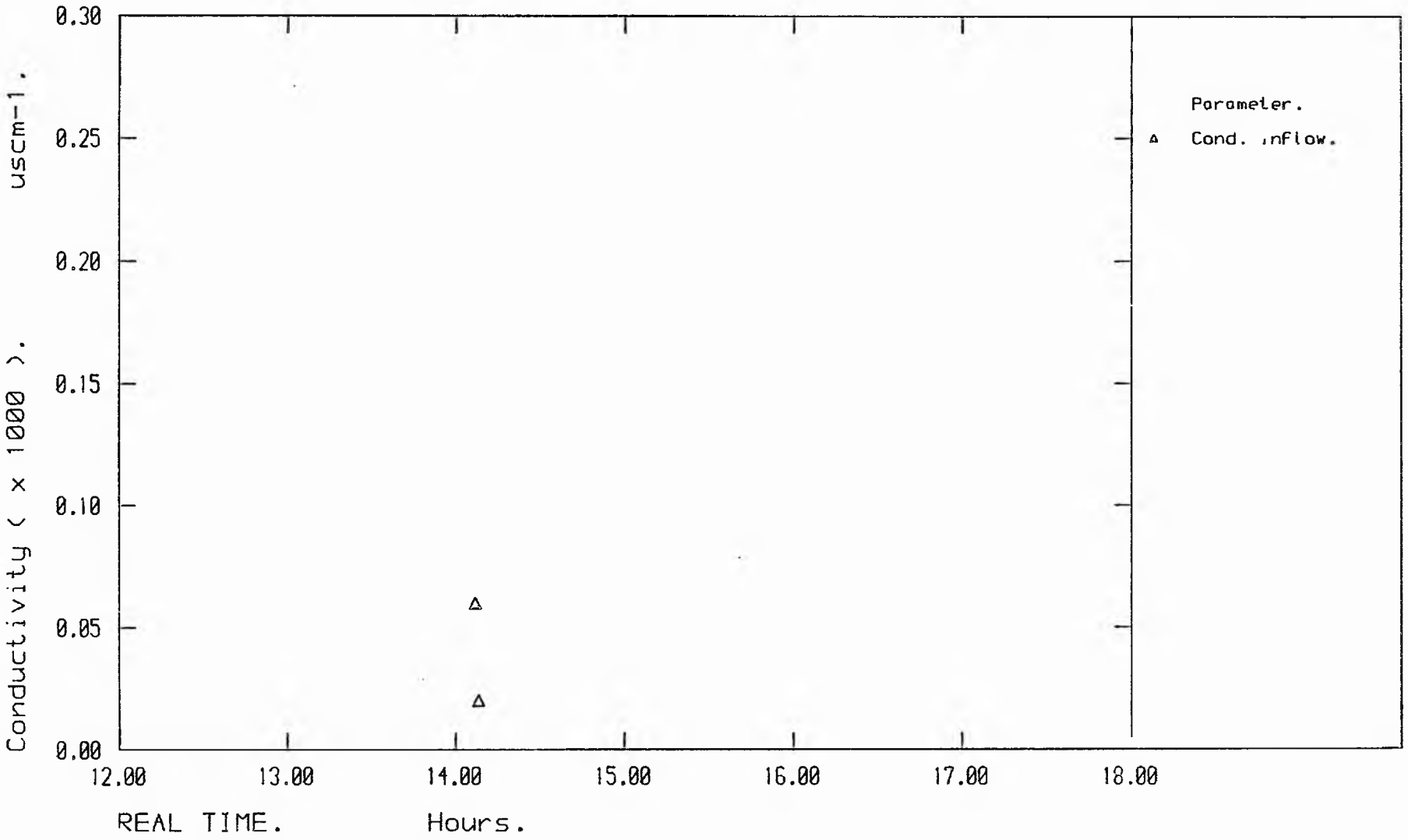
REAL TIME Hours	Na mgl-1	K mgl-1	Mg mgl-1	Zn mgl-1
1407	4.6	0.4	0.8	0.1
1413	2.2	0.5	0.8	0.1



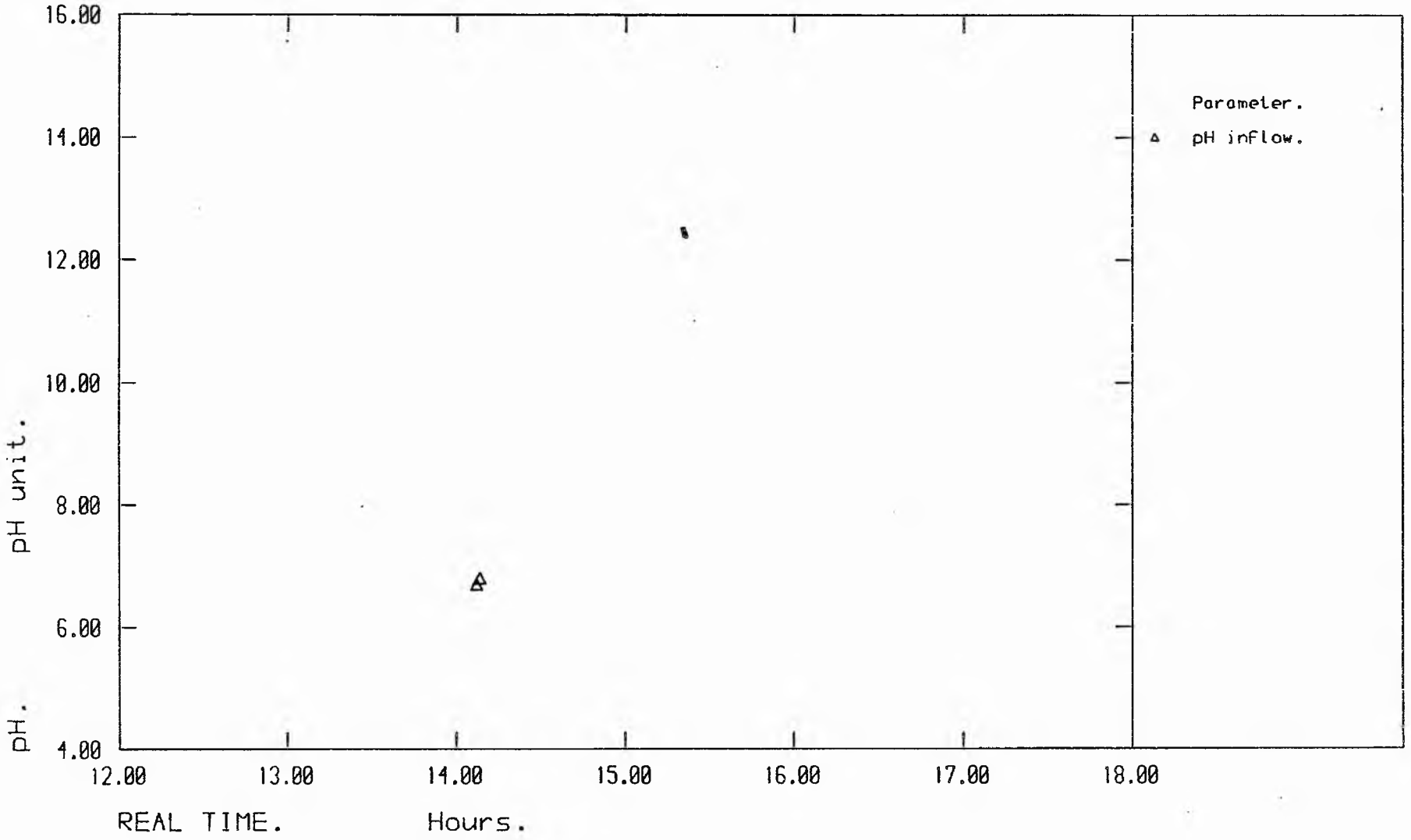
Graph of Suspended Solids for Storm VII on Tame Close.
The graph shows inflow and outflow water quality data.



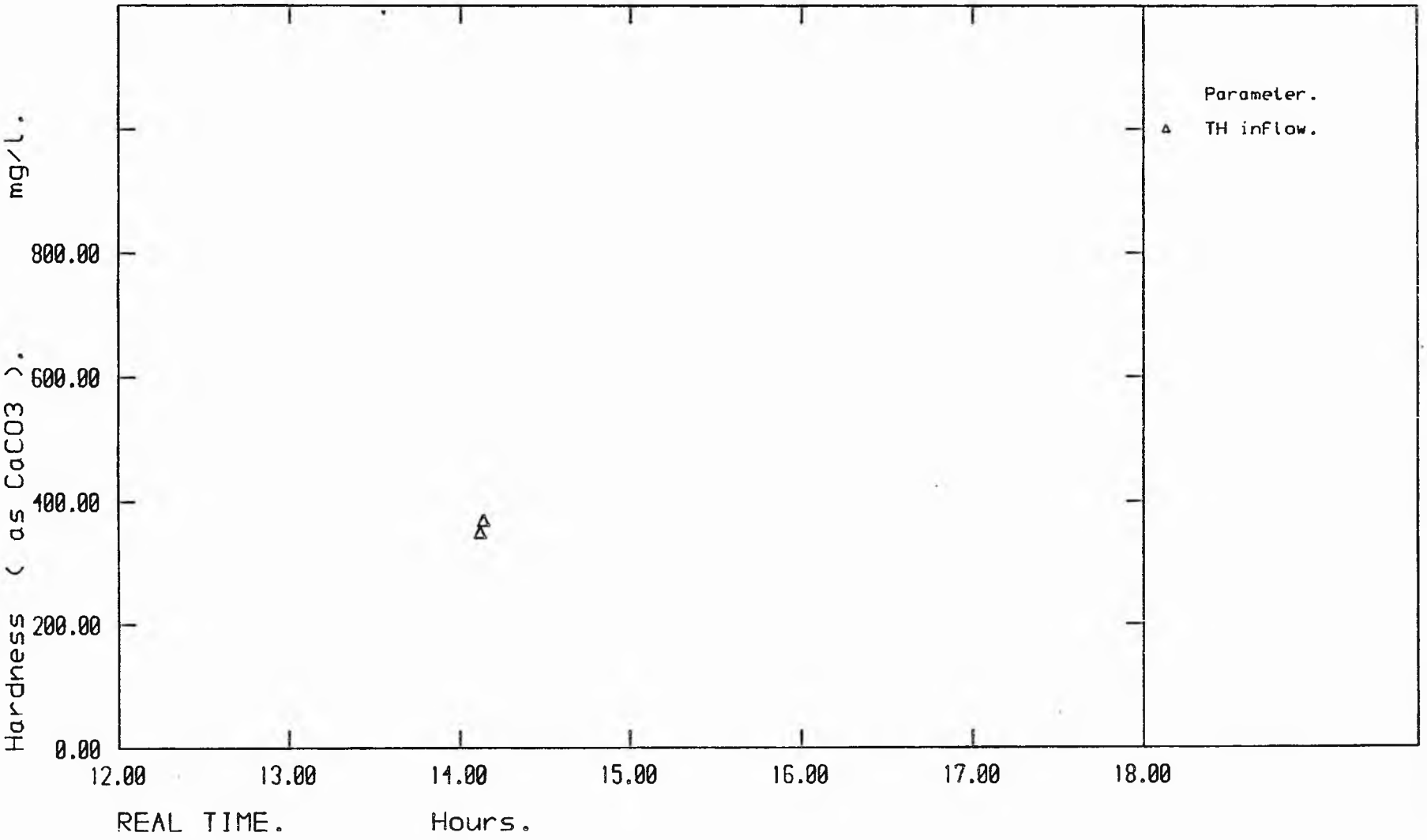
Graph of Chemical Oxygen Demand for Storm VII on Tame Close.
The graph shows inflow and outflow water quality data.



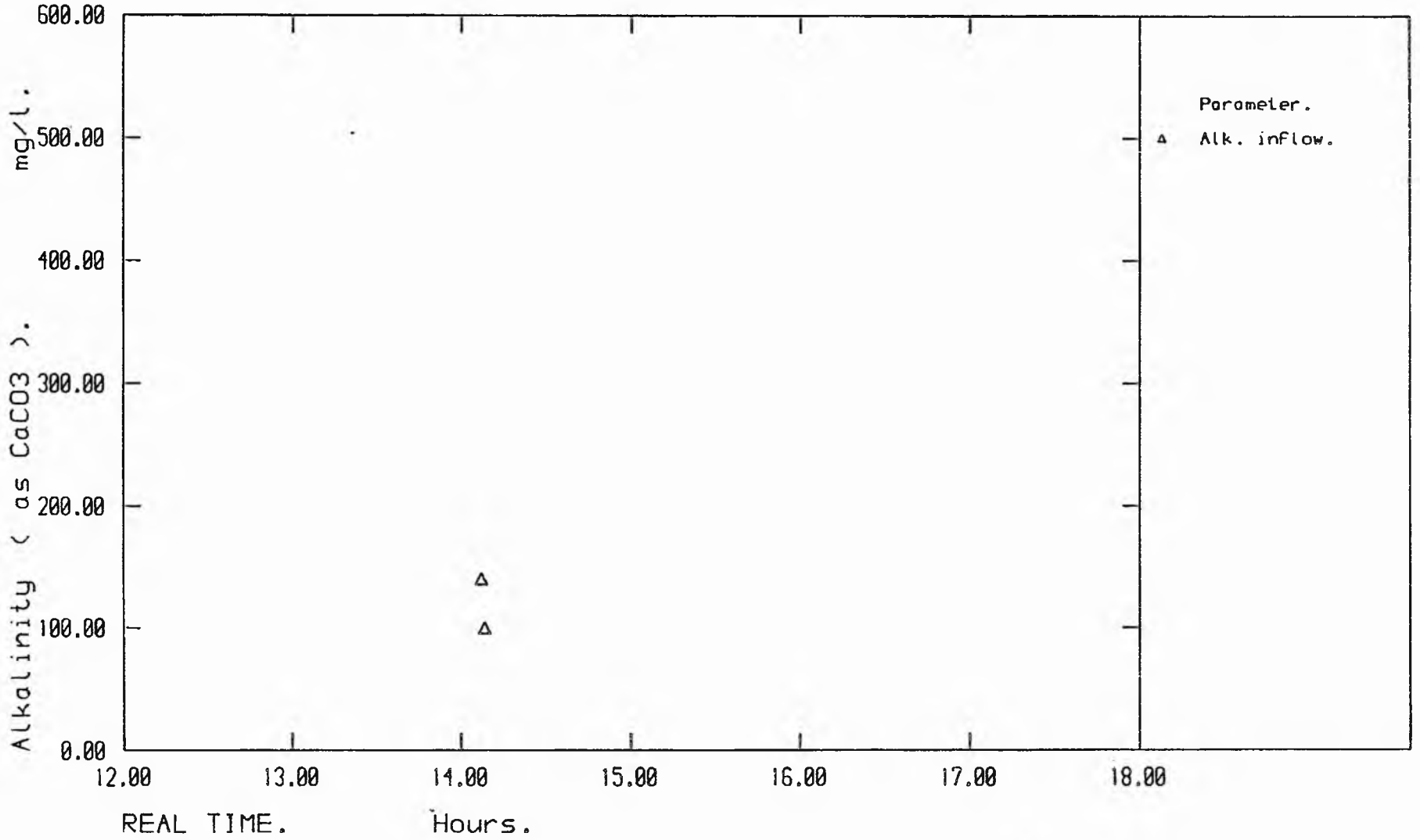
Graph of Conductivity for Storm VII on Tame Close.
The graph shows inflow and outflow water quality data.



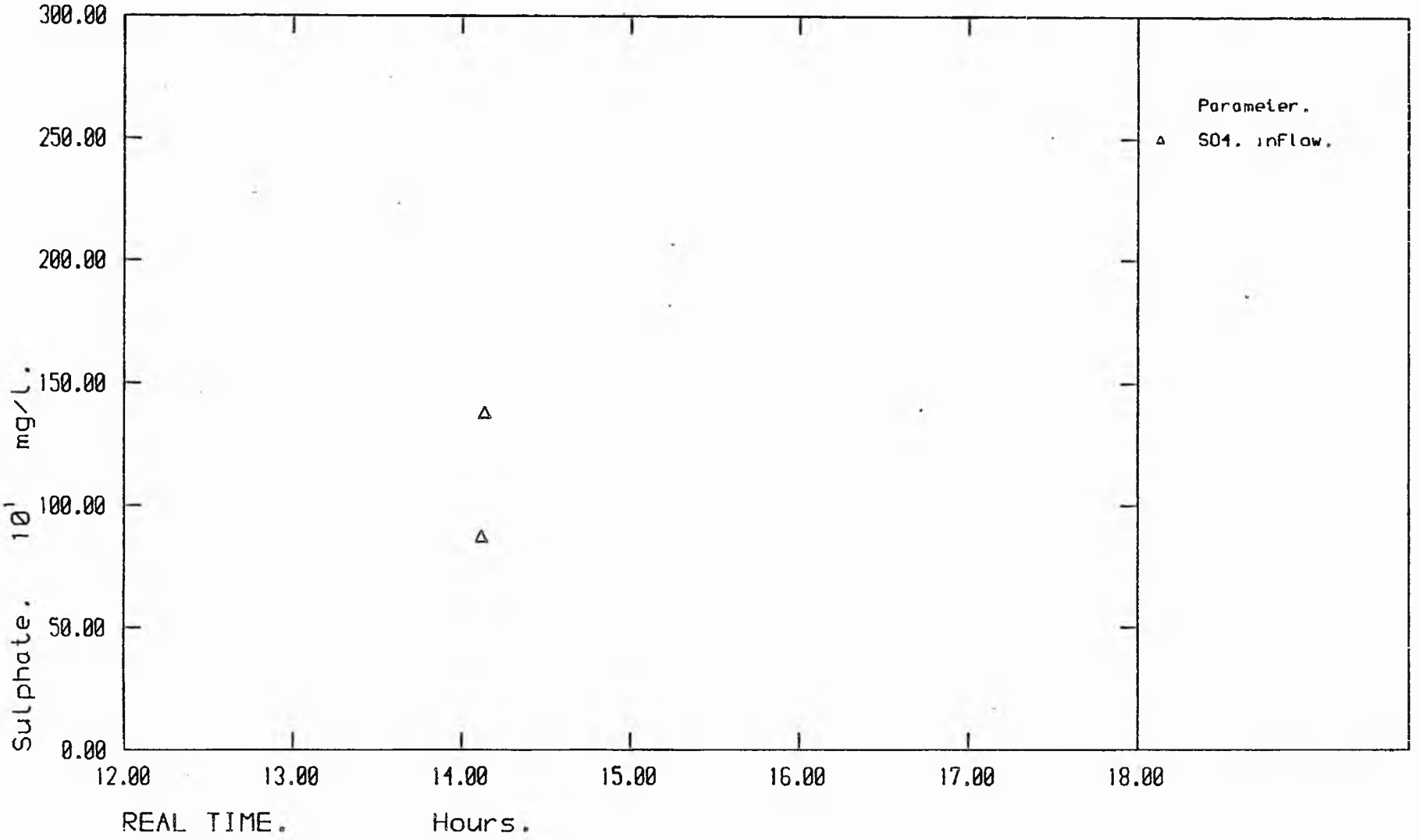
Graph of pH for Storm VII on Tame Close.
The graph shows inflow and outflow water quality data.



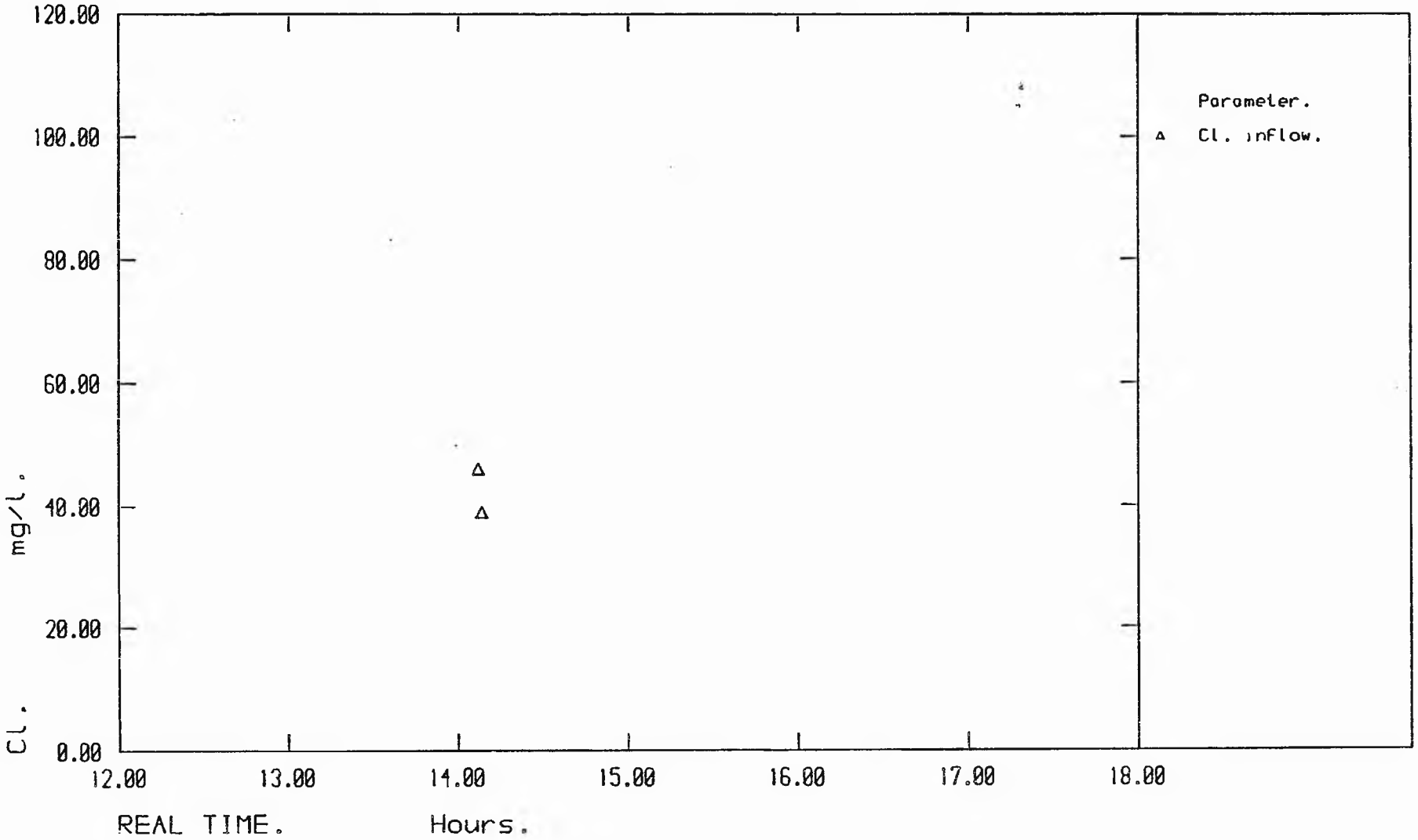
Graph of Total Hardness For Storm VII on Tame Close.
The graph shows inflow and outflow water quality data.



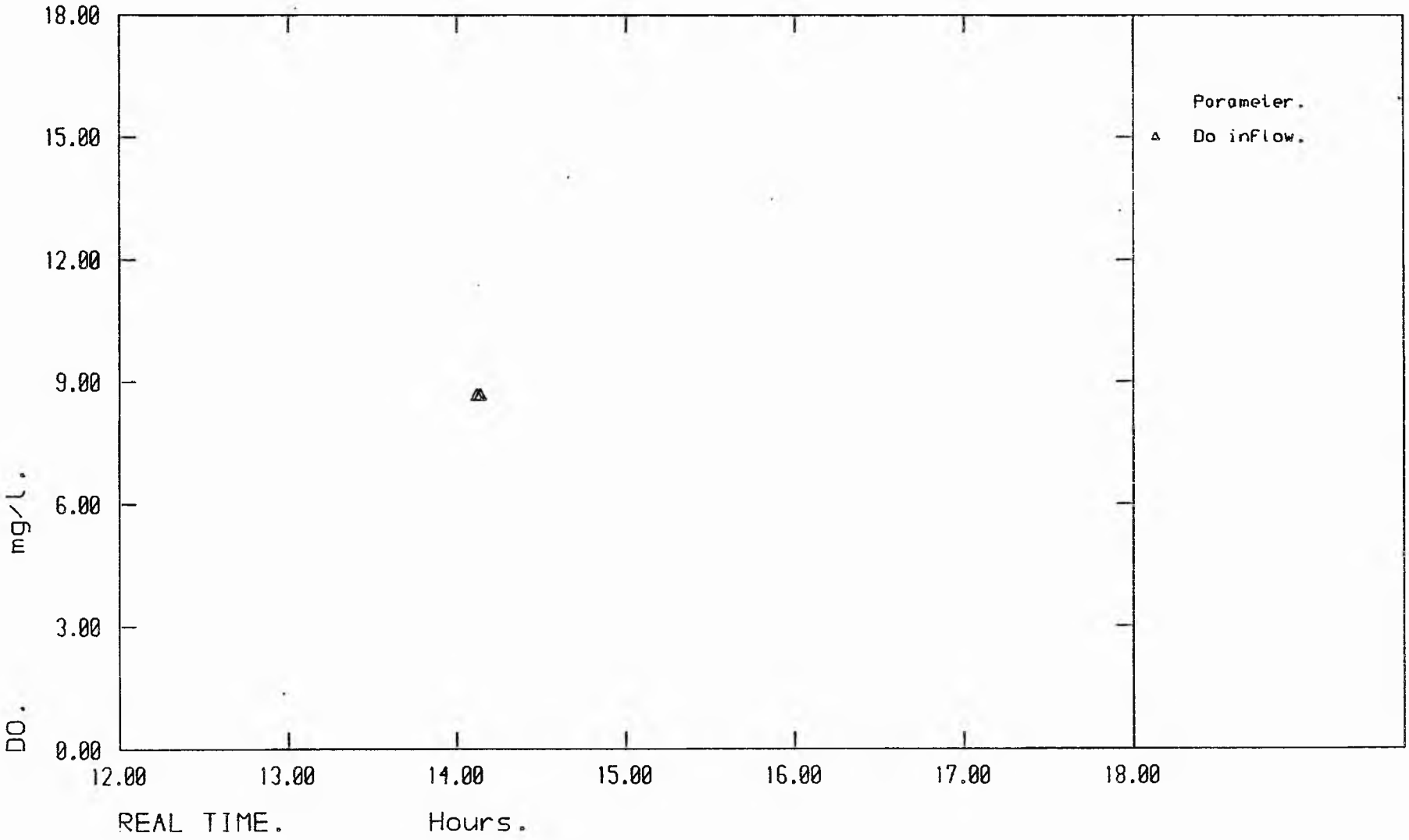
Graph of Total Alkalinity for Storm VII on Tame Close.
The graph shows inflow and outflow water quality data.



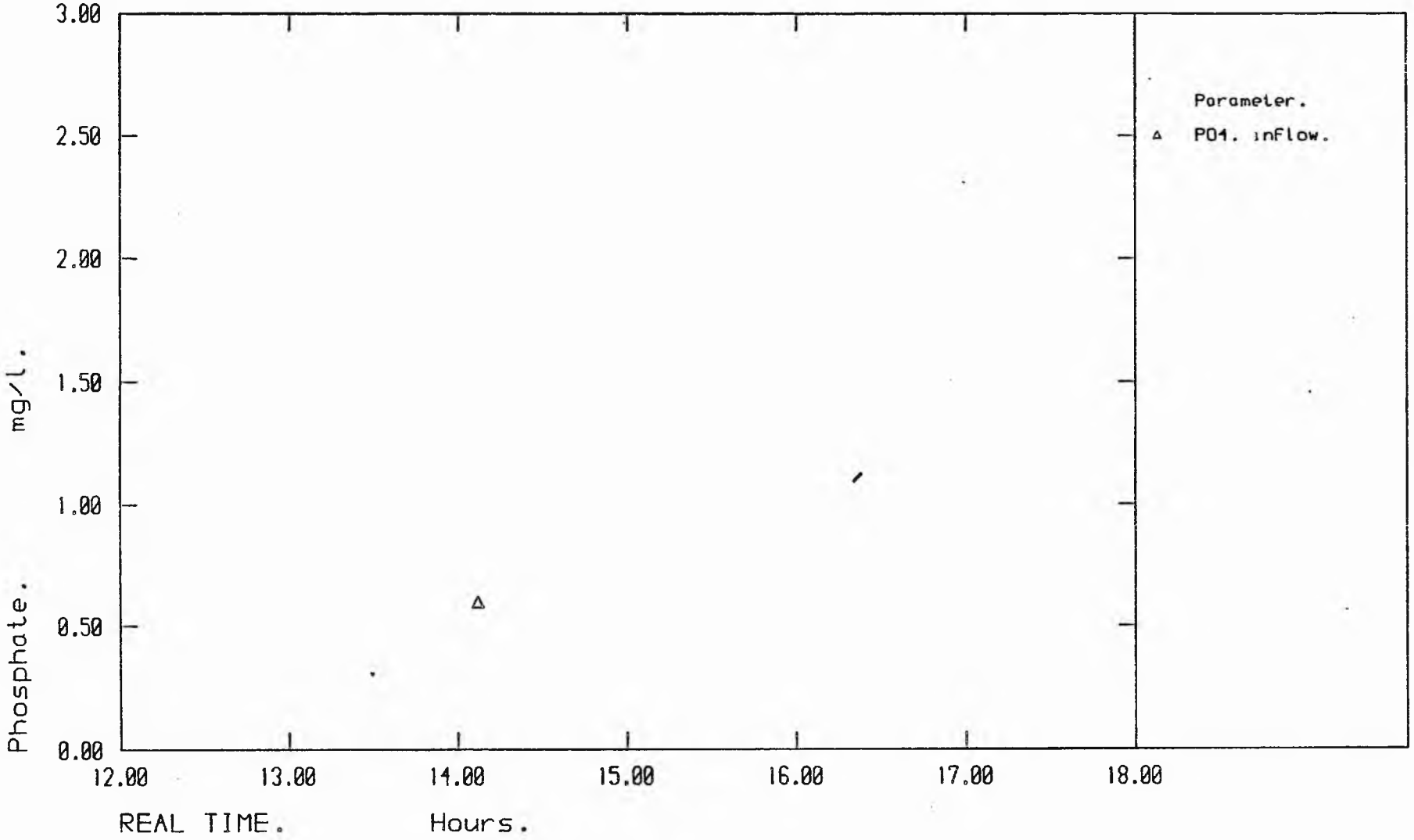
Graph of Sulphate for Storm VII on Tame Close.
The graph shows inflow and outflow water quality data.



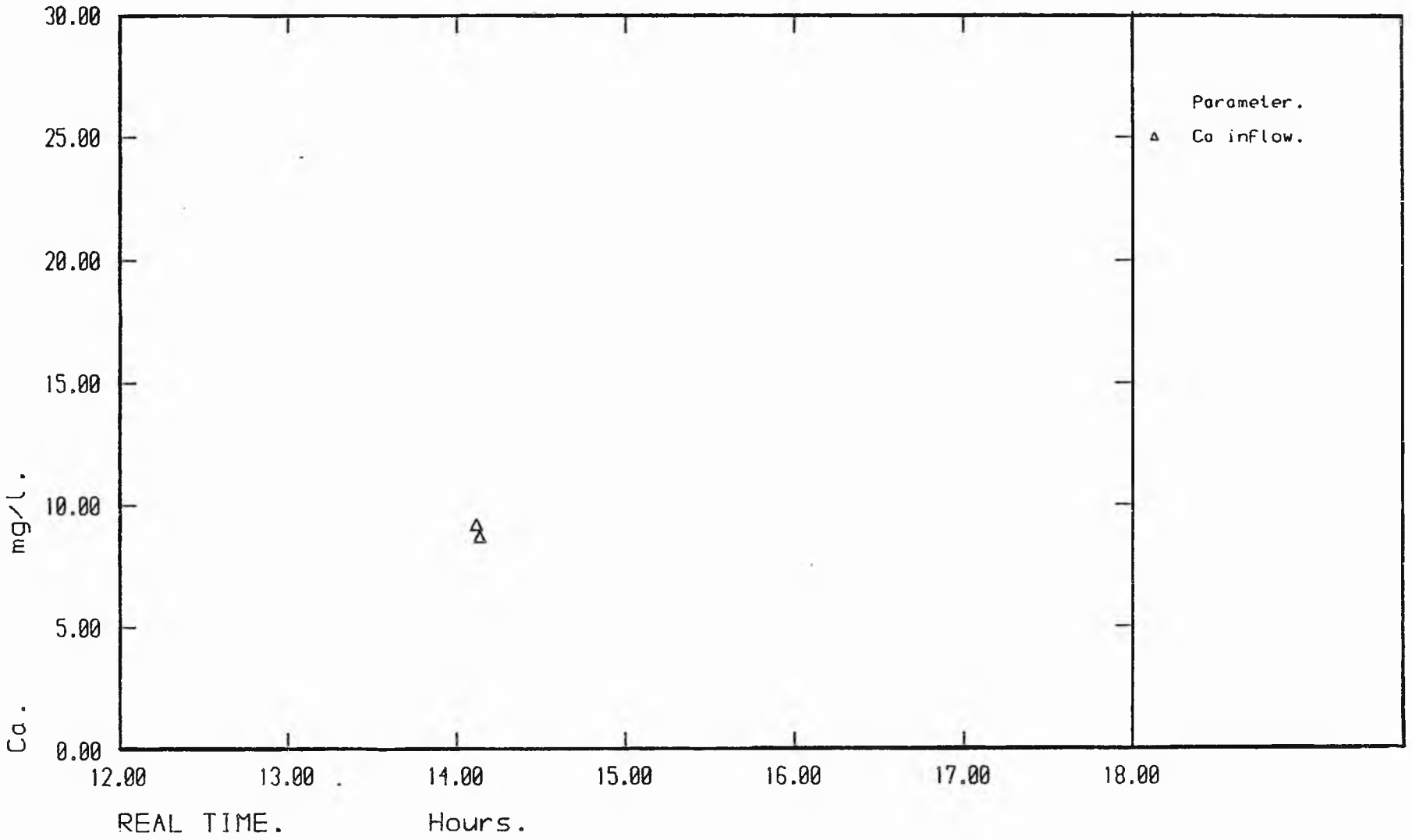
Graph of Chloride for Storm VII on Tame Close.
The graph shows inflow and outflow water quality data.



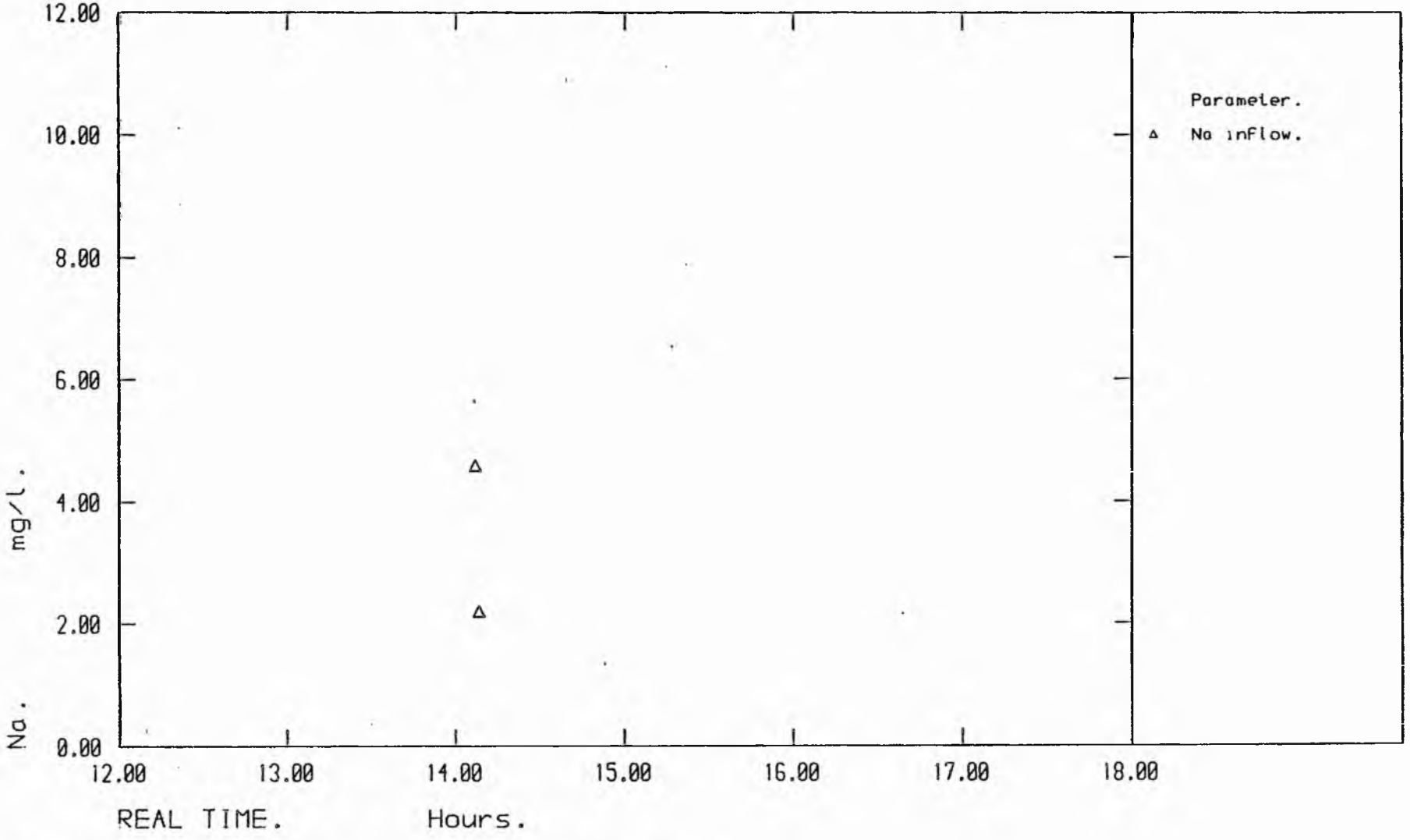
Graph of Dissolved Oxygen for Storm VII on Tame Close.
The graph shows inflow and outflow water quality data.



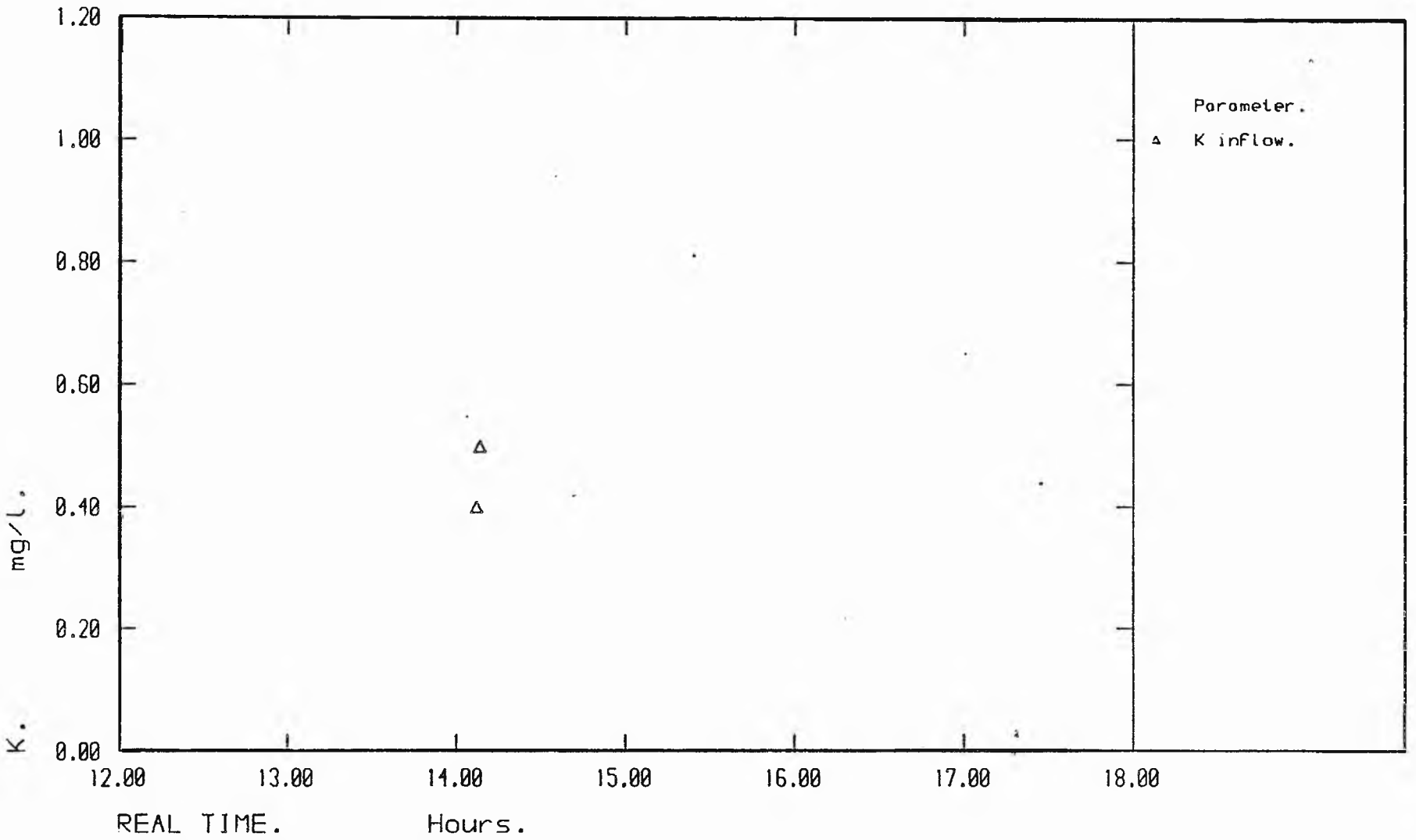
Graph of Phosphate for Storm VII on Tame Close.
The graph shows inflow and outflow water quality data.



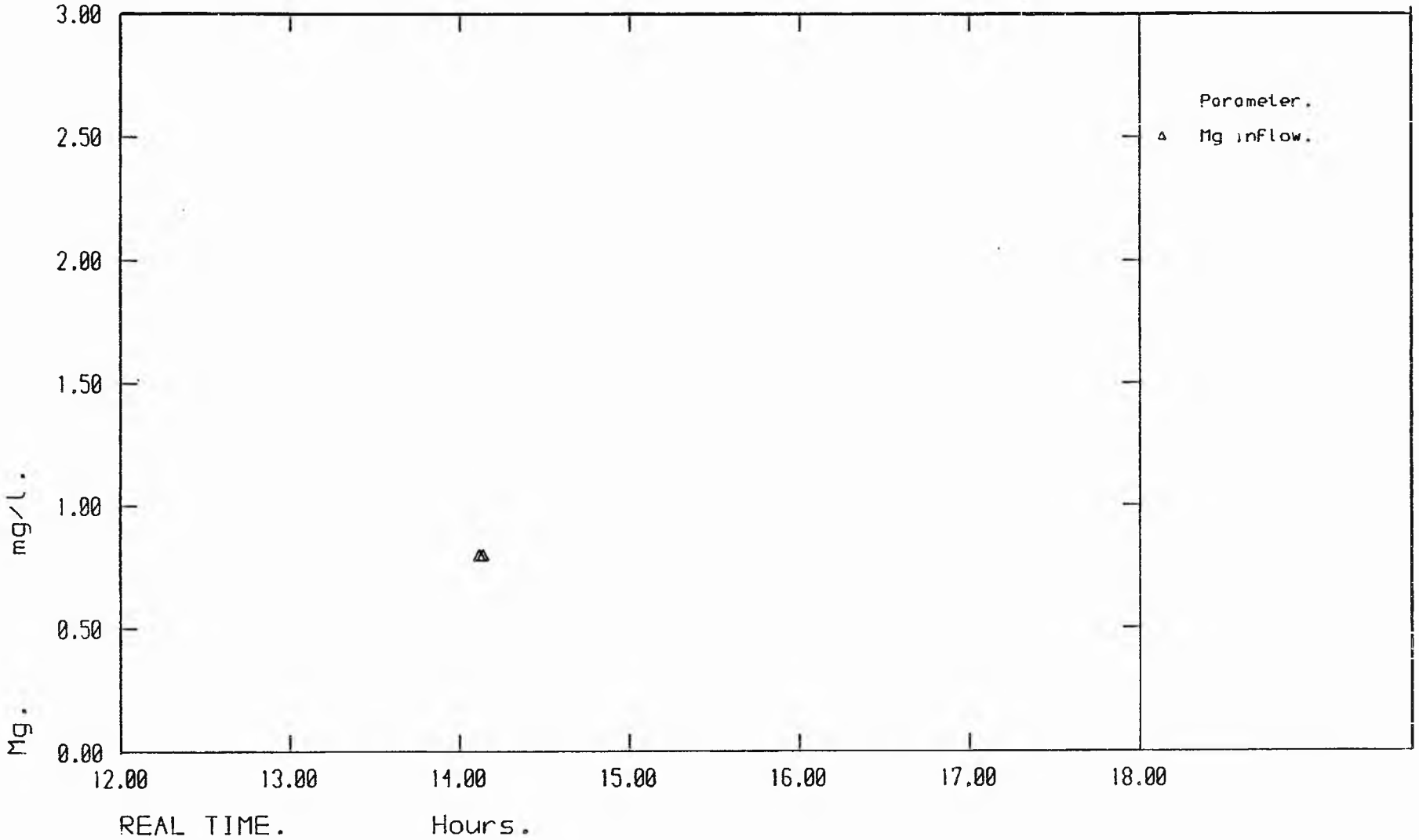
Graph of Calcium for Storm VII on Tame Close.
The graph shows inflow and outflow water quality data.



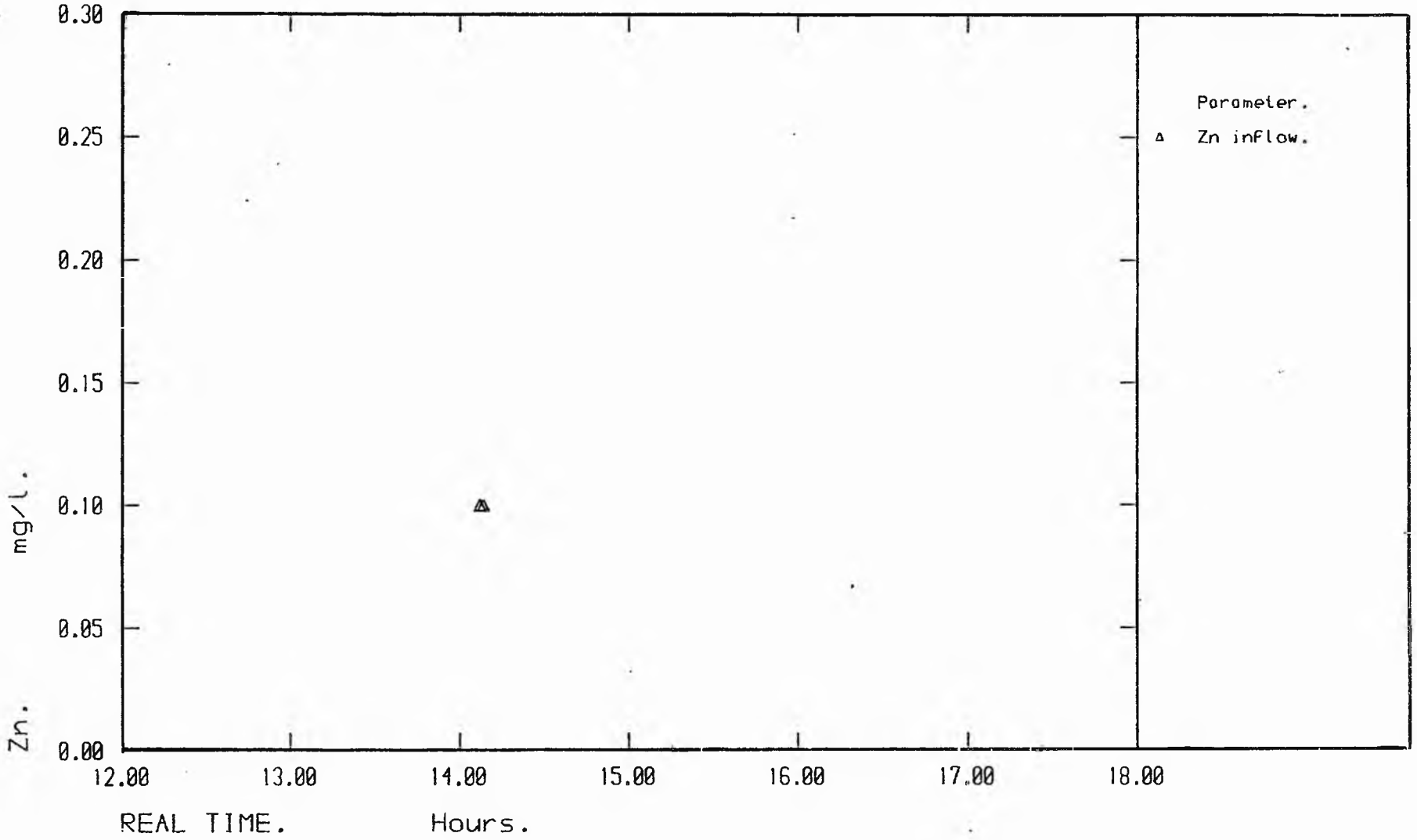
Graph of Sodium for Storm VII on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Potassium for Storm VII on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Magnesium for Storm VII on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc For Storm VII on Tame Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 26th. July 1985 (850726)
STORM NUMBER : VII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
1337	24	9	256
1338	14	10	196
1339	24	9	111
1340	25	7	221
1341	36	9	141
1342	56	8	171
1345	58	9	211
1348	60	2	246
1351	59	5	181
1354	17	4	181
1357	15	3	121
1400	17	10	85

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 26th. July 1985 (850726)
STORM NUMBER : VII

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
1337	24	2	75
1357	31	1	121
1417	36	1	141
1437	34	0	60
1457	37	5	101
1517	42	0	90
1537	37	0	60
1557	40	0	65
1617	42	3	60
1637	26	4	90
1657	28	7	106
1717	46	14	101

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 26th. July 1985 (850726)
STORM NUMBER : VII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
1337	0.29	8.2	6.2
1338	0.29	8.2	6.2
1339	0.28	8.0	6.2
1340	0.28	7.3	6.2
1341	0.26	7.5	6.3
1342	0.26	7.7	6.4
1345	0.26	7.4	6.3
1348	0.25	7.5	6.4
1351	0.18	7.6	6.3
1354	0.12	7.8	6.3
1357	0.13	7.8	6.6
1400	0.13	7.6	6.4

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 26th. July 1985 (850726)
STORM NUMBER : VII

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mg]-1	pH pH units
1337	0.18	3.5	6.6
1357	0.19	4.1	6.6
1417	0.18	4.4	6.7
1437	0.16	6.4	6.9
1457	0.22	4.3	6.7
1517	0.21	4.4	6.7
1537	0.22	5.2	6.8
1557	0.21	4.9	6.8
1617	0.21	6.1	7.0
1637	0.21	5.0	6.8
1657	0.21	5.4	6.9
1717	0.22	5.3	6.9

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 26th. July 1985 (850726)
STORM NUMBER : VII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

REAL TIME Hours	TH mgl-1	ALK mgl-1	SO4 mgl-1	Cl mgl-1
1337	620.0	860.0	1431	173.7
1338	560.0	190.0	1201	223.3
1339	480.0	230.0	1643	85.1
1340	490.0	230.0	1479	35.5
1341	370.0	250.0	5472	141.0
1342	370.0	150.0	1538	67.4
1345	410.0	170.0	1259	60.3
1348	390.0	60.0	1134	49.6
1351	280.0	130.0	1268	28.4
1354	270.0	50.0	634	28.4
1357	220.0	90.0	1431	24.8
1400	320.0	90.0	1431	31.9

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 26th. July 1985 (850726)
STORM NUMBER : VII

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	TH mgl-1	Alk mgl-1	SO4 mgl-1	Cl mgl-1
1337	420.0	140.0	2114	39.0
1357	420.0	130.0	2057	46.1
1417	440.0	110.0	1980	46.1
1437	720.0	120.0	2076	53.2
1457	370.0	320.0	1557	42.5
1517	470.0	80.0	2181	31.9
1537	320.0	110.0	1845	46.1
1557	420.0	130.0	1643	46.1
1617	320.0	130.0	1518	74.4
1637	360.0	130.0	1537	42.5
1657	330.0	260.0	1634	53.2
1717	320.0	130.0	1720	49.6

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 26th. July 1985 (850726)
STORM NUMBER : VII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Phosphate mgl-1
1337	0.3	3.1	1.4
1338	0.3	2.5	1.1
1339	0.3	2.8	1.5
1340	0.3	2.5	1.4
1341	0.3	2.2	1.3
1342	0.3	2.2	0.8
1345	0.3	5.9	0.8
1348	0.2	4.8	2.4
1351	0.2	4.2	0.8
1354	0.2	6.0	1.1
1357	0.2	6.4	0.8
1400	0.2	7.1	0.7

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 26th. July 1985 (850726)
STORM NUMBER : VII

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Ammonia mgl-1	Nitrate mgl-1	Phosphate mgl-1
1337	0.3	0.4	0.8
1357	0.3	0.4	0.6
1417	0.3	1.0	0.6
1437	0.3	0.5	1.1
1457	0.3	0.4	0.8
1517	0.3	0.5	0.7
1537	0.3	1.1	0.8
1557	0.3	0.8	1.3
1617	0.3	0.6	0.7
1637	0.3	1.1	0.7
1657	0.3	1.0	0.7
1717	0.2	1.1	1.4

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 26th. July 1985 (850726)
STORM NUMBER : VII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
1337	10.4	3.7	31.0	8.5
1338	7.7	2.5	32.2	6.3
1339	6.2	1.9	31.0	5.5
1340	8.3	1.9	29.7	5.5
1341	6.2	1.7	28.0	5.3
1342	6.8	1.7	32.2	5.3
1345	6.6	1.7	29.7	5.1
1348	7.3	1.9	29.0	5.3
1351	4.5	1.2	20.0	3.5
1354	4.6	1.0	16.7	2.8
1357	6.4	1.2	18.5	3.2
1400	5.2	1.1	17.5	2.8

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 26th. July 1985 (850726)
STORM NUMBER : VII

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Na mgl-1	K mgl-1	Ca mgl-1	Mg mgl-1
1337	10.0	2.0	24.2	1.3
1357	14.5	2.0	24.2	2.2
1417	12.0	1.7	24.2	2.0
1437	12.2	1.5	23.5	1.3
1457	16.9	2.0	23.5	2.0
1517	15.3	1.7	23.5	2.0
1537	15.0	1.9	24.8	2.0
1557	14.0	1.6	26.0	2.2
1617	12.2	1.5	25.5	2.0
1637	13.4	1.6	24.8	2.1
1657	12.8	2.0	24.8	2.3
1717	13.7	1.9	24.8	2.2

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 26th. July 1985 (850726)
STORM NUMBER : VII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

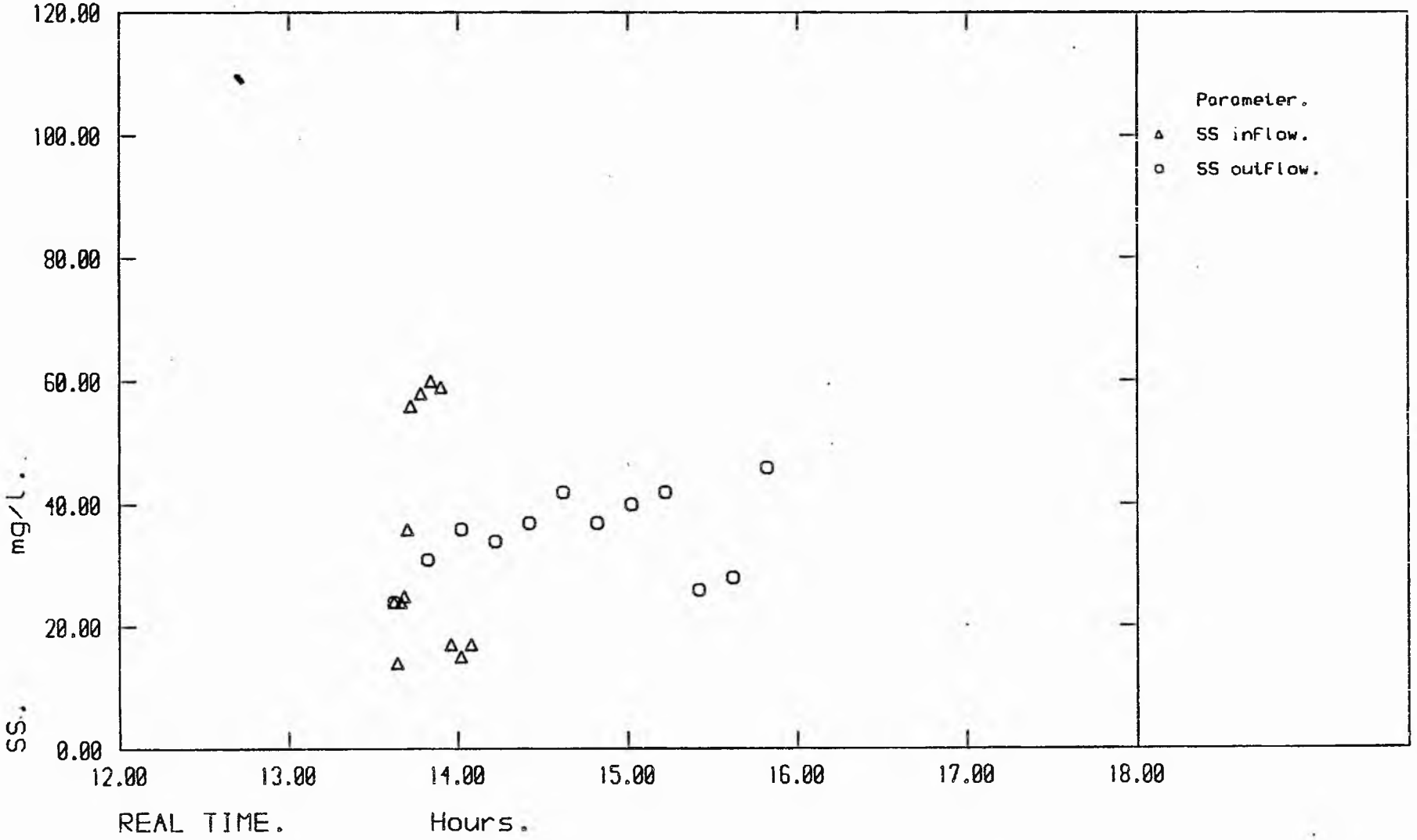
REAL TIME Hours	Mn mgl-1	Zn mgl-1
1337	0.6	0.4
1338	0.6	0.4
1339	0.6	0.3
1340	0.6	0.3
1341	0.6	0.3
1342	0.5	0.3
1345	0.5	0.3
1348	0.5	0.2
1351	0.3	0.2
1354	0.3	0.2
1357	0.2	0.2
1400	0.2	0.2

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

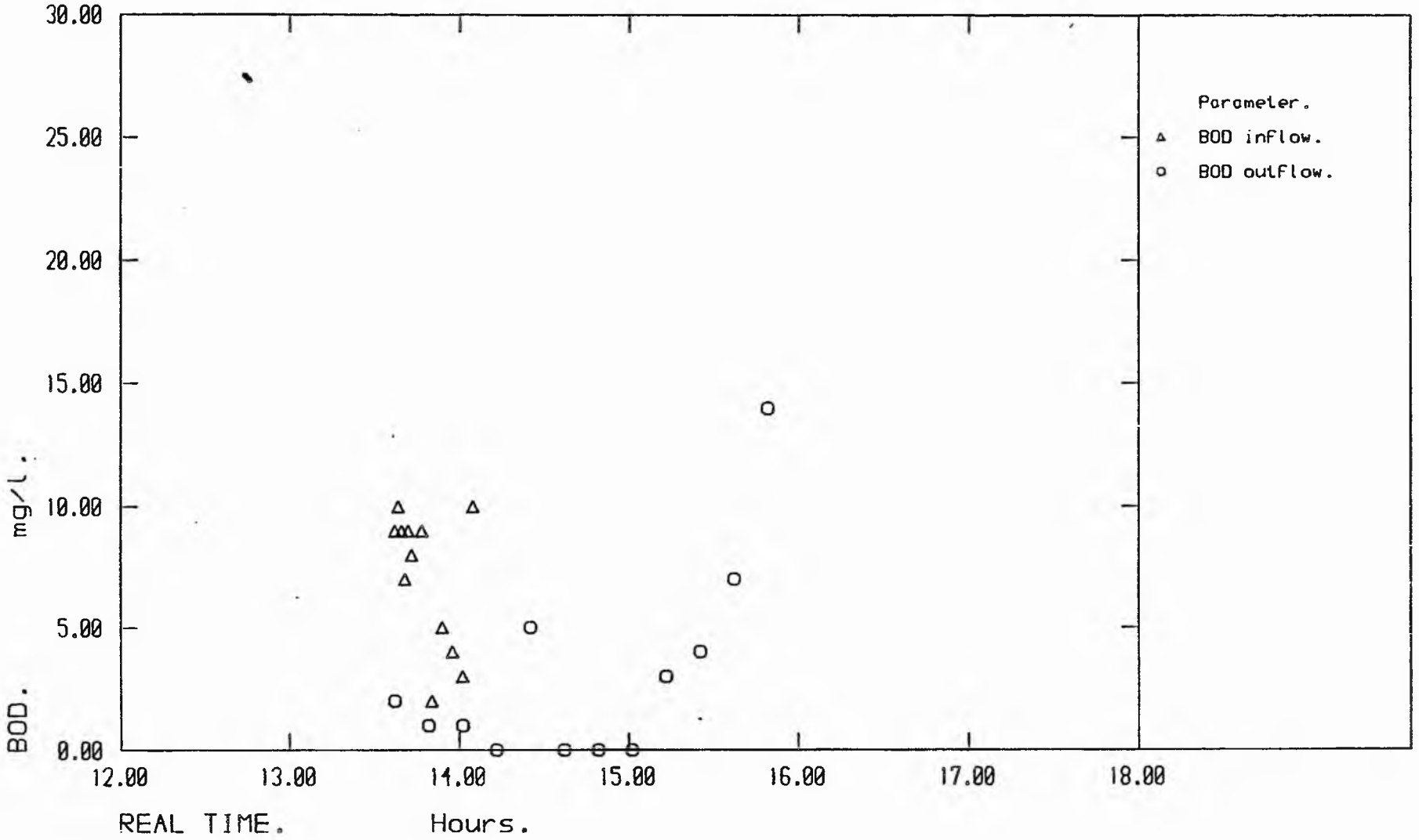
CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 26th. July 1985 (850726)
STORM NUMBER : VII

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

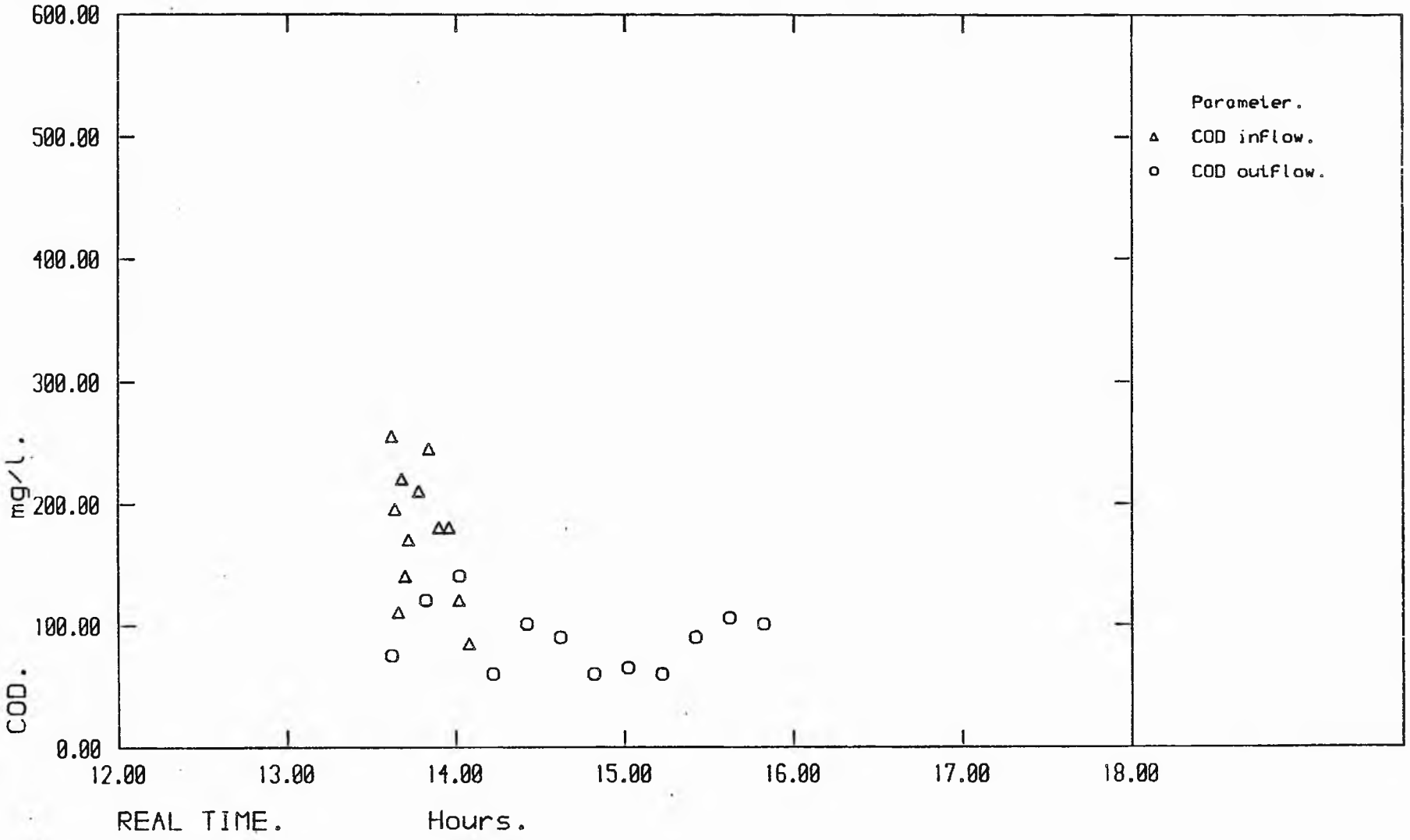
REAL TIME Hours	Mn mgl-1	Zn mgl-1
1337	0.3	0.5
1357	0.2	0.3
1417	0.2	0.3
1437	0.2	0.1
1457	0.3	0.3
1517	0.3	0.2
1537	0.3	0.3
1557	0.3	0.2
1617	0.2	0.1
1637	0.2	0.2
1657	0.2	0.2
1717	0.2	0.2



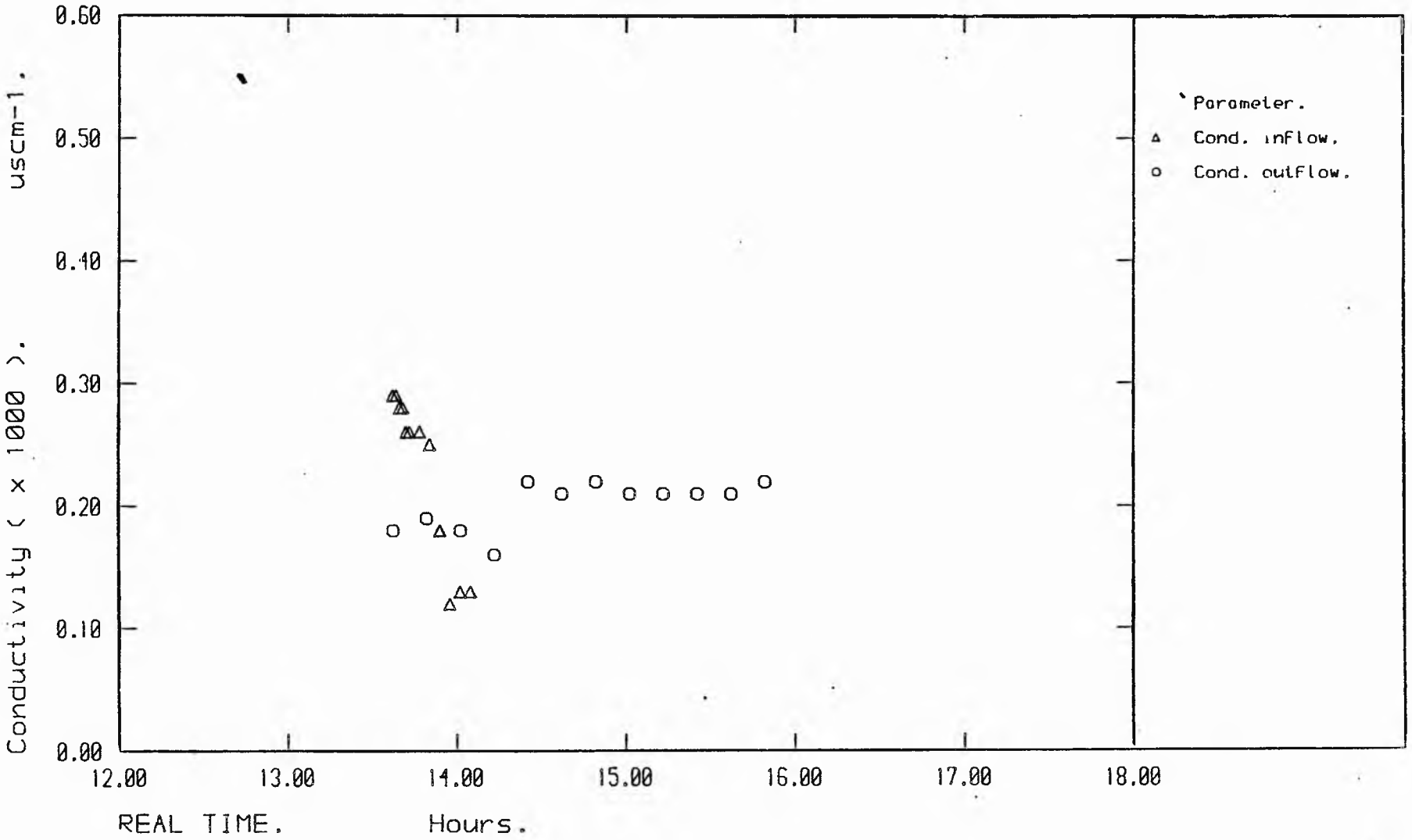
Graph of Suspended Solids for Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



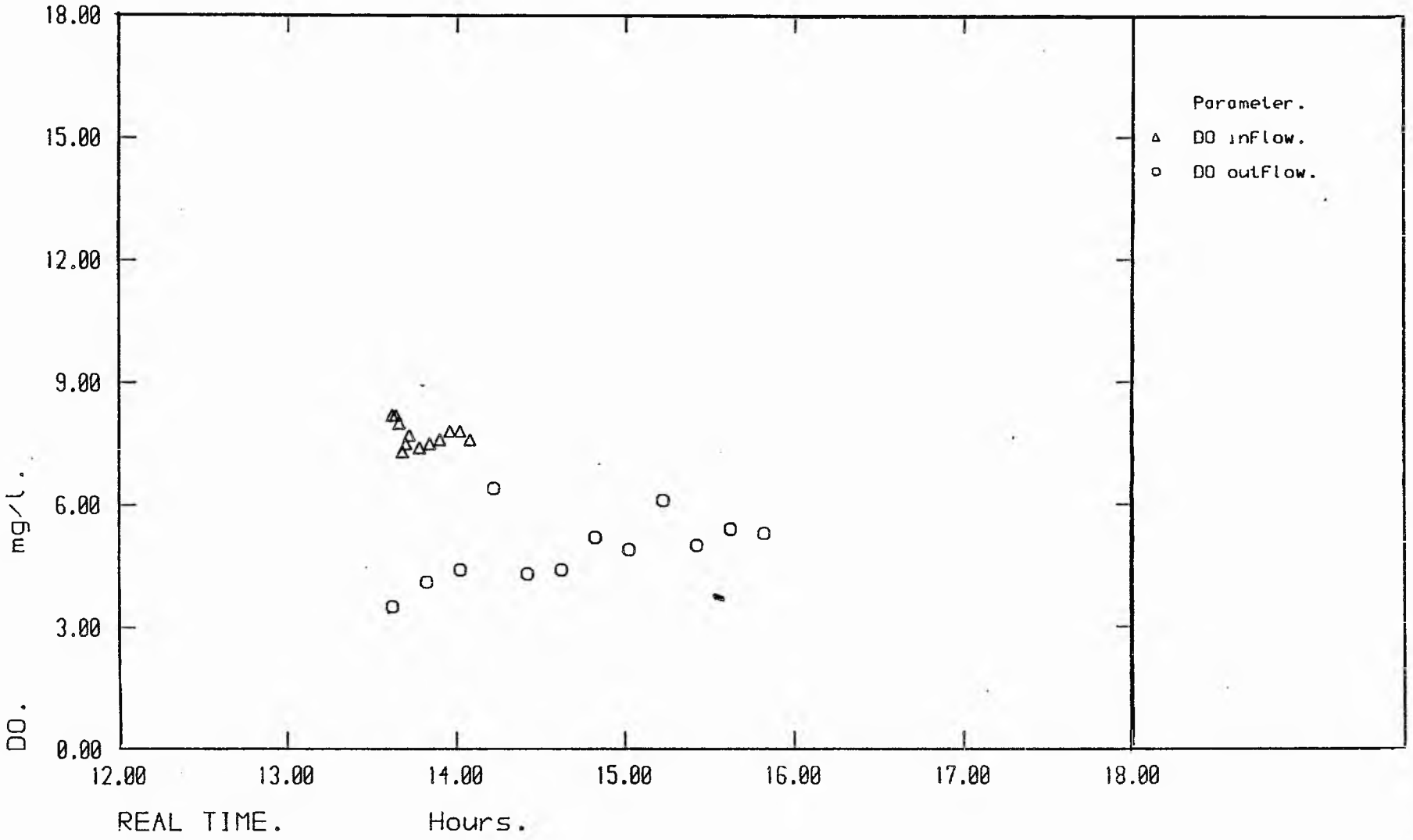
Graph of Biochemical Oxygen Demand for Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



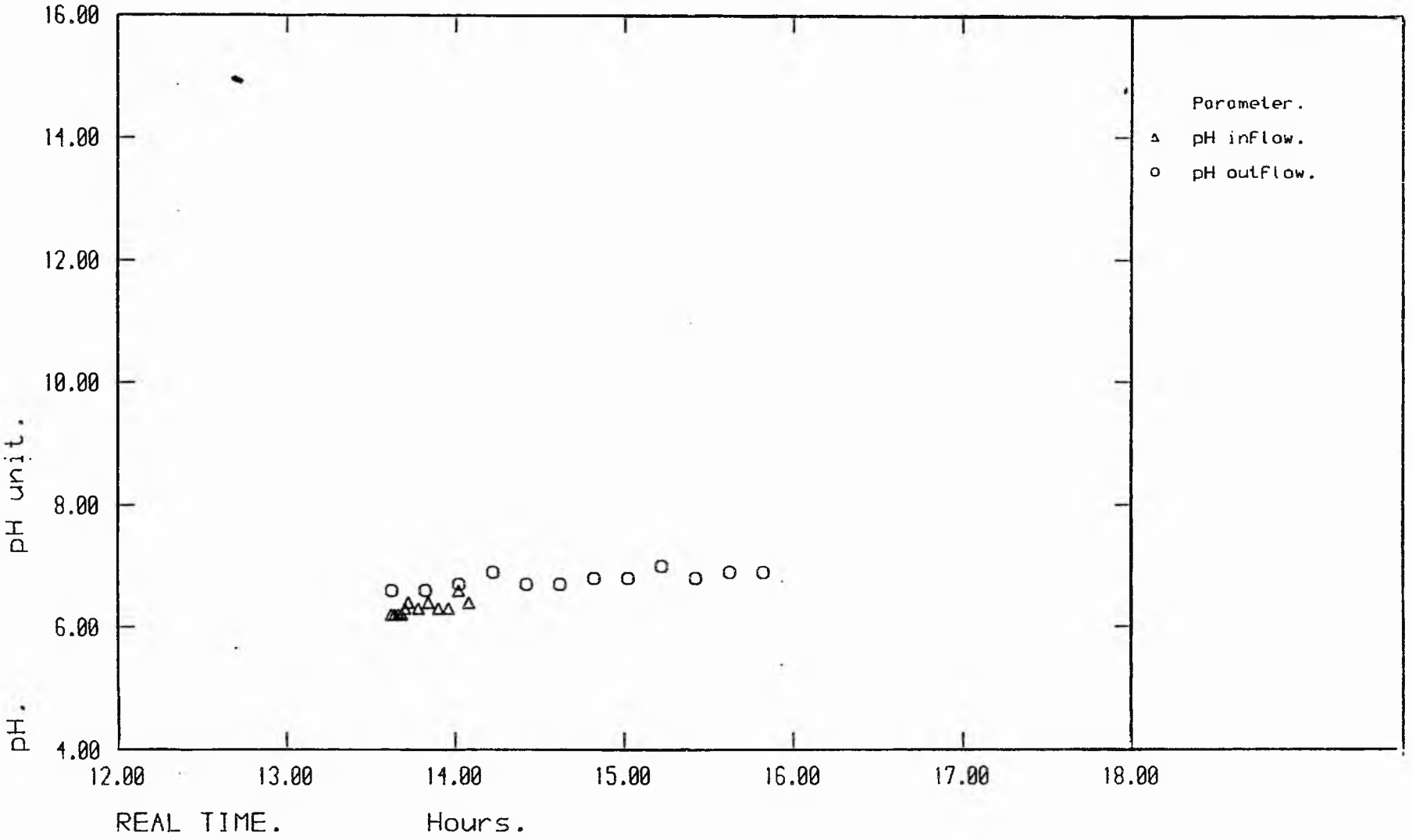
Graph of Chemical Oxygen Demand For Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



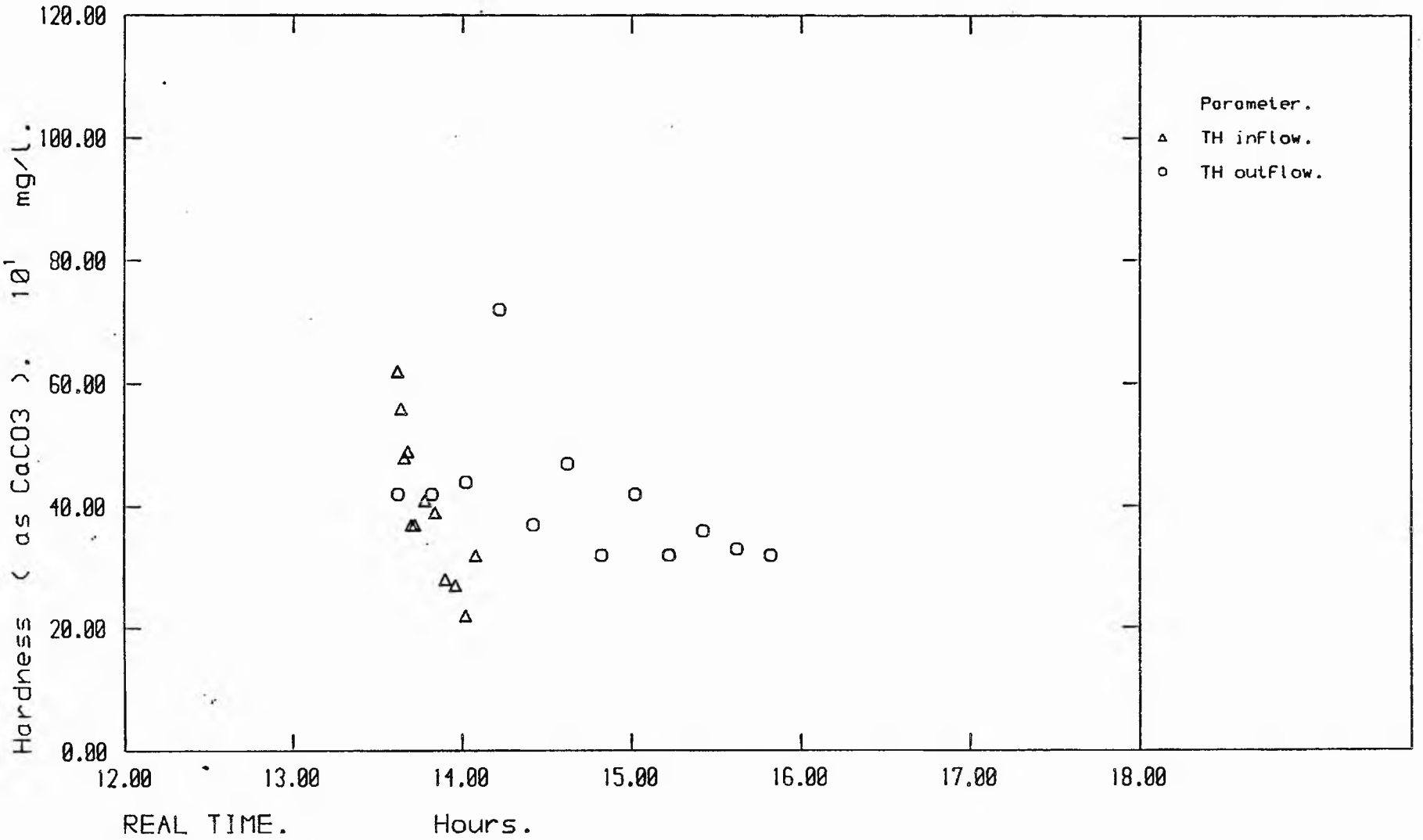
Graph of Conductivity for Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



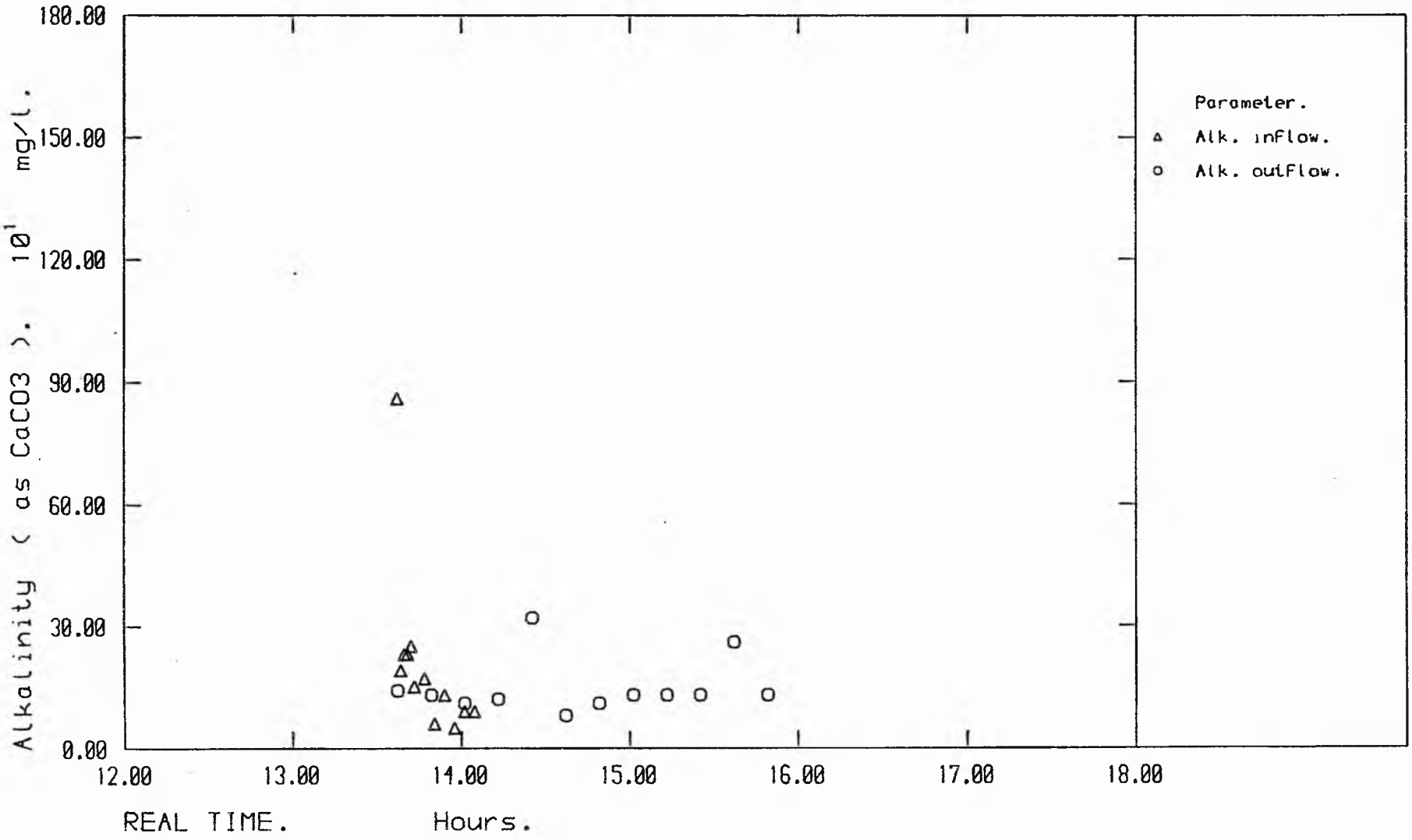
Graph of Dissolved Oxygen for Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



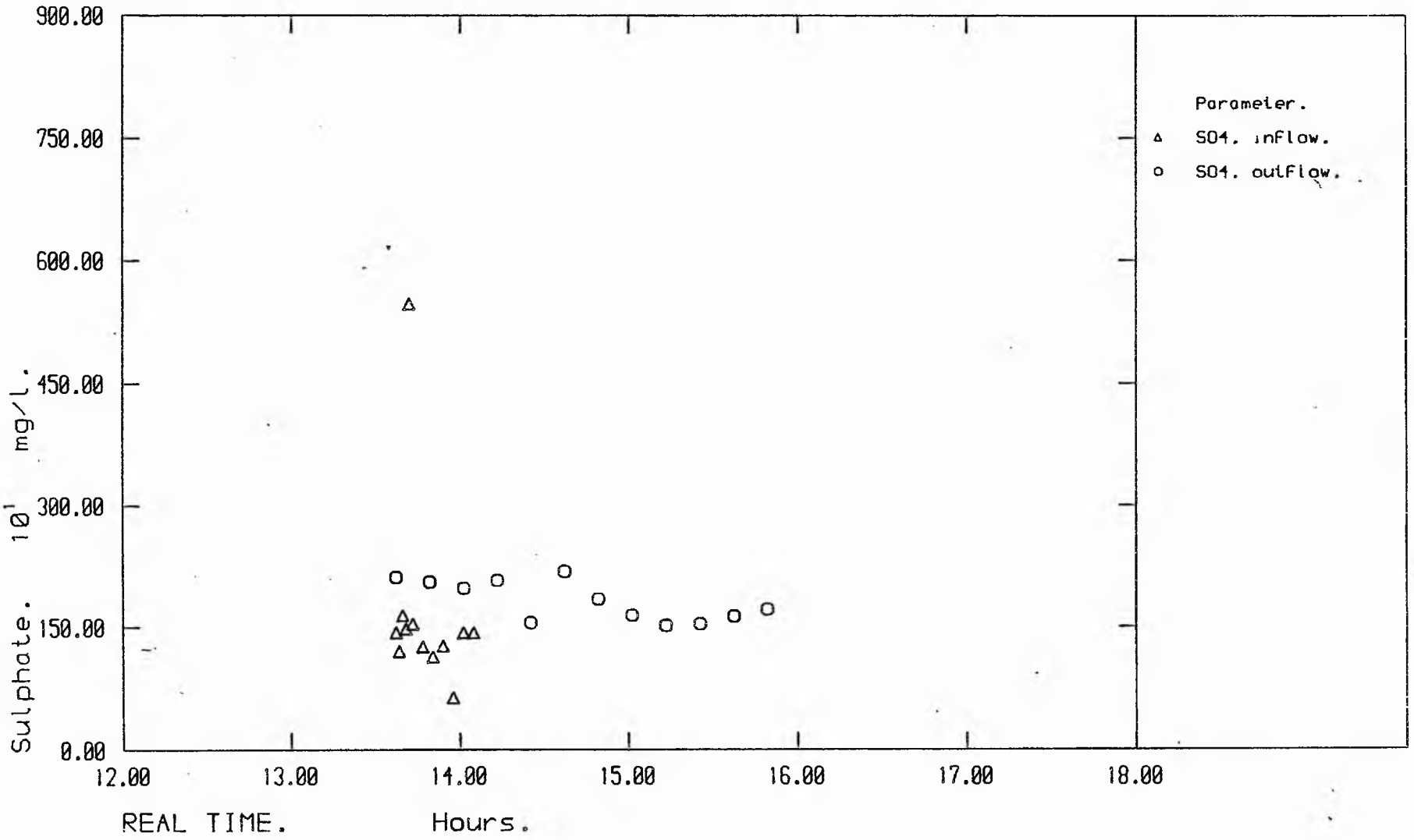
Graph of pH for Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



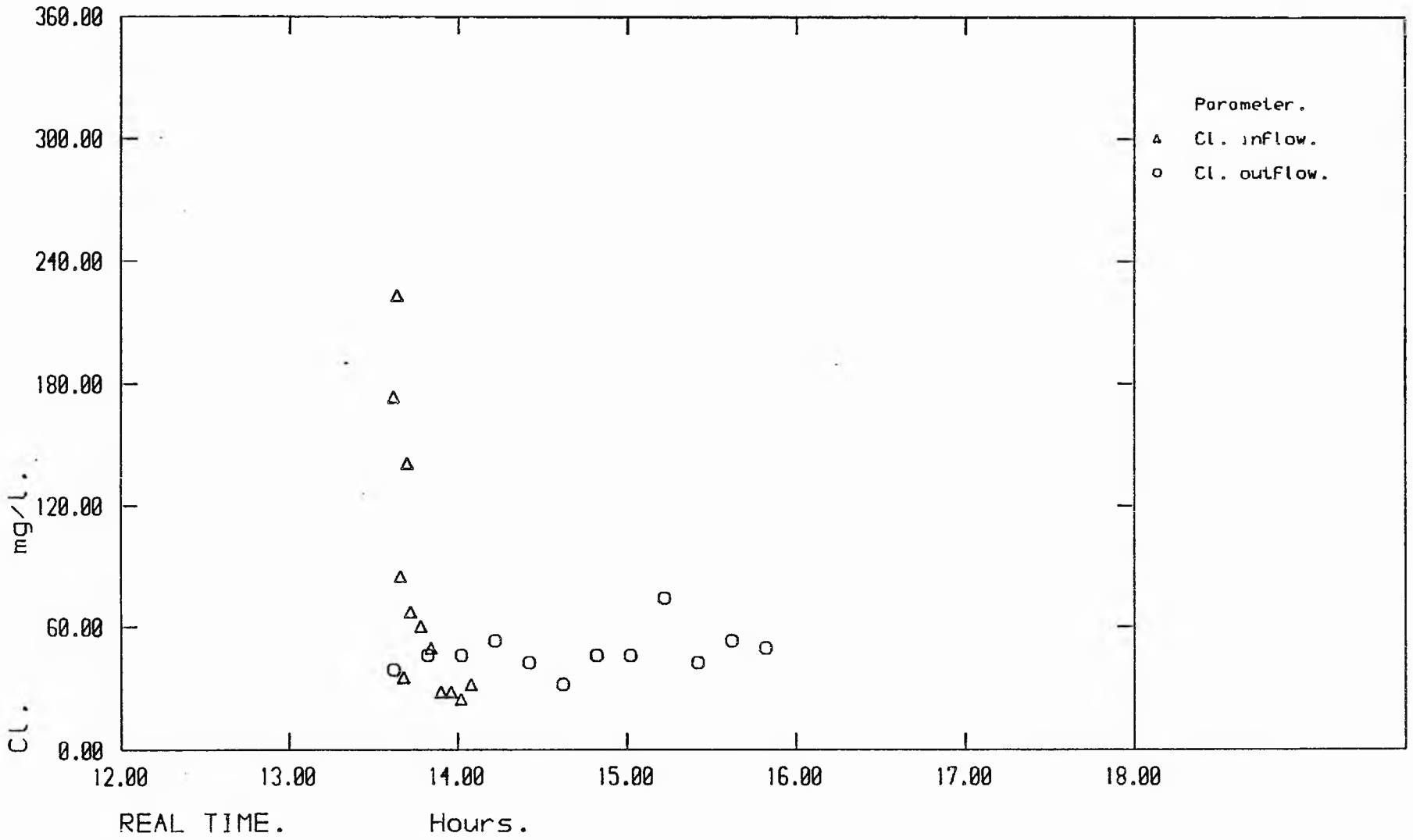
Graph of Total Hardness for Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



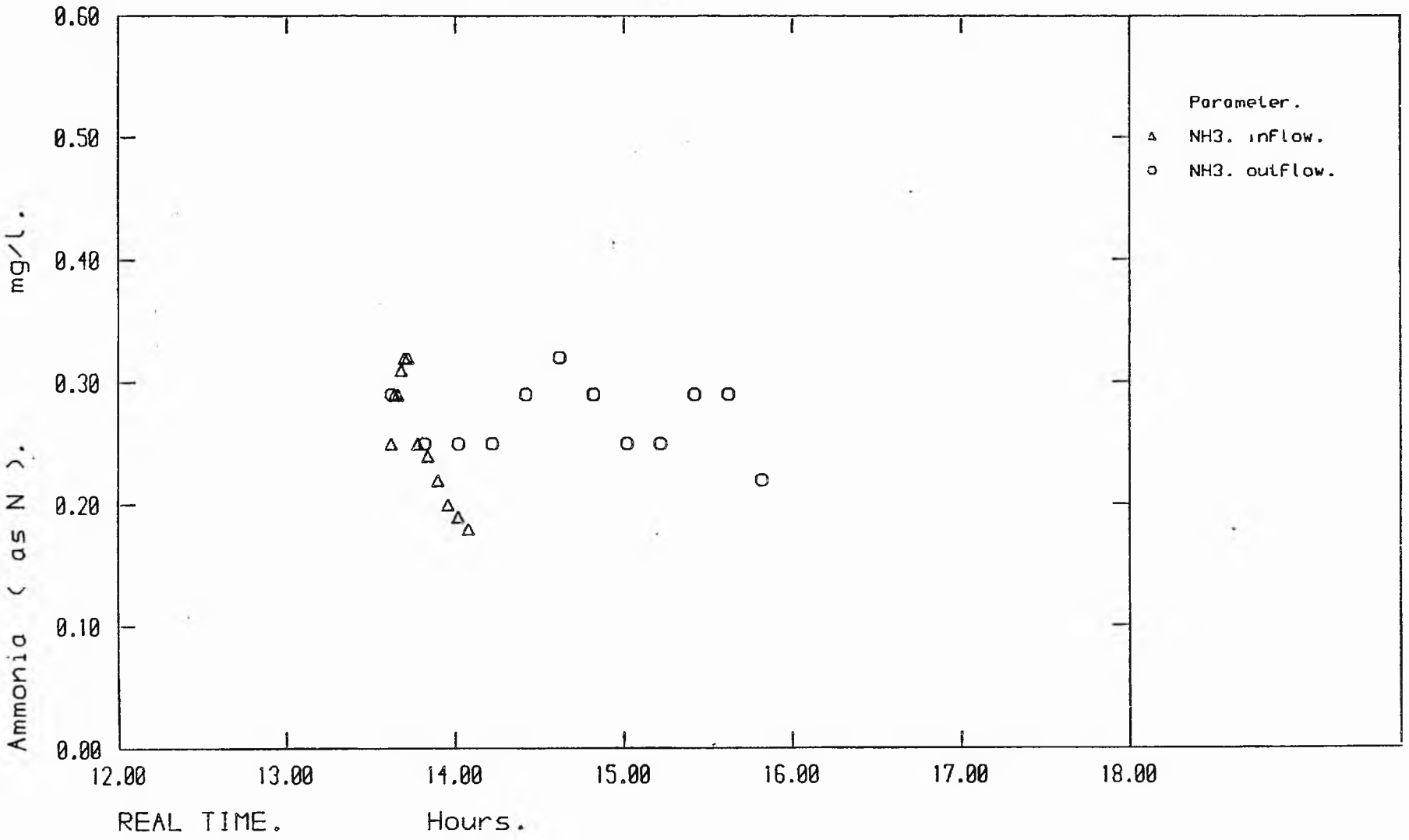
Graph of Total Alkalinity for Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



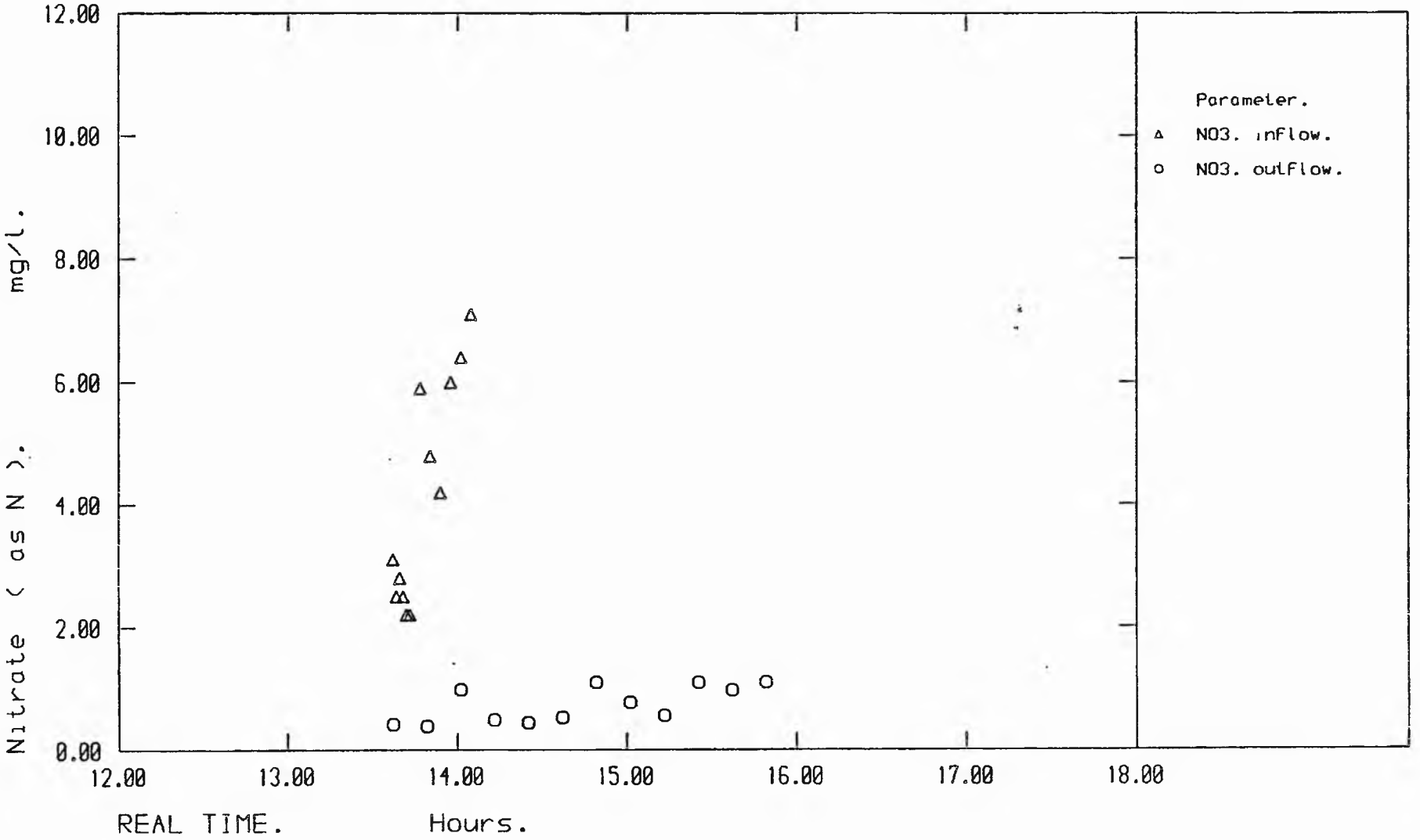
Graph of Sulphate for Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



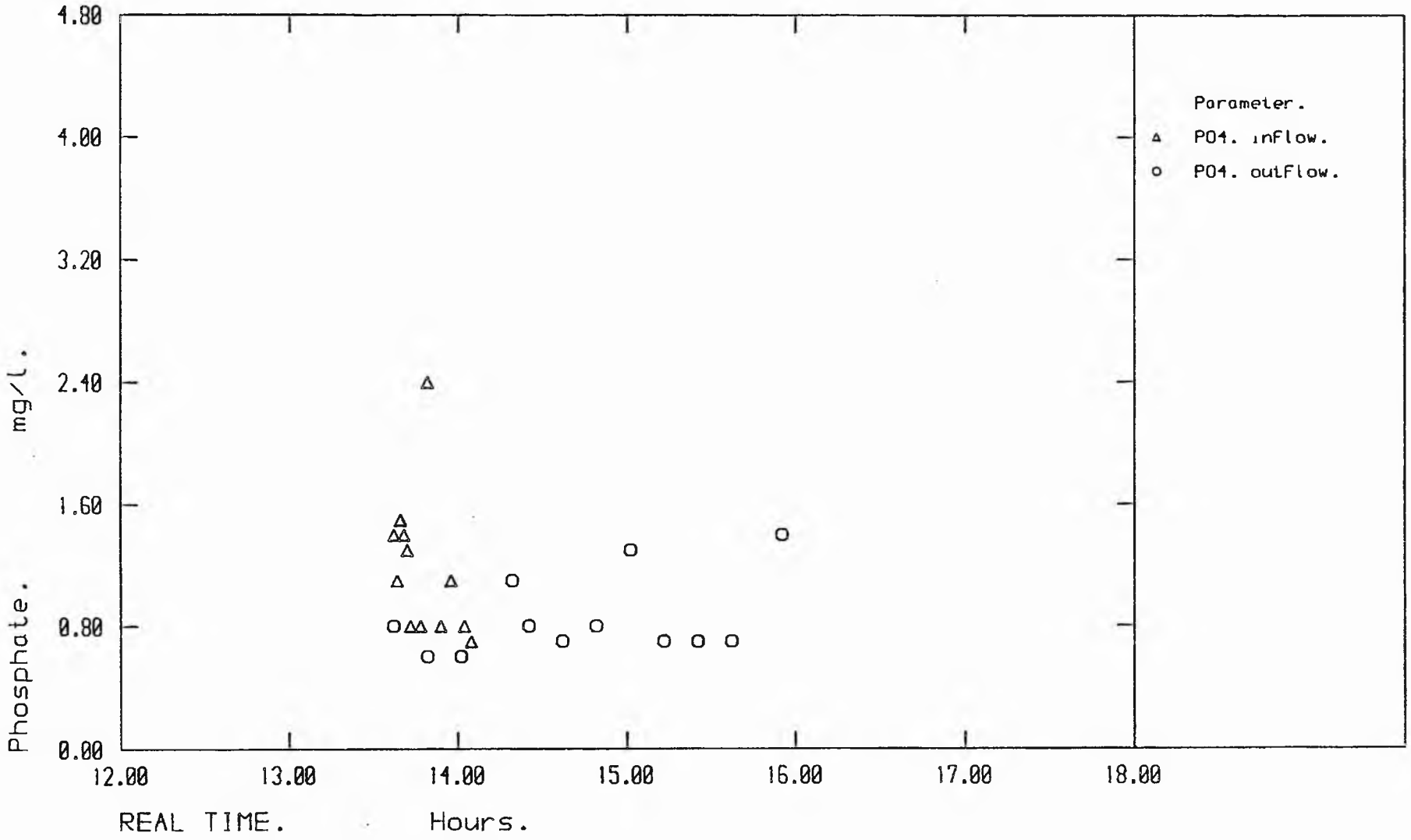
Graph of Chloride For Storm VII on TwyFord Gardens.
The graph shows inflow and outflow water quality data.



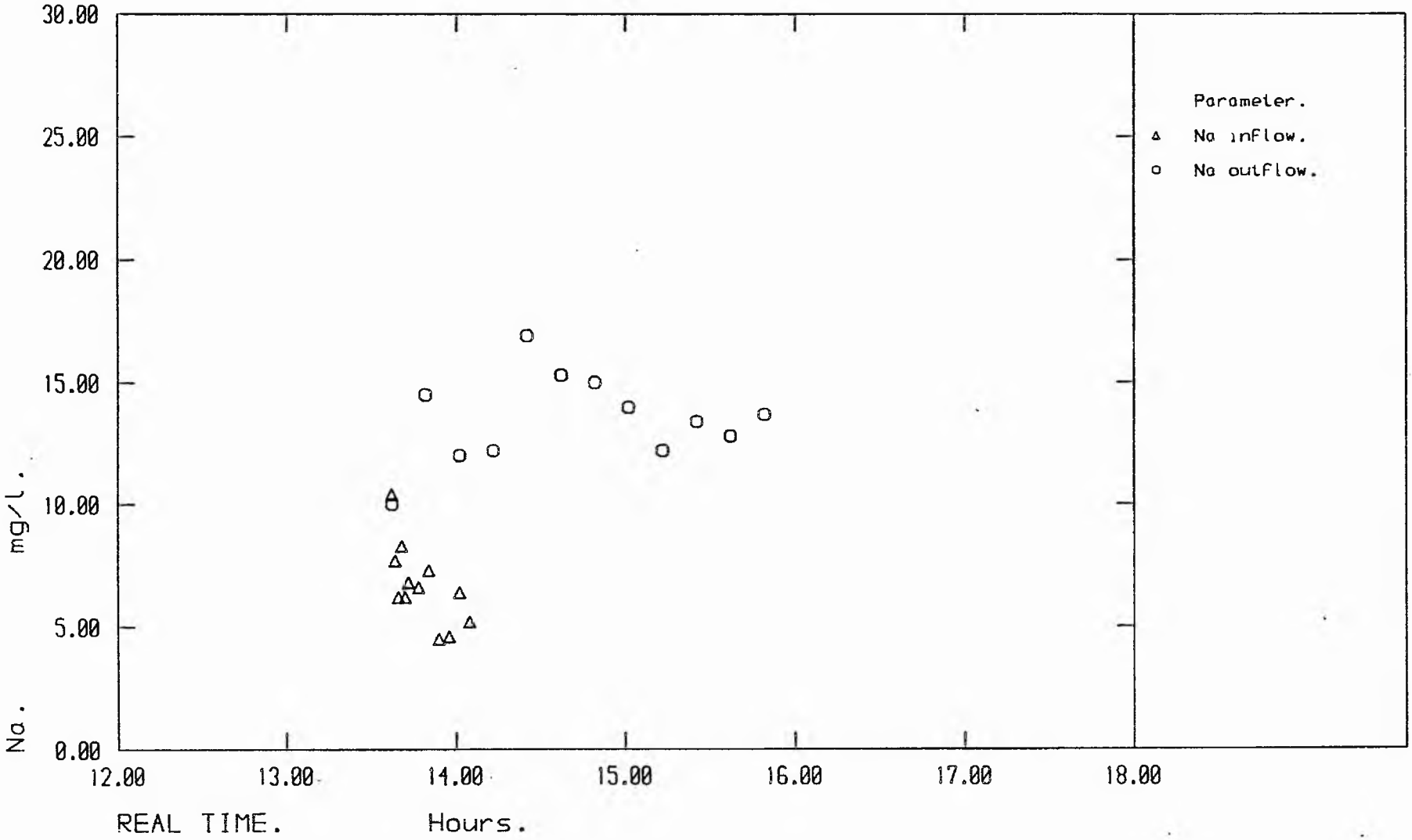
Graph of Ammonia for Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



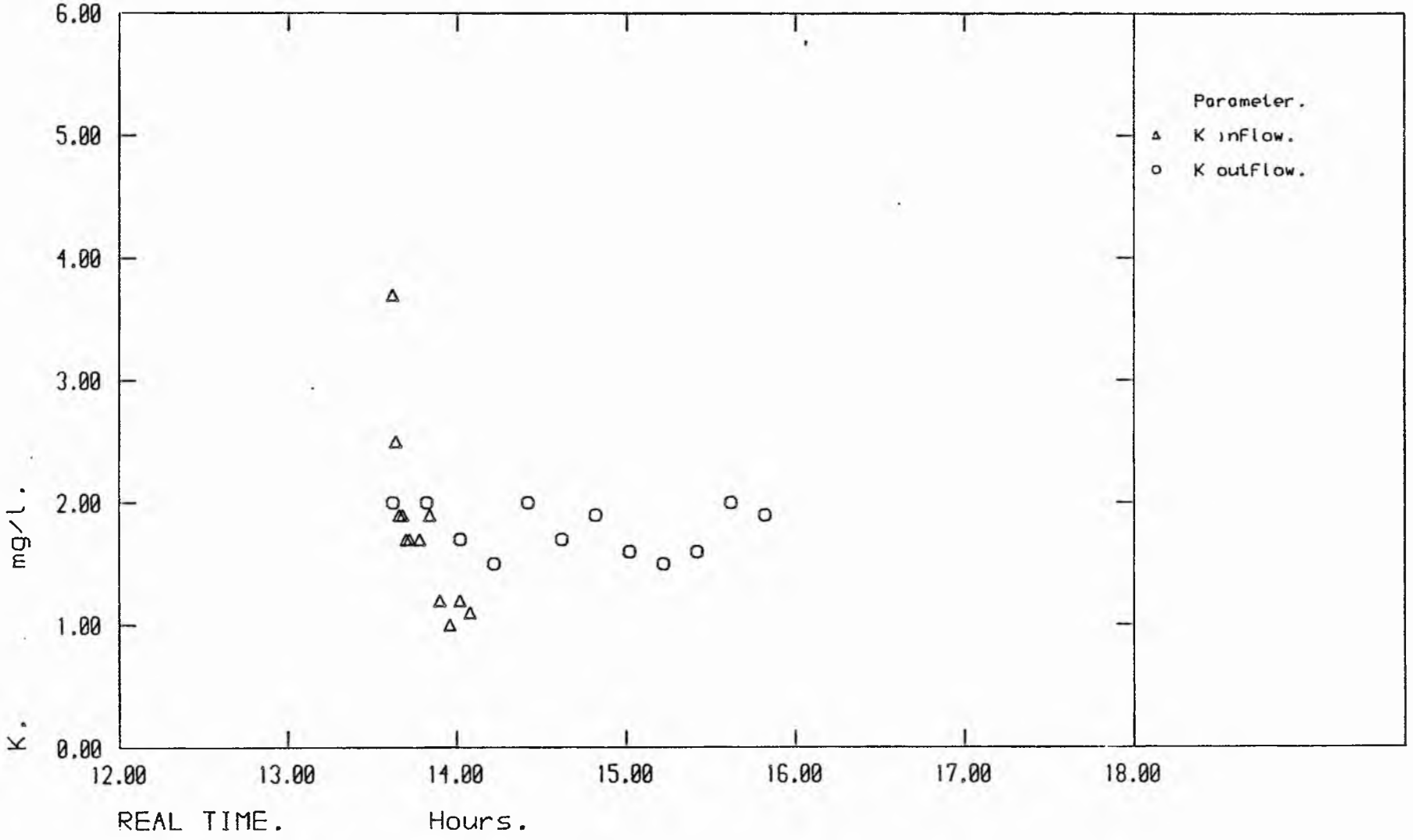
Graph of Nitrate for Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



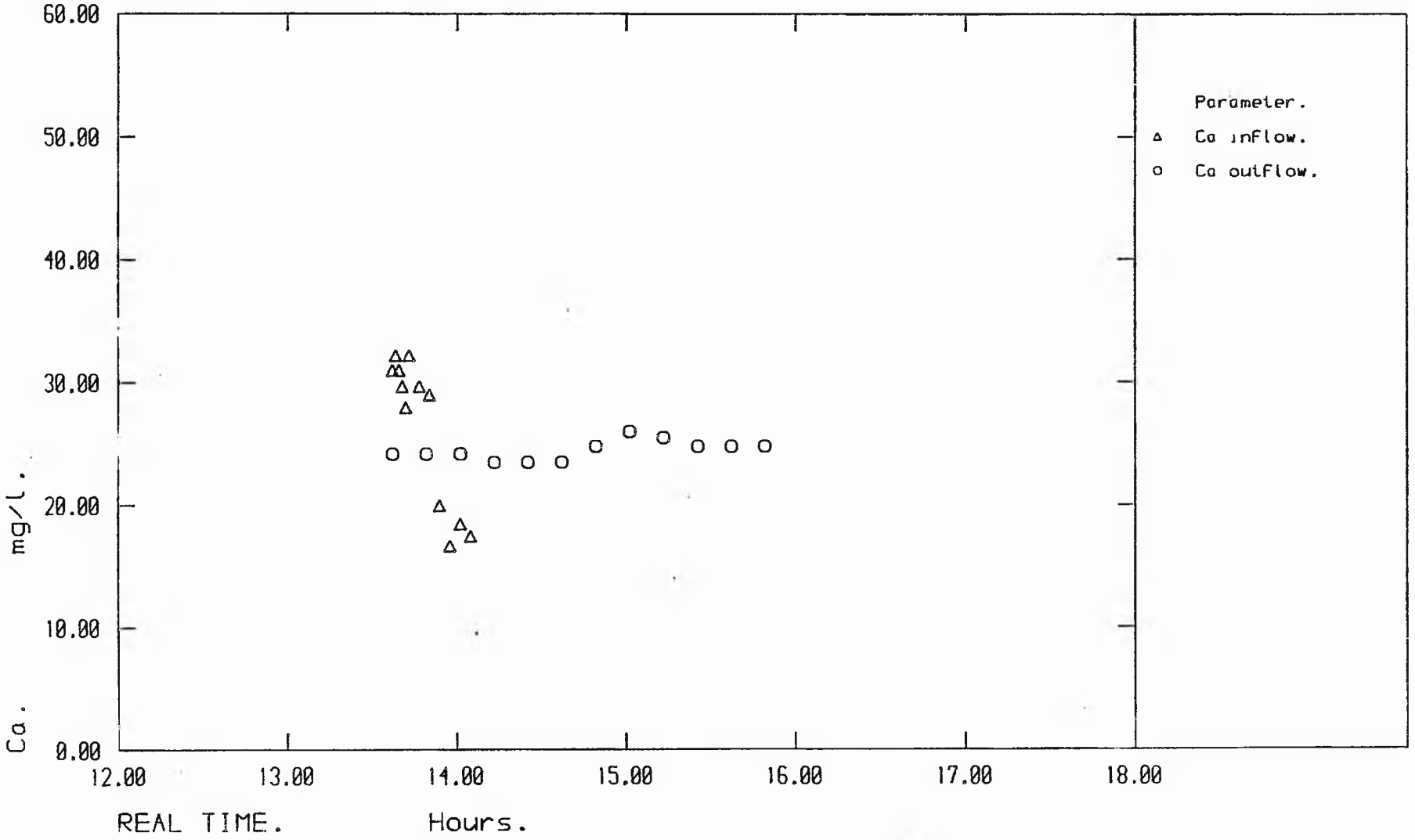
Graph of Phosphate for Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



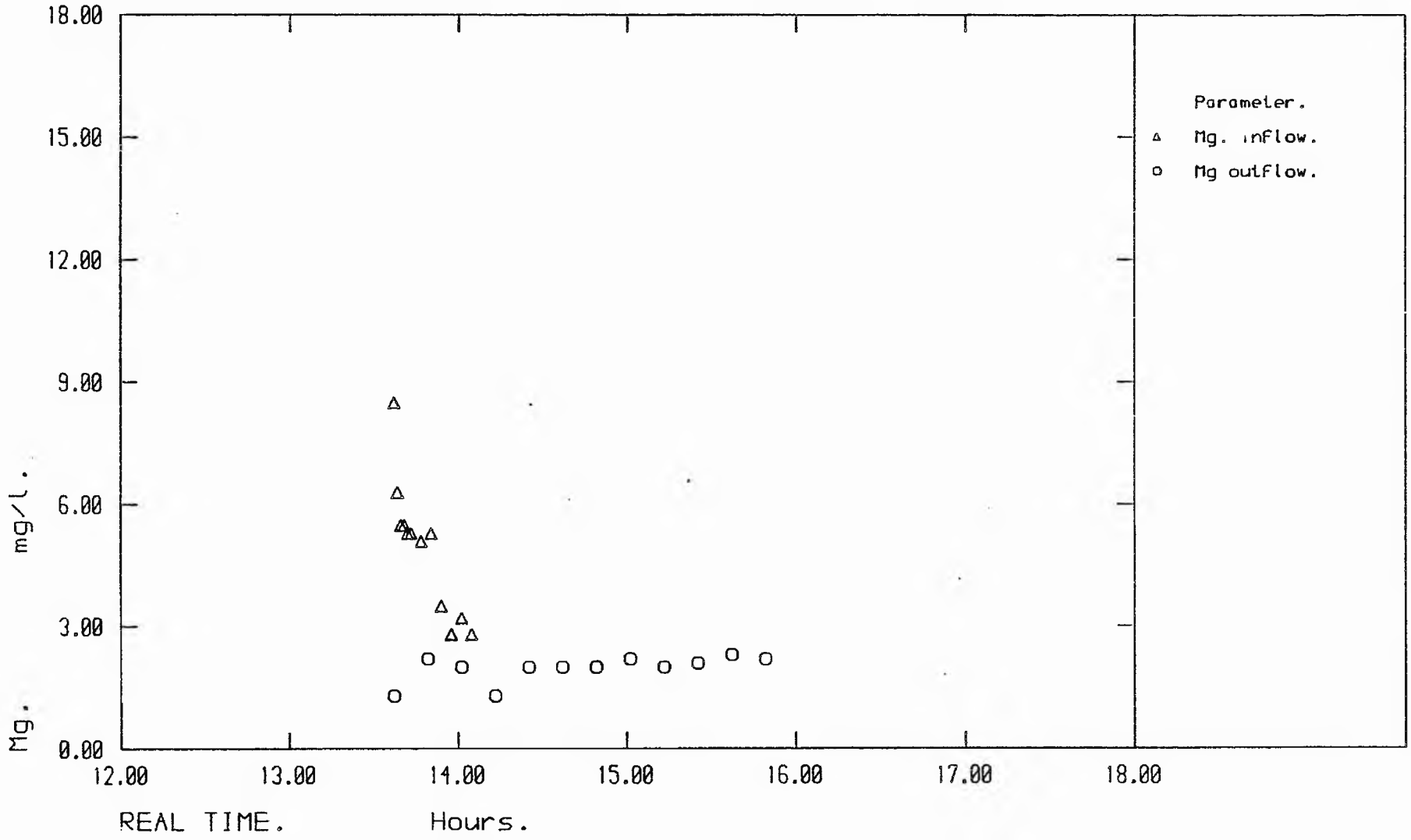
Graph of Sodium for Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



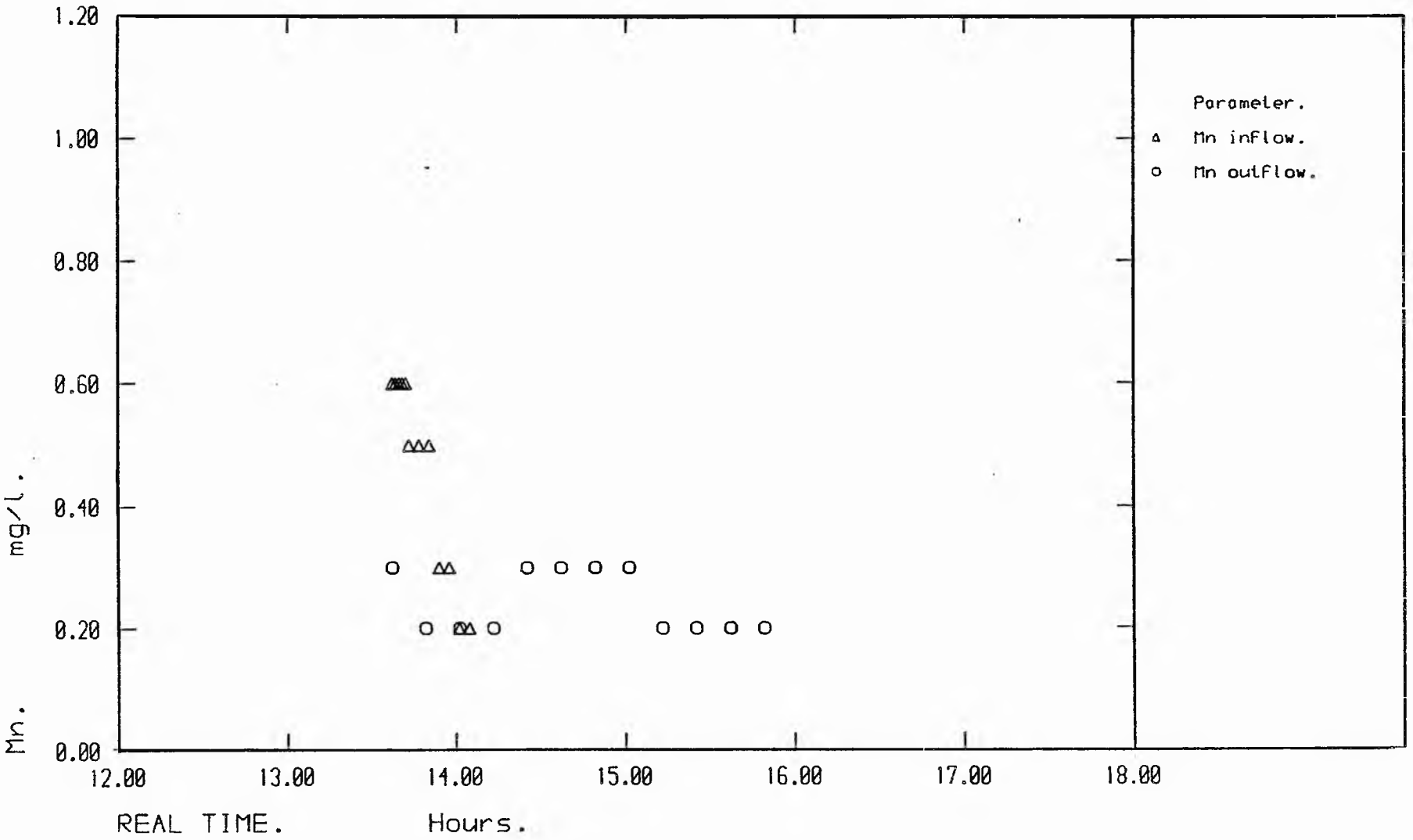
Graph of Potassium for Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



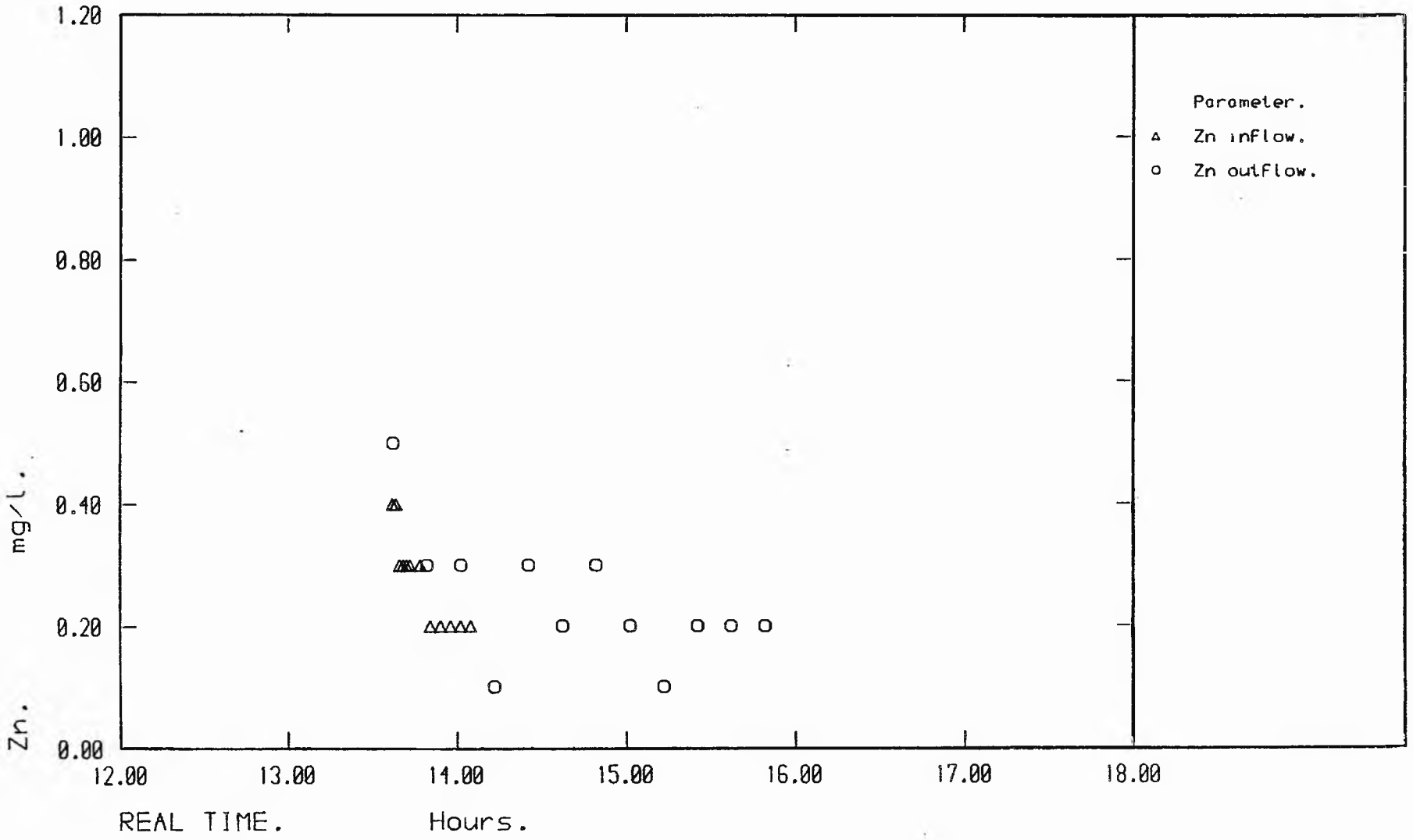
Graph of Calcium for Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Magnesium For Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Manganese for Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm VII on Twyford Gardens.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 13th. September 1985 (850913)
STORM NUMBER : VIII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1	TOC mgl-1
0645	99	66	362	104
0646	112	49	332	90
0648	137	50	281	84

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 13th. September 1985 (850913)
STORM NUMBER : VIII

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1	TOC mgl-1
0745	100	21	95	44
0805	102	25	106	42
0825	118	21	111	35
0845	80	15	95	33
0905	93	14	75	28
0925	106	14	90	31
0945	89	9	101	37
1005	117	16	55	33
1025	134	12	35	28

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 13th. September 1985 (850913)
STORM NUMBER : VIII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

REAL TIME Hours	DO mgl-1	pH pH units	Cl mgl-1
0645	4.4	6.7	46.1
0646	4.2	6.1	42.5
0648	3.8	6.1	42.5

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 13th. September 1985 (850913)
STORM NUMBER : VIII

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	DO mgl-1	pH pH units	Cl mgl-1
0745	4.8	6.6	31.9
0805	0.0	6.5	28.4
0825	4.4	6.6	28.4
0845	0.0	6.6	28.4
0905	0.0	6.6	28.4
0925	0.0	6.7	28.4
0945	4.3	6.6	28.4
1005	0.0	6.6	24.8
1025	5.8	6.6	28.4
1035	5.8	*	*

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 13th. September 1985 (850913)
STORM NUMBER : VIII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

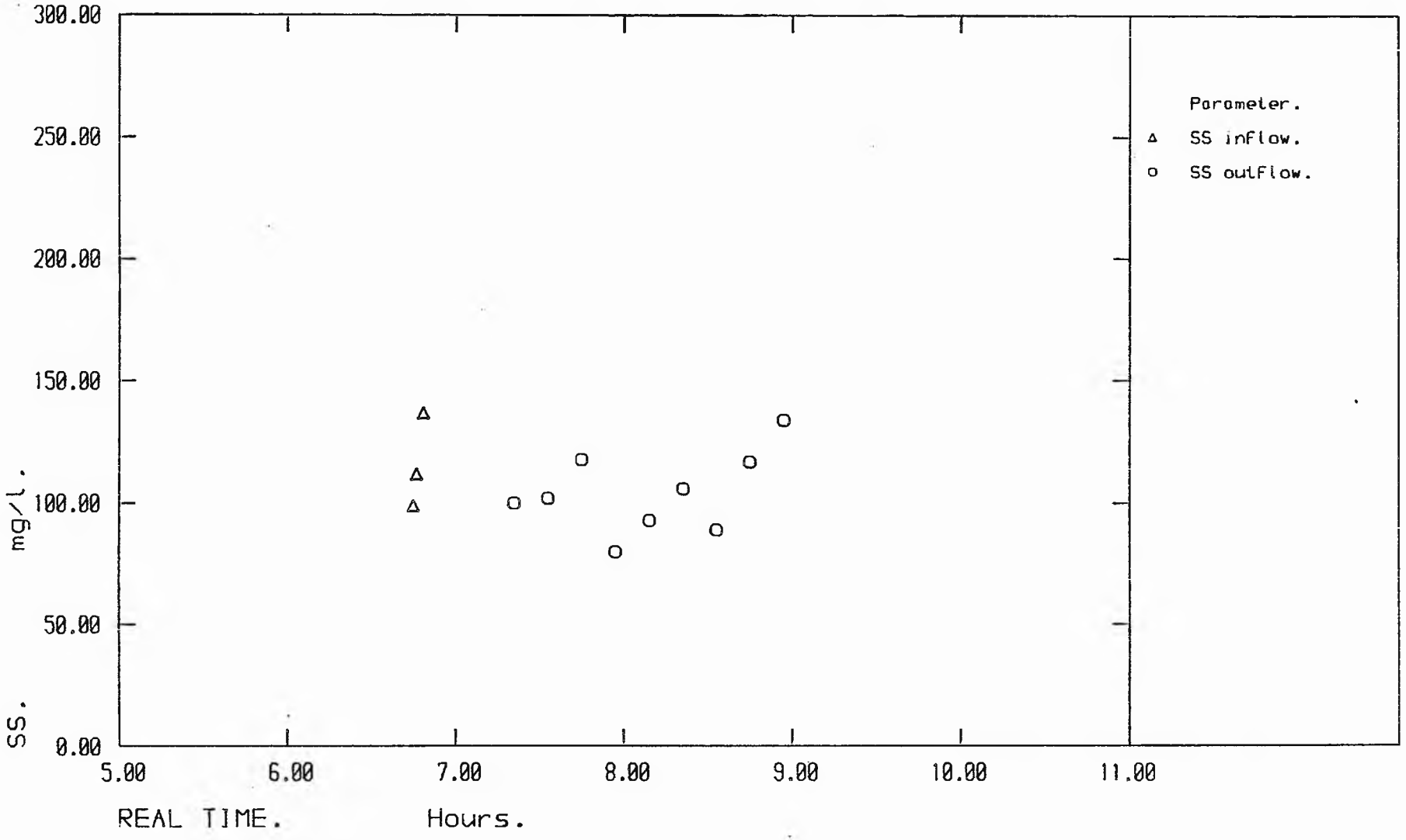
REAL TIME Hours	Cond uscm-1 (x1000)	Cu mgl-1	Zn mgl-1
0645	0.40	0.07	0.60
0646	0.38	0.07	0.55
0648	0.37	0.07	0.60

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

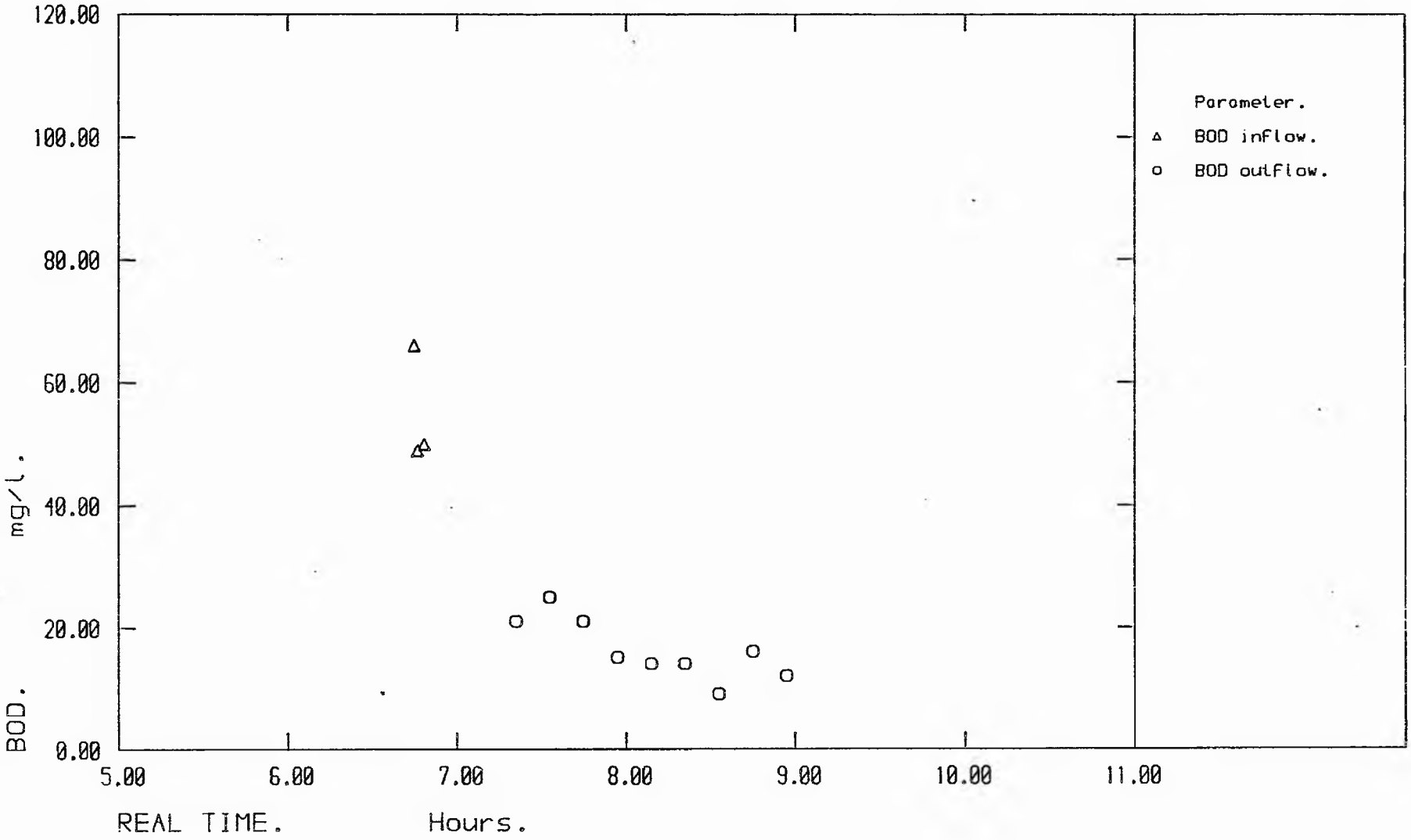
CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 13th. September 1985 (850913)
STORM NUMBER : VIII

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

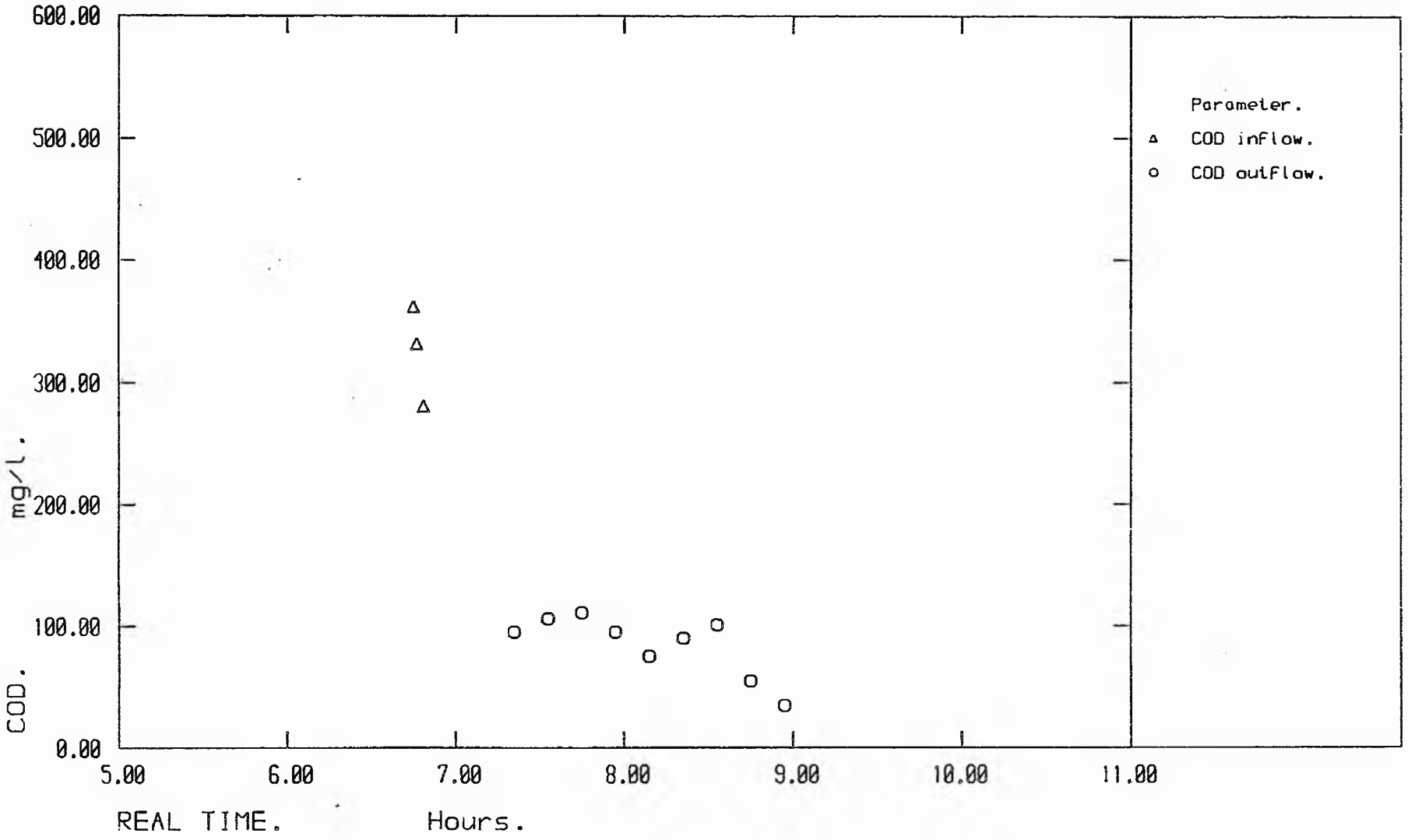
REAL TIME Hours	Cond uscm-1 (x1000)	Zn mgl-1
0745	0.21	0.14
0805	0.23	0.12
0825	0.20	0.17
0845	0.18	0.17
0905	0.16	0.42
0925	0.18	0.14
0945	0.18	0.26
1005	0.18	0.28
1025	0.18	0.30



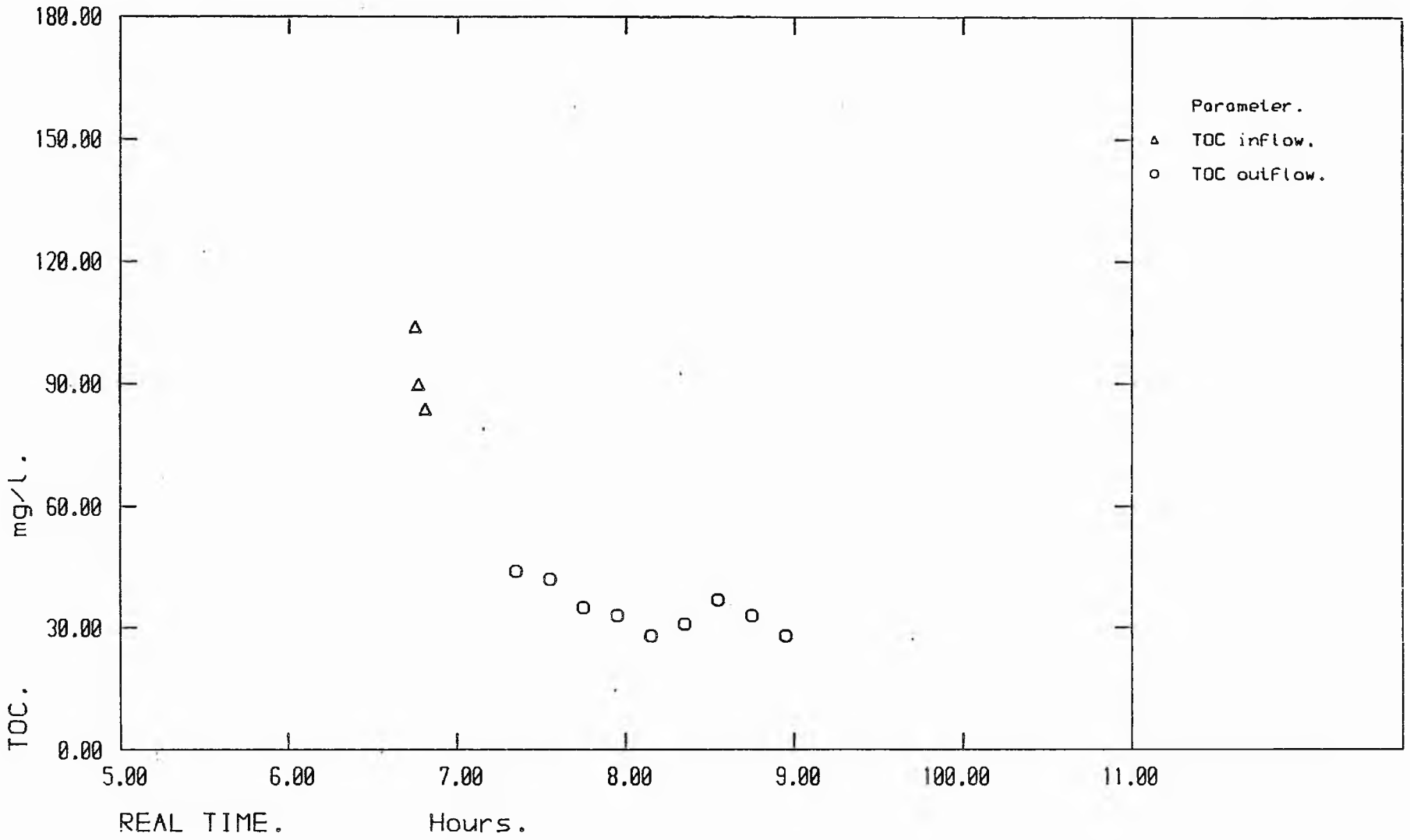
Graph of Suspended Solids for Storm VIII on Tame Close.
The graph shows inflow and outflow water quality data.



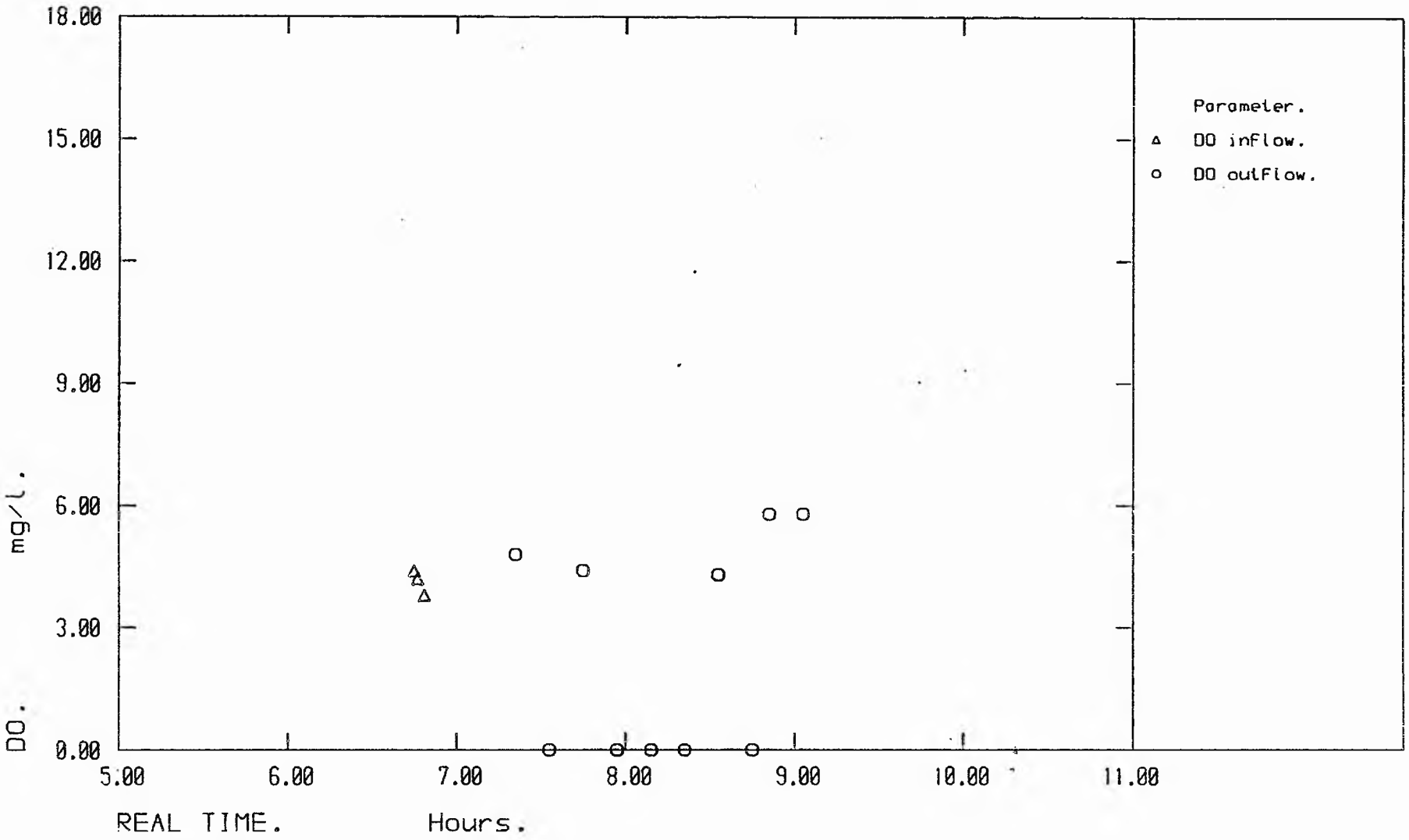
Graph of Biochemical Oxygen Demand for Storm VIII on Tame Close.
The graph shows inflow and outflow water quality data.



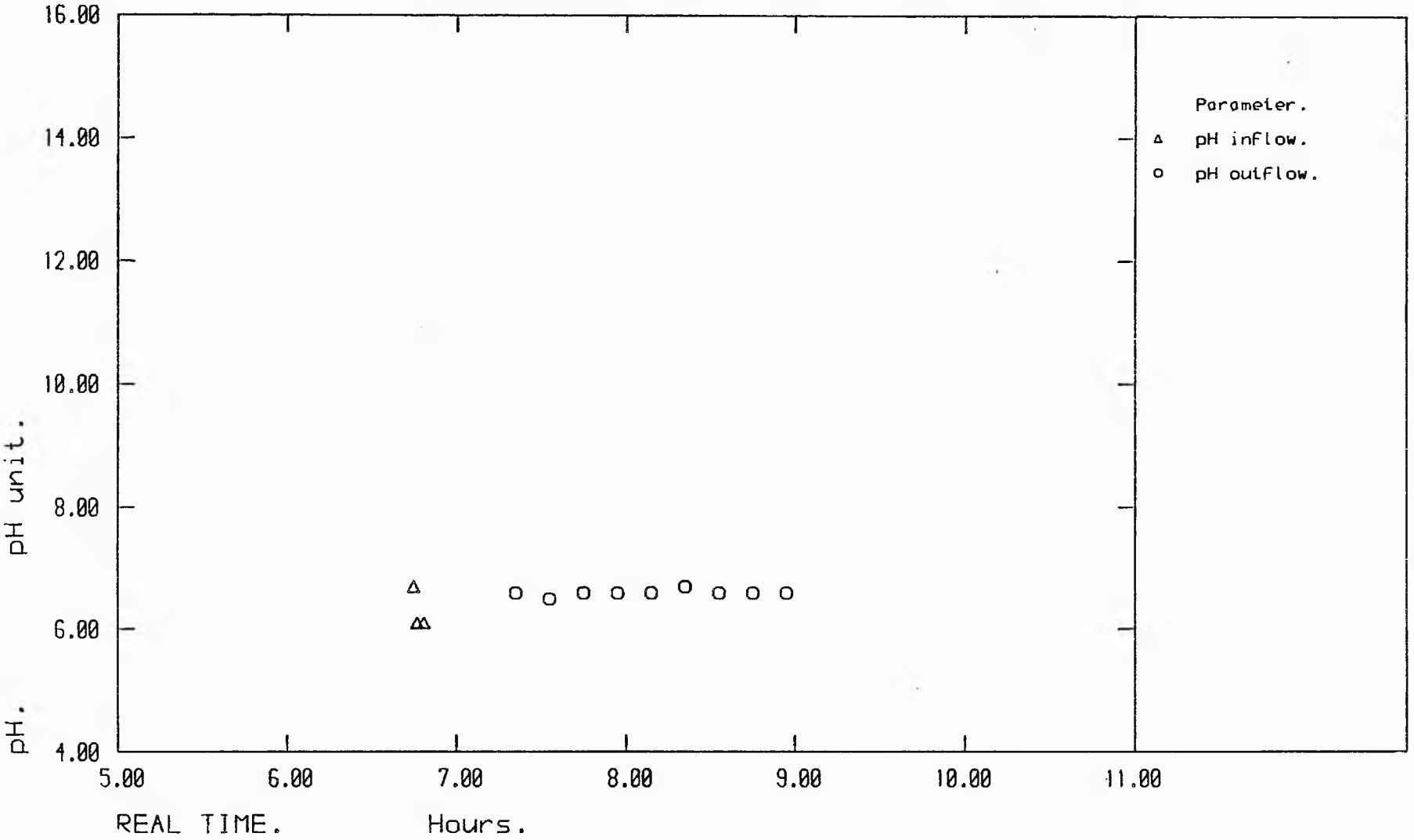
Graph of Chemical Oxygen Demand for Storm VIII on Tame Close.
The graph shows inflow and outflow water quality data.



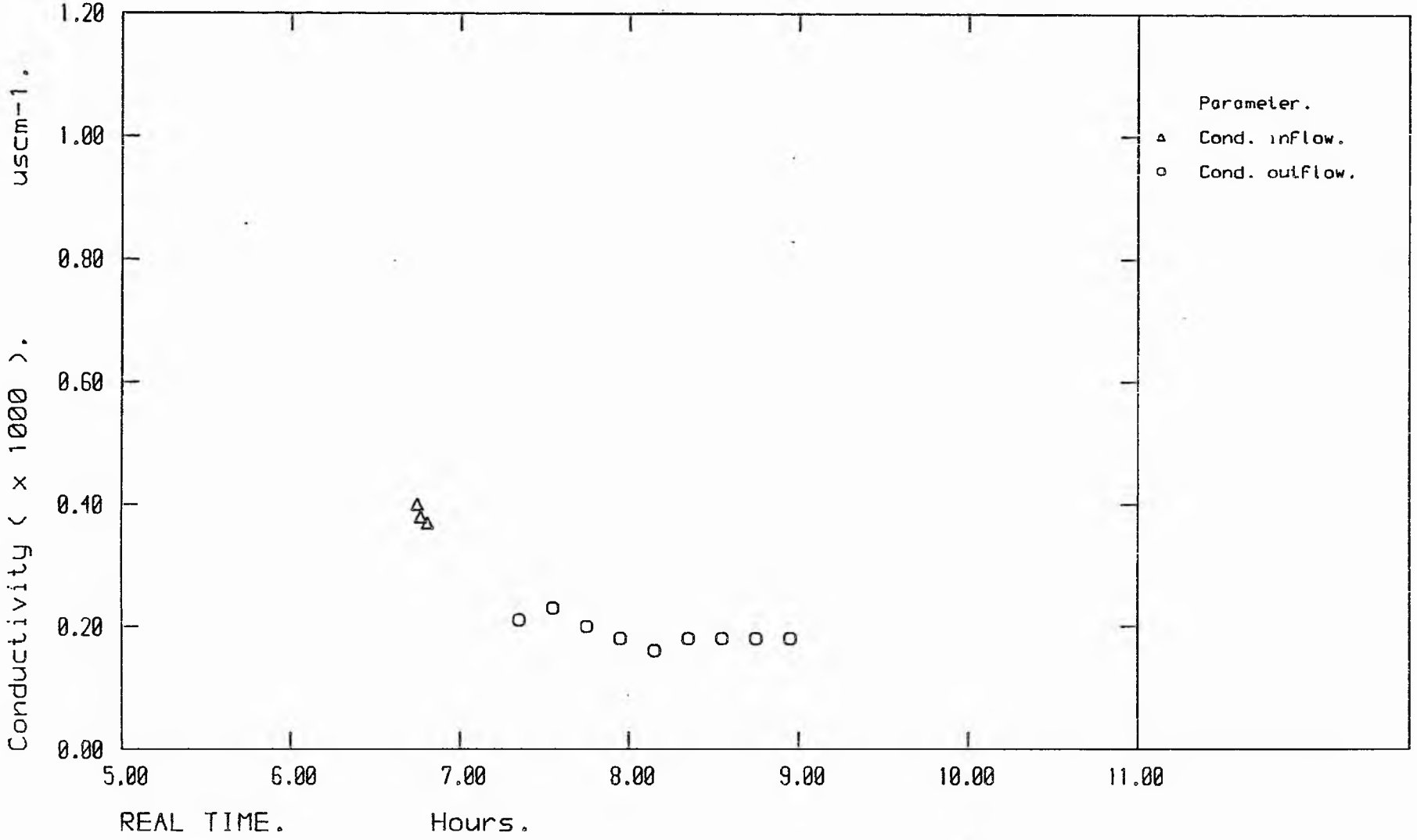
Graph of TOC for Storm VIII on Tame Close.
The graph shows inflow and outflow water quality data.



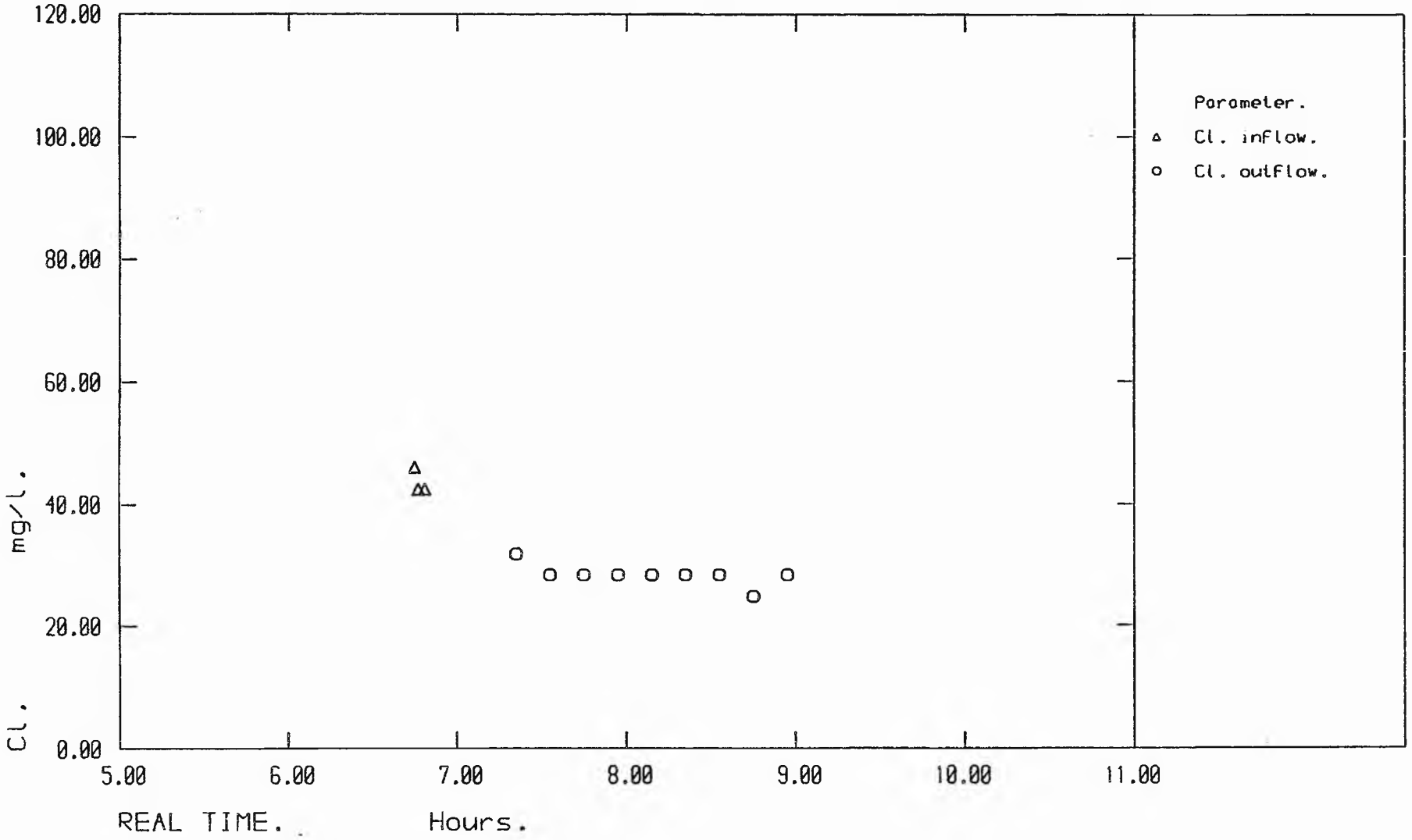
Graph of Dissolved Oxygen for Storm VIII on Tame Close.
The graph shows inflow and outflow water quality data.



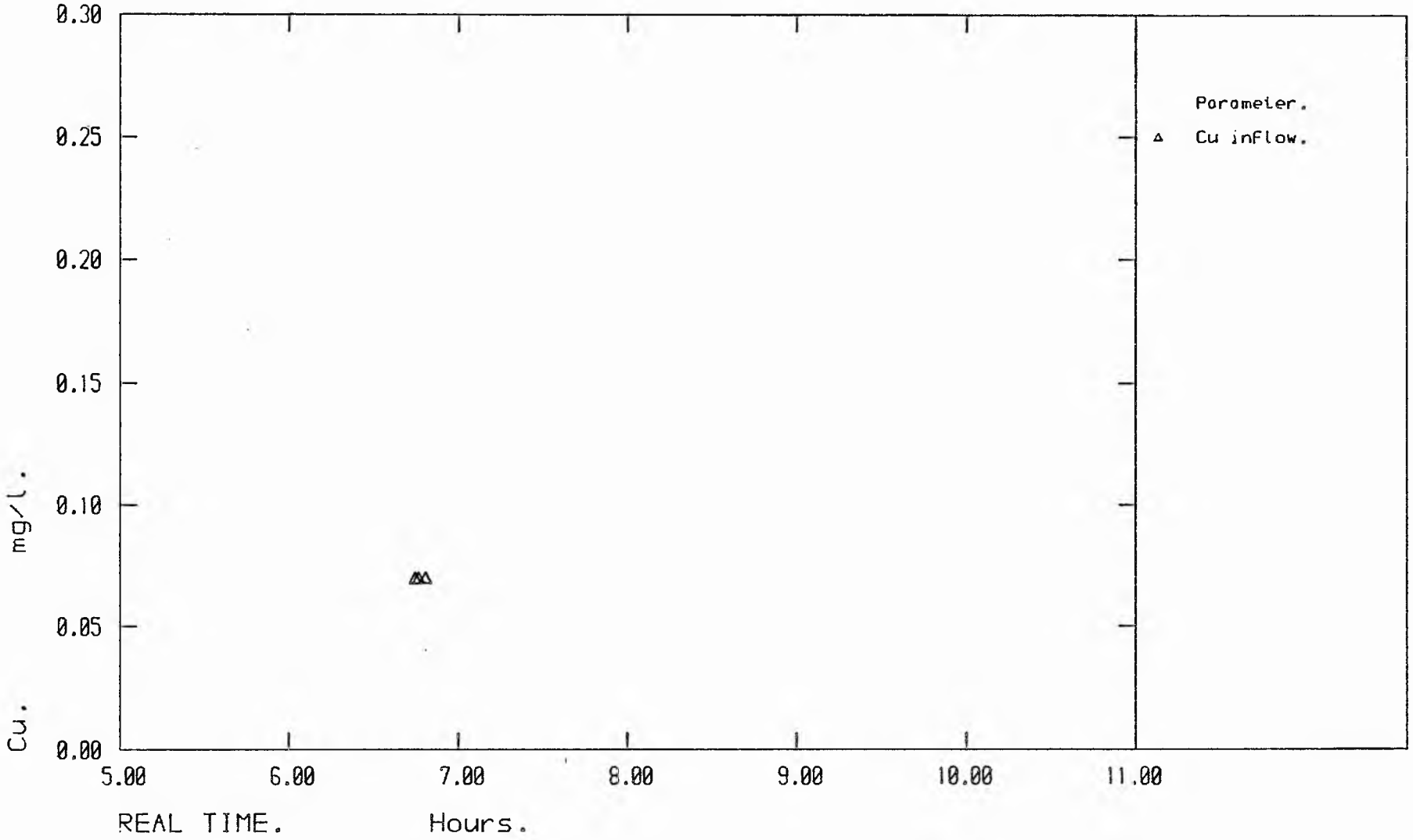
Graph of pH for Storm VIII on Tame Close.
The graph shows inflow and outflow water quality data.



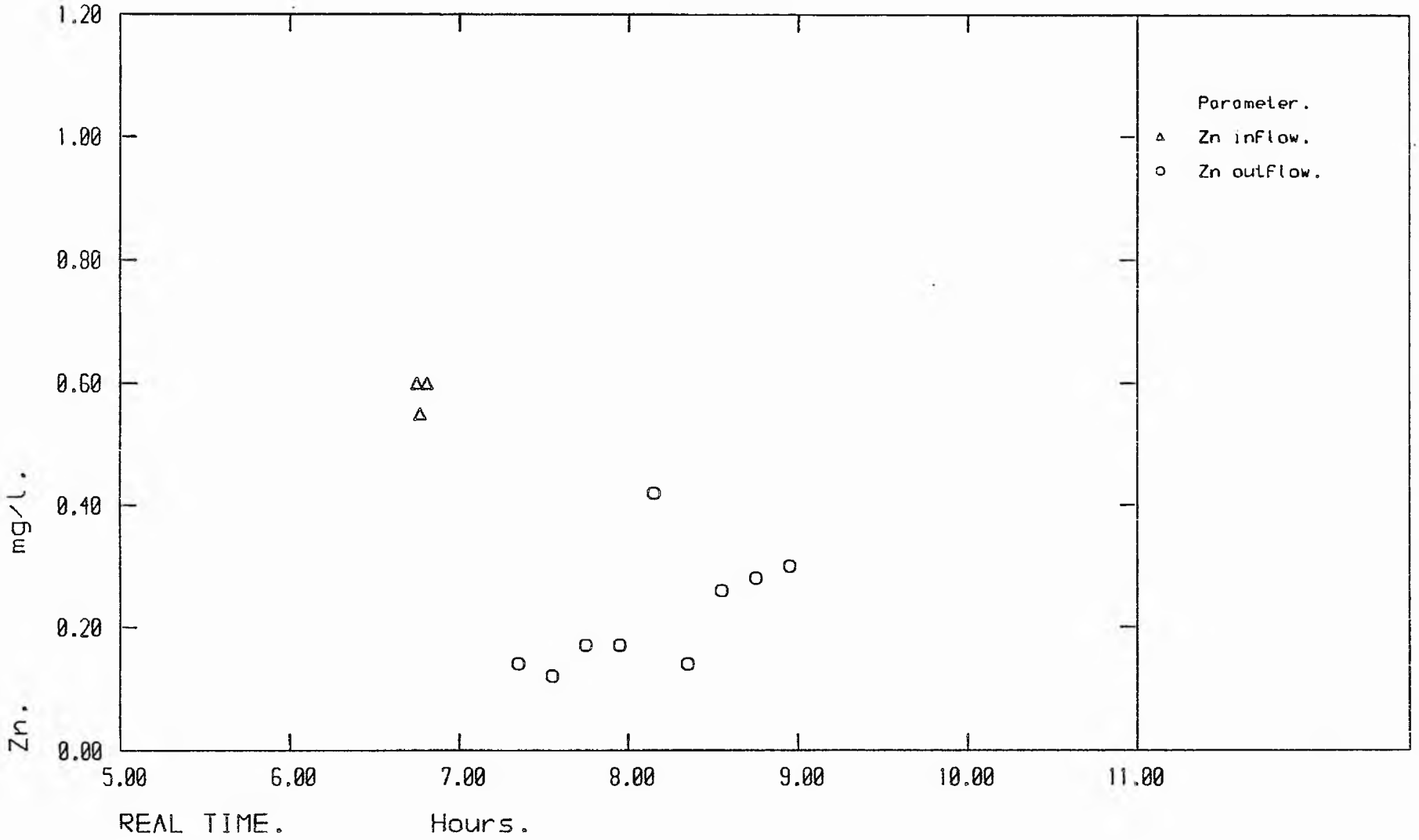
Graph of Conductivity for Storm VIII on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Chloride for Storm VIII on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Copper for Storm VIII on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm VIII on Tame Close.
The graph shows inflow and outflow water.quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 6th. October 1985 (851006)
STORM NUMBER : IX

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
0408	185	0	0
0409	214	14	333
0410	24	0	0
0411	322	10	103
0412	205	0	0
0413	171	7	195
0414	161	0	0
0415	152	9	154
0416	165	0	0
0417	107	12	112
0418	163	0	0
0419	113	8	51
0420	151	0	0
0421	*	0	51
0422	139	0	0
0423	51	6	108
0424	65	0	0
0425	58	5	72
0426	184	0	0
0427	*	26	226
0428	291	0	0
0429	*	0	190
0430	294	0	0
0431	*	27	231

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close

DATE OF THE STORM EVENT : 6th. October 1985 (851006)

STORM NUMBER : IX

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
0408	0.16	7.5	6.7
0410	0.09	7.3	6.5
0412	0.10	6.7	6.4
0414	0.08	7.1	6.4
0416	0.09	7.2	6.4
0418	0.09	7.2	6.4
0420	0.09	7.0	6.6
0422	0.09	6.7	6.4
0424	0.09	7.3	6.5
0426	0.17	7.9	6.9
0428	0.15	8.1	7.0
0430	0.11	8.1	6.9

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close

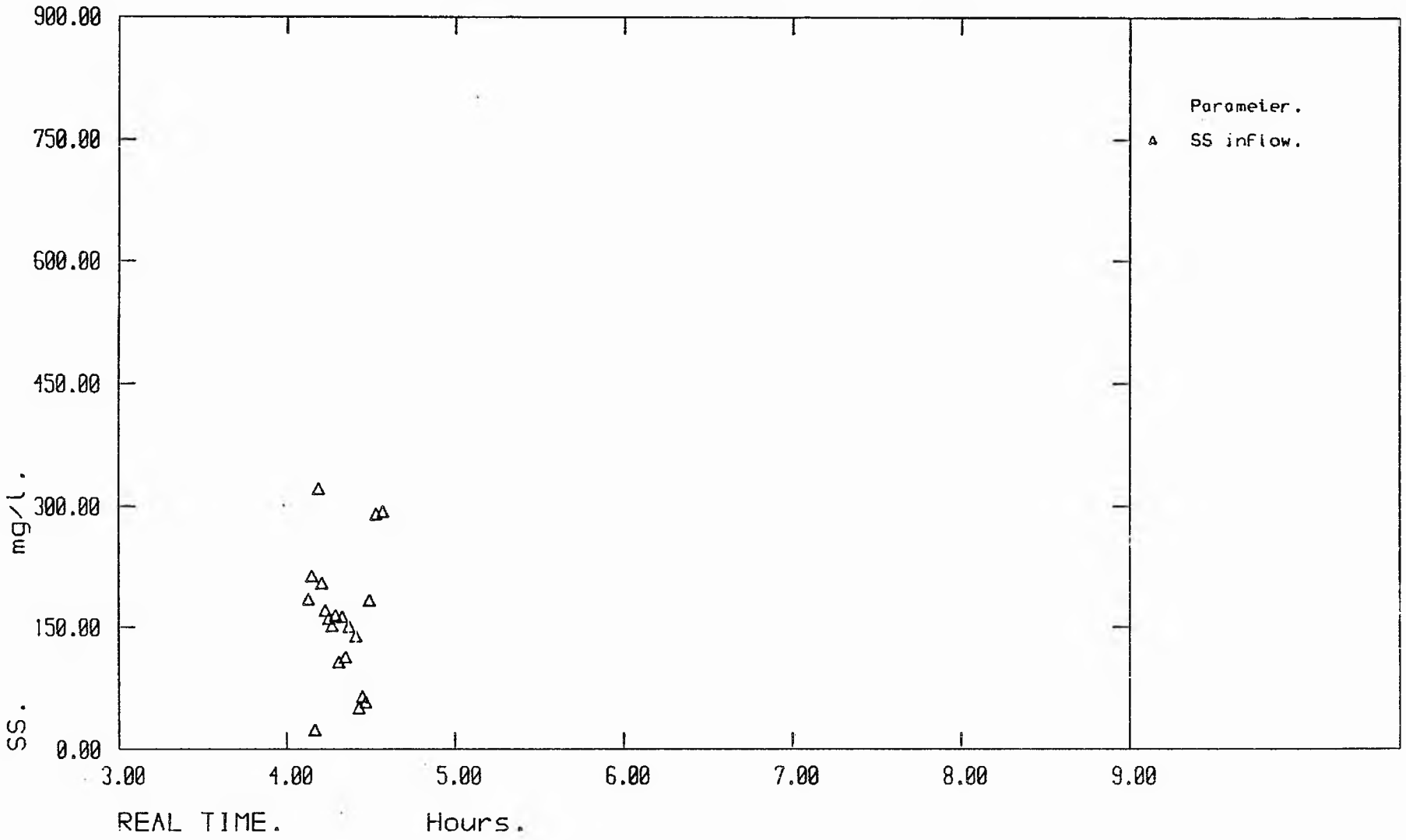
DATE OF THE STORM EVENT : 6th. October 1985 (851006)

STORM NUMBER : IX

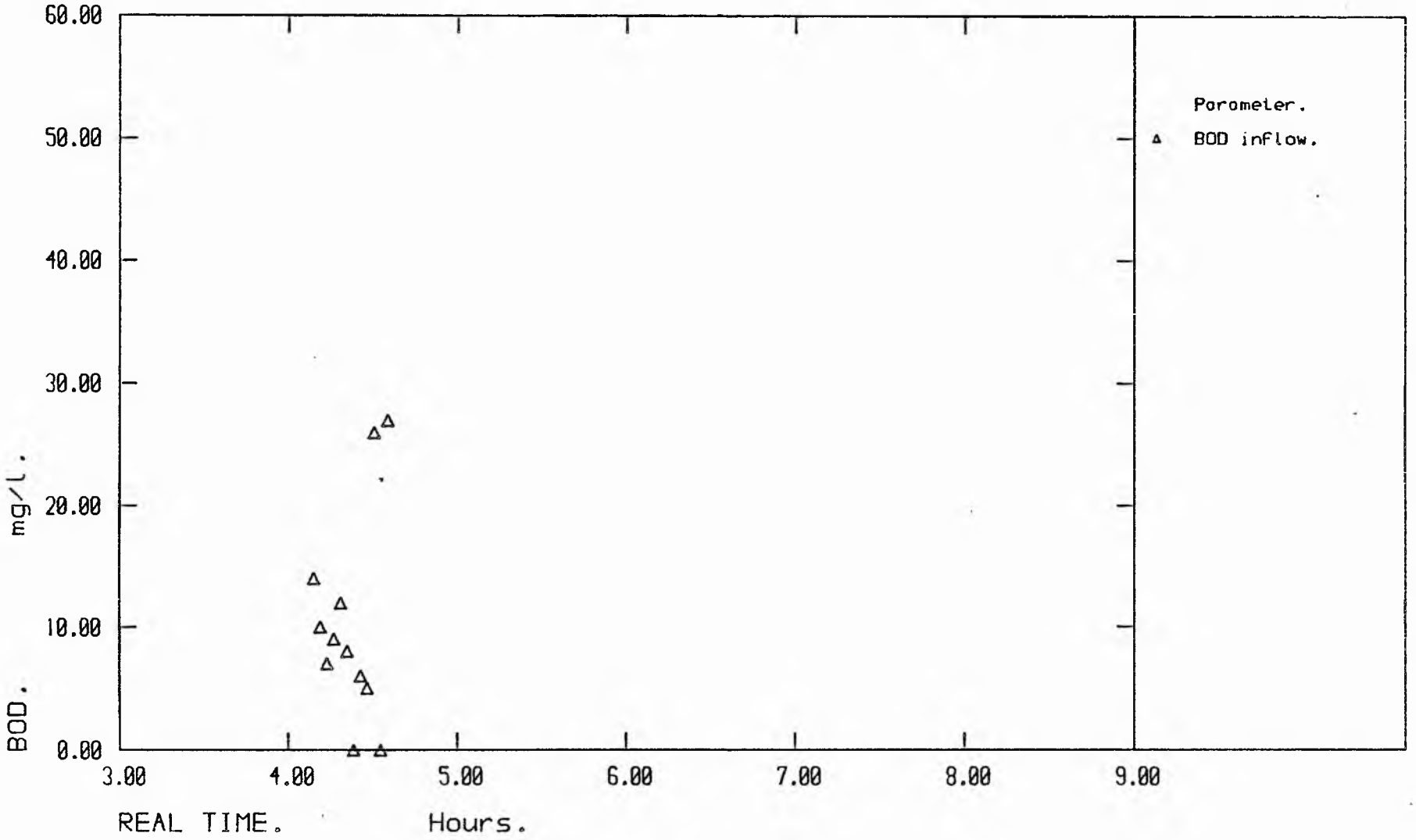
ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Alk mgl-1	Cl mgl-1	Zn mgl-1
0408	30	24.8	0.43
0410	30	21.3	0.43
0412	30	24.8	0.26
0414	20	21.3	0.24
0416	20	24.8	0.34
0418	20	21.3	0.26
0420	20	21.3	0.24
0422	30	24.8	0.26
0424	30	24.8	0.18
0426	30	28.4	0.24
0428	30	24.8	0.26
0430	*	*	0.37

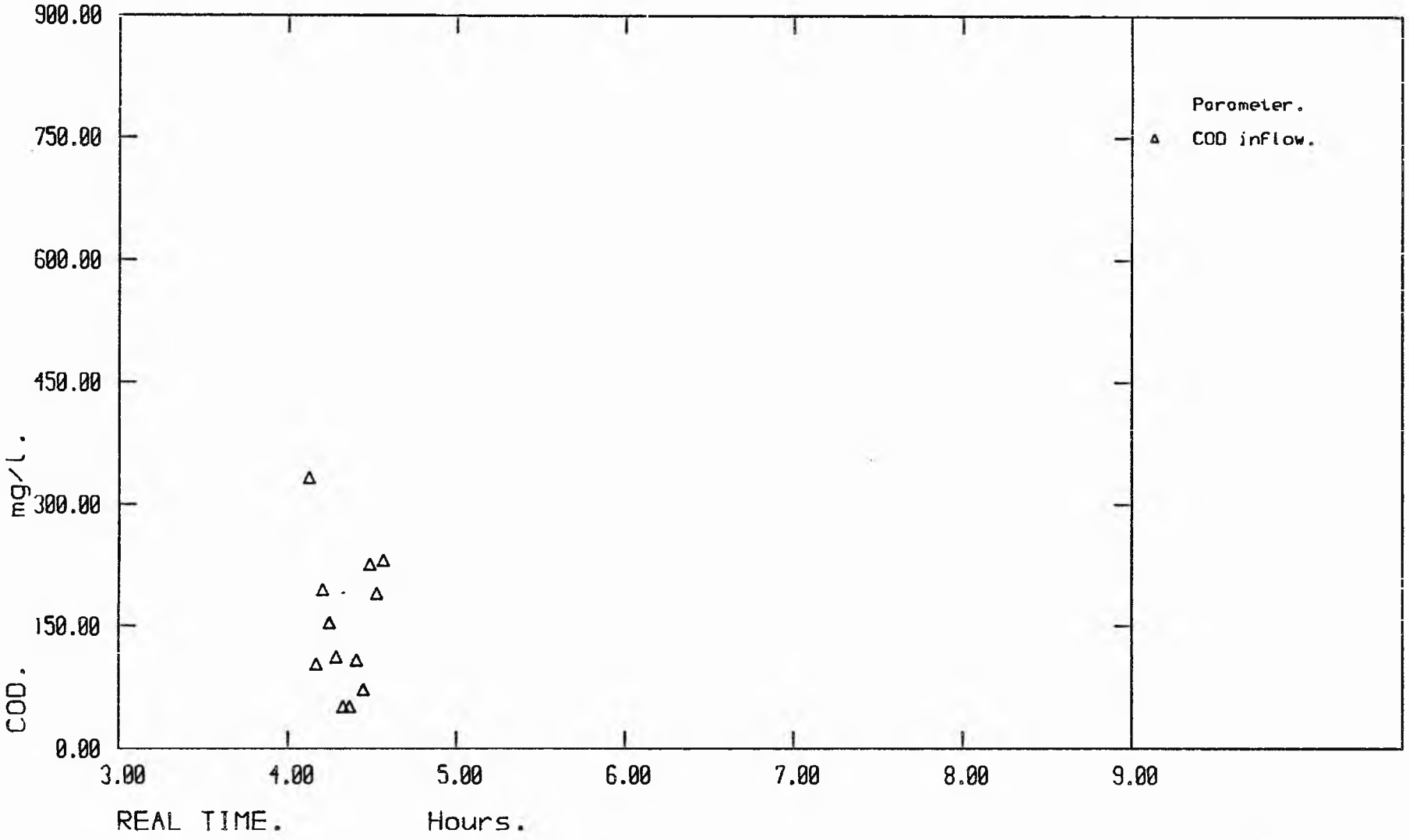
* = No Analysis



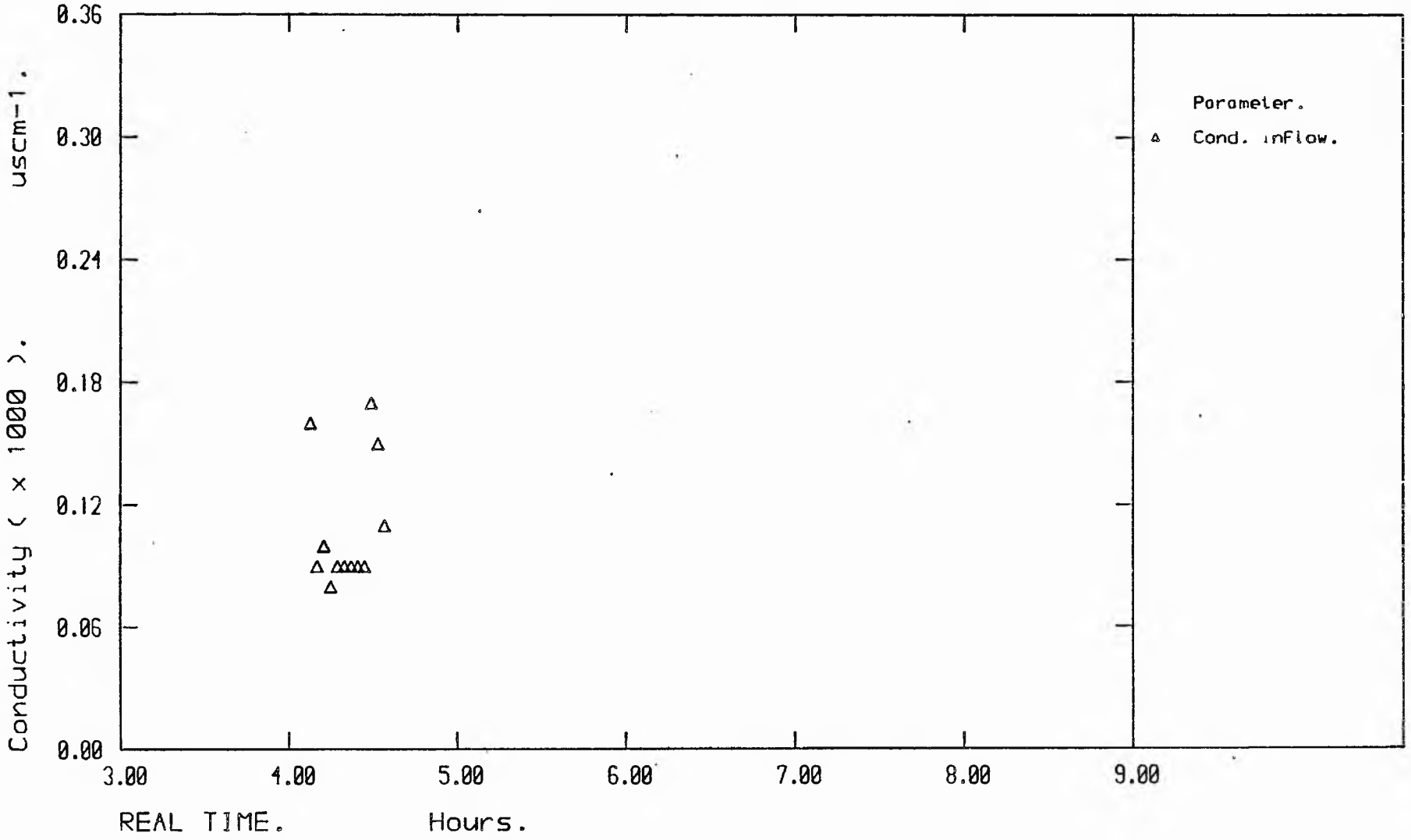
Graph of Suspended Solids for Storm IX on Tame Close.
The graph shows inflow and outflow water quality data.



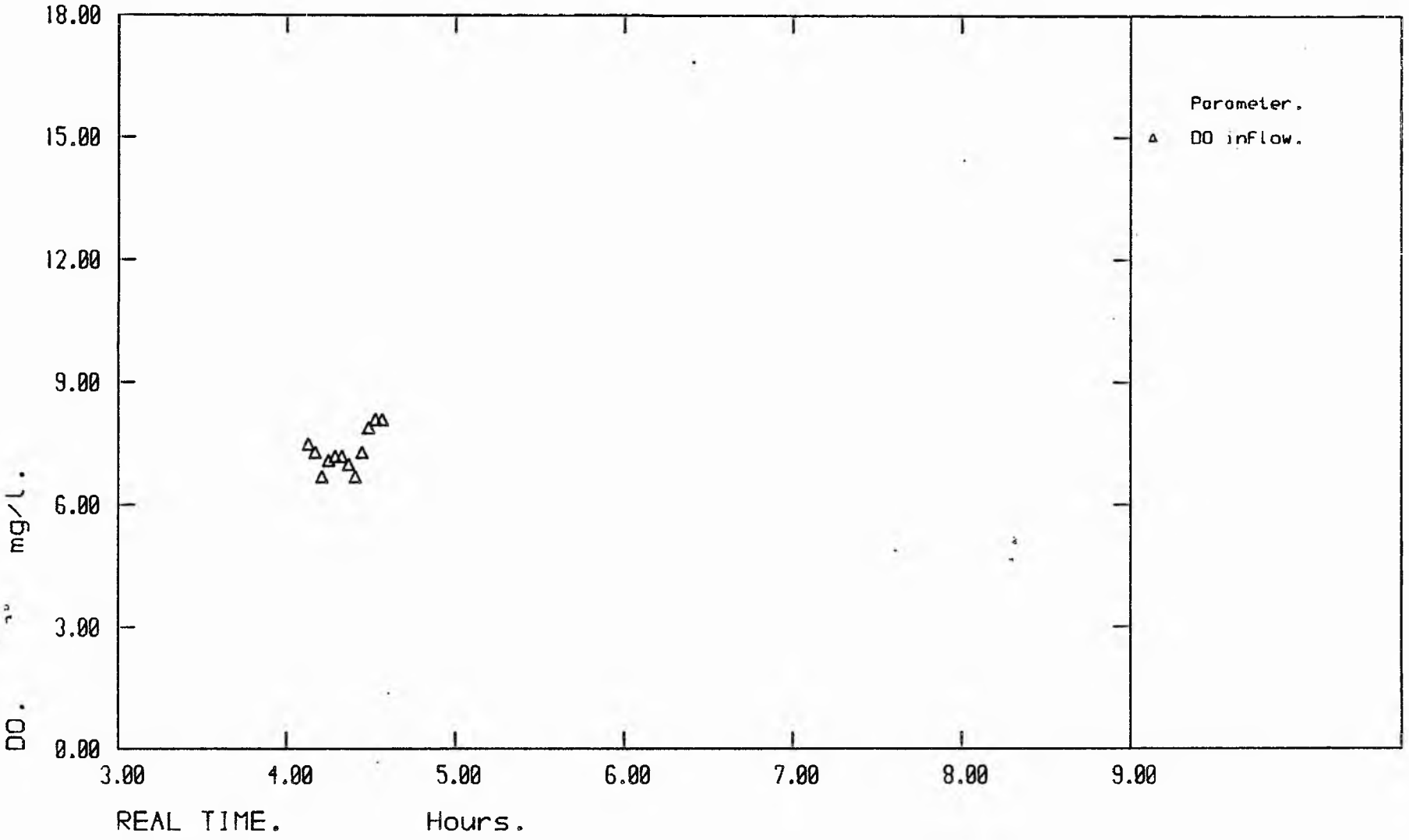
Graph of Biochemical Oxygen Demand for Storm IX on Tame Close.
The graph shows inflow and outflow water quality data.



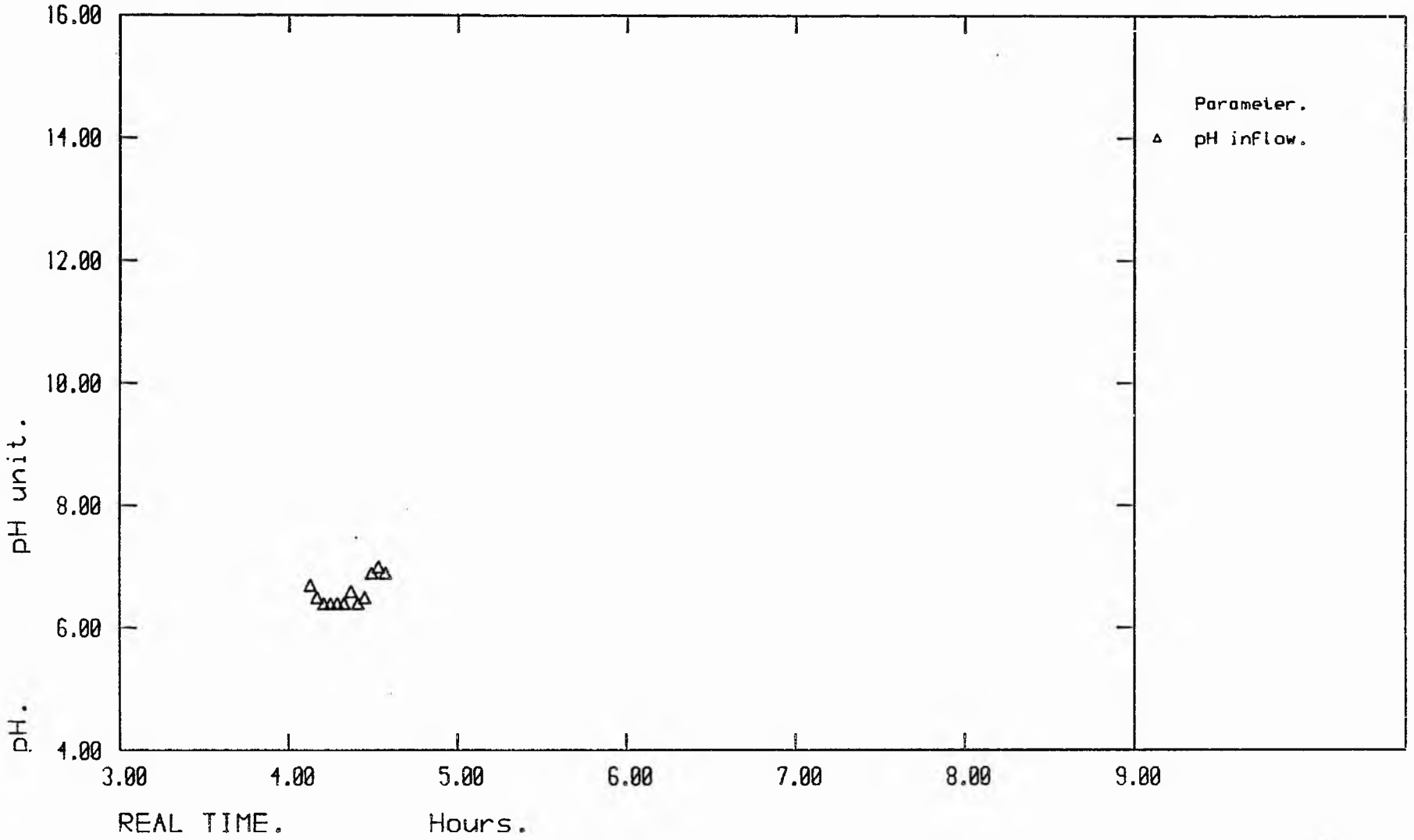
Graph of Chemical Oxygen Demand for Storm IX on Tame Close.
The graph shows inflow and outflow water quality data.



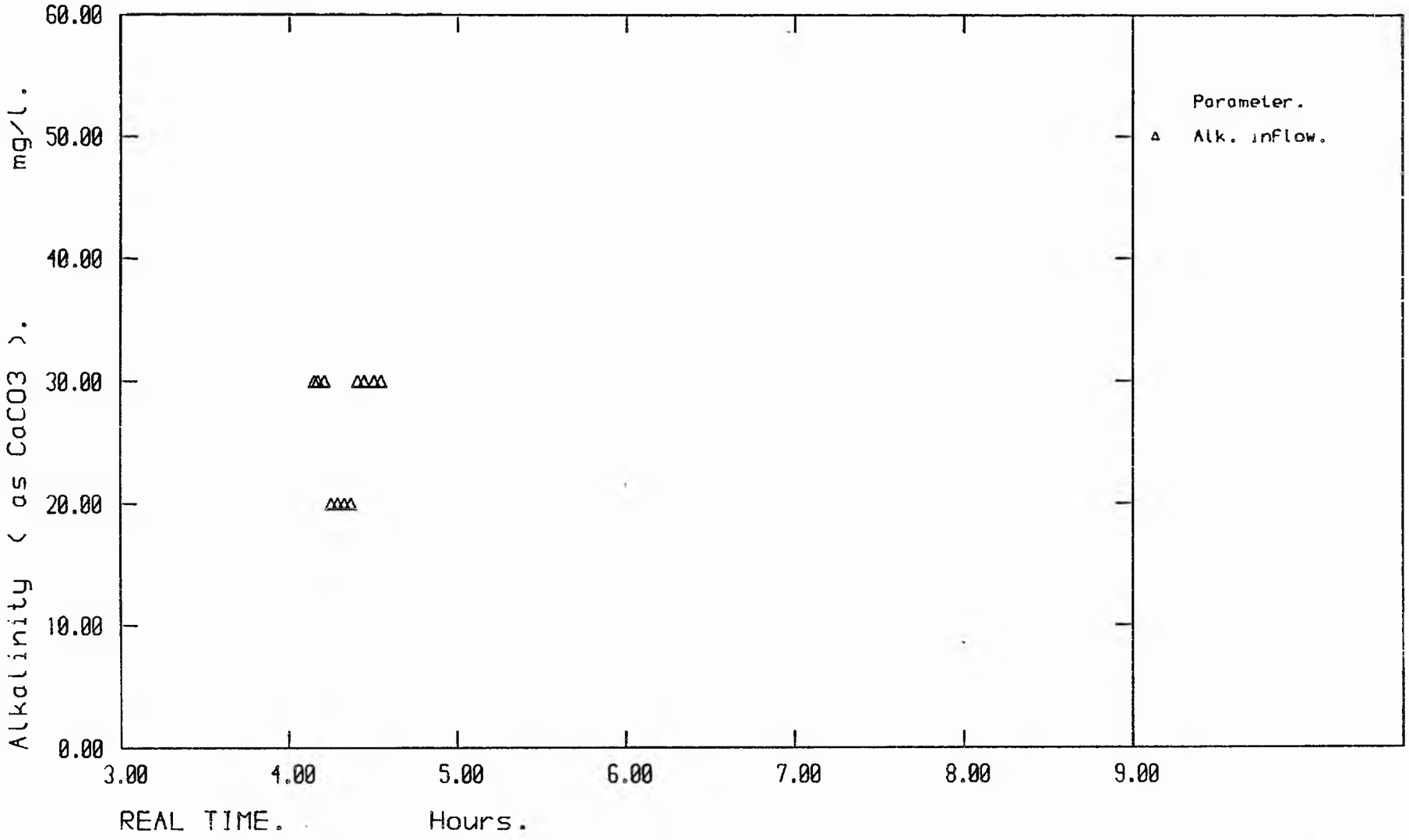
Graph of Conductivity for Storm IX on Tame Close.
The graph shows inflow and outflow water quality data.



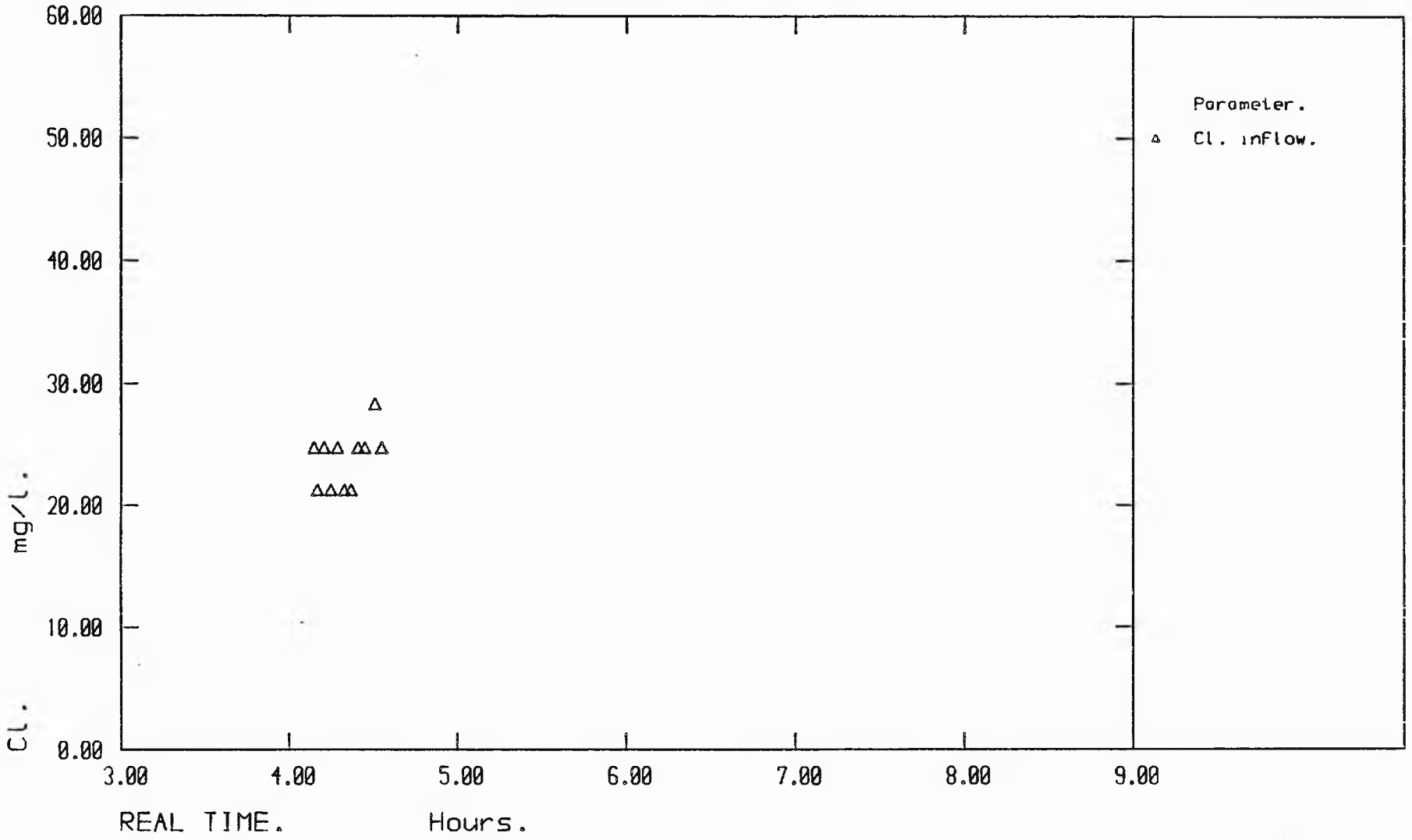
Graph of Dissolved Oxygen for Storm IX on Tame Close.
The graph shows inflow and outflow water quality data.



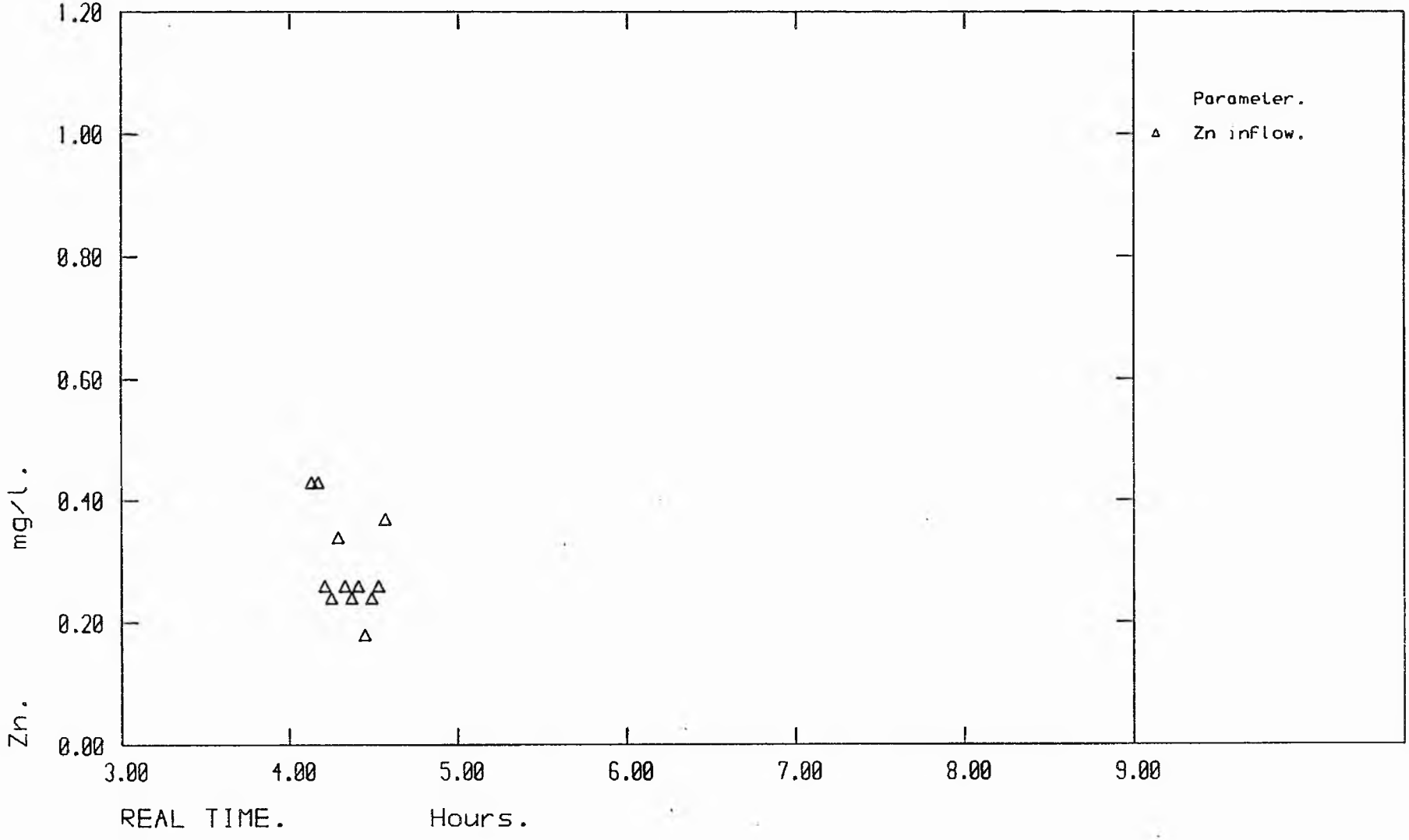
Graph of pH for Storm IX on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Total Alkalinity for Storm IX on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Chloride for Storm IX on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm IX on Tame Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 6th. October 1985 (851006)
STORM NUMBER : IX

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
0418	70	7	205
0419	37	*	*
0420	77	7	138
0421	46	*	*
0422	22	5	154
0423	145	*	*
0424	18	6	118
0425	42	*	*
0426	30	5	190
0427	44	*	*
0428	31	7	123
0429	47	*	*
0430	312	5	169
0431	65	*	*
0432	53	8	205.
0433	58	*	*
0434	48	5	364
0435	64	*	8
0436	86	6	200
0437	93	*	*
0438	67	7	174
0439	118	*	*
0440	82	0	123

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 6th. October 1985 (851006)
STORM NUMBER : IX

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	BOD mgl-1	COD mgl-1
0418	54	7	134
0428	31	*	*
0438	65	9	114
0448	28	*	*
0458	100	6	134
0508	38	*	*
0518	124	10	114
0528	103	*	*
0538	77	12	134
0548	98	*	*
0558	81	6	94
0608	39	*	*
0618	76	8	74
0628	43	*	*
0638	81	8	104
0648	47	*	*
0658	84	7	45
0708	57	*	*
0718	88	8	30
0728	60	*	*
0738	86	0	40
0748	50	*	*
0758	89	0	15
0808	64	*	*

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 6th. October 1985 (851006)
STORM NUMBER : IX

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
0418	0.19	7.7	6.3
0420	0.20	7.4	8.0
0422	0.20	7.6	6.5
0424	0.22	7.4	6.5
0426	0.21	7.7	6.6
0428	0.24	7.5	6.8
0430	0.25	7.4	6.8
0432	0.23	7.6	6.8
0434	0.23	7.9	6.9
0436	0.23	8.1	7.0
0438	0.22	8.1	7.0
0440	0.23	8.0	7.1

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 6th. October 1985 (851006)
STORM NUMBER : IX

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	Cond uscm-1 (x1000)	DO mgl-1	pH pH units
0418	0.26	4.8	7.2
0438	0.26	5.2	7.1
0458	0.26	6.5	7.2
0518	0.28	7.3	7.3
0538	0.28	4.0	7.1
0558	0.22	5.2	7.0
0618	0.16	4.4	6.8
0638	0.14	5.8	6.9
0658	0.11	6.5	7.0
0718	0.07	6.0	6.8
0738	0.06	6.5	6.8
0758	0.05	6.5	6.8

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 6th. October 1985 (851006)
STORM NUMBER : IX

ANALYSIS OF INFLOW WATER TO THE GULLY POT

REAL TIME Hours	Alk mgl-1	Cl mgl-1	Zn mgl-1
0418	20	24.8	0.37
0420	20	32.0	0.34
0422	30	28.4	0.34
0424	30	35.5	0.26
0426	20	28.4	0.27
0428	30	28.4	0.24
0430	30	35.5	0.15
0432	30	32.0	0.24
0434	30	28.4	0.24
0436	30	32.0	0.24
0438	40	32.0	0.24
0440	*	*	0.15

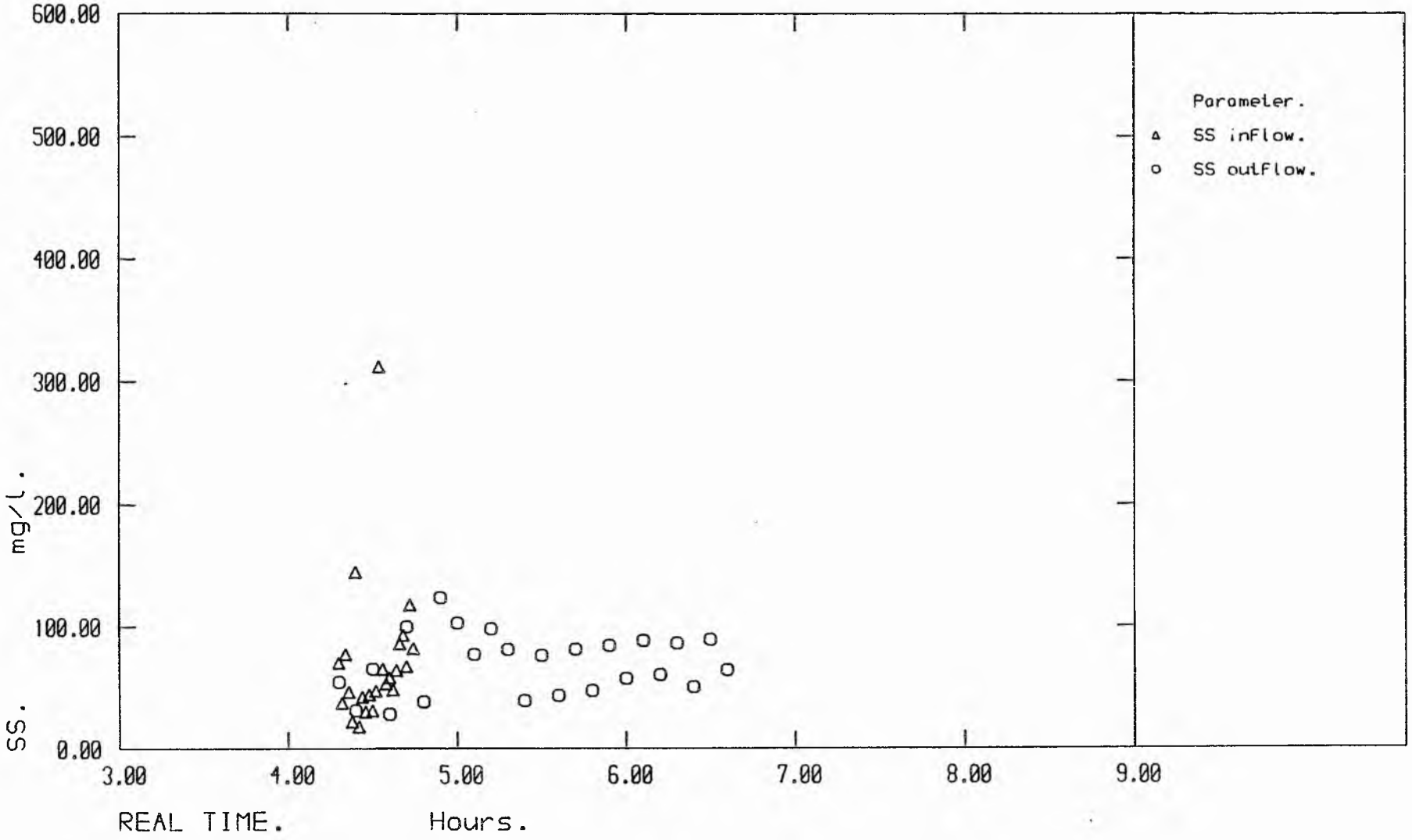
* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

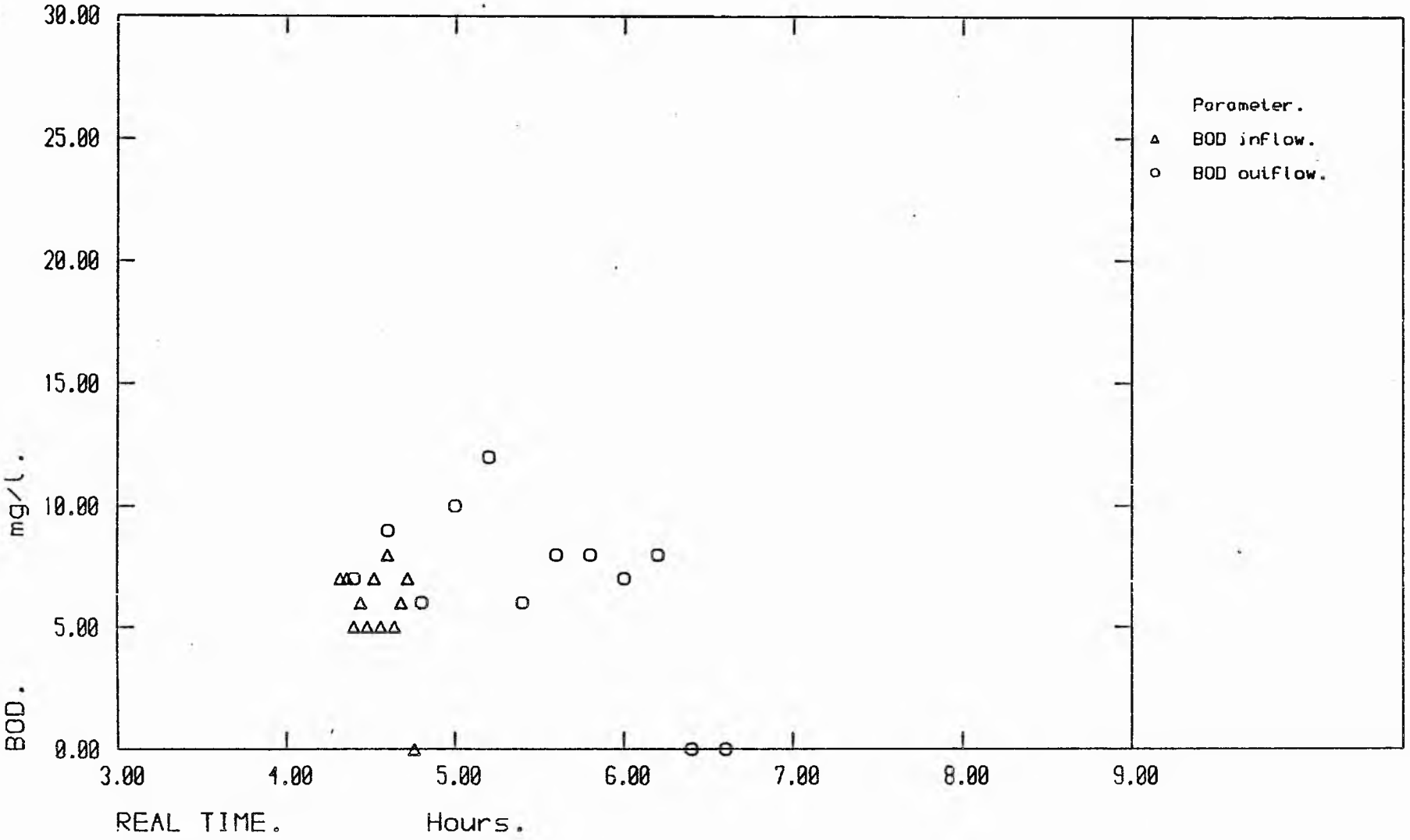
CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 6th. October 1985 (851006)
STORM NUMBER : IX

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

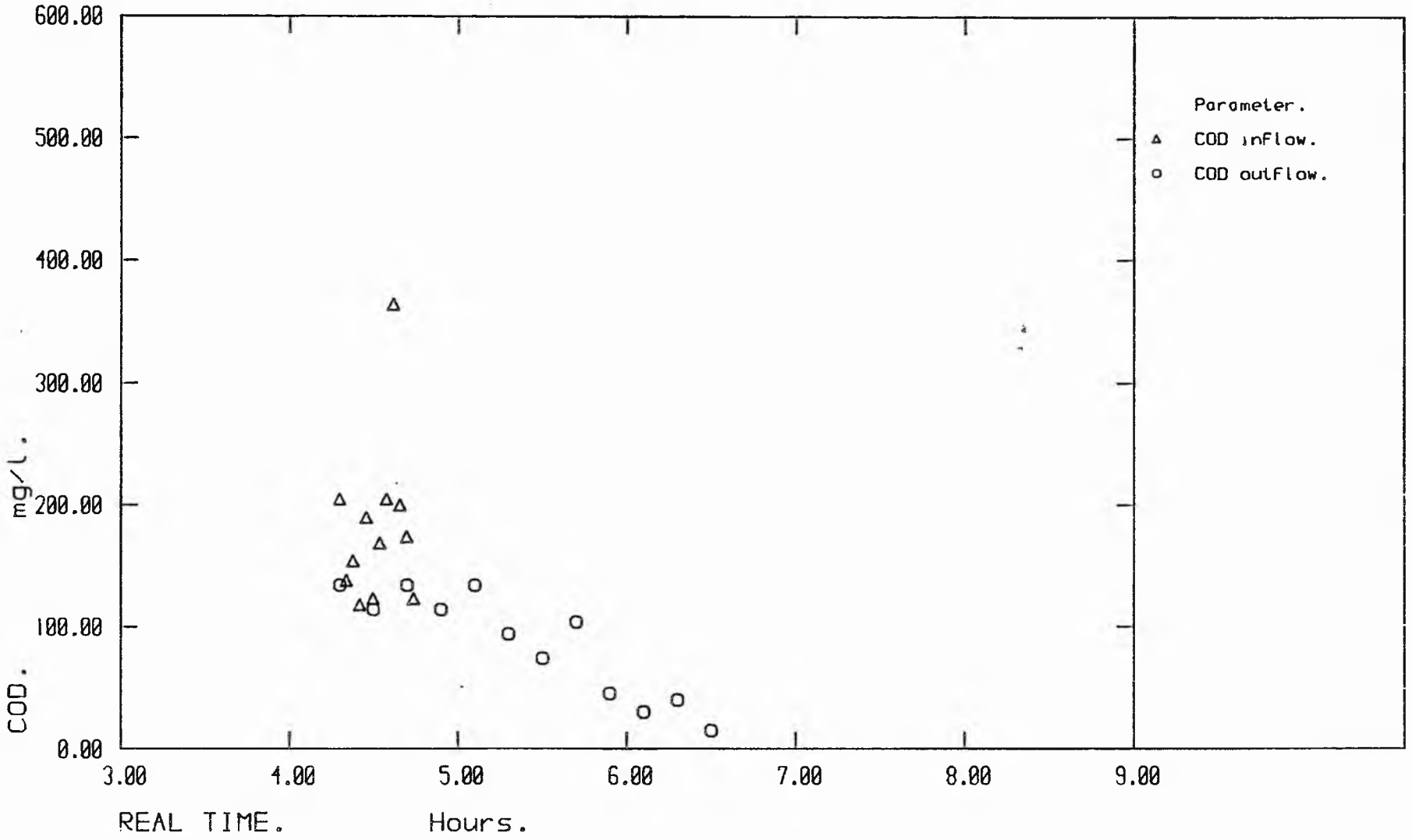
REAL TIME Hours	Alk mgl-1	Cl mgl-1	Zn mgl-1
0418	80	35.5	0.34
0438	70	35.5	0.33
0458	70	32.0	0.18
0518	50	28.4	0.30
0538	70	32.0	.0.42
0558	60	35.5	0.25
0618	50	28.4	0.42
0638	40	24.8	0.34
0658	30	24.8	0.18
0718	20	24.8	0.18
0738	20	21.3	0.34
0758	20	21.3	0.26



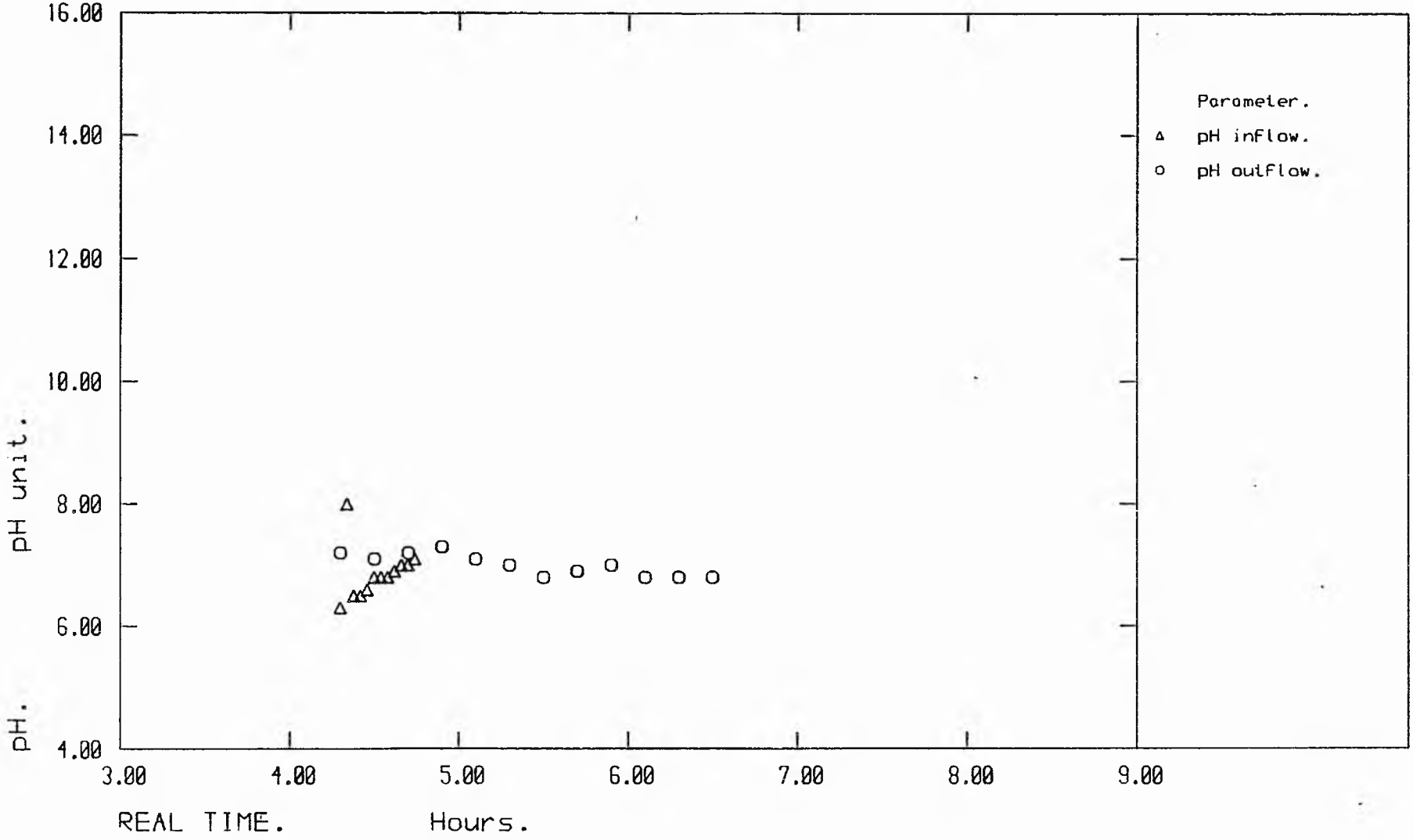
Graph of Suspended Solids for Storm IX on Twyford Gardens.
The graph shows inflow and outflow water quality data.



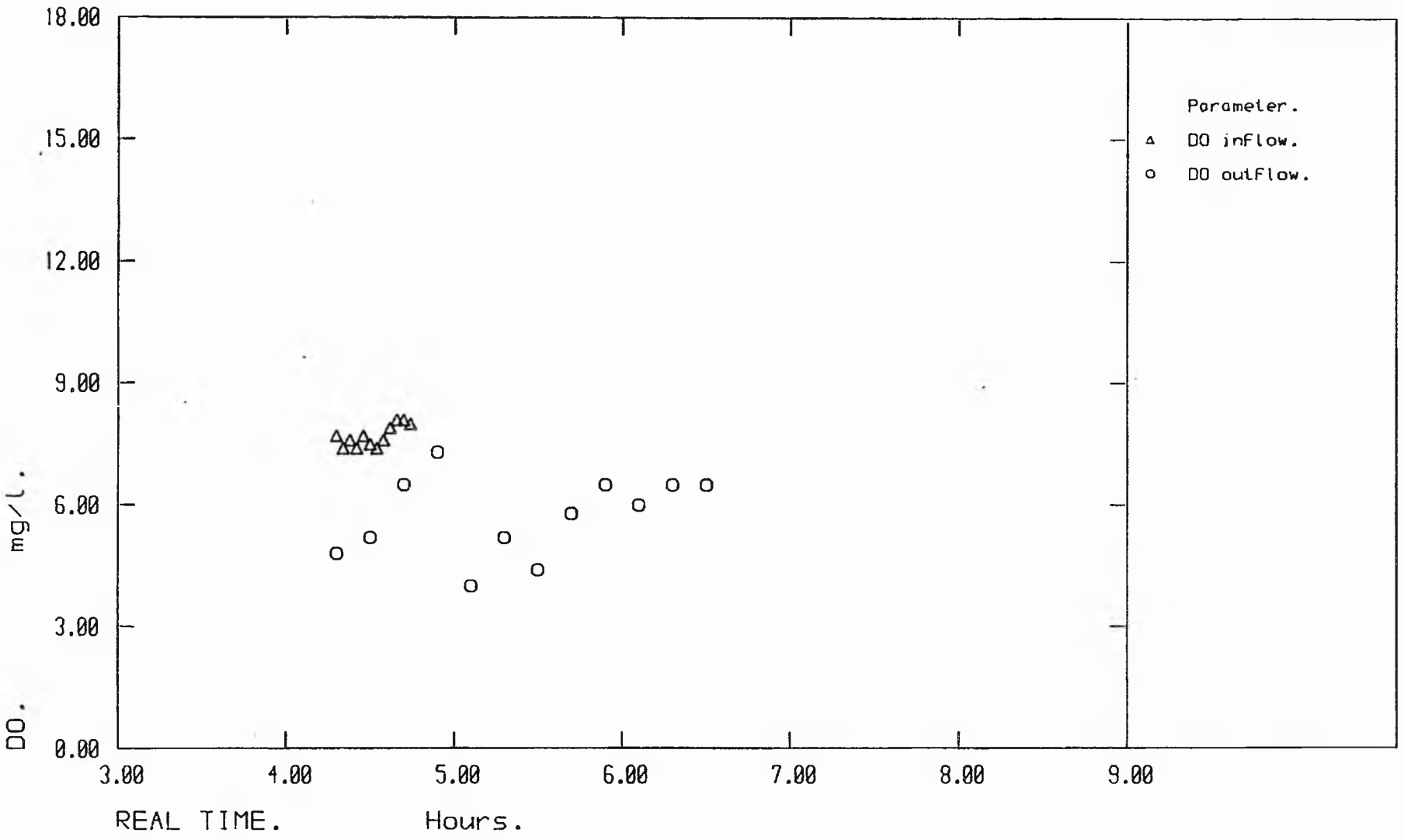
Graph of Biochemical Oxygen Demand for Storm IX on Twyford Gardens.
The graph shows inflow and outflow water quality data.



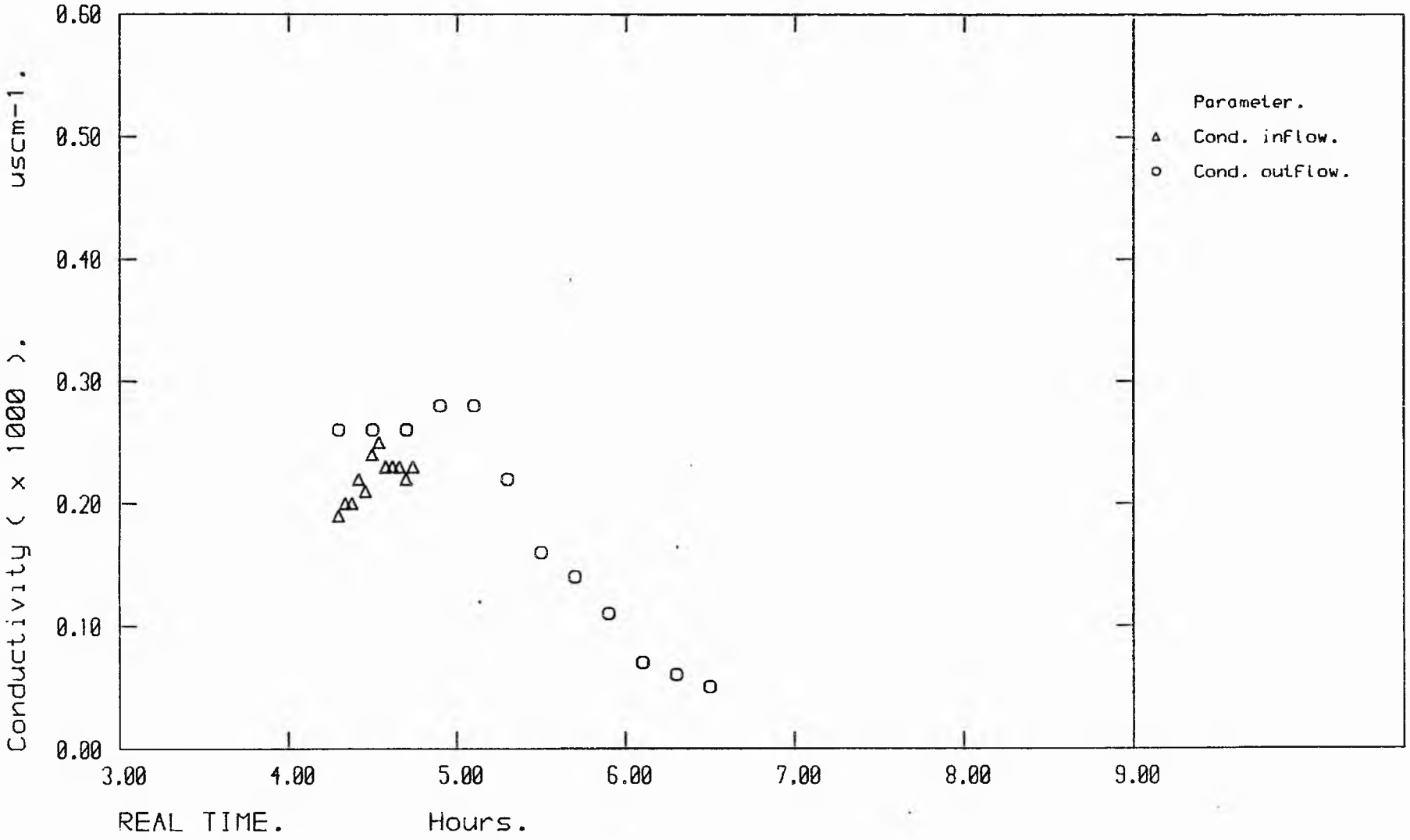
Graph of Chemical Oxygen Demand for Storm IX on Twyford Gardens.
The graph shows inflow and outflow water quality data.



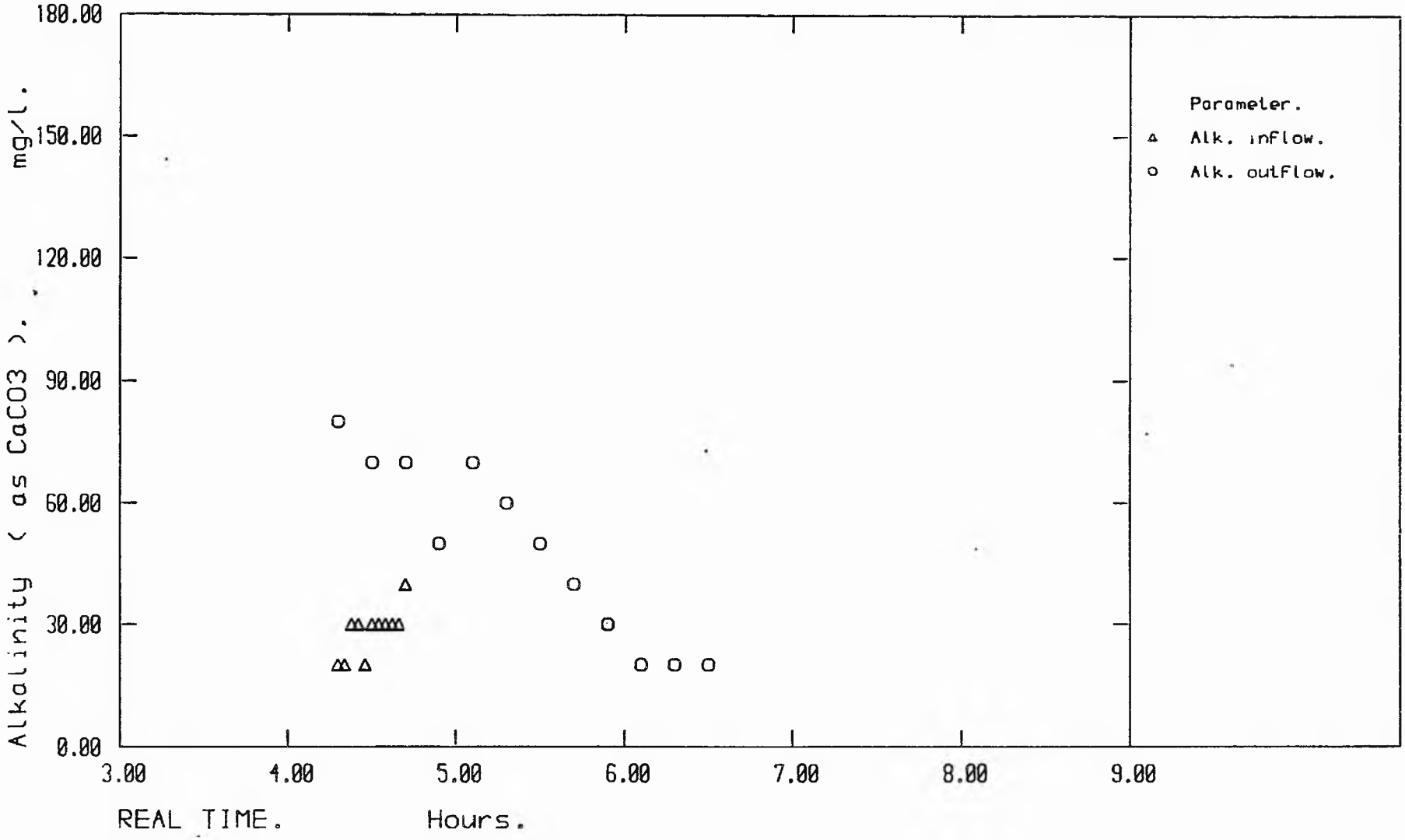
Graph of pH for Storm IX on Twyford Gardens.
The graph shows inflow and outflow water quality data.



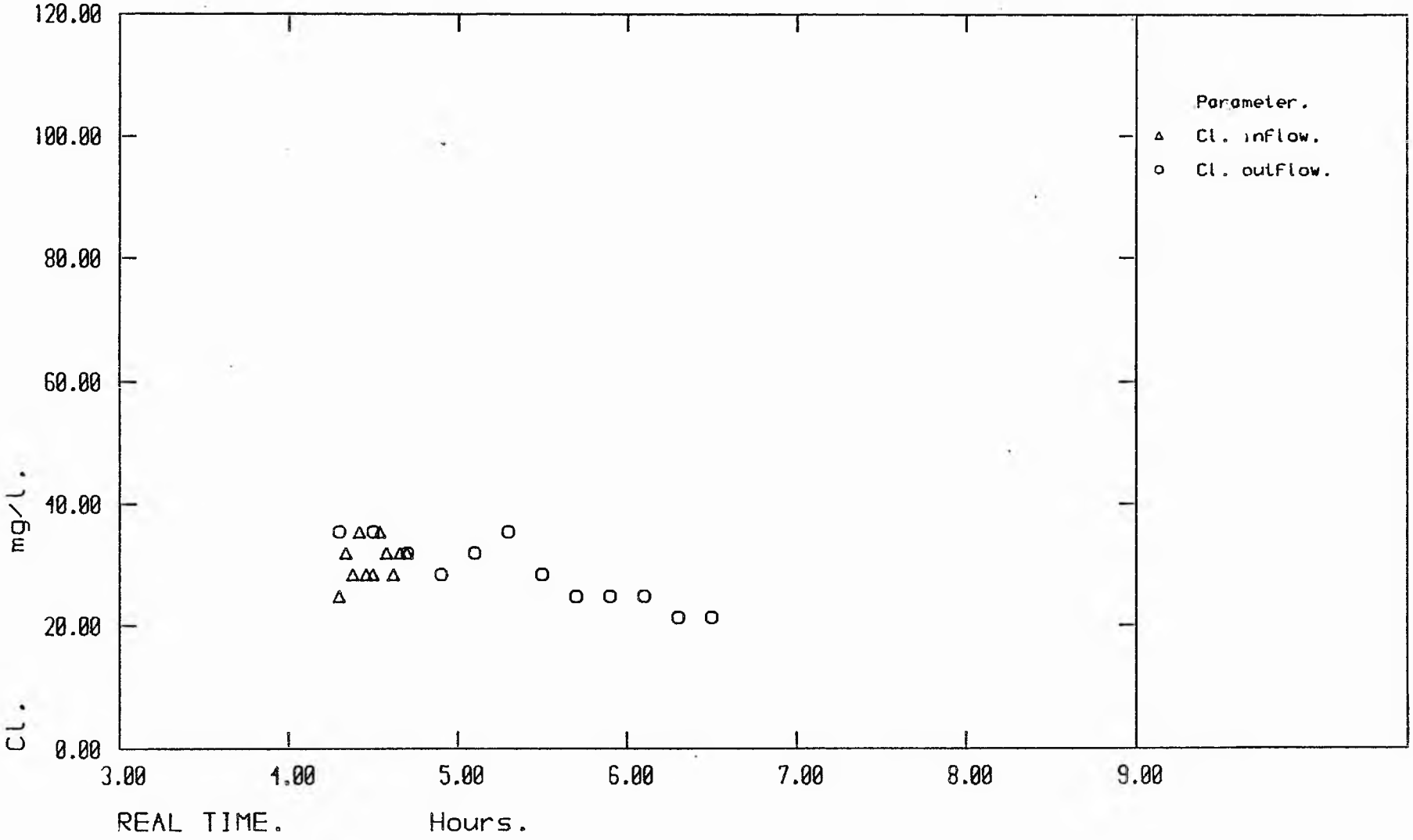
Graph of Dissolved Oxygen for Storm IX on Twyford Gardens.
The graph shows inflow and outflow water quality data.



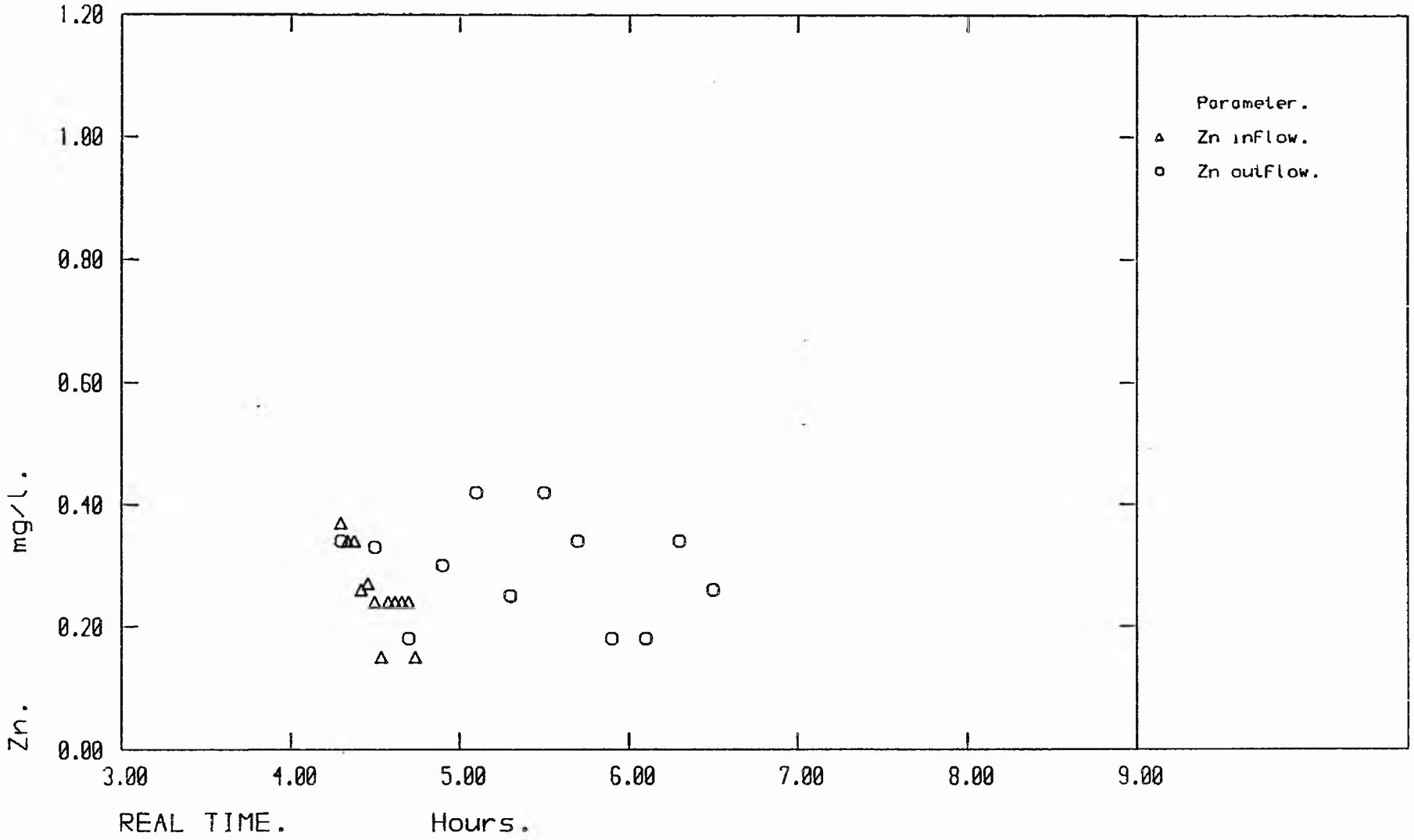
Graph of Conductivity for Storm IX on TwyFord Gardens.
The graph shows inflow and outflow water quality data.



Graph of Total Alkalinity for Storm IX on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Chloride for Storm IX on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm IX on Twyford Gardens.
The graph shows inflow and outflow water quality data.

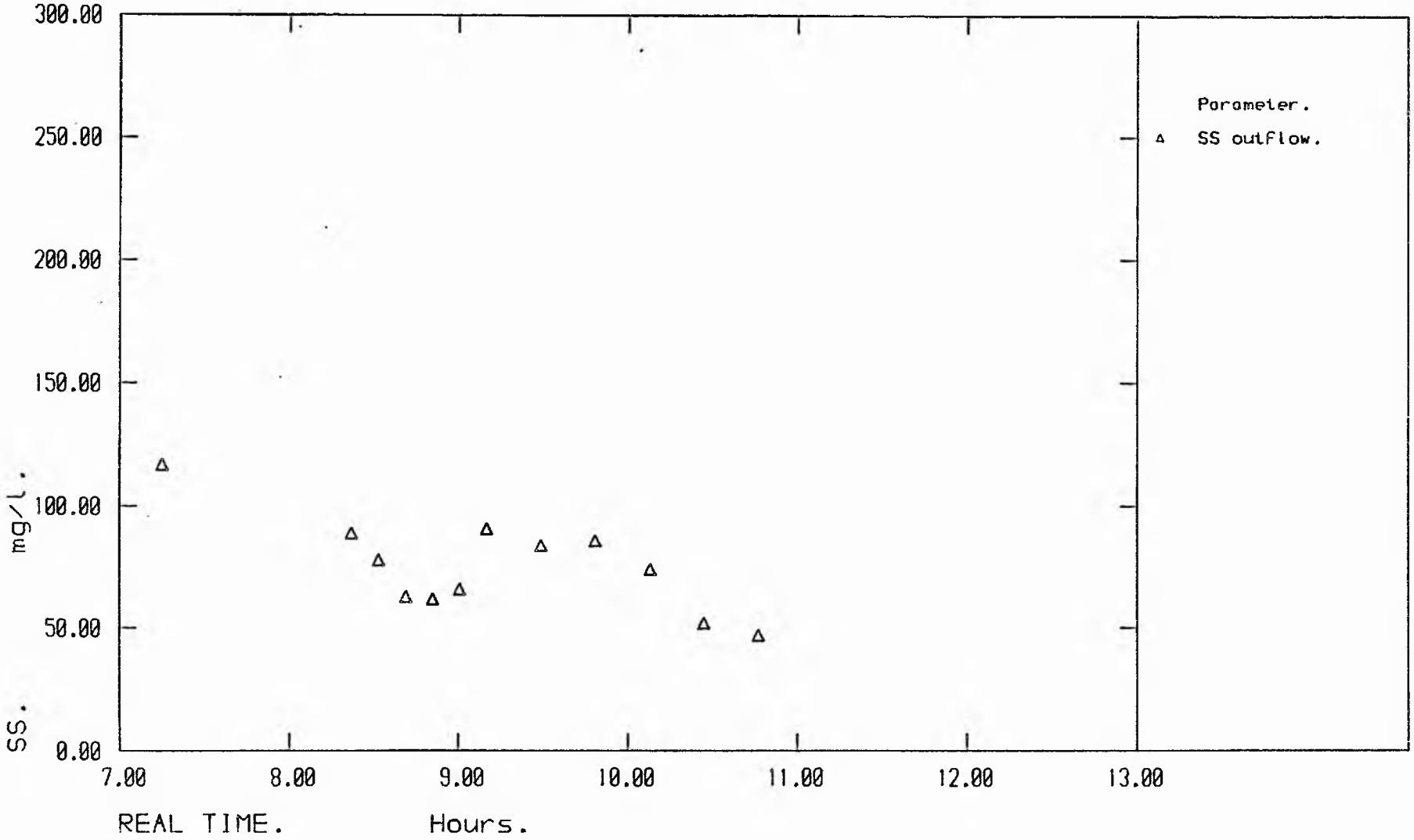
RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 6th. November 1985 (851106)
STORM NUMBER : X

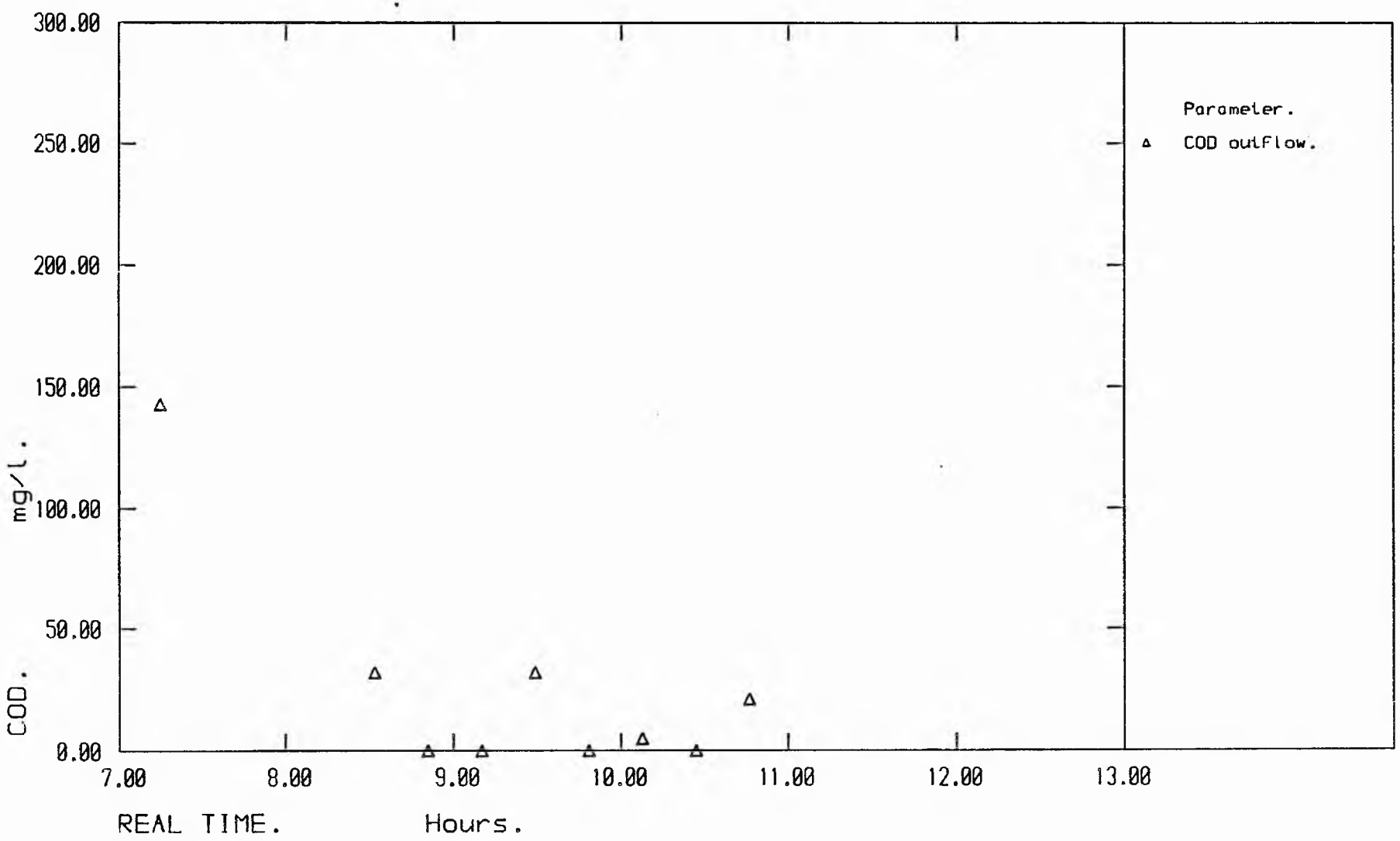
ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	COD mgl-1	TOC mgl-1	Zn mgl-1
0715	117	143	48	0.54
0825	89	*	59	0.41
0835	78	32	48	0.44
0845	63	*	48	0.35
0855	62	0	52	0.39
0905	66	*	51	0.39
0915	91	0	54	0.54
0925	*	*	52	*
0935	84	32	53	0.39
0945	*	*	53	*
0955	86	0	53	0.30
1005	*	*	50	*
1015	74	5	46	0.35
1025	*	*	46	*
1035	52	0	46	0.36
1045	*	*	46	*
1055	47	21	48	0.37

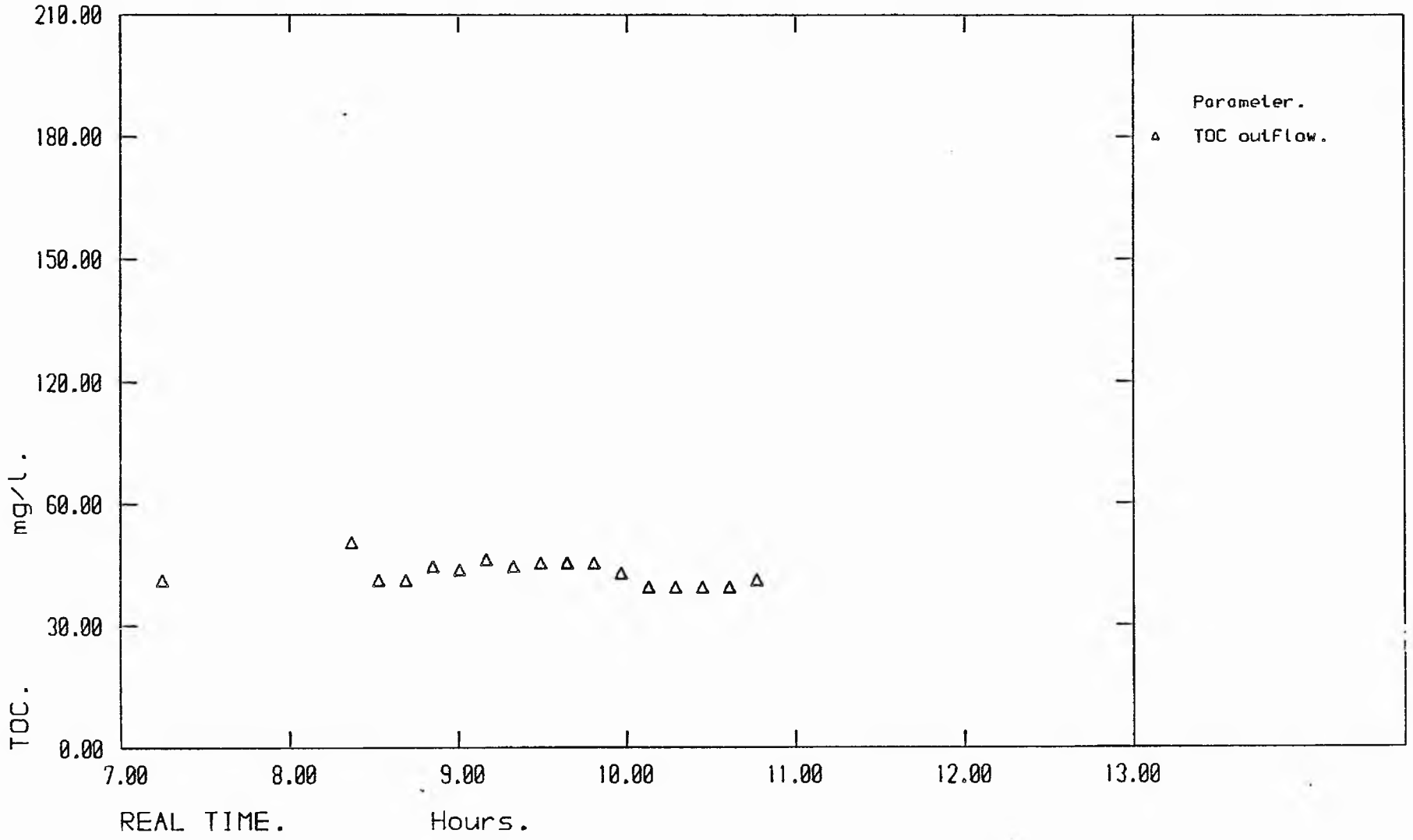
* = No Analysis



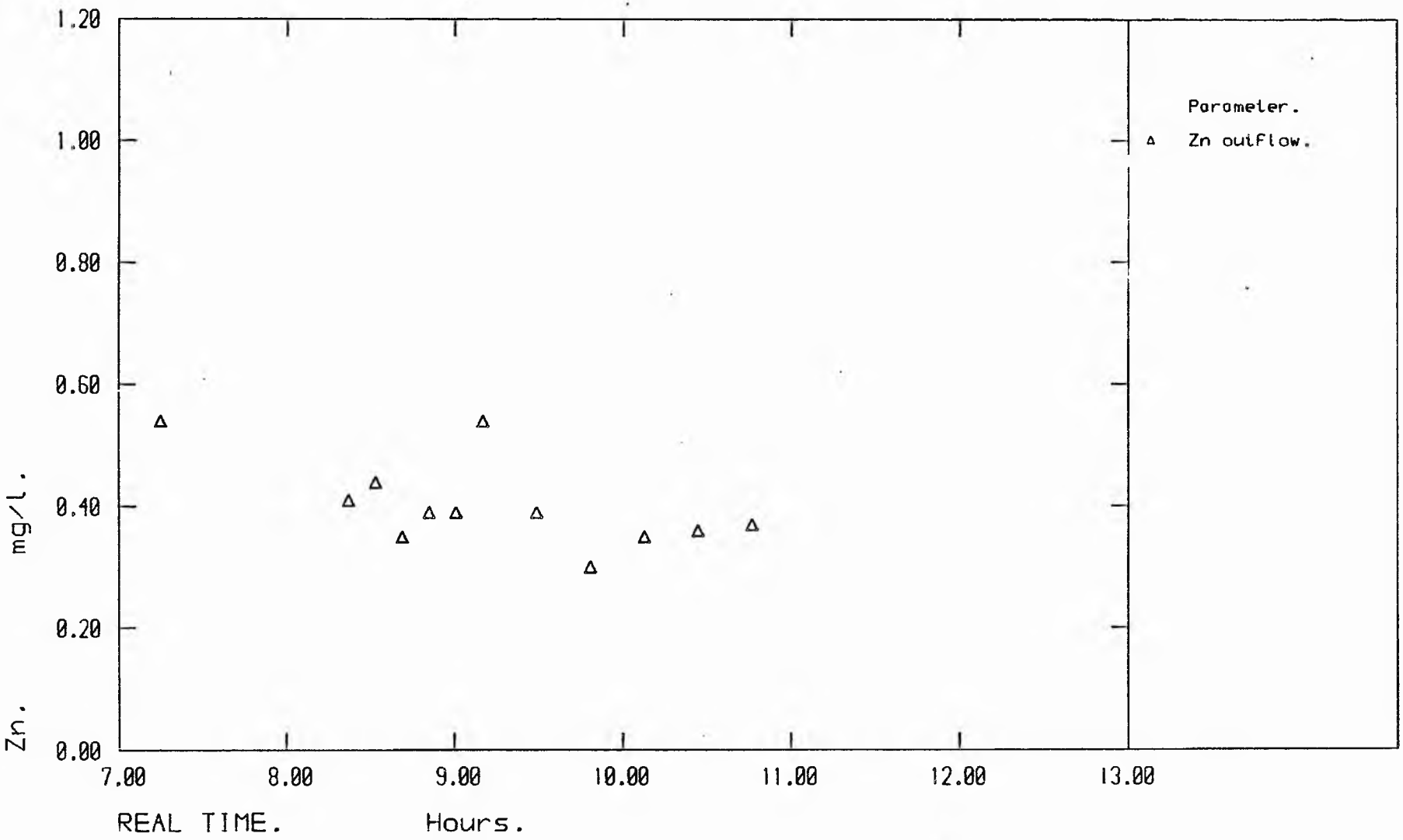
Graph of Suspended Solids for Storm X on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Chemical Oxygen Demand for Storm X on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of TOC for Storm X on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm X on Tame Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 6th. November 1985 (851106)
STORM NUMBER : X

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

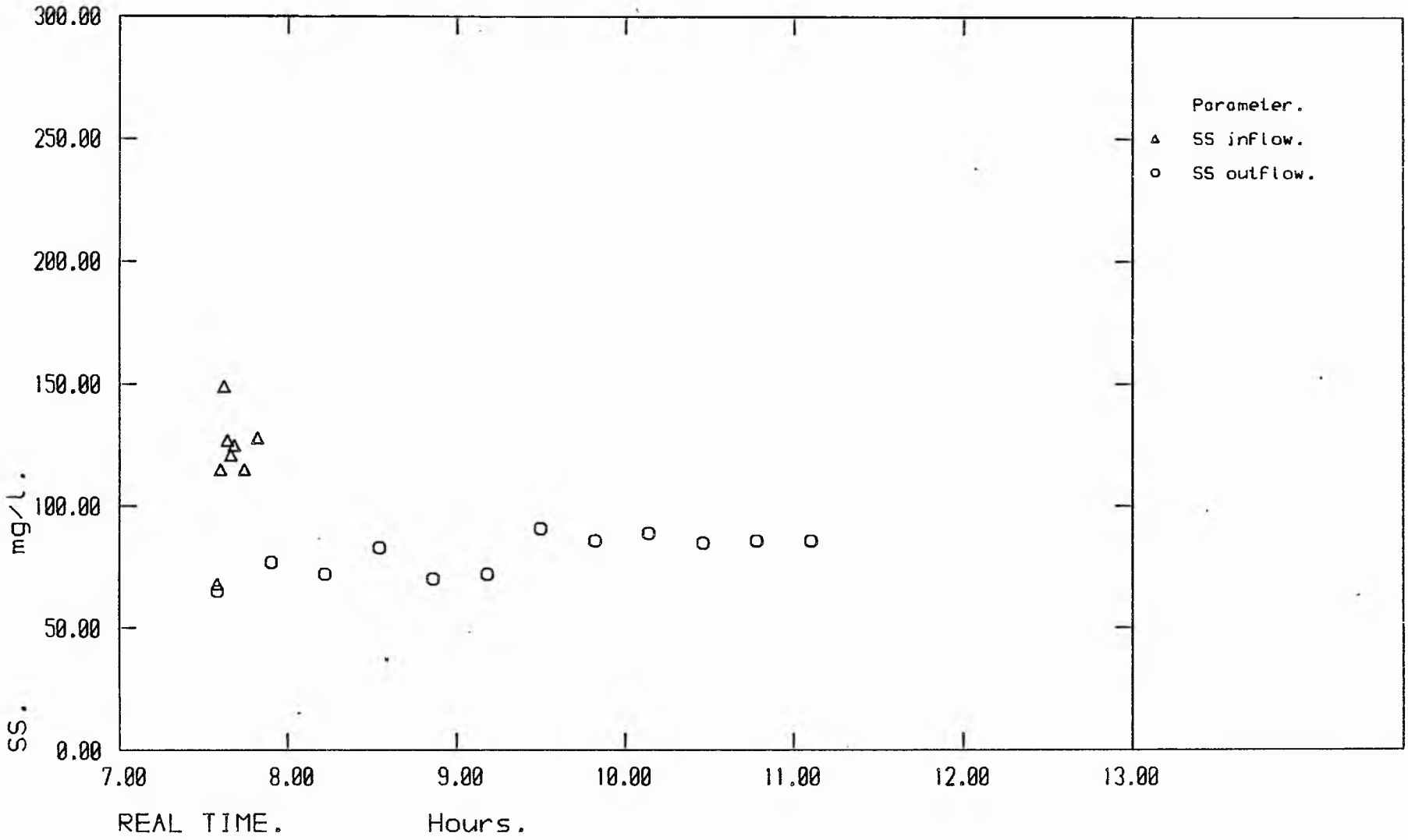
REAL TIME Hours	SS mgl-1	COD mgl-1	TOC mgl-1	Zn mgl-1
0735	68	138	55	0.58
0736	115	201	55	0.67
0737	149	53	56	0.46
0738	127	95	54	0.48
0739	121	95	46	0.28
0740	125	148	55	0.35
0743	115	53	50	0.26
0747	128	69	52	0.33

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

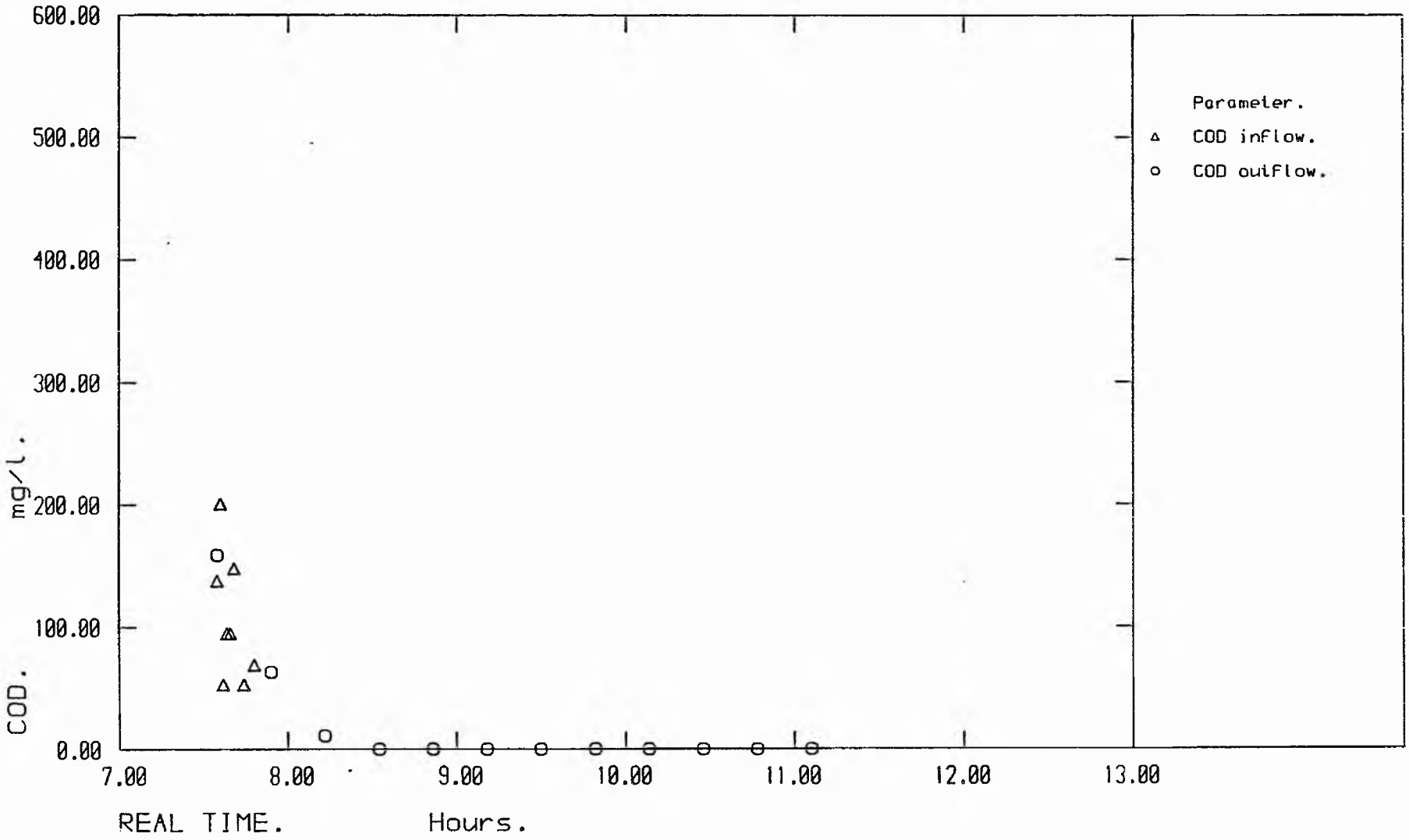
CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 6th. November 1985 (851106)
STORM NUMBER : X

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

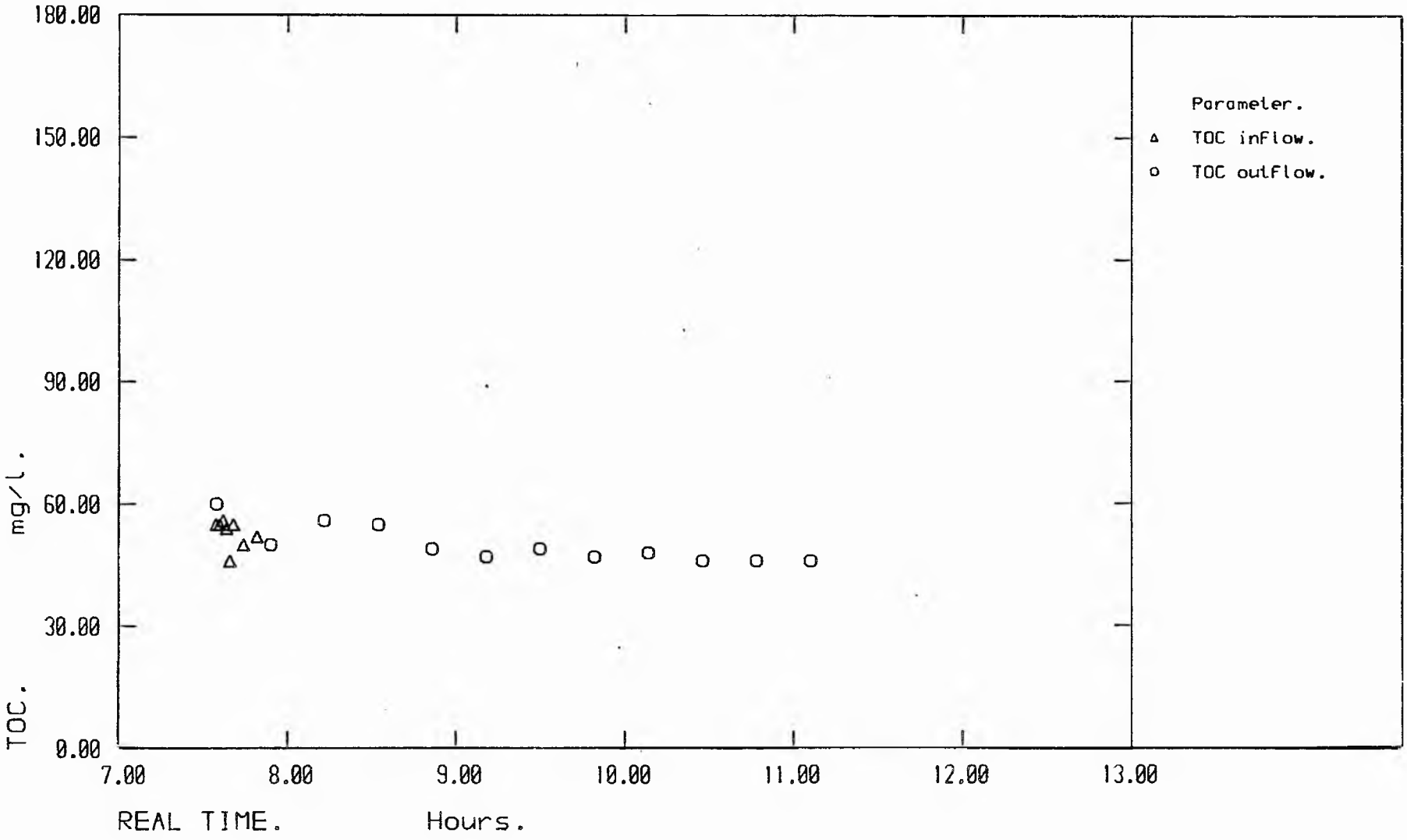
REAL TIME Hours	SS mg l-1	COD mg l-1	TOC mg l-1	Zn mg l-1
0735	65	159	60	0.22
0755	77	63	50	0.20
0815	72	11	56	0.20
0835	83	0	55	0.17
0855	70	0	49	0.26
0915	72	0	47	0.17
0935	91	0	49	0.28
0955	86	0	47	0.24
1015	89	0	48	0.22
1035	85	0	46	0.26
1055	86	0	46	0.28
1115	86	0	46	0.28



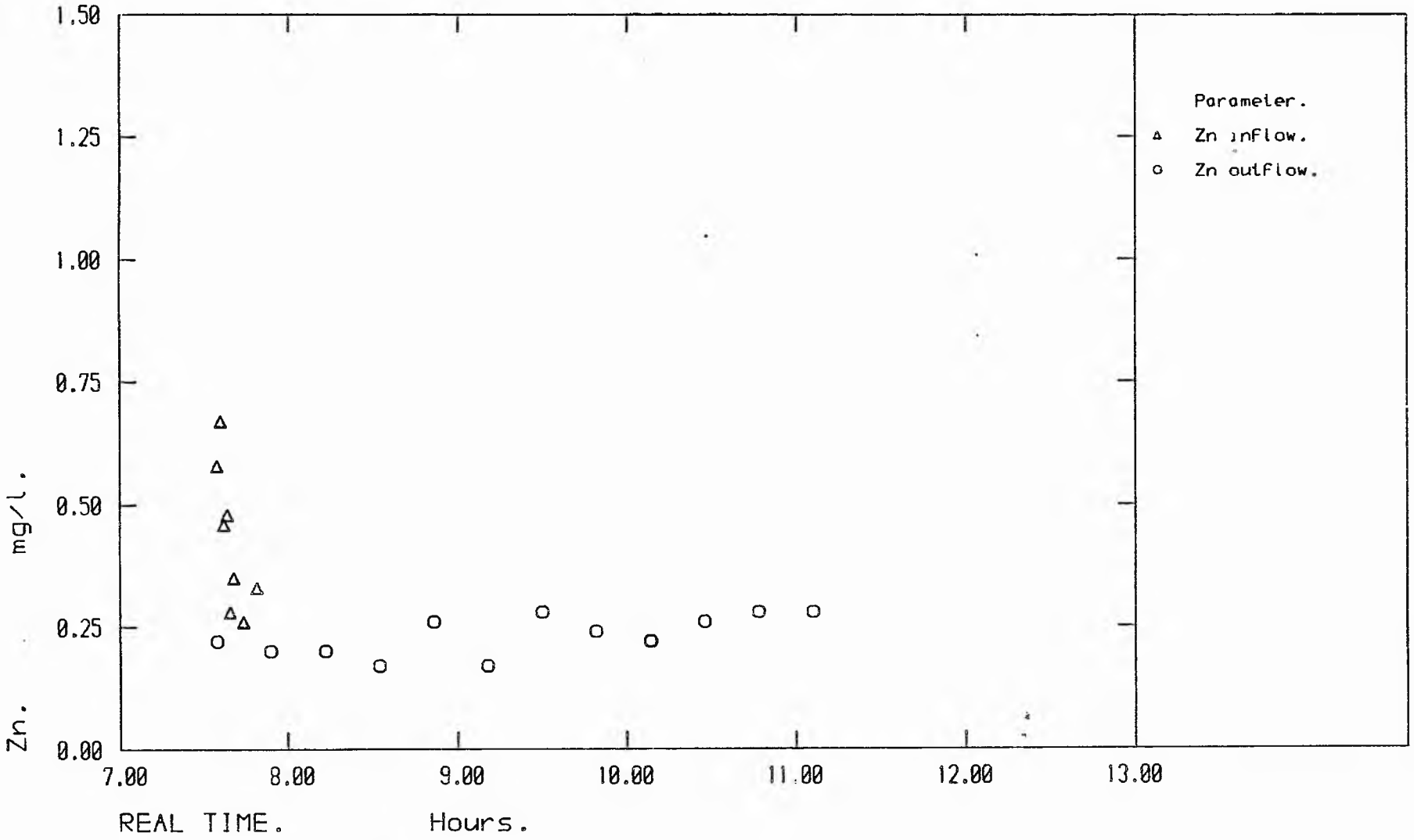
Graph of Suspended Solids for Storm X on Churnet Close.
The graph shows inflow and outflow water quality data.



Graph of Chemical Oxygen Demand For Storm X on Churnet Close.
The graph shows inflow and outflow water quality data.



Graph of TOC For Storm X on Churnet Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm X on Churnet Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 7th. November 1985 (851107)
STORM NUMBER : XI

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	COD mgl-1	TOC mgl-1
1225	158	253	34
1226	80	155	32
1227	0	77	13
1228	64	144	25
1229	61	108	22
1230	100	160	12
1231	142	124	16
1232	181	170	15
1233	132	155	13
1234	186	170	15
1235	205	170	12
1236	124	180	12
1237	180	255	11
1238	261	260	11
1239	156	245	12
1240	330	221	8
1241	292	289	7
1242	130	206	7
1243	357	216	6
1244	220	152	7
1245	99	132	7
1246	158	118	6
1247	188	108	10
1248	99	152	10

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close

DATE OF THE STORM EVENT : 7th. November 1985 (851107)

STORM NUMBER : XI

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

REAL TIME Hours	Cu mgl-1	Pb mgl-1	Zn mgl-1
1225	0.02	0.00	0.38
1226	0.00	0.00	0.33
1227	0.00	0.00	0.22
1228	0.00	0.00	0.40
1229	0.00	0.00	0.37
1230	0.00	0.07	0.35
1231	0.00	0.00	0.35
1232	0.00	0.00	0.24
1233	0.00	0.00	0.26
1234	0.00	0.00	0.35
1235	0.00	0.00	0.33
1236	0.00	0.00	0.24
1237	0.00	0.00	0.24
1238	0.00	0.00	0.22
1239	0.00	0.07	0.21
1240	0.00	0.00	0.19
1241	0.00	0.00	0.19
1242	0.00	0.00	0.21
1243	0.00	0.00	0.19
1244	0.00	0.00	0.24
1245	0.00	0.00	0.21
1246	0.00	0.00	0.21
1247	0.00	0.00	0.15
1248	0.00	0.00	0.11

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 7th. November 1985 (851107)
STORM NUMBER : XI

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

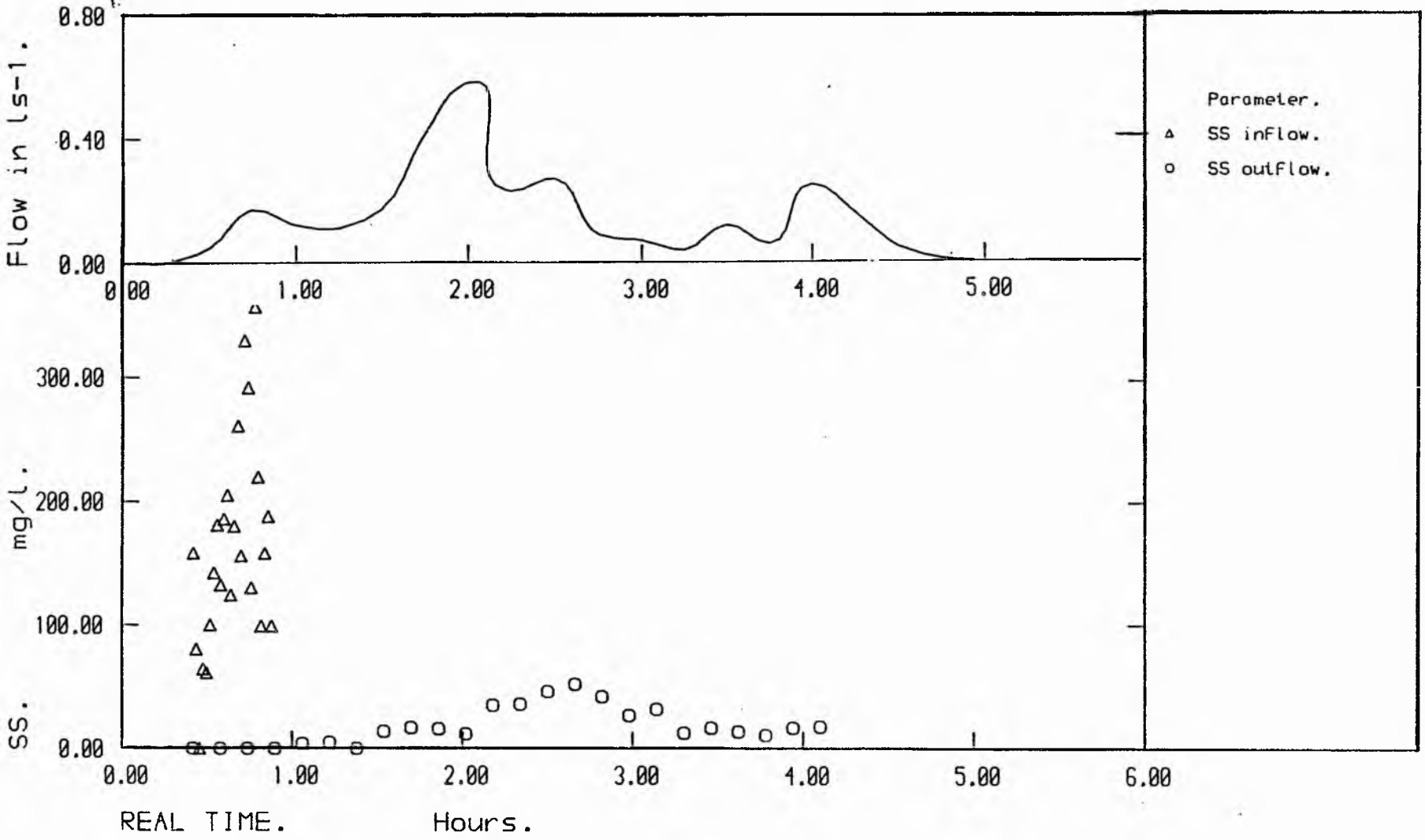
REAL TIME Hours	SS mgl-1	COD mgl-1	TOC mgl-1
1225	0	85	33
1235	0	95	35
1245	0	95	36
1255	0	45	36
1305	4	55	37
1315	5	50	33
1325	0	55	36
1335	14	45	33
1345	17	45	32
1355	16	25	38
1405	12	50	35
1415	35	10	36
1425	36	20	34
1435	46	54	34
1445	52	69	32
1455	42	54	35
1505	27	64	34
1515	32	54	34
1525	13	64	34
1535	17	64	33
1545	14	59	33
1555	11	49	32
1605	17	54	34
1615	18	54	34

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

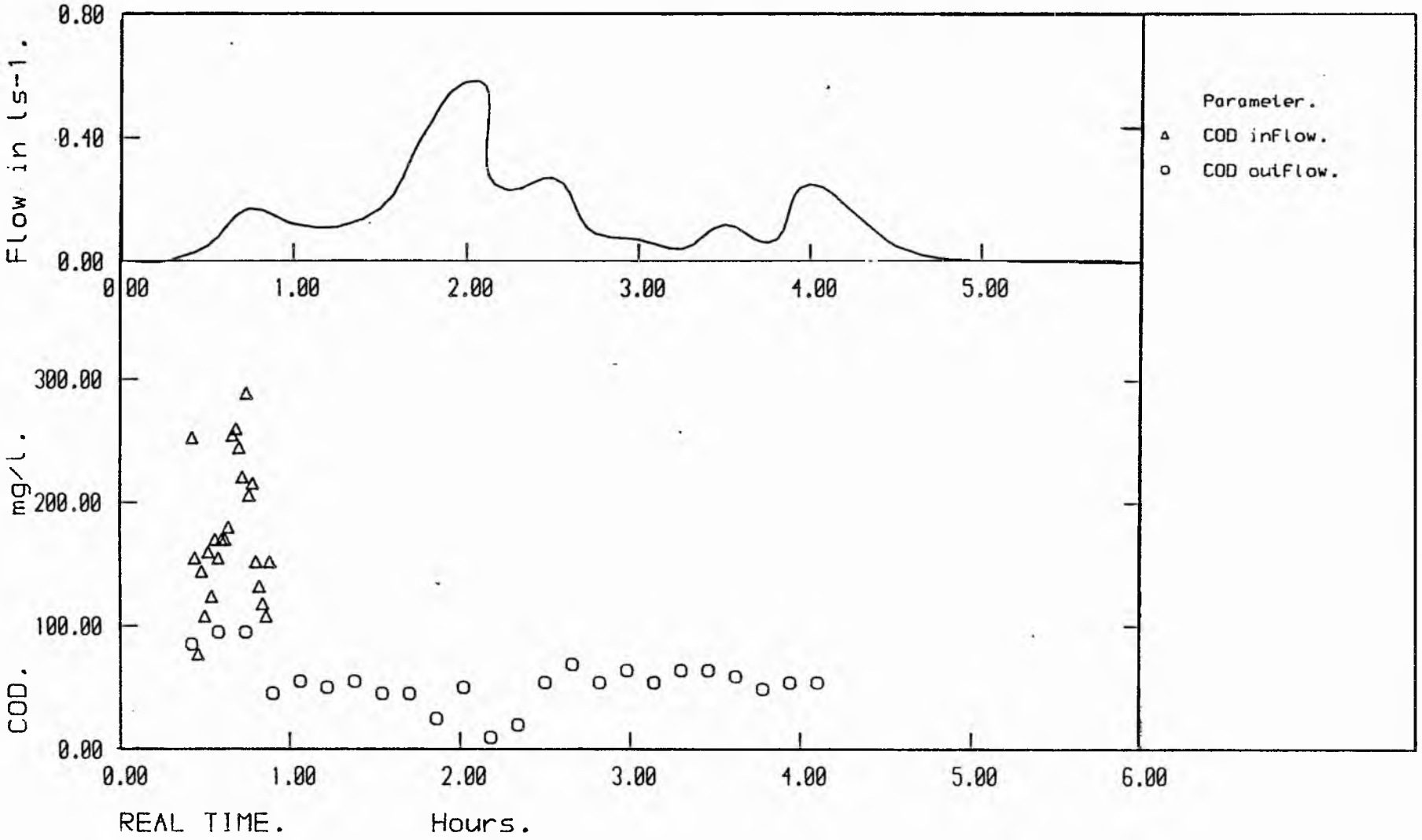
CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 7th. November 1985 (851107)
STORM NUMBER : XJ

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

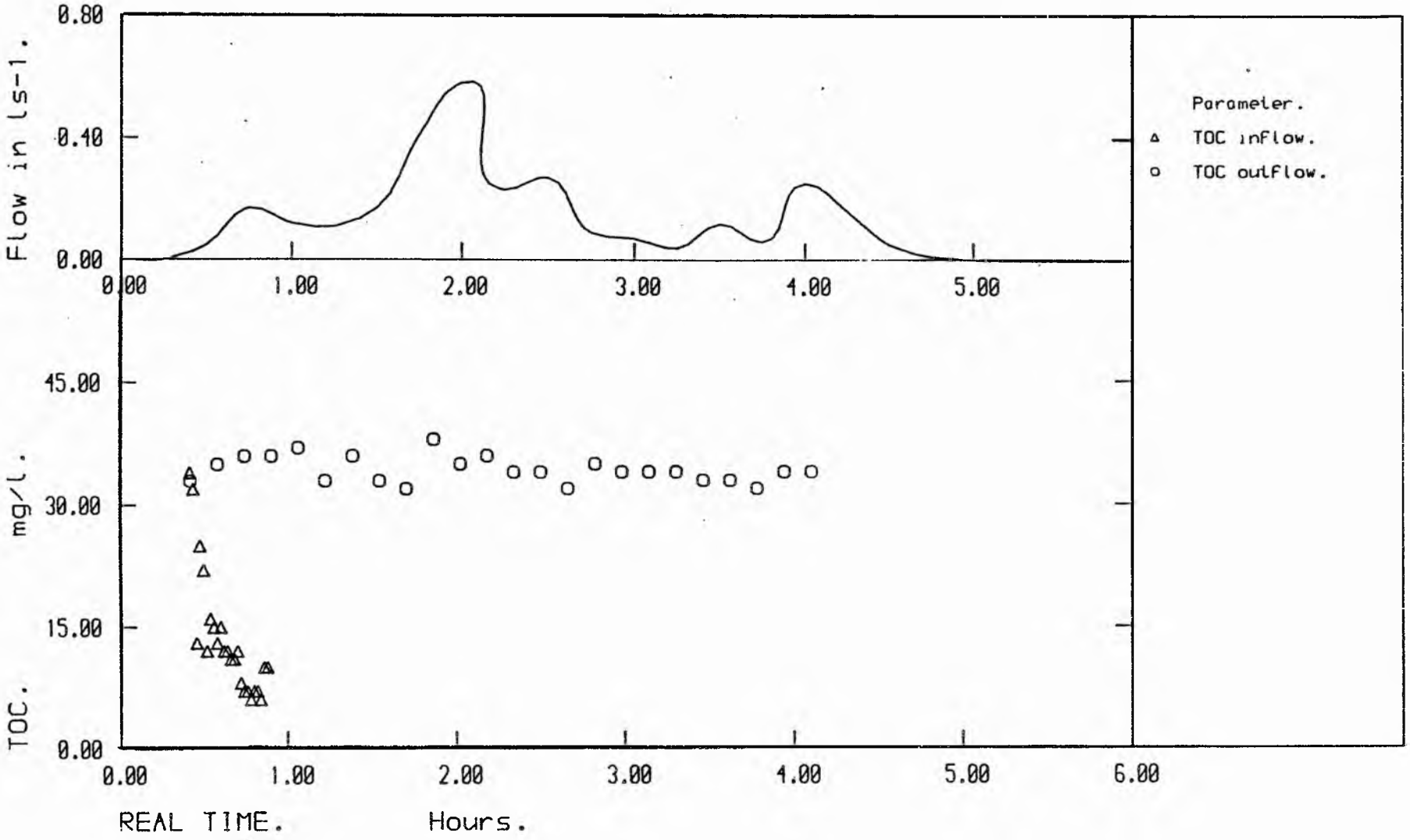
REAL TIME Hours	Pb mgl-1	Zn mgl-1
1225	0.05	0.35
1235	0.00	0.42
1245	0.05	0.37
1255	0.00	0.37
1305	0.00	0.35
1315	0.15	0.42
1325	0.00	0.26
1335	0.05	0.24
1345	0.00	0.33
1355	0.05	0.21
1405	0.00	0.23
1415	0.00	0.26
1425	0.15	0.36
1435	0.00	0.33
1445	0.00	0.26
1455	0.00	0.24
1505	0.00	0.18
1515	0.05	0.22
1525	0.05	0.23
1535	0.00	0.26
1545	0.00	0.23
1555	0.15	0.23
1605	0.22	0.26
1615	0.00	0.26



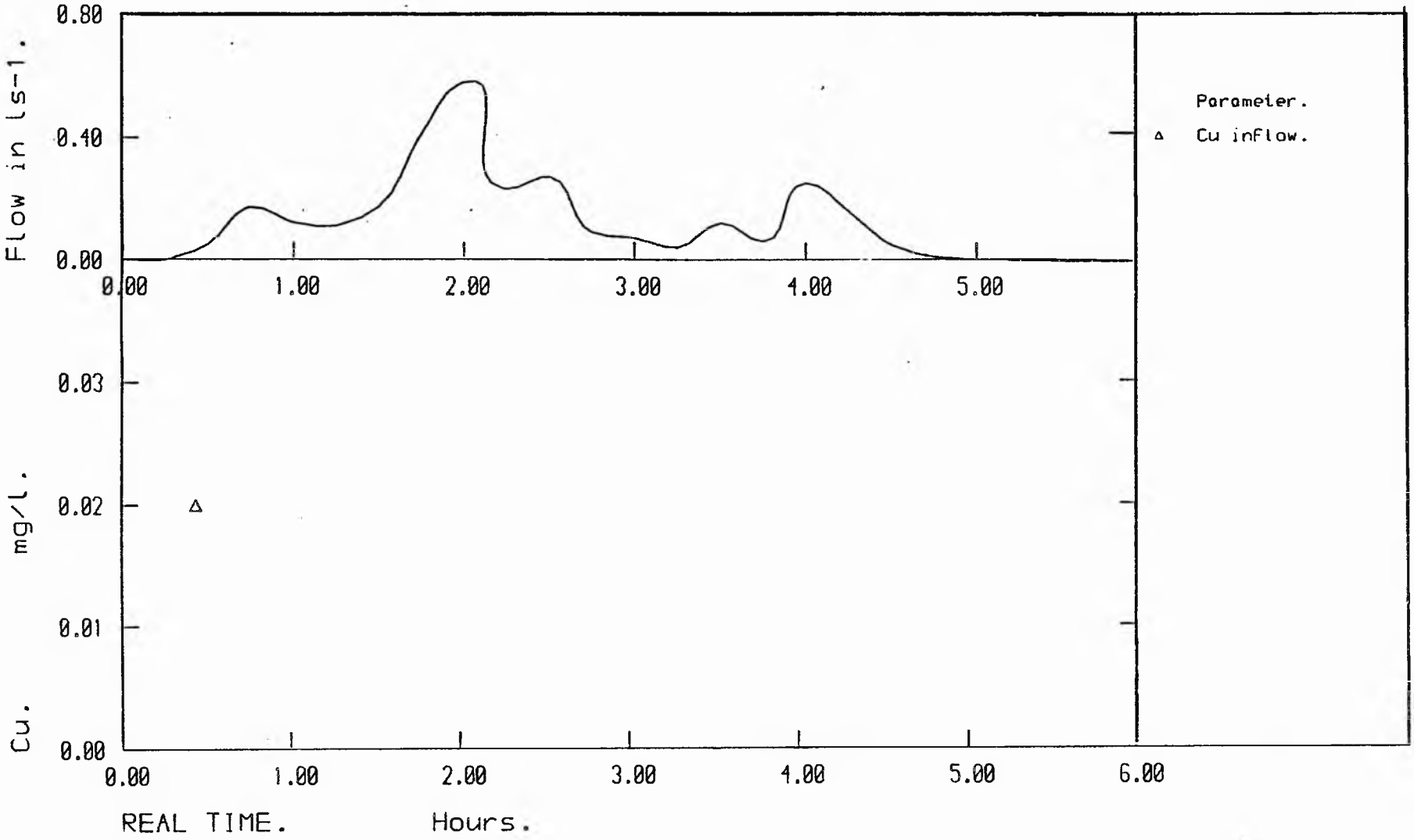
Graph of Suspended Solids for Storm XI on Tame Close.
The graph shows inflow and outflow water quality data.



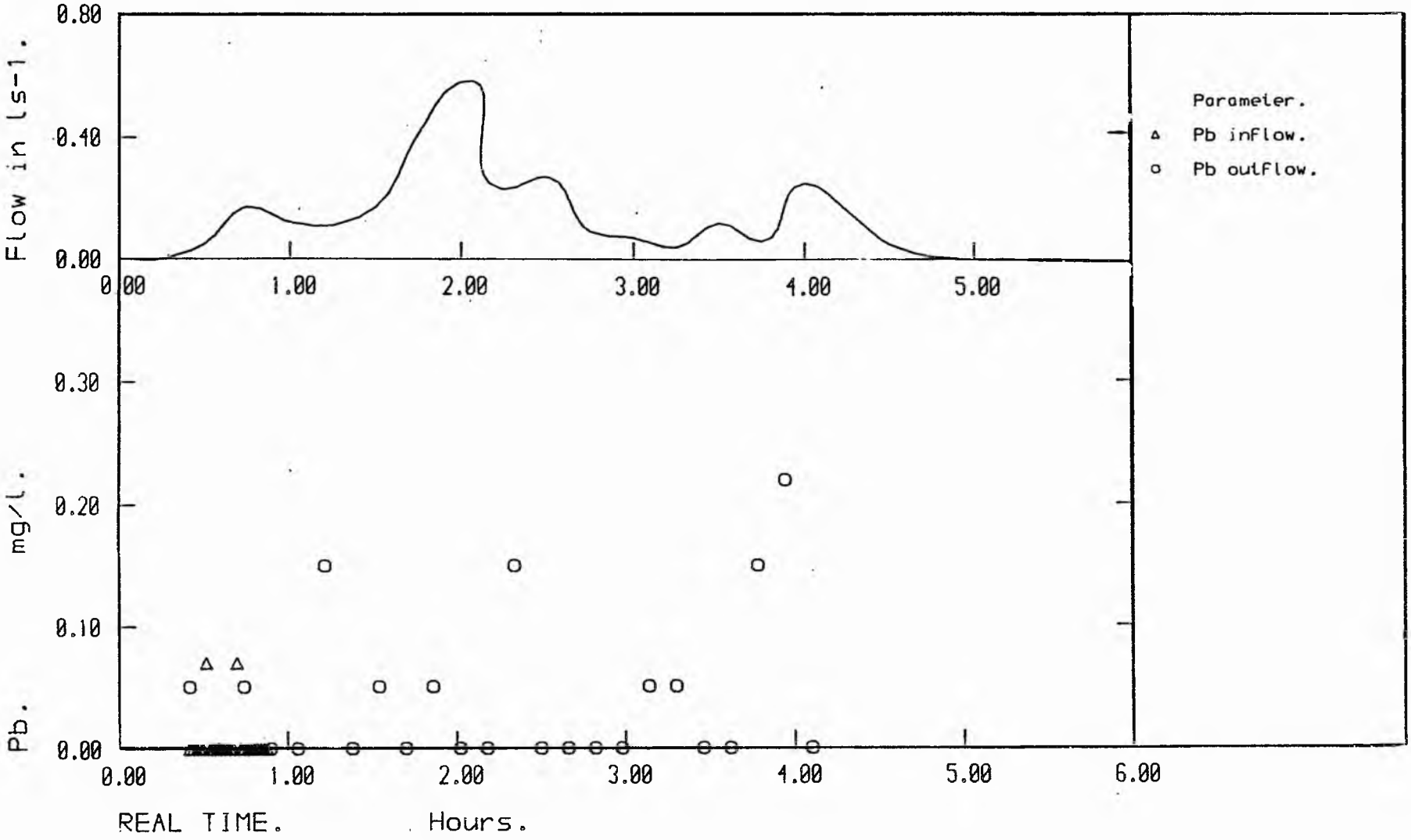
Graph of Chemical Oxygen Demand for Storm XI on Tame Close.
The graph shows inflow and outflow water quality data.



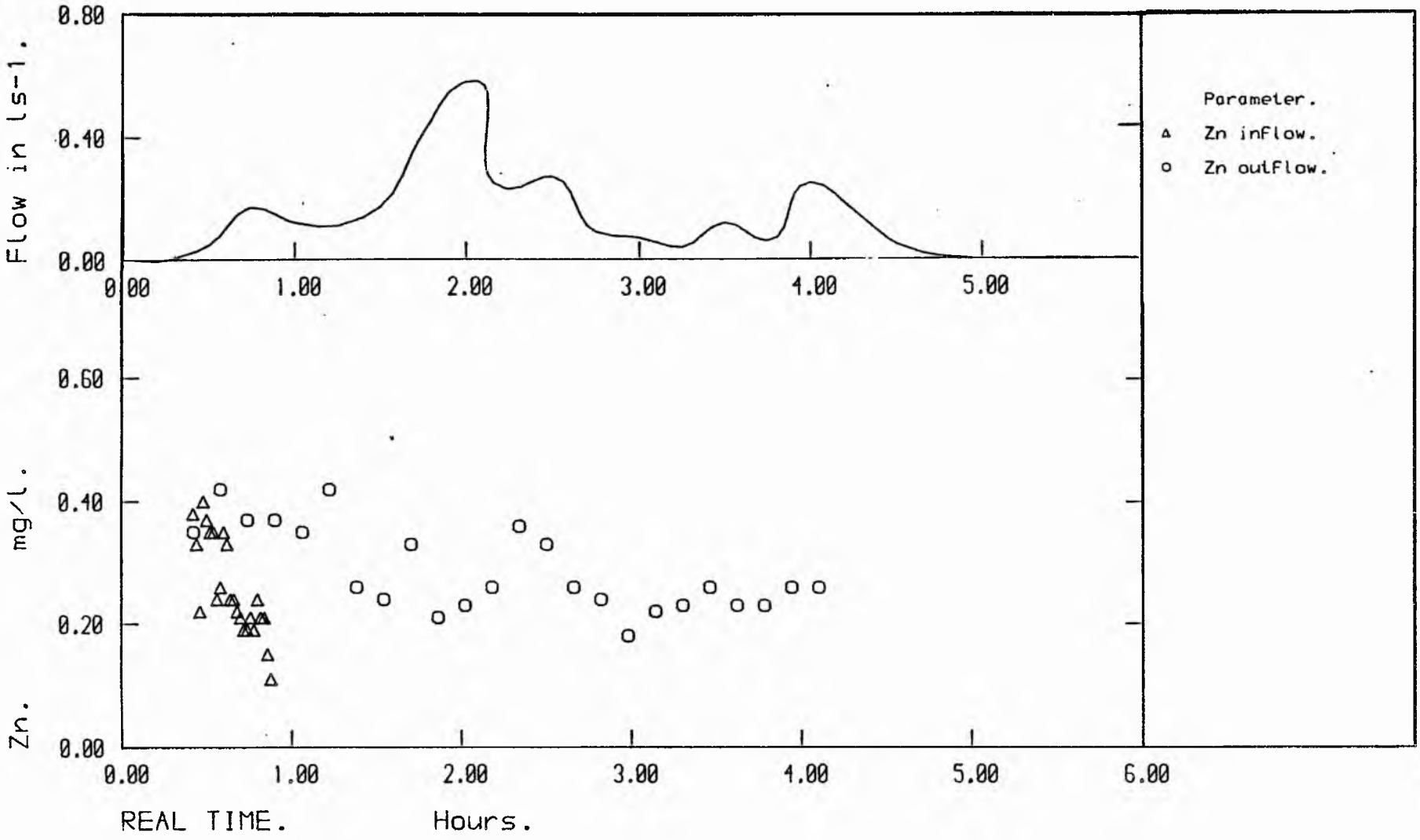
Graph of TOC for Storm XI on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Copper for Storm XI on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Lead For Storm XI on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc For Storm XI on Tame Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 7th. November 1985 (851107)
STORM NUMBER : XI

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	COD mgl-1	TOC mgl-1
1245	132	160	15
1246	83	108	13
1247	65	88	13
1248	15	77	13
1249	37	36	*
1250	35	72	13
1251	*	*	*
1252	*	*	*
1253	74	62	14
1254	*	*	*
1255	*	*	*
1256	86	144	19
1257	*	*	*
1258	*	*	13
1259	46	26	*
1300	*	*	13
1301	*	*	*
1302	40	98	16
1303	*	*	*
1304	*	*	*
1305	38	62	10
1306	*	*	*
1307	*	*	*
1308	38	15	10

* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 7th. November 1985 (851107)
STORM NUMBER : XI

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

REAL TIME Hours	Pb mg1-1	Zn mg1-1
1245	0.00	0.32
1246	0.05	0.29
1247	0.05	0.26
1248	0.00	0.25
1249	0.05	0.23
1250	0.05	0.34
1253	0.00	0.27
1256	0.05	0.34
1259	0.00	0.26
1302	0.00	0.25
1305	0.05	0.26
1308	0.05	0.21

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 7th. November 1985 (851107)
STORM NUMBER : XI

ANALYSIS OF OUTFLOW STORMWATER TO THE GULLY POT

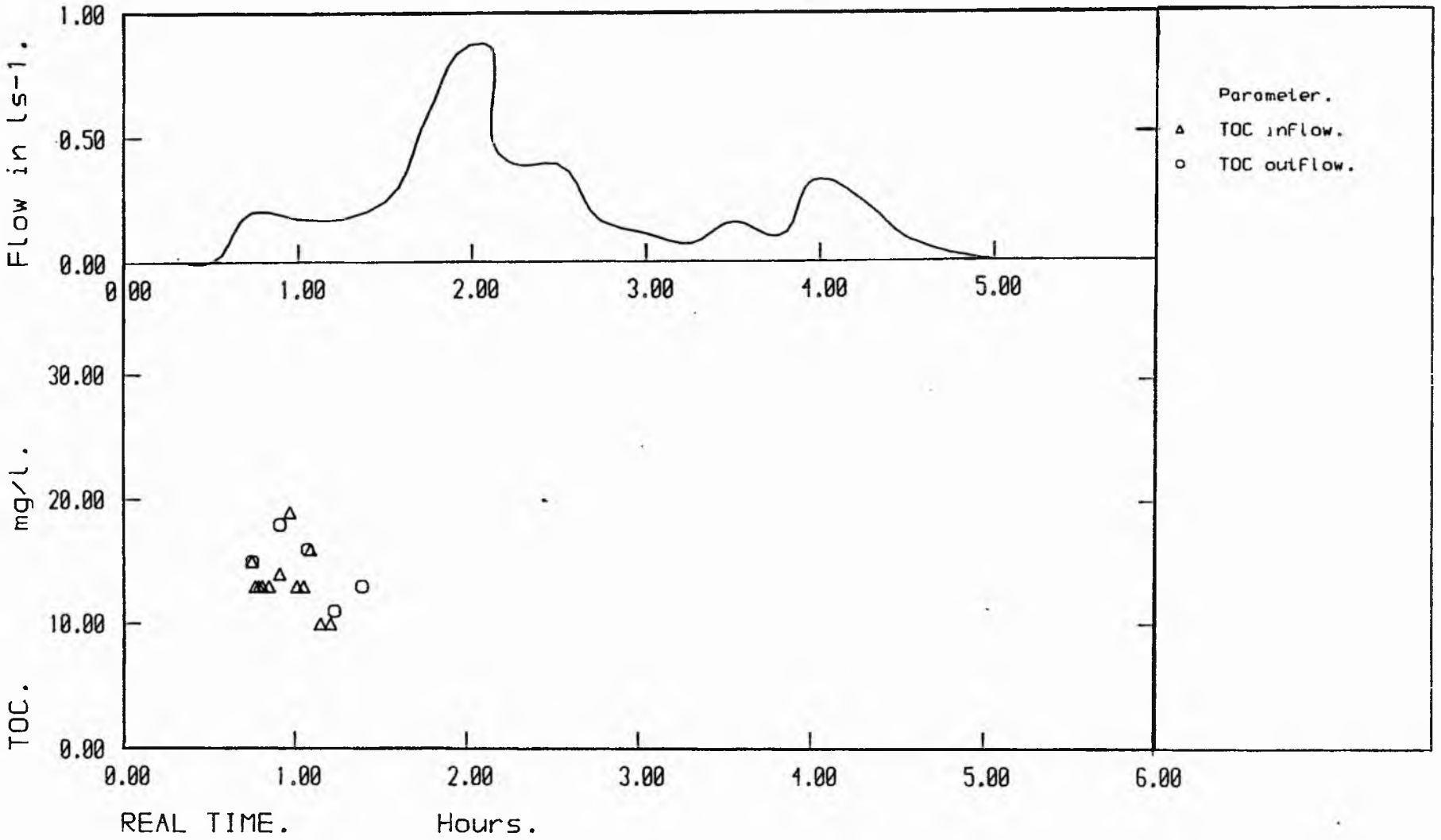
REAL TIME Hours	SS mgl-1	COD mgl-1	TOC mgl-1
1245	18	247	15
1255	8	32	18
1305	9	47	16
1315	10	47	11
1325	23	21	13

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

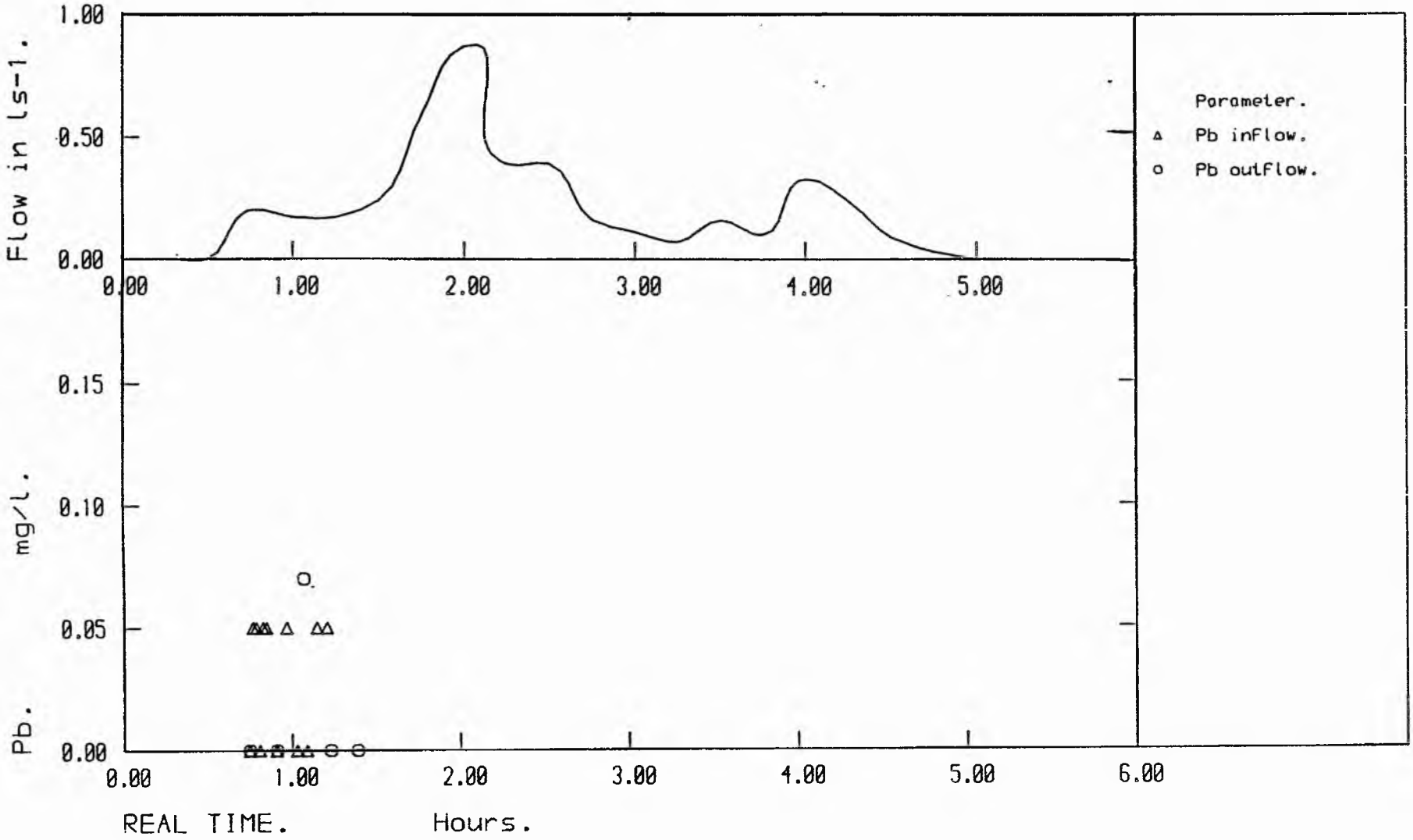
CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 7th. November 1985 (851107)
STORM NUMBER : X1

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

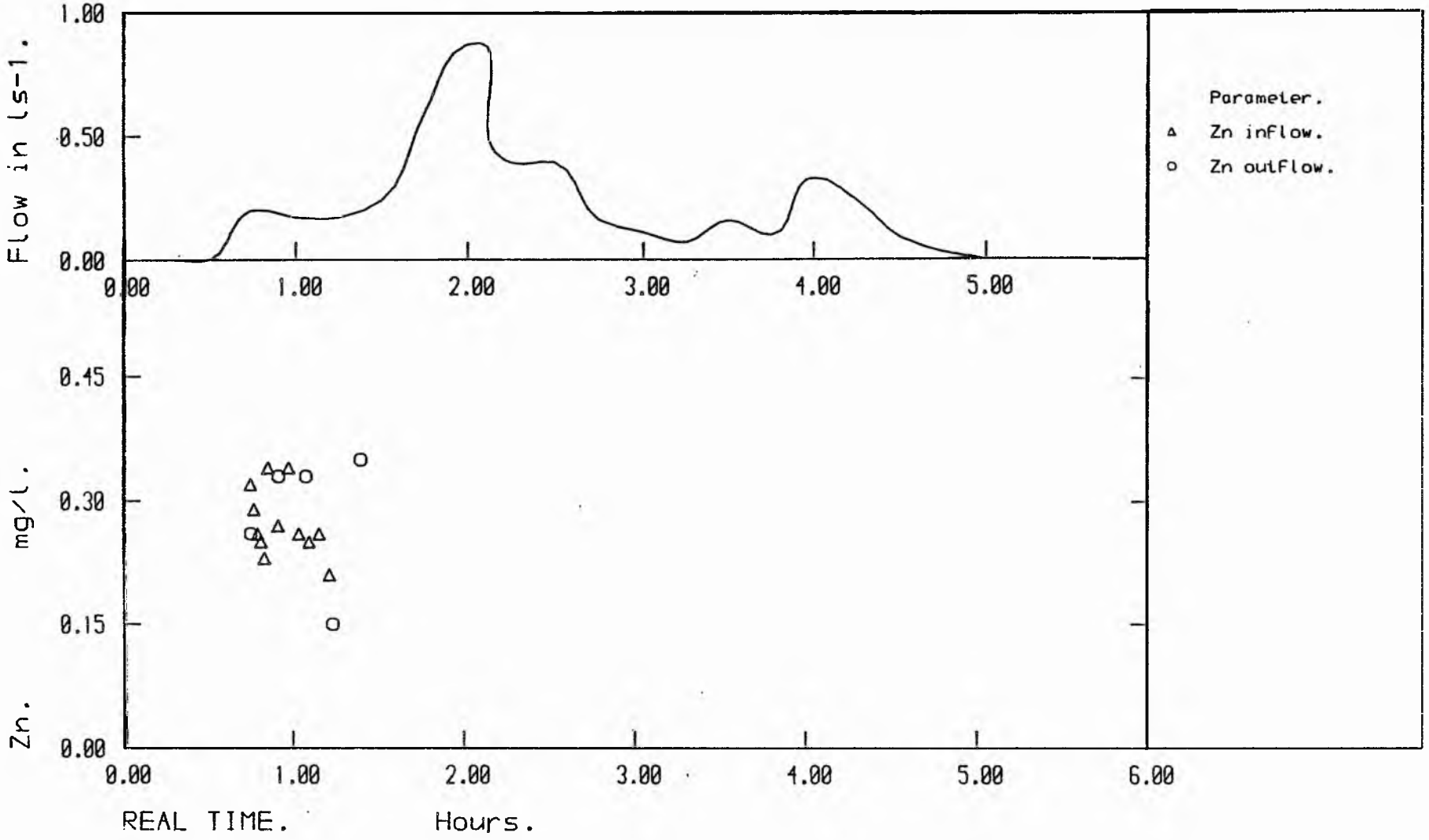
REAL TIME Hours	Pb mg1-1	Zn mg1-1
1245	0.00	0.26
1255	0.00	0.33
1305	0.07	0.33
1315	0.00	0.15
1325	0.00	0.35



Graph of TOC for Storm XI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Lead For Storm XI on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm XI on Twyford Gardens.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 14th. November 1985 (851114)
STORM NUMBER : XII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

REAL TIME Hours	SS mg l-1	COD mg l-1	TOC mg l-1	Zn mg l-1
2035	397	179	30	0.31
2036	224	98	26	0.38
2037	30	0	12	0.22
2038	148	130	21	0.31
2039	455	130	20	0.25
2040	272	147	17	0.29
2041	287	*	18	0.28
2042	173	*	20	0.23
2043	303	120	17	0.23
2044	295	*	17	0.21
2045	177	*	17	0.38
2046	114	76	16	0.25
2047	*	*	15	0.00
2048	147	*	15	0.25
2049	168	109	15	0.21
2050	168	*	16	0.21
2051	157	*	15	0.23
2052	104	98	15	0.21
2053	144	*	15	0.29
2054	124	*	14	0.21
2055	126	87	14	0.21
2056	96	*	13	0.19
2057	122	*	14	0.19
2058	166	43	12	0.19

* = No Analysis

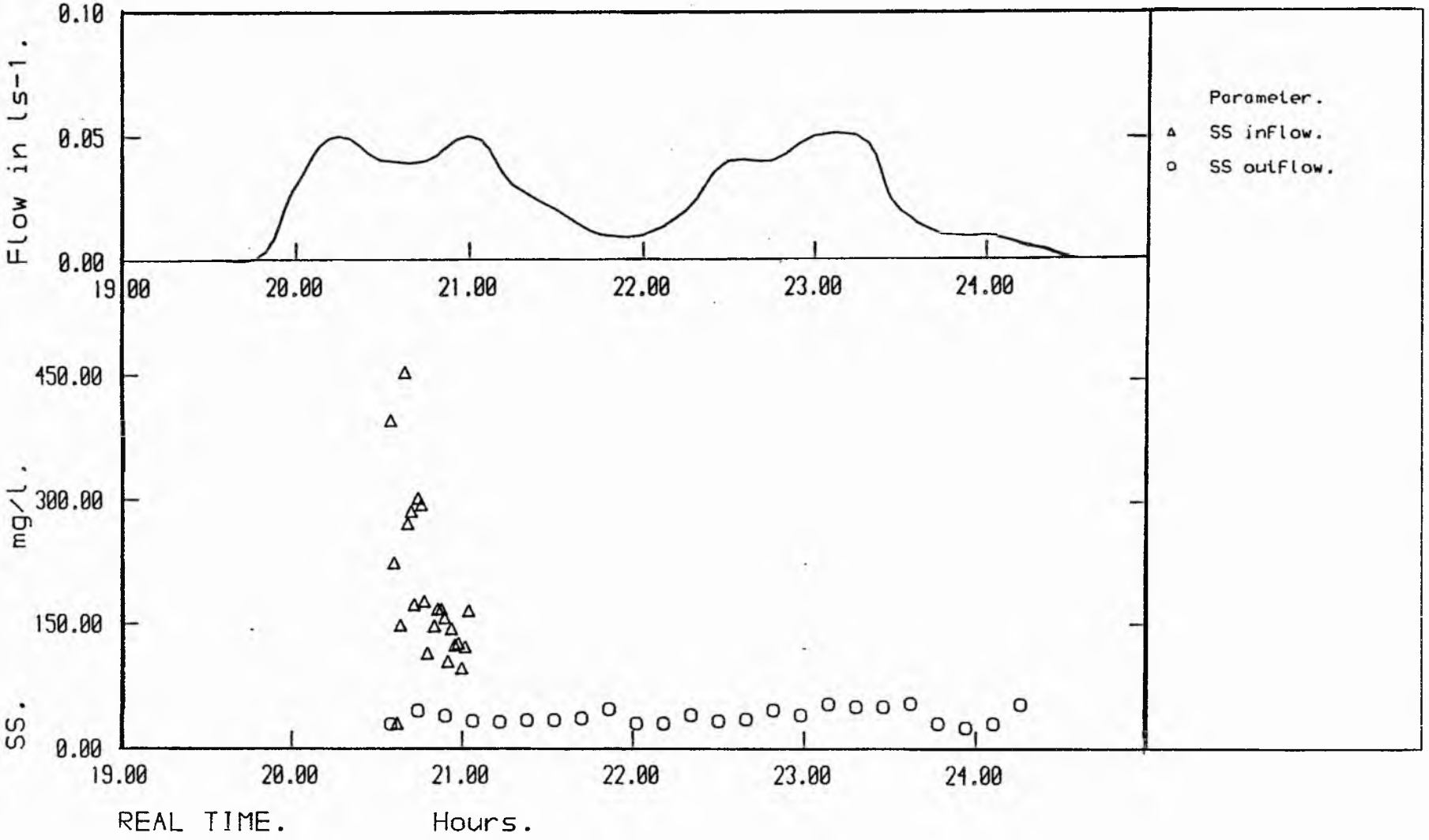
RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 14th. November 1985 (851114)
STORM NUMBER : XII

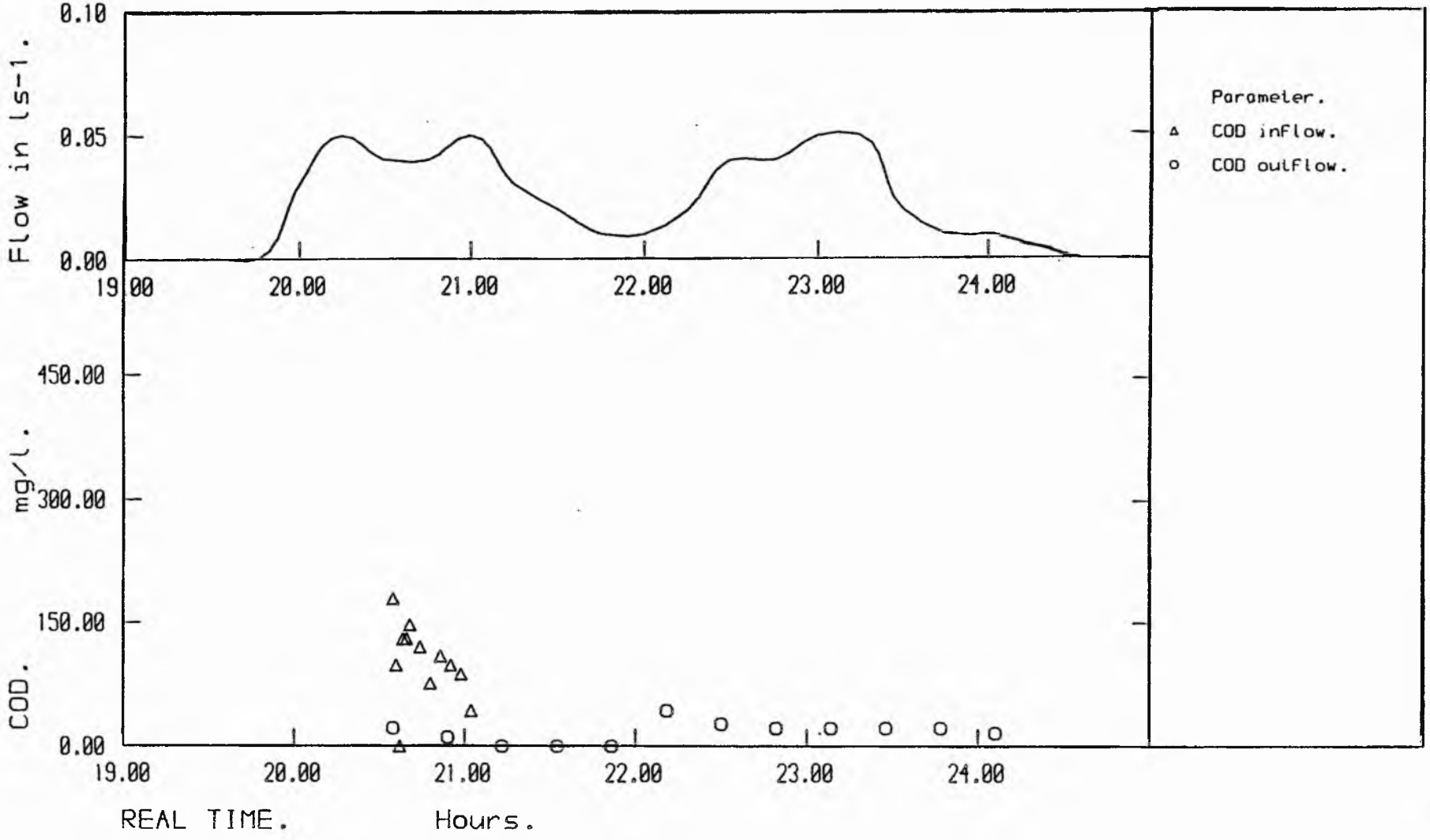
ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	COD mgl-1	TOC mgl-1	Zn mgl-1
2035	29	22	32	0.23
2045	45	*	34	0.23
2055	39	11	31	0.23
2105	33	*	32	0.31
2115	32	0	30	0.19
2125	34	*	31	0.31
2135	34	0	31	0.23
2145	36	*	32	0.21
2155	47	0	30	0.29
2205	30	*	30	0.21
2215	30	43	30	0.25
2225	40	*	31	0.28
2235	33	27	29	0.28
2245	35	*	30	0.31
2255	46	22	32	0.28
2305	40	*	28	0.28
2315	53	22	30	0.21
2325	50	*	30	0.28
2335	50	22	28	0.23
2345	54	*	28	0.29
2355	30	22	28	0.29
0005	25	*	31	0.29
0015	30	16	29	0.31
0025	53	*	29	0.28

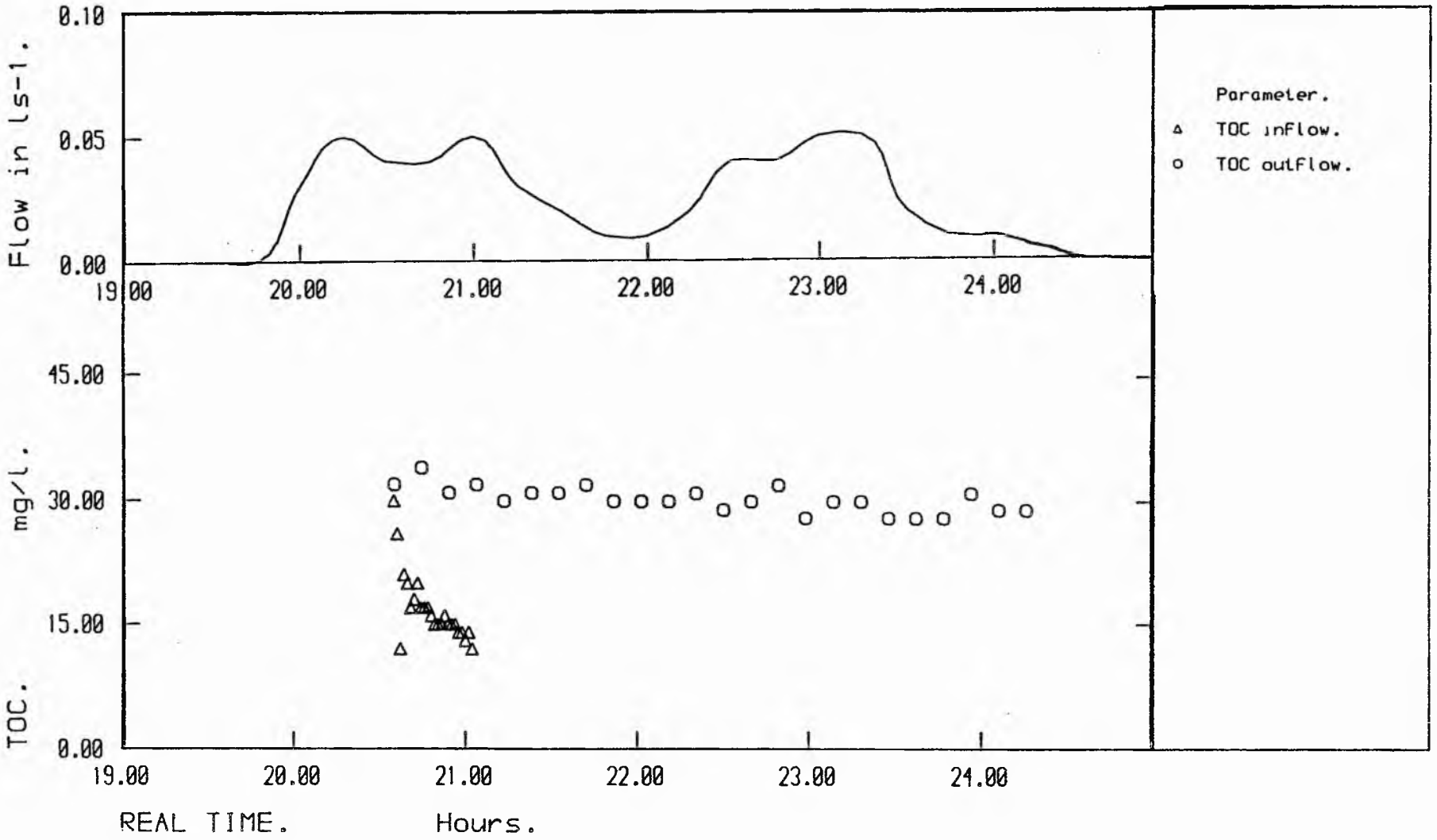
* = No Analysis



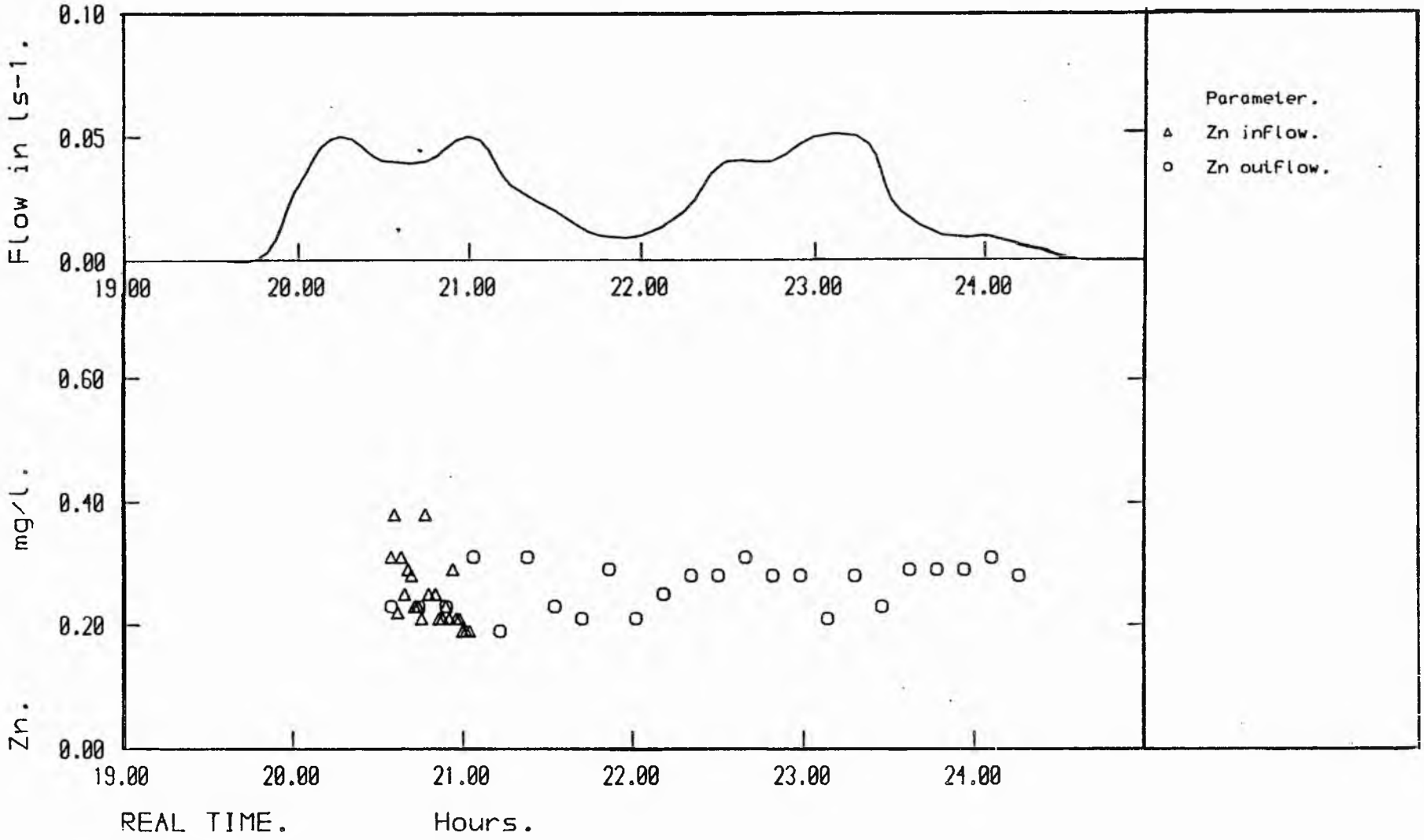
Graph of Suspended Solids for Storm XII on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Chemical Oxygen Demand for Storm XII on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of TOC for Storm XII on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm XII on Tame Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 30th. November 1985 (851130)
STORM NUMBER : XIII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

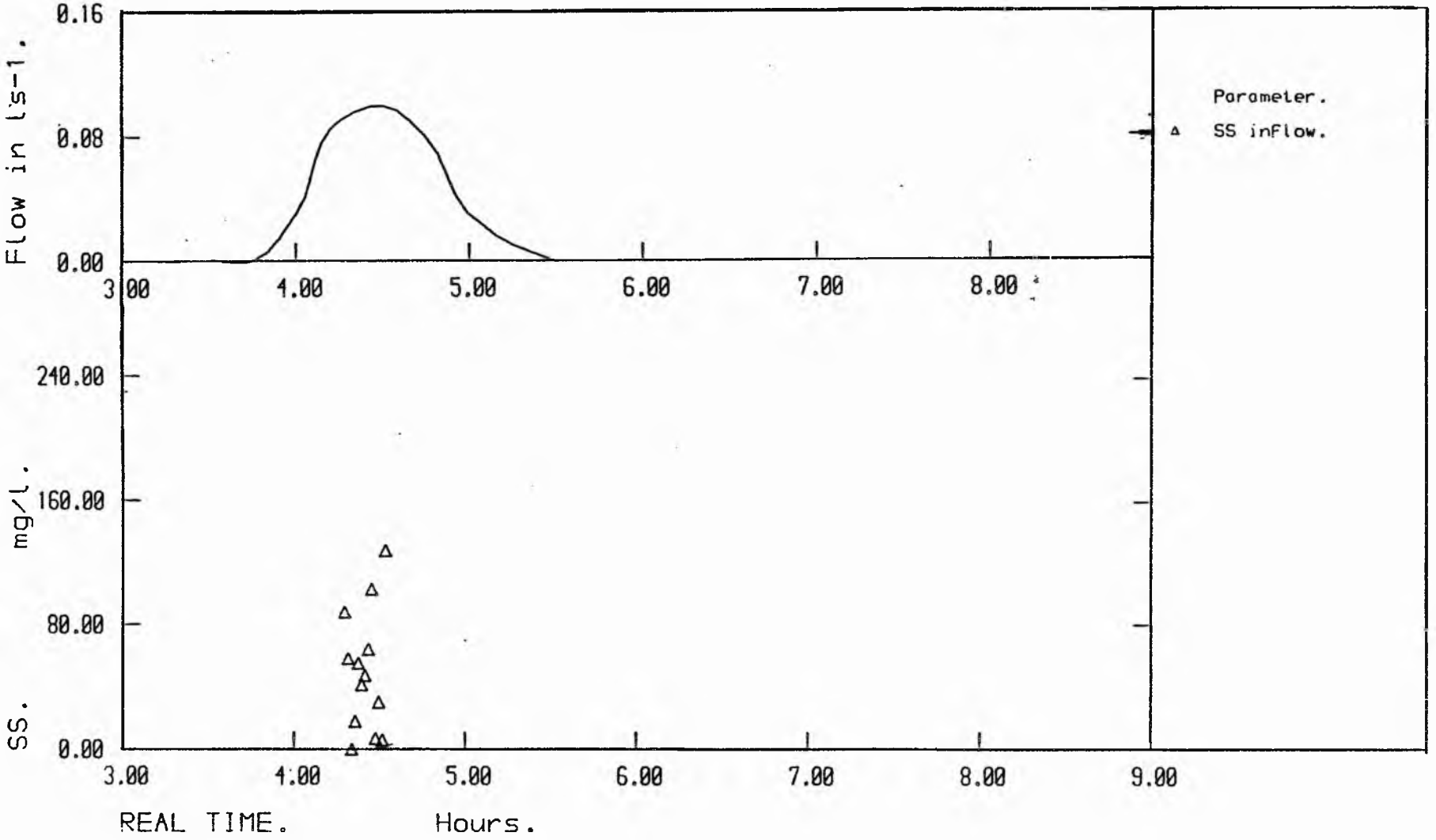
REAL TIME Hours	SS mgl-1	COD mgl-1	TOC mgl-1
0418	88	207	22
0419	58	76	20
0420	0	51	19
0421	18	66	19
0422	55	56	18
0423	41	56	15
0424	47	66	12
0425	64	76	10
0426	103	126	10
0427	7	61	12
0428	30	20	10
0429	6	20	10
0430	128	81	6

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

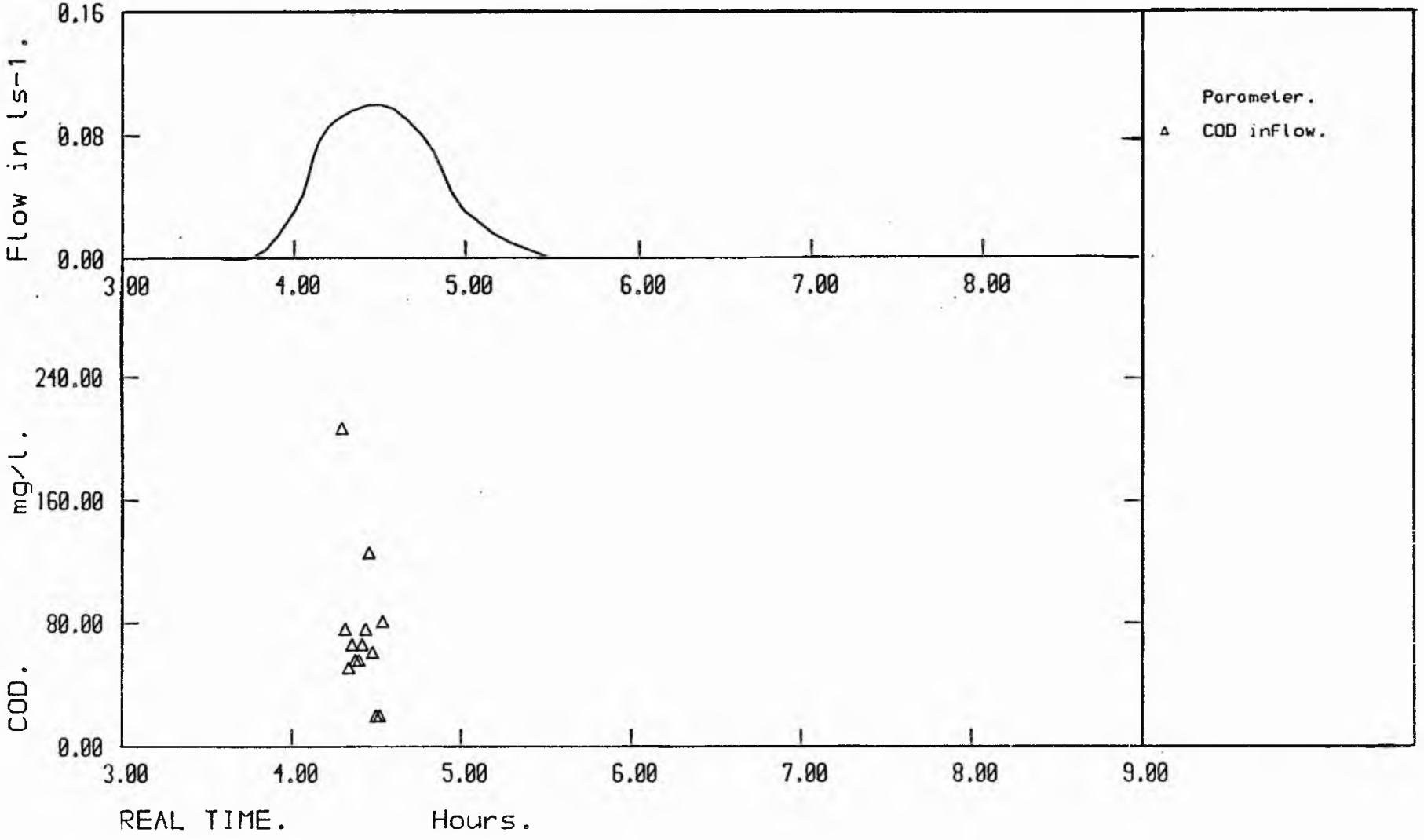
CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 30th. November 1985 (851130)
STORM NUMBER : XIII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

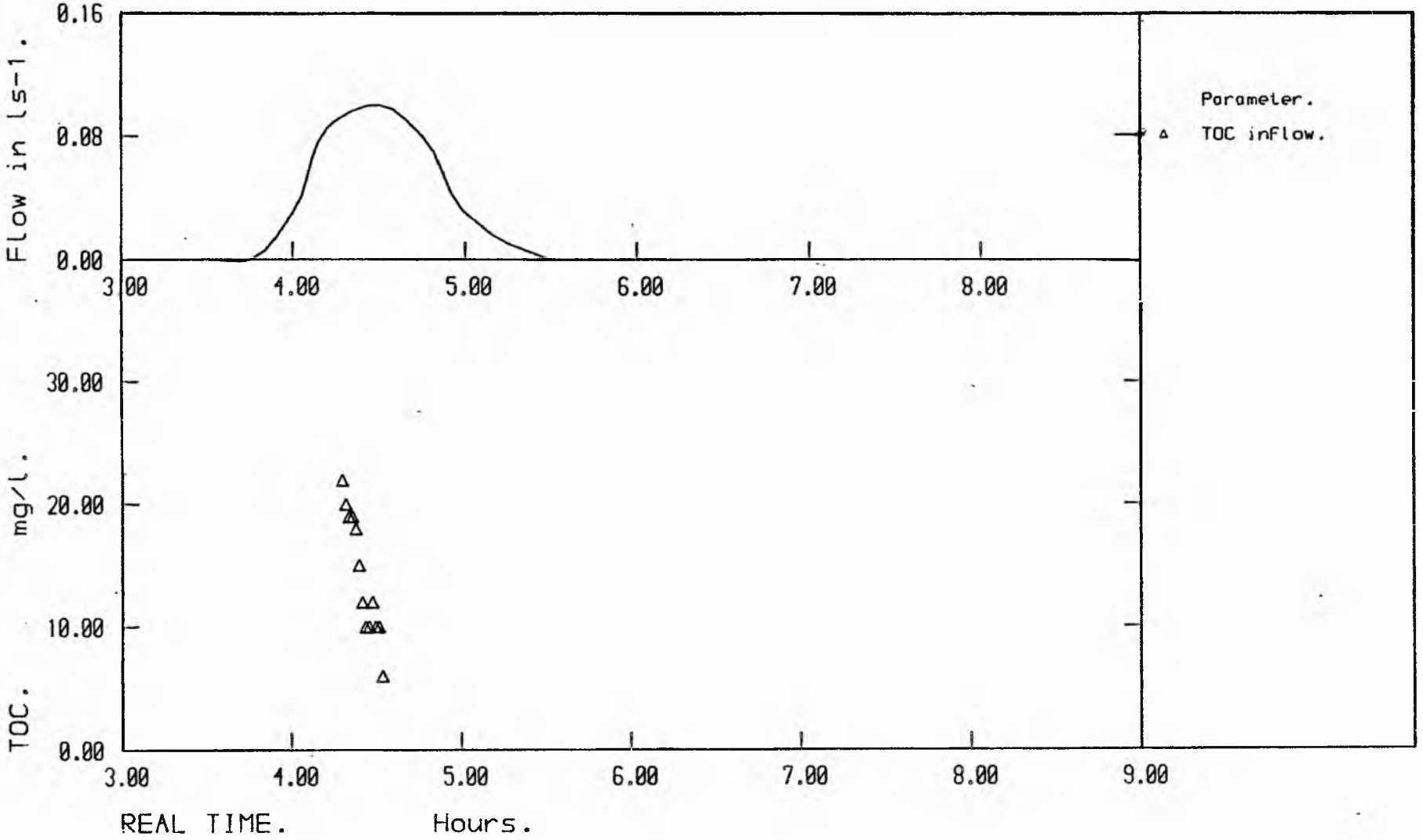
REAL TIME Hours	Zn mg1-1	Cu mg1-1	Pb mg1-1
0418	0.32	0.00	0.00
0419	0.25	0.04	0.00
0420	0.25	0.04	0.00
0421	0.26	0.00	0.08
0422	0.16	0.04	0.08
0423	0.26	0.00	0.00
0424	0.16	0.00	0.00
0425	0.20	0.04	0.17
0426	0.22	0.08	0.17
0427	0.16	0.00	0.17
0428	0.25	0.00	0.00
0429	0.22	0.00	0.00
0430	0.26	0.08	0.00



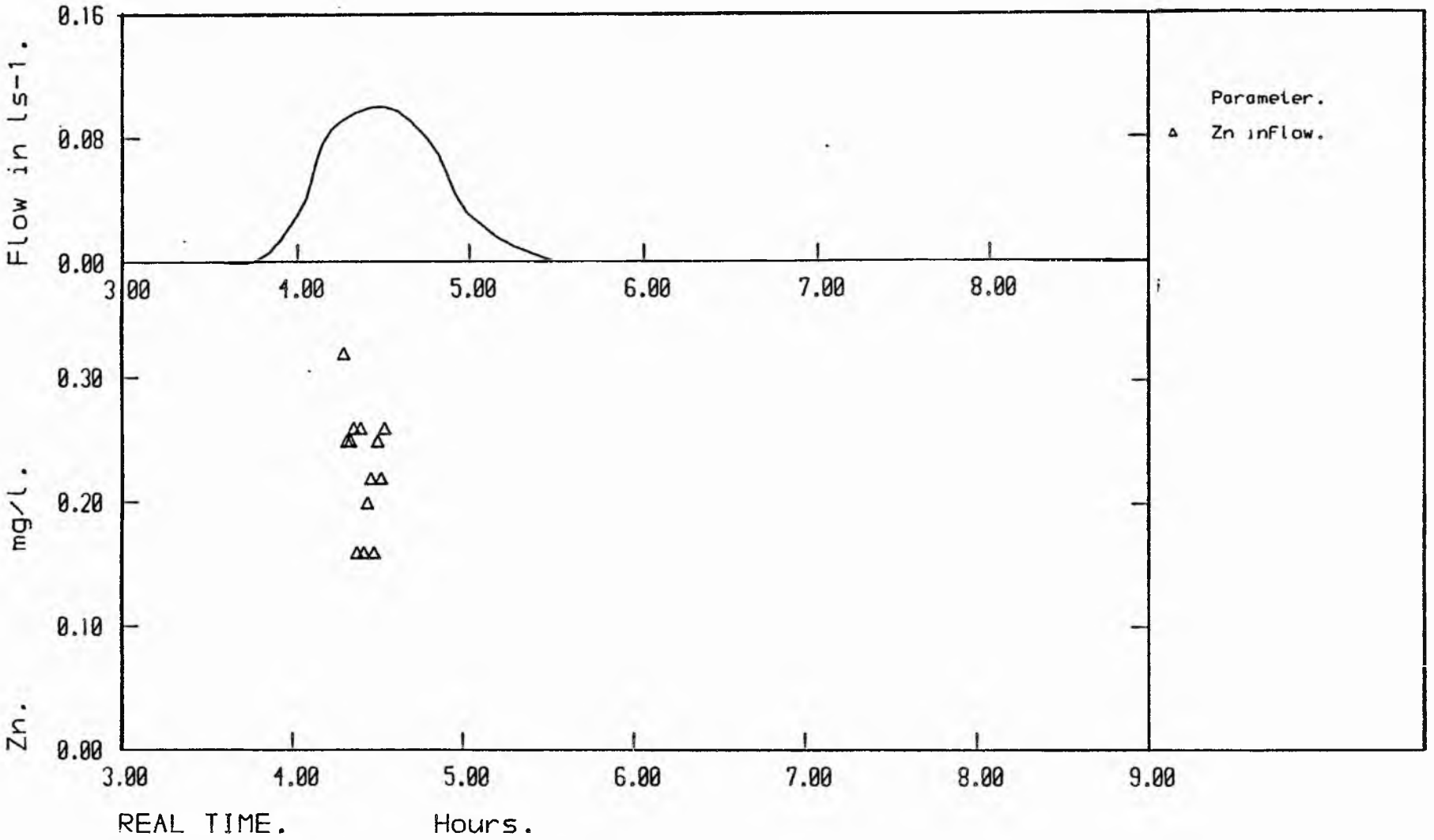
Graph of Suspended Solids for Storm XIII on Tame Close.
The graph shows inflow and outflow water quality data.



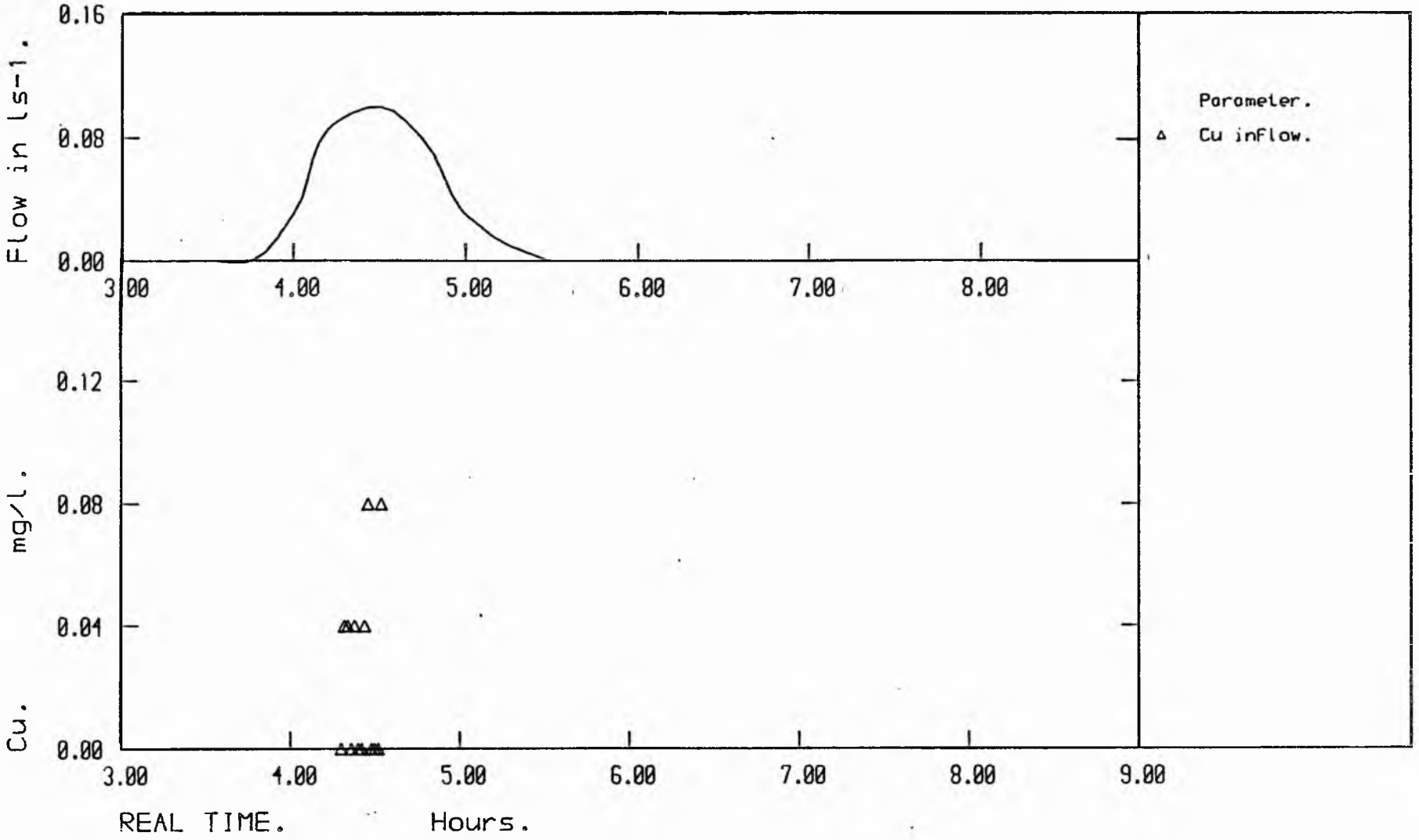
Graph of Chemical Oxygen Demand for Storm XIII on Tame Close.
The graph shows inflow and outflow water quality data.



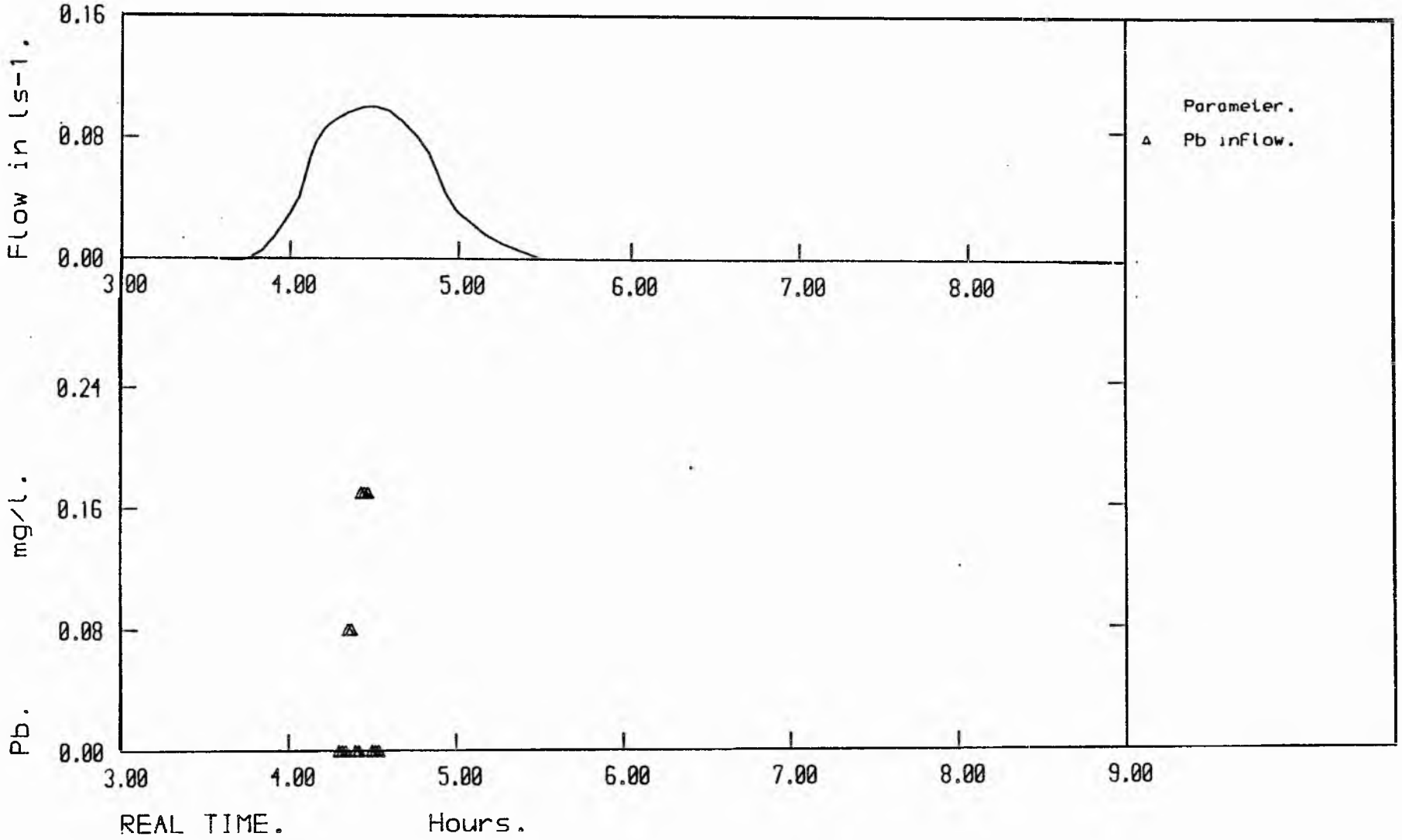
Graph of TOC for Storm XIII on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm XIII on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Copper For Storm XIII on Tame Close.
The graph shows inFlow and outFlow water quality data.



Graph of Lead for Storm XIII on Tame Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 30th. November 1985 (851130)
STORM NUMBER : XIII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

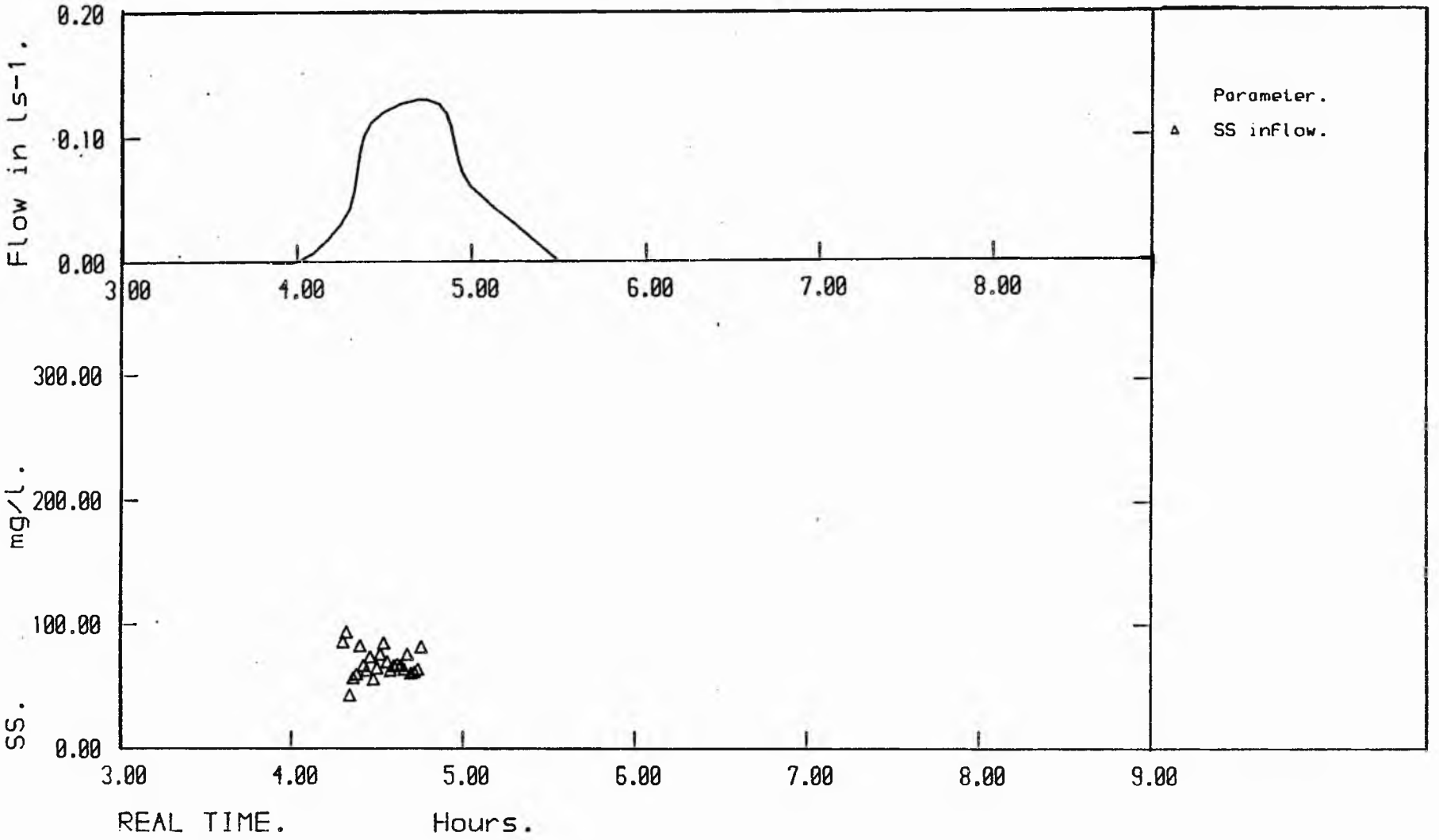
REAL TIME Hours	SS mgl-1	COD mgl-1	TOC mgl-1
0418	86	117	6
0419	94	97	6
0420	43	112	7
0421	57	82	6
0422	60	112	5
0423	83	112	6
0424	67	107	5
0425	63	87	6
0426	74	107	4
0427	56	133	5
0428	65	97	4
0429	76	87	5
0430	85	173	4
0431	70	117	5
0432	63	199	3
0433	67	148	4
0434	68	122	5
0435	67	148	4
0436	64	122	4
0437	76	97	5
0438	61	128	5
0439	62	107	4
0440	64	107	4
0441	82	276	4

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

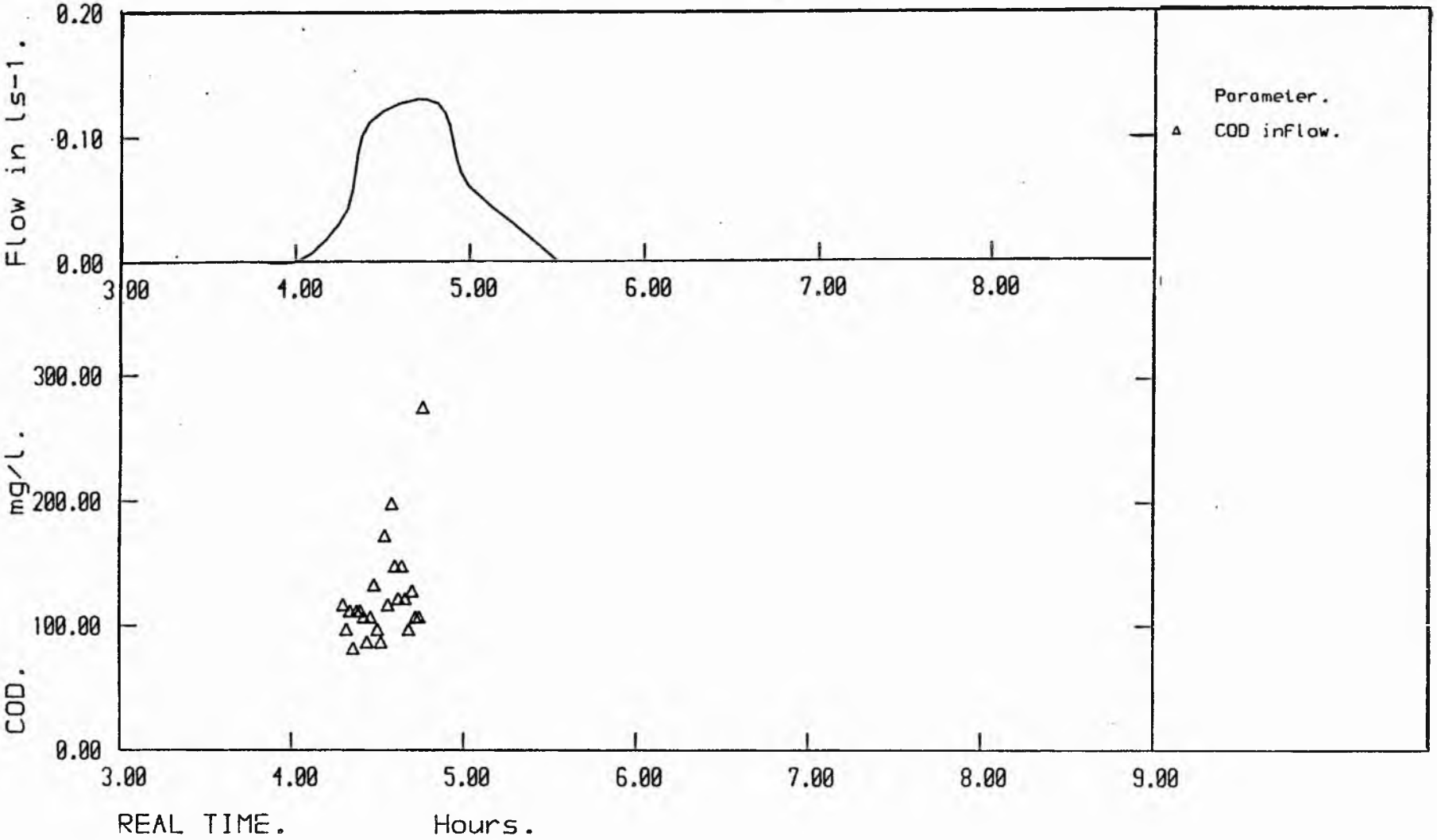
CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 30th. November 1985 (851130)
STORM NUMBER : XIII

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

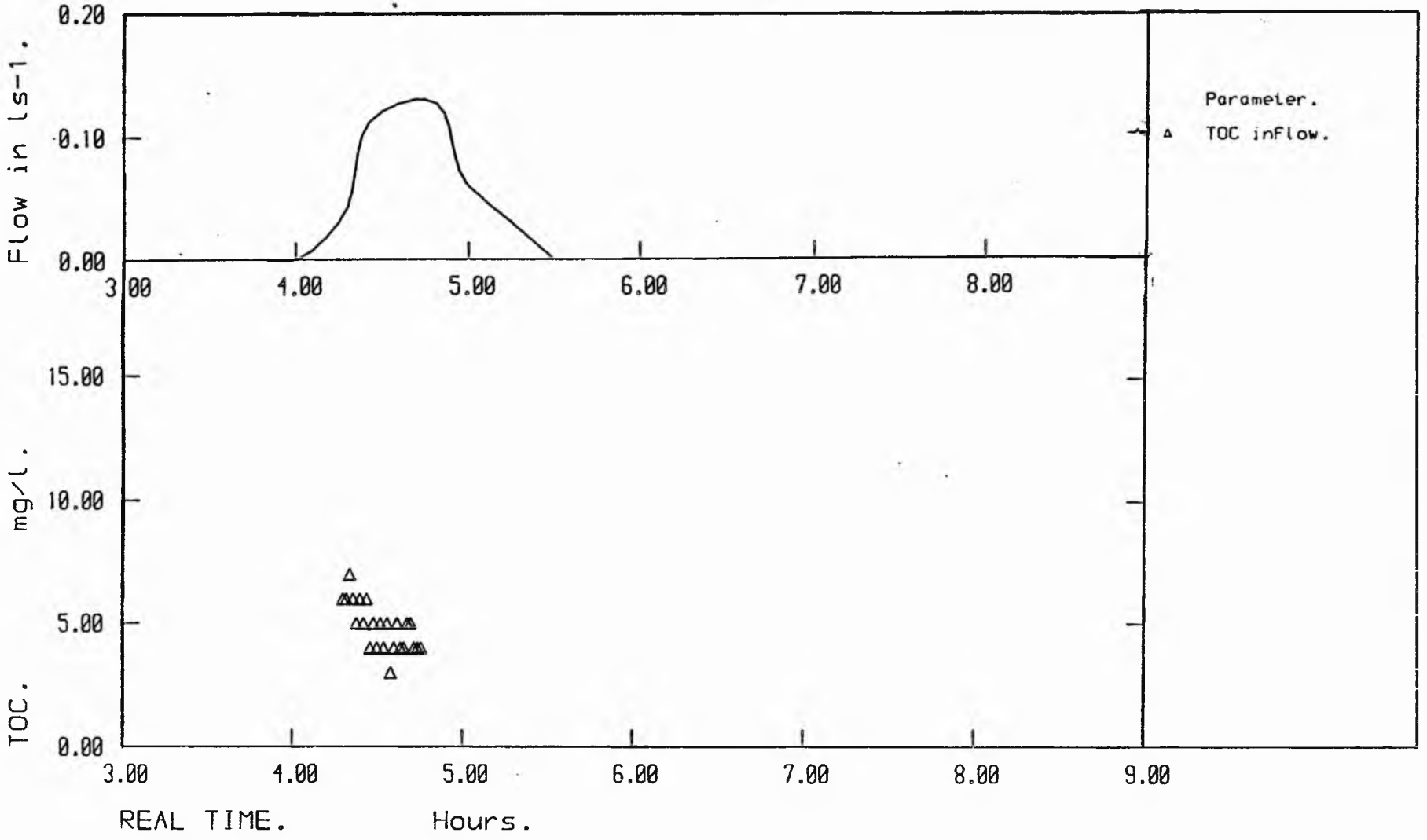
REAL TIME Hours	Zn mg1-1	Cu mg1-1	Pb mg1-1
0418	0.32	0.08	0.00
0419	0.34	0.00	0.00
0420	0.46	0.00	0.00
0421	0.34	0.08	0.08
0422	0.25	0.04	0.08
0423	0.34	0.00	0.08
0424	0.25	0.00	0.17
0425	0.26	0.04	0.17
0426	0.26	0.00	0.08
0427	0.25	0.00	0.00
0428	0.22	0.00	0.00
0429	0.26	0.00	0.00
0430	0.26	0.04	0.00
0431	0.22	0.08	0.00
0432	0.22	0.04	0.00
0433	0.26	0.00	0.08
0434	0.16	0.00	0.17
0435	0.16	0.00	0.17
0436	0.16	0.04	0.08
0437	0.25	0.00	0.00
0438	0.16	0.00	0.00
0439	0.22	0.00	0.00
0440	0.16	0.04	0.00
0441	0.12	0.00	0.00



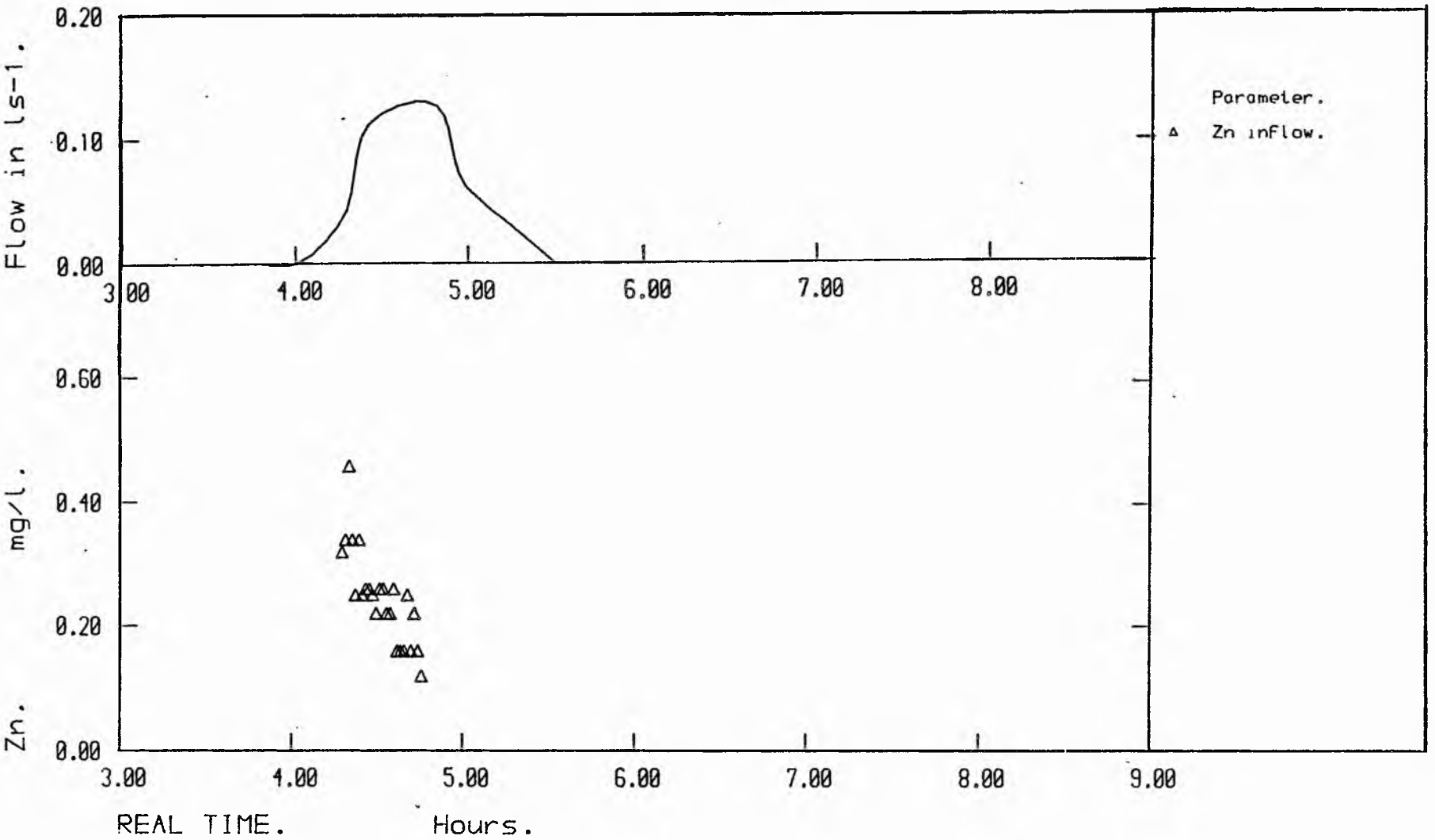
Graph of Suspended Solids for Storm XIII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



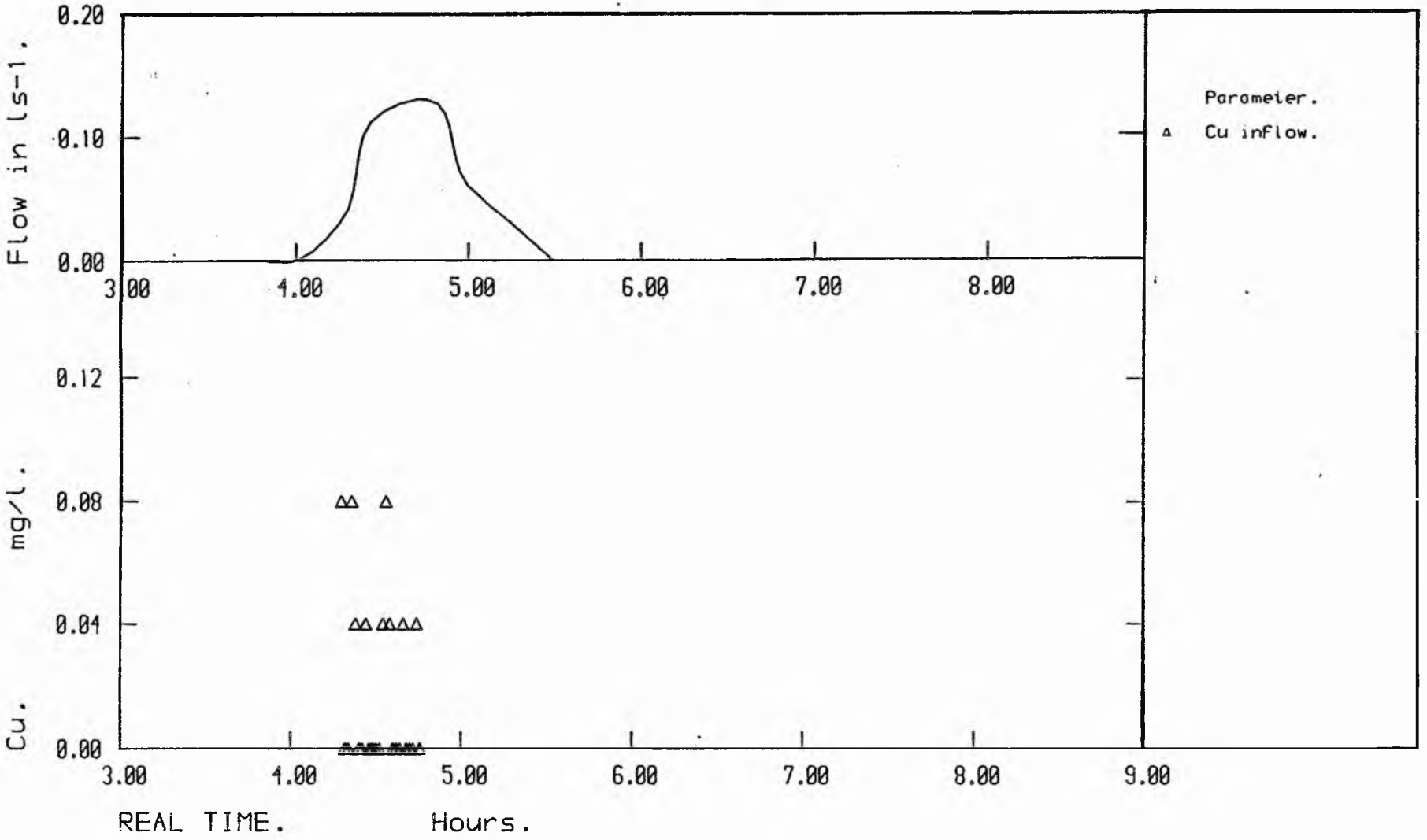
Graph of Chemical Oxygen Demand for Storm XIII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



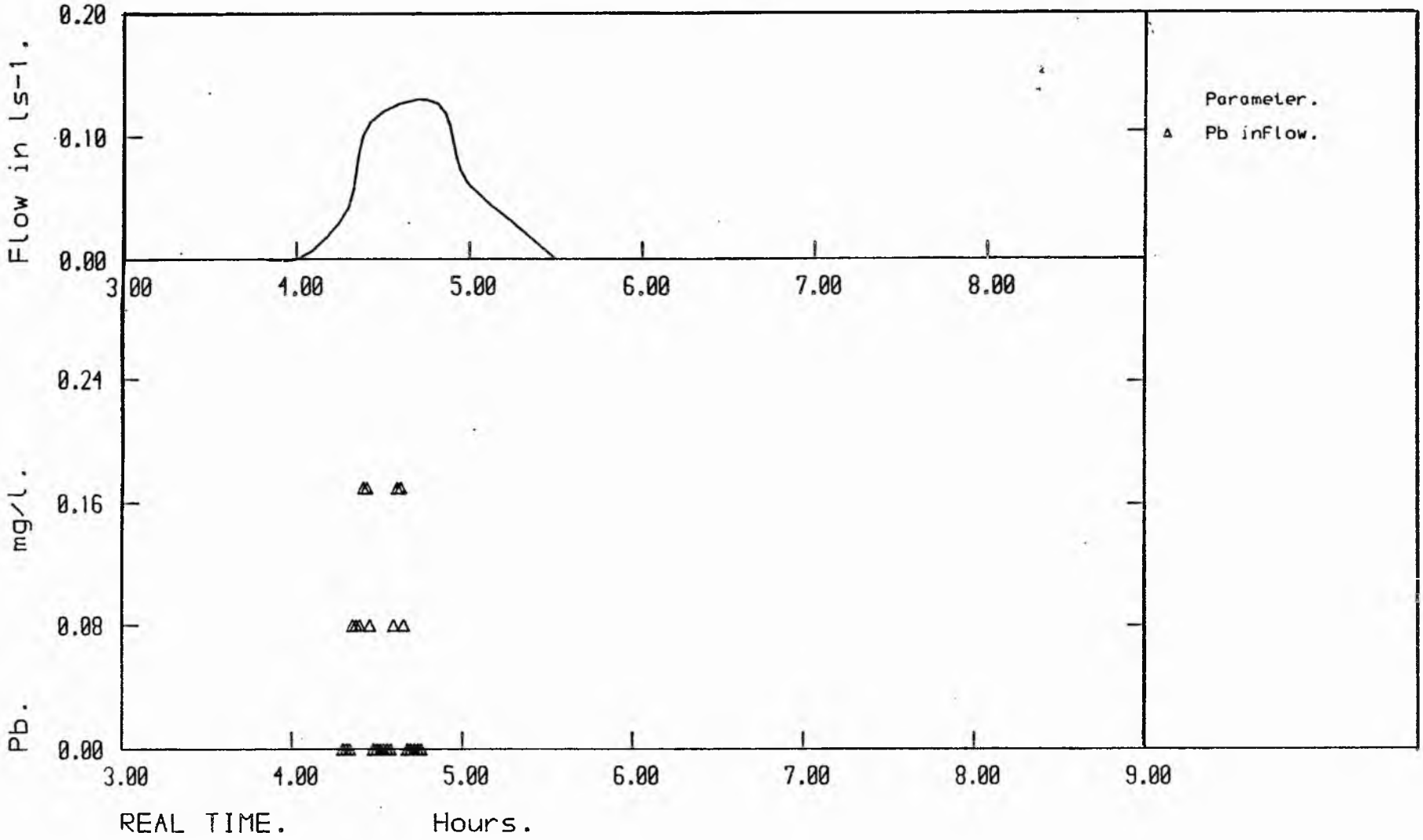
Graph of TOC for Storm XIII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm XIII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Copper for Storm XIII on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Lead for Storm XIII on Twyford Gardens.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 5th. December 1985 (851205)
STORM NUMBER : XIV

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

REAL TIME Hours	SS mgl-1	COD mgl-1	TOC mgl-1	Zn mgl-1
1245	4	71	8	0.10
1246	11	40	7	0.12
1247	10	56	8	0.09
1248	*	66	9	0.14
1249	11	56	7	0.12
1250	8	51	8	0.10
1251	24	40	8	0.12
1252	4	40	8	0.12
1253	*	141	*	*
1254	*	126	*	*
1255	*	288	*	*
1256	*	172	*	*
1257	3	71	12	0.12

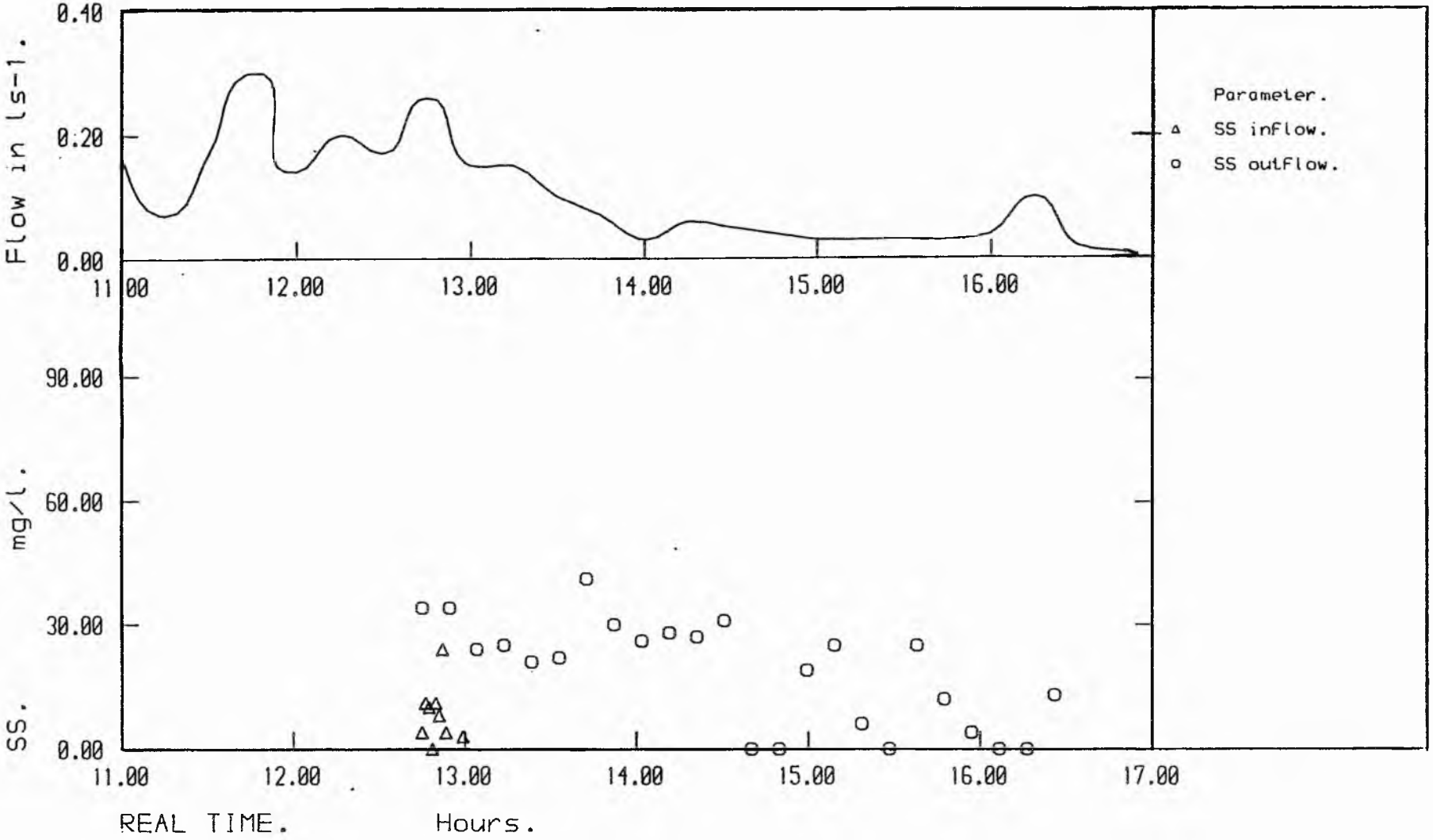
* = No Analysis

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

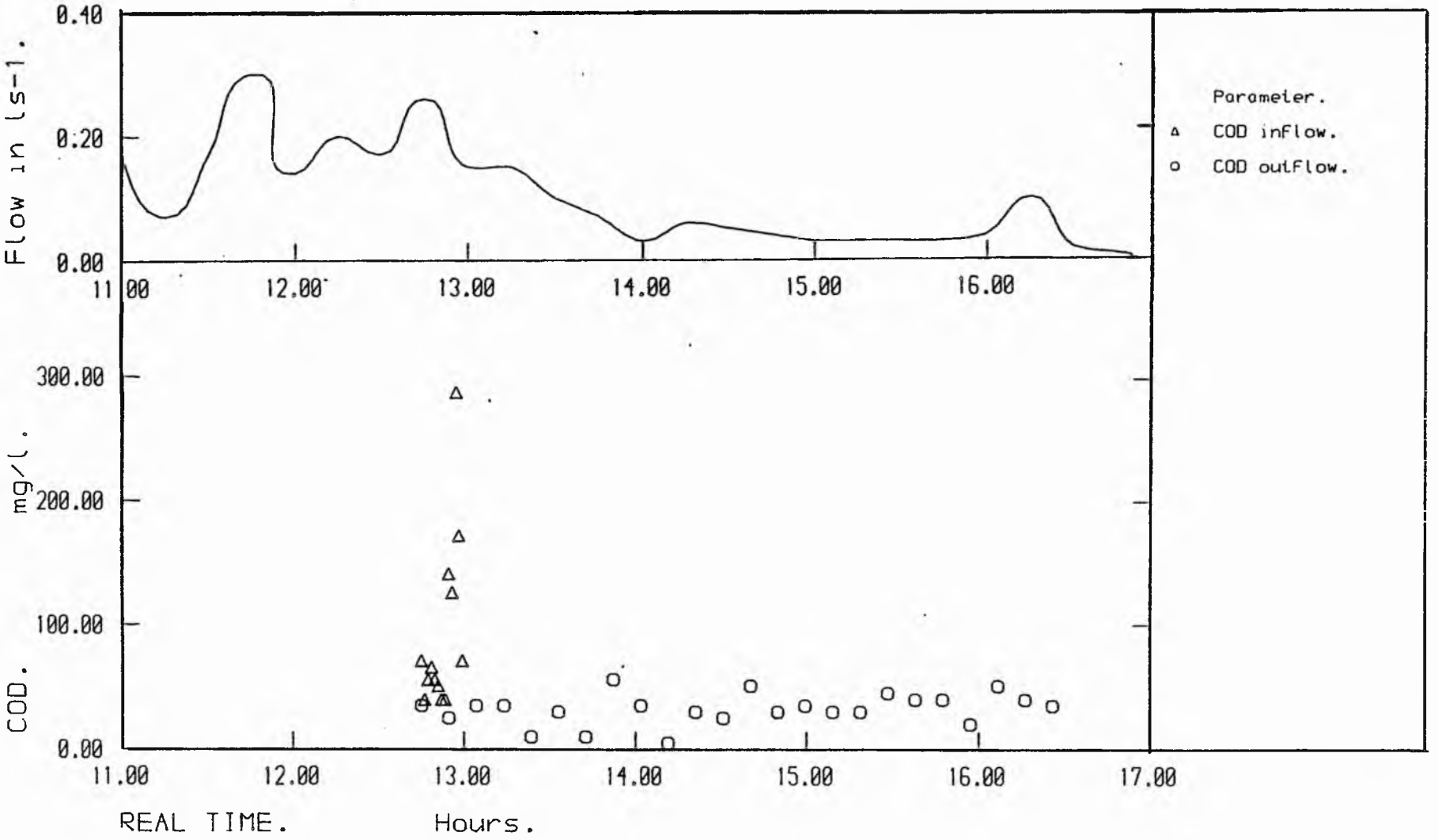
CATCHMENT : Churnet Close
DATE OF THE STORM EVENT : 5th. December 1985 (851205)
STORM NUMBER : XIV

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

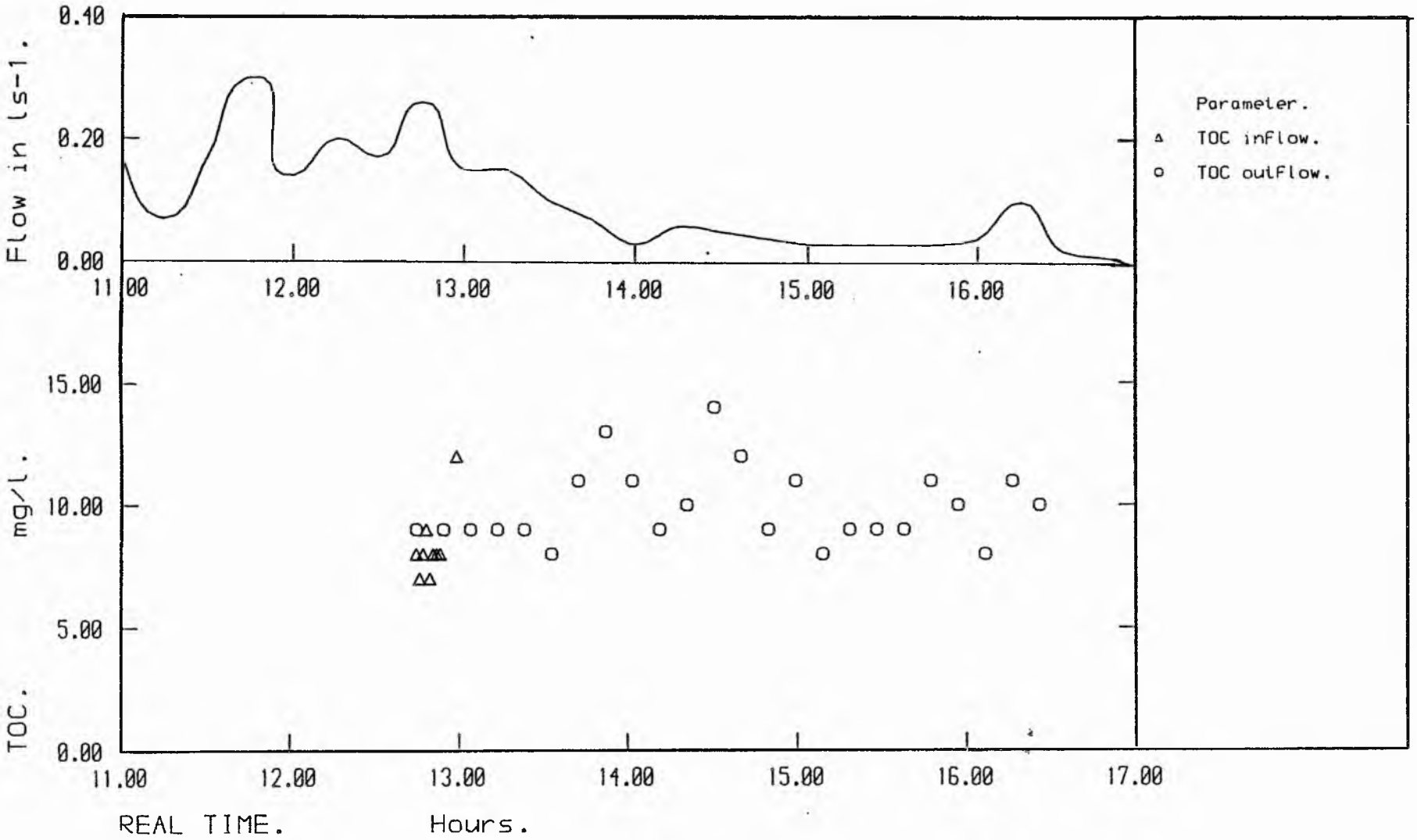
REAL TIME Hours	SS mgl-1	COD mgl-1	TOC mgl-1	Zn mgl-1
1245	34	35	9	0.14
1255	34	25	9	0.13
1305	24	35	9	0.13
1315	25	35	9	0.18
1325	21	10	9	0.06
1335	22	30	8	0.13
1345	41	10	11	0.07
1355	30	56	13	0.10
1405	26	35	11	0.14
1415	28	5	9	0.09
1425	27	30	10	0.06
1435	31	25	14	0.10
1445	0	51	12	0.14
1455	0	30	9	0.17
1505	19	35	11	0.14
1515	25	30	8	0.14
1525	6	30	9	0.10
1535	0	45	9	0.14
1545	25	40	9	0.14
1555	12	40	11	0.12
1605	4	20	10	0.19
1615	0	51	8	0.18
1625	0	40	11	0.17
1635	13	35	10	0.13



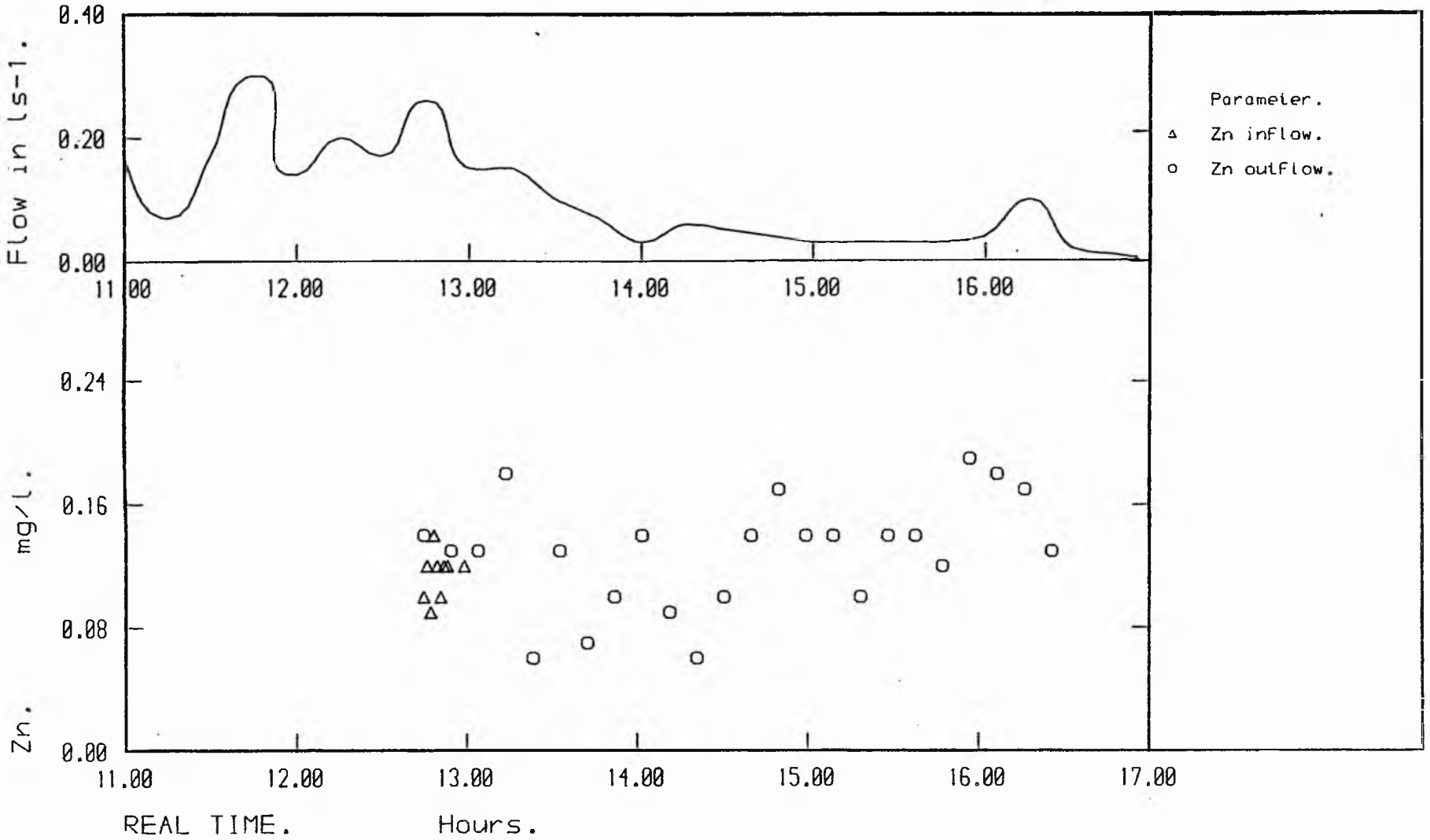
Graph of Suspended Solids for Storm XIV on Churnet Close.
The graph shows inflow and outflow water quality data.



Graph of Chemical Oxygen Demand for Storm XIV on Churnet Close.
The graph shows inflow and outflow water quality data.



Graph of TOC for Storm XIV on Churnet Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc For Storm XIV on Churnet Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 6th. December 1985 (851206)
STORM NUMBER : XV

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

REAL TIME Hours	SS mg l-1	COD mg l-1	TOC mg l-1	Zn mg l-1
1505	441	360	7	0.06
1506	216	165	8	0.10
1507	*	45	7	0.22
1508	563	475	9	0.07

* = No Analysis

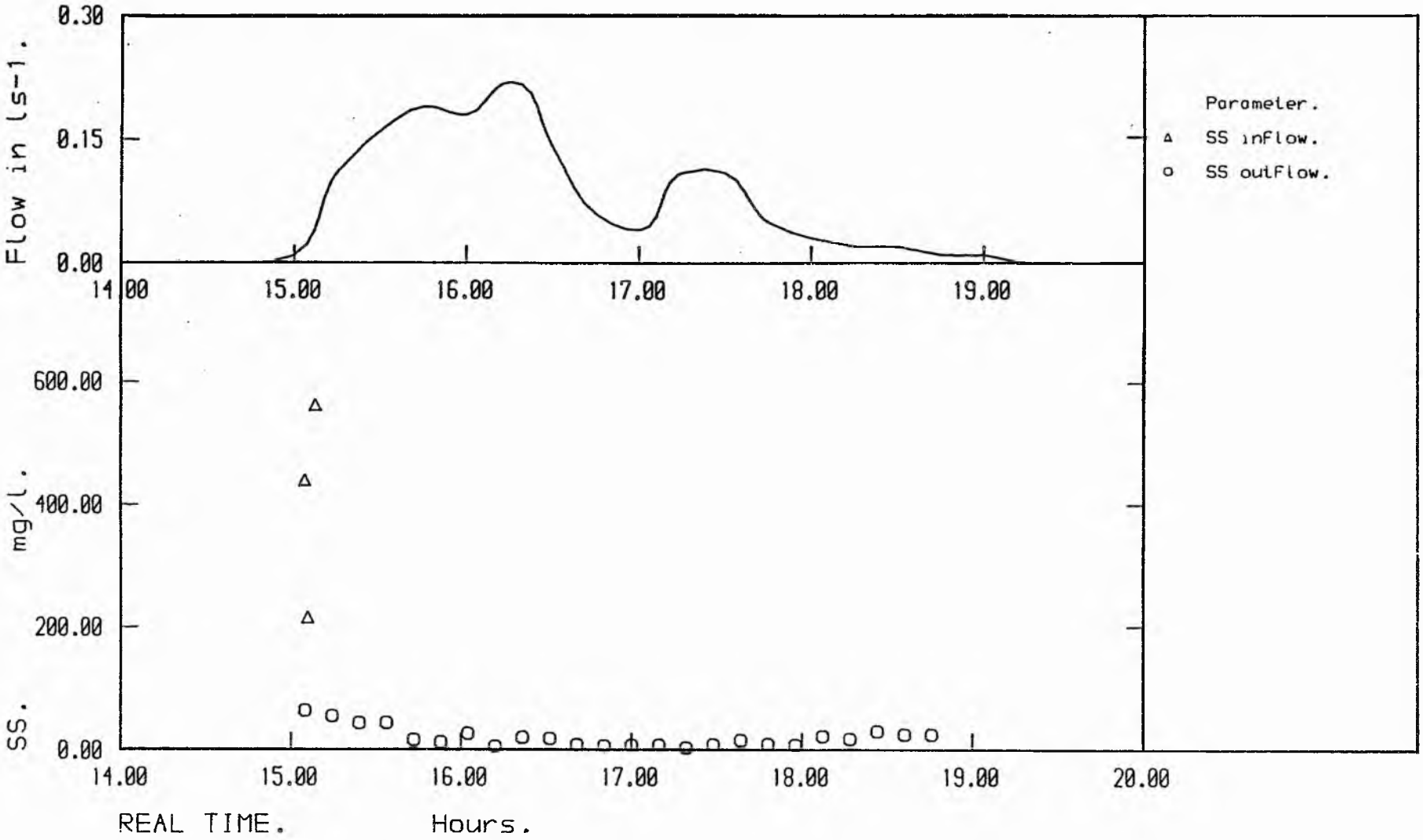
RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Tame Close
DATE OF THE STORM EVENT : 6th. December 1985 (851206)
STORM NUMBER : XV

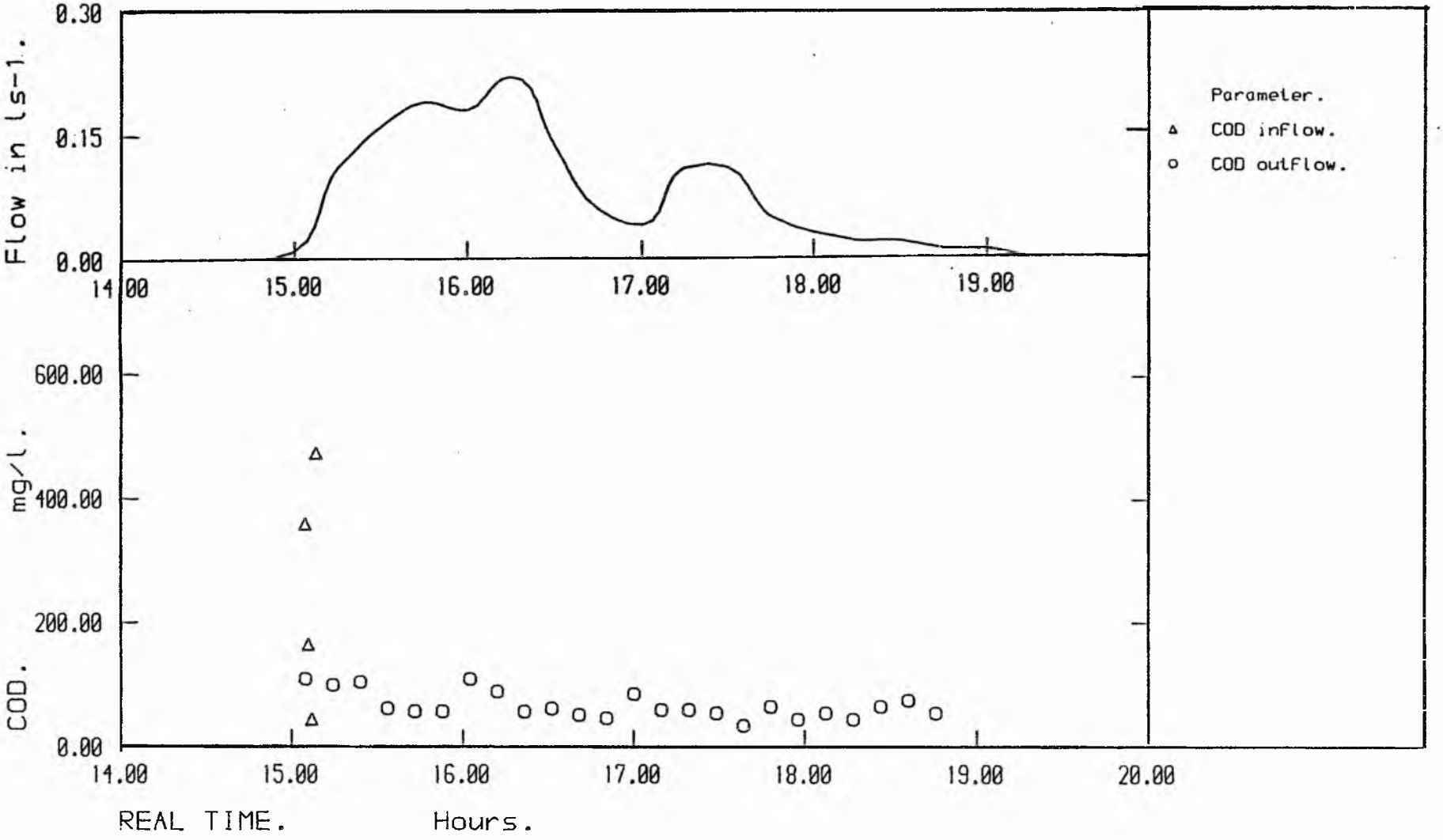
ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

REAL TIME Hours	SS mgl-1	COD mgl-1	TOC mgl-1	Zn mgl-1	Cu mgl-1
1505	64	109	38	0.11	0.06
1515	55	99	26	0.17	*
1525	44	104	21	0.18	*
1535	44	62	18	0.19	*
1545	17	57	12	0.19	*
1555	13	57	12	0.27	*
1605	27	109	12	0.17	0.03
1615	6	89	14	0.24	*
1625	21	57	12	0.24	*
1635	19	62	15	0.18	*
1645	9	52	11	0.12	*
1655	7	47	12	0.15	*
1705	8	85	9	0.18	*
1715	8	60	9	0.22	*
1725	4	60	8	0.12	0.03
1735	9	55	8	0.17	0.03
1745	16	35	8	0.10	0.03
1755	10	65	10	0.15	0.03
1805	8	45	8	0.17	0.03
1815	22	55	8	0.12	0.06
1825	18	45	8	0.17	*
1835	30	65	9	0.15	0.03
1845	25	75	8	0.15	0.03
1855	25	55	9	0.15	0.03

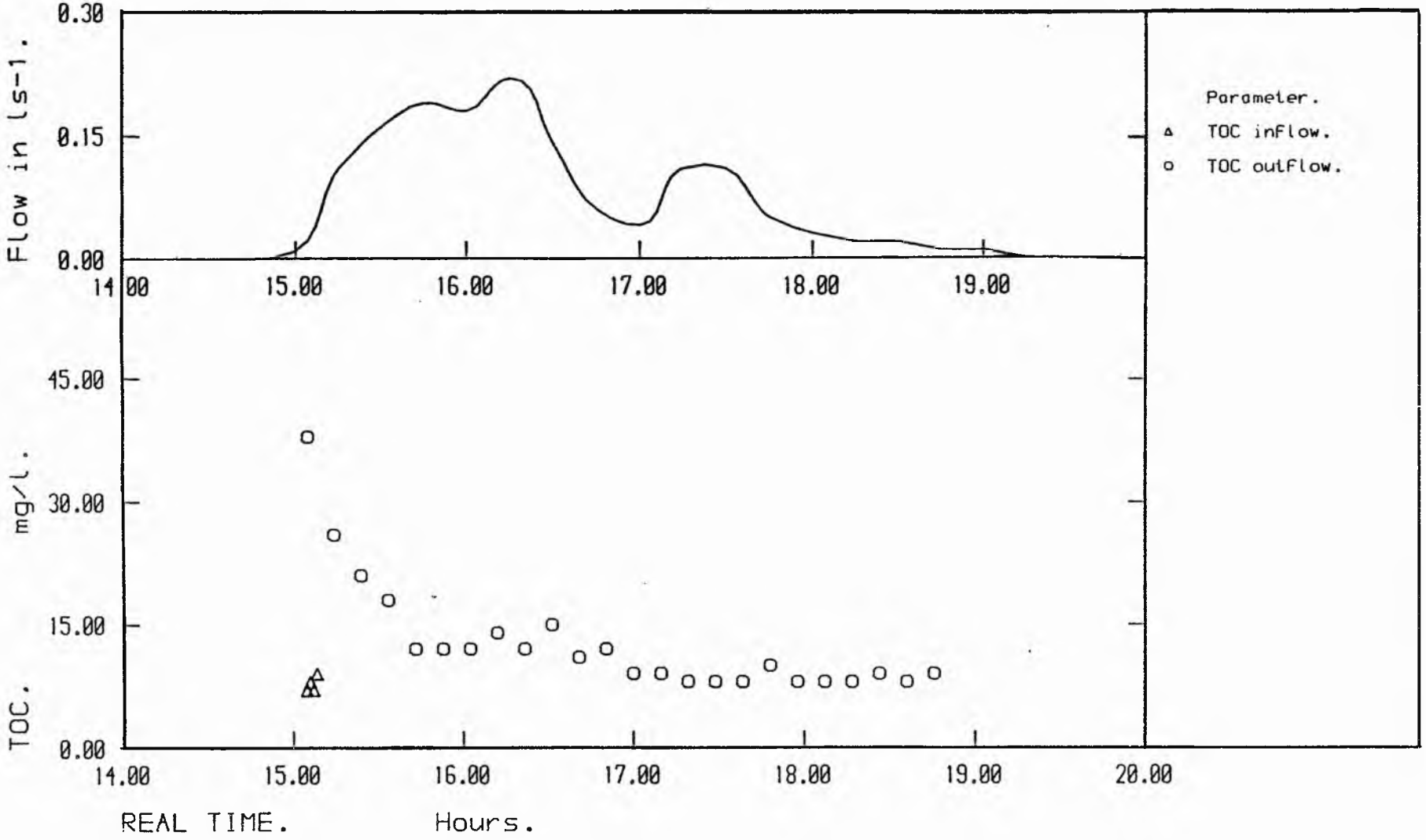
* = No Analysis



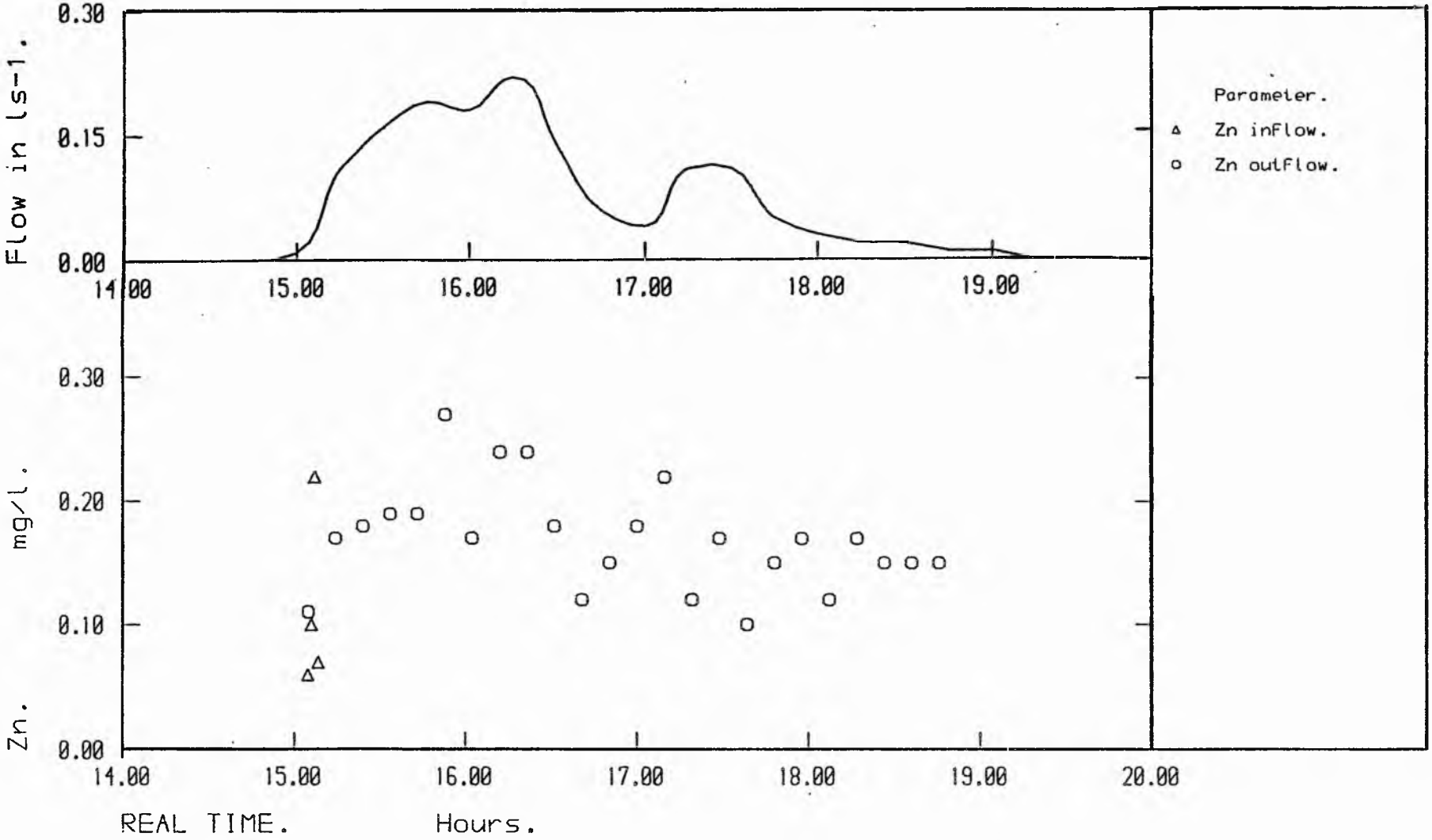
Graph of Suspended Solids For Storm XV on Tame Close.
The graph shows inflow and outflow water quality data.



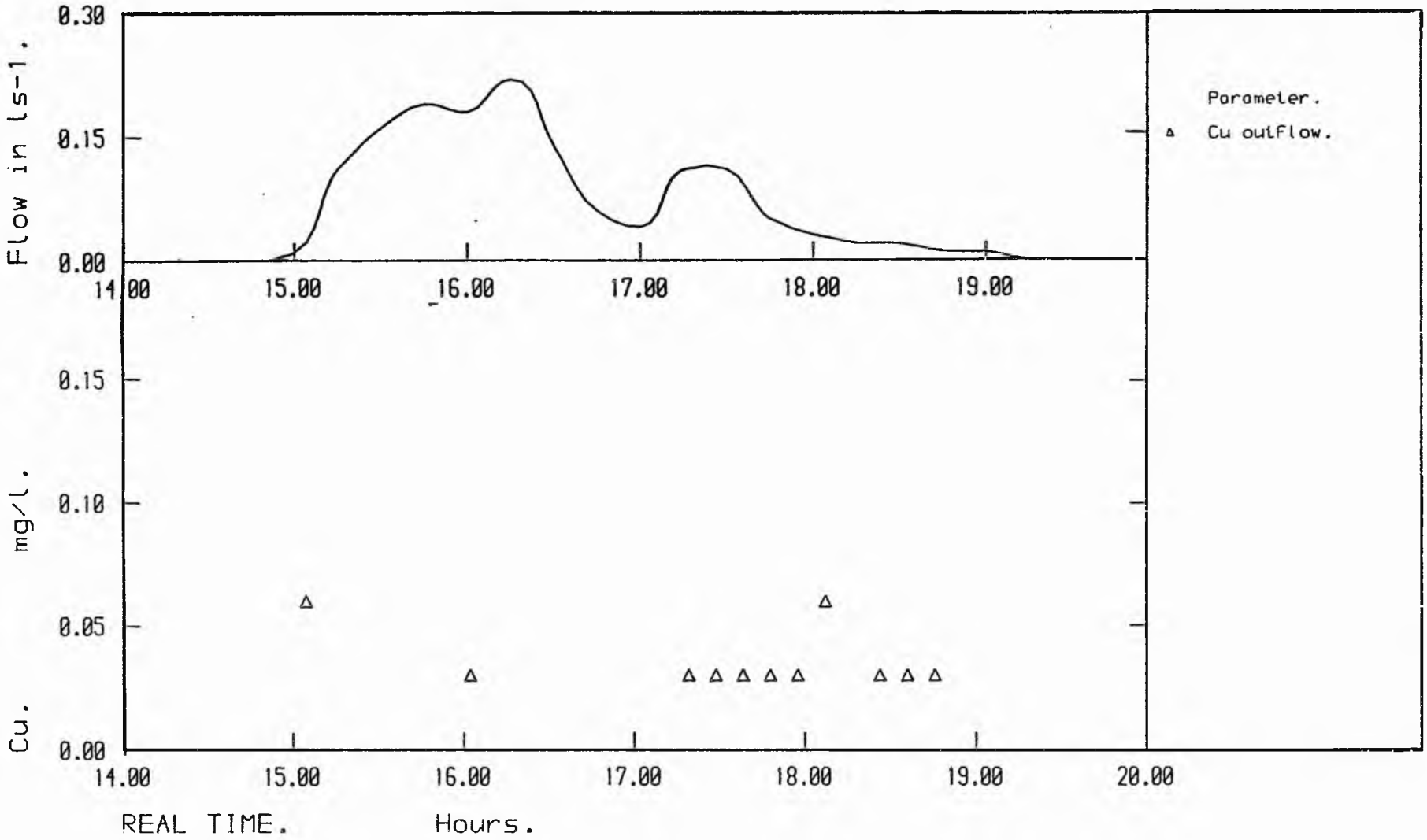
Graph of Chemical Oxygen Demand For Storm XV on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of TOC for Storm XV on Tame Close.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm XV on Tame Close.
The graph shows inflow and outflow water quality data.



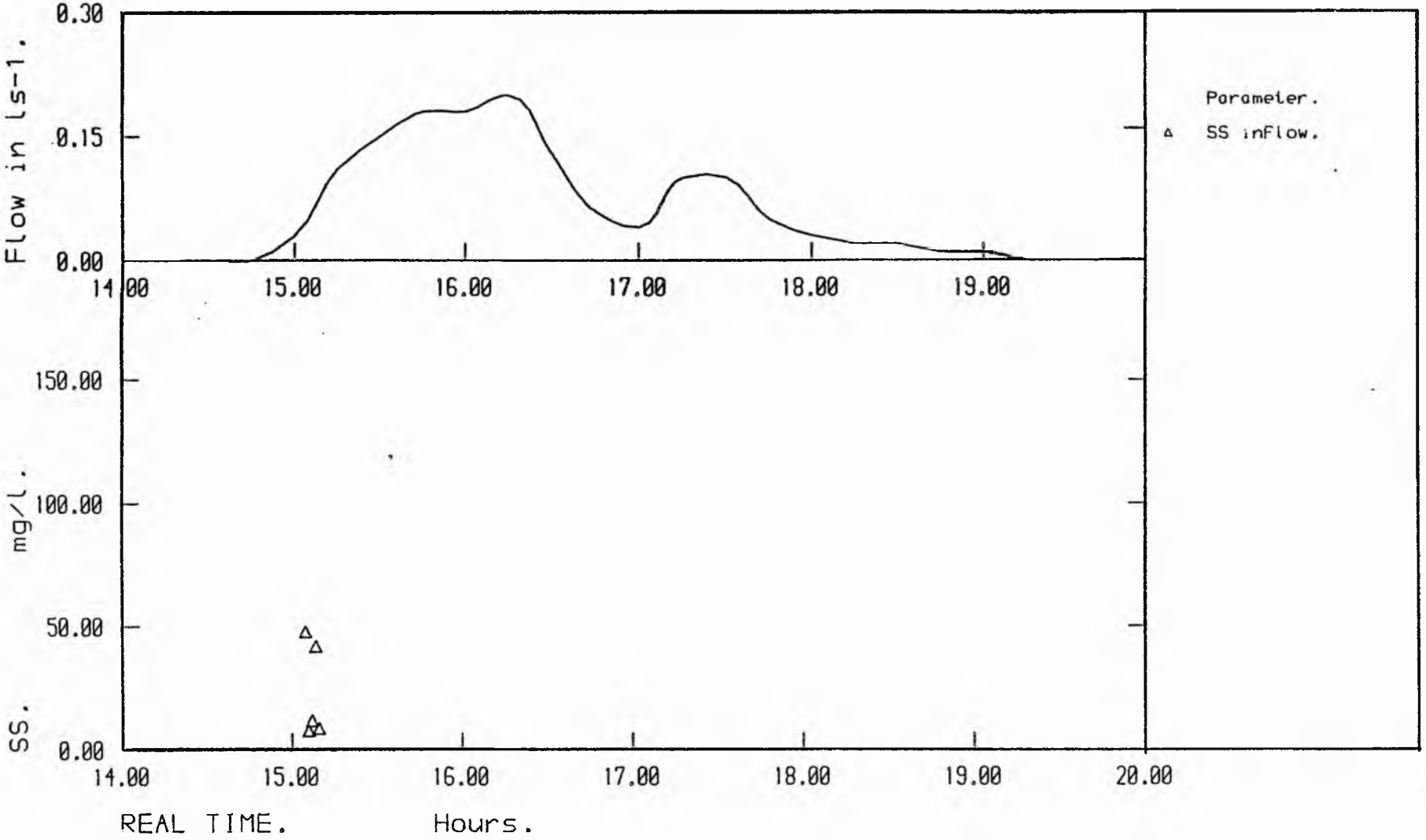
Graph of Copper for Storm XV on Tame Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

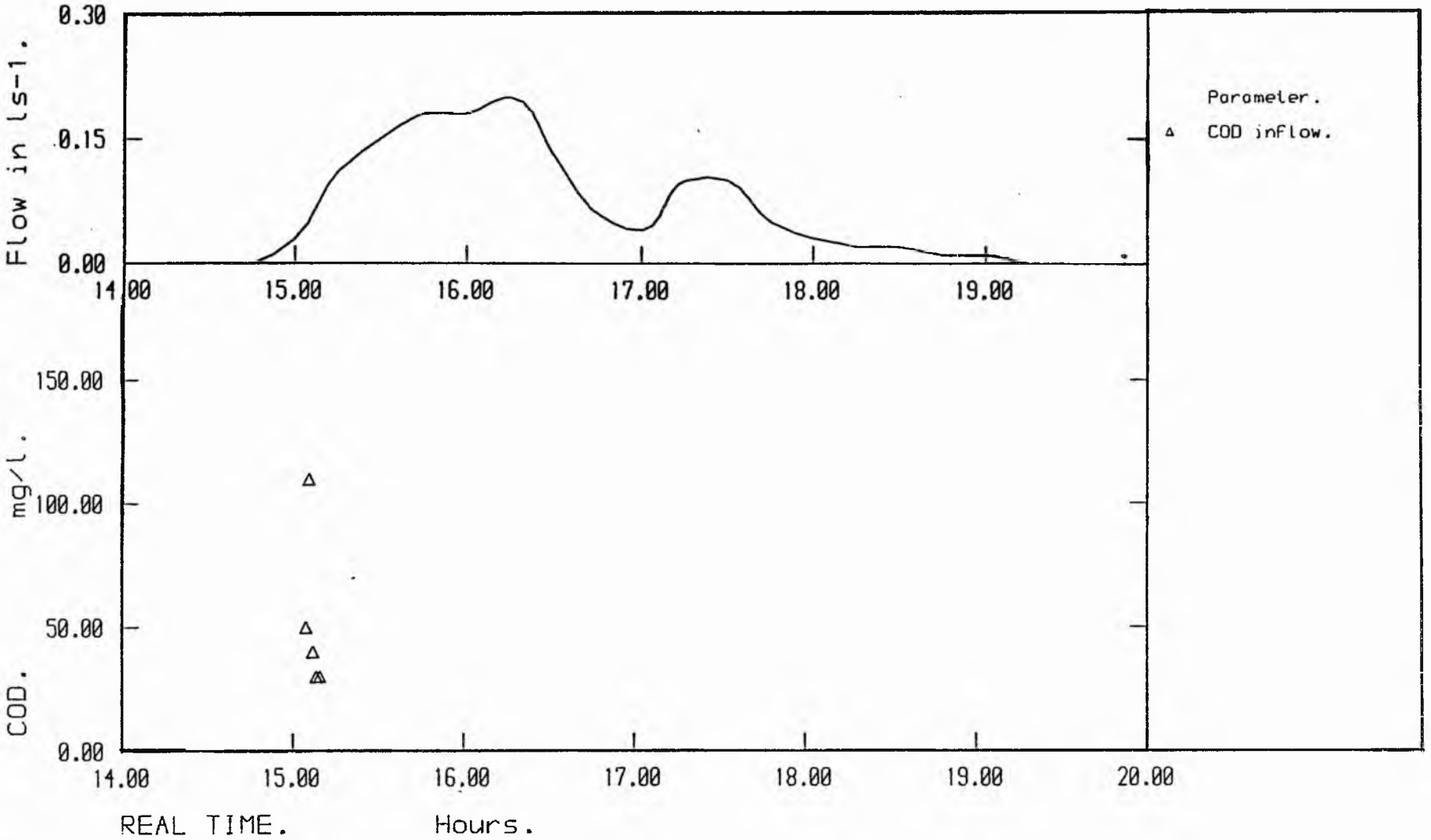
CATCHMENT : Churnet close
DATE OF THE STORM EVENT : 6th. December 1985 (851206)
STORM NUMBER : XV

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

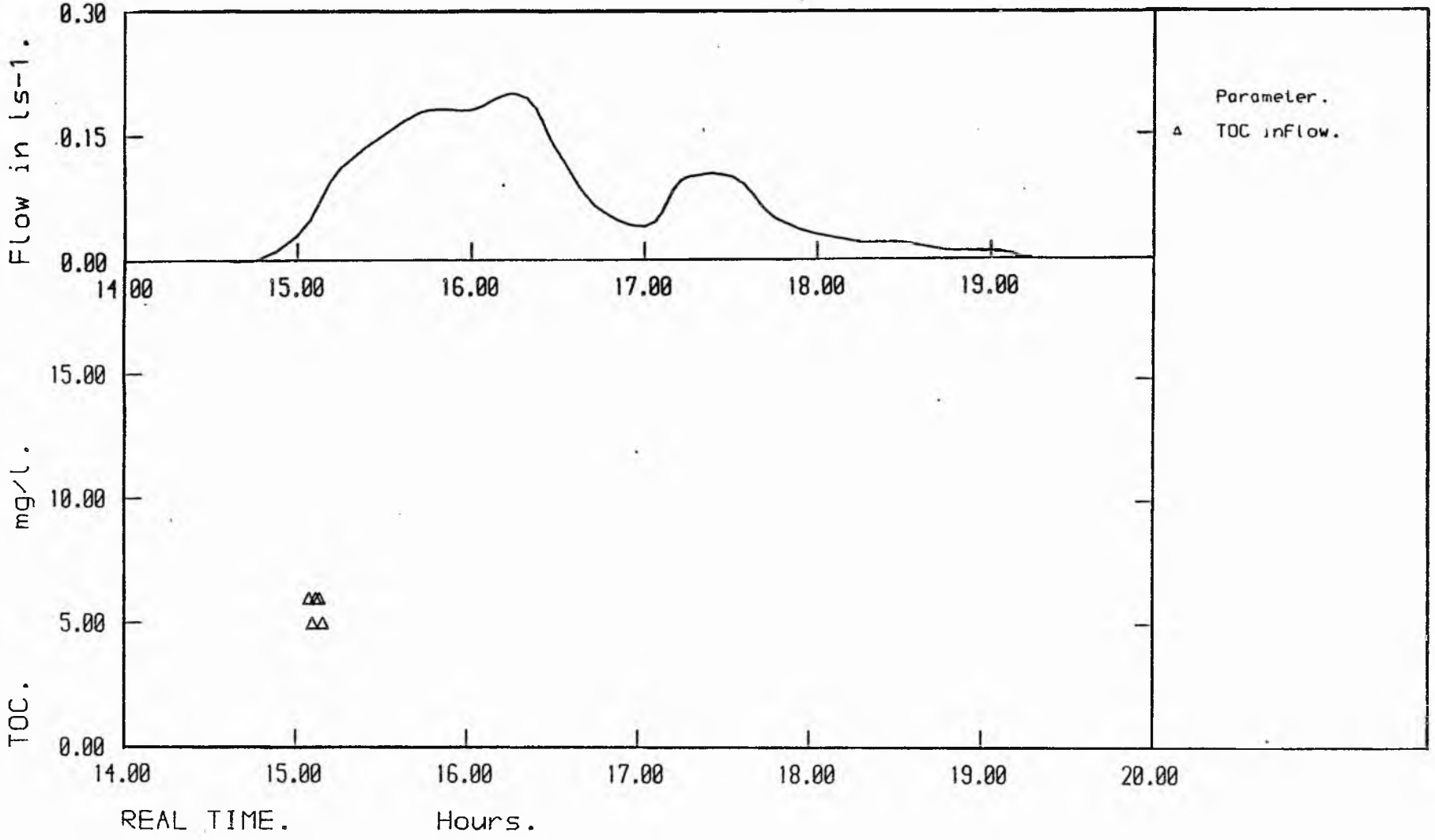
REAL TIME Hours	SS mg l-1	COD mg l-1	TOC mg l-1	Zn mg l-1
1505	48	50	6	0.08
1506	8	110	5	0.05
1507	12	40	6	0.06
1508	42	30	6	0.05
1509	9	30	5	0.04



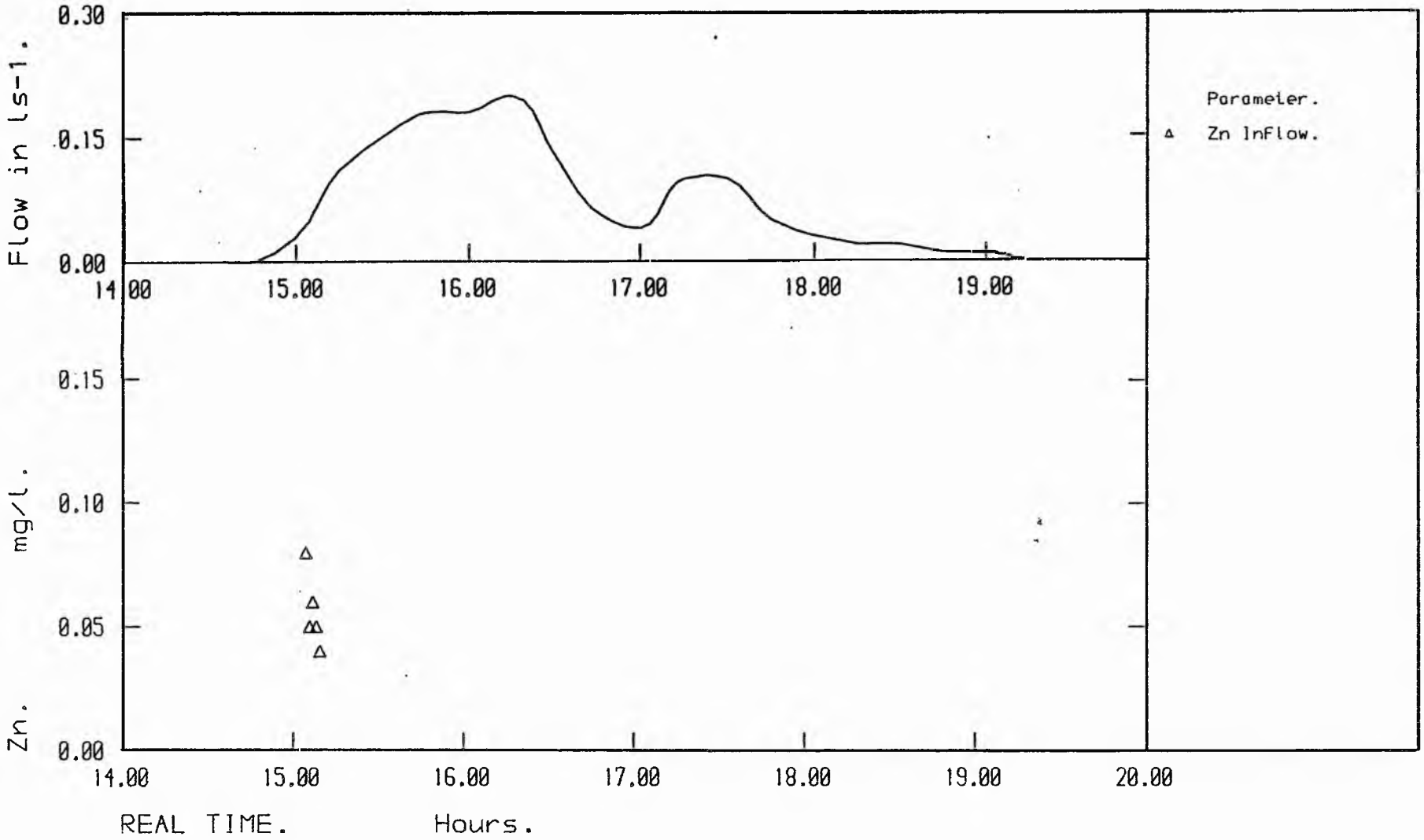
Graph of Suspended Solids For Storm XV on Churnet Close.
The graph shows inflow and outflow water quality data.



Graph of Chemical Oxygen Demand For Storm XV on Churnet Close.
The graph shows inflow and outflow water quality data.



Graph oF TOC For Storm XV on Churnet Close.
The graph shows inFlow and outFlow water quality data.



Graph of Zinc for Storm XV on Churnet Close.
The graph shows inflow and outflow water quality data.

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 6th. December 1985 (851206)
STORM NUMBER : XV

ANALYSIS OF INFLOW STORMWATER TO THE GULLY POT

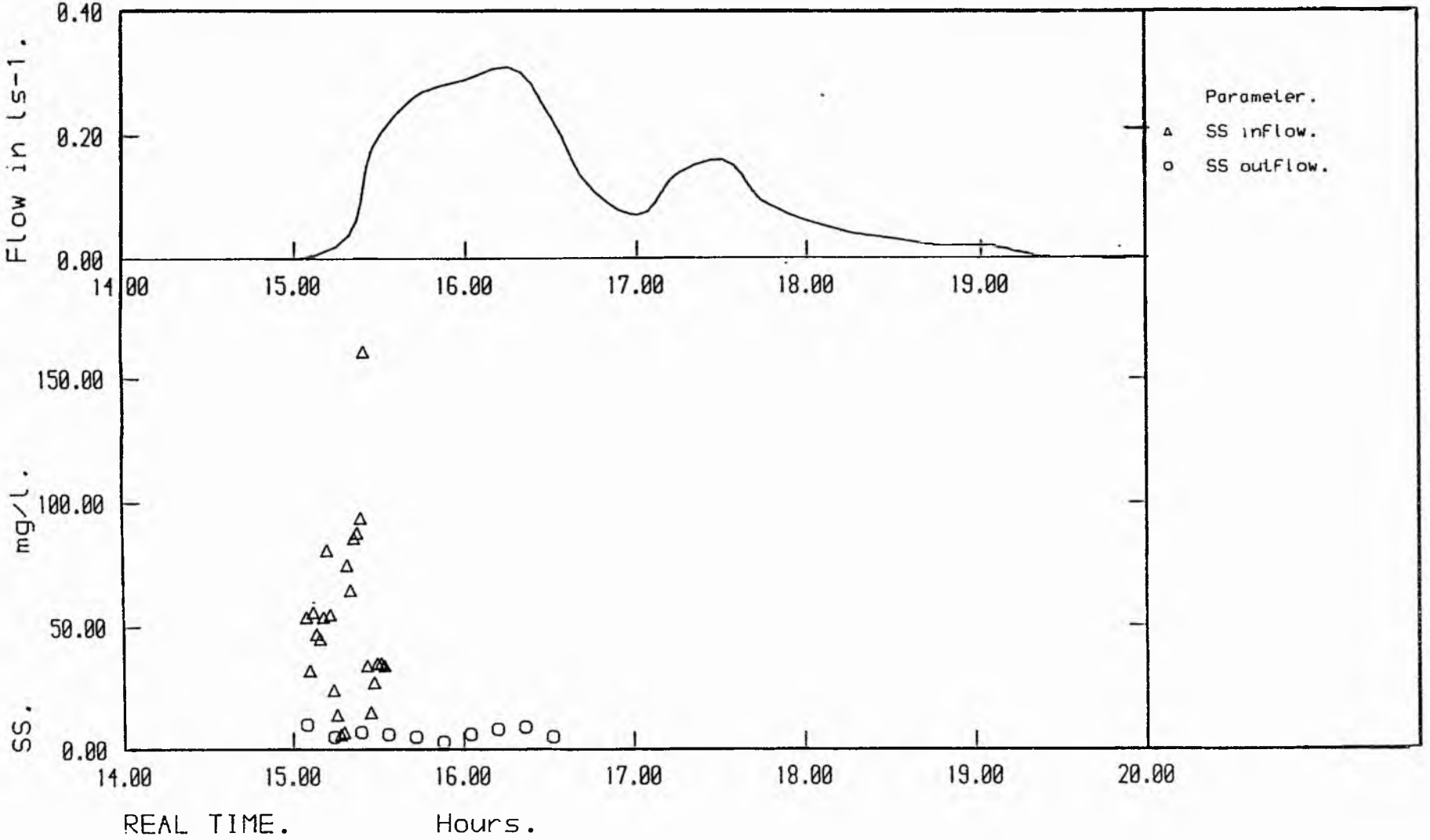
REAL TIME Hours	SS mgl-1	COD mgl-1	TOC mgl-1	Zn mgl-1
1505	54	51	10	0.18
1506	32	40	9	0.15
1507	56	20	11	0.12
1508	47	20	9	0.17
1509	45	35	8	0.11
1510	54	51	9	0.11
1511	81	51	8	0.12
1512	55	25	11	0.18
1513	24	40	9	0.11
1514	14	30	10	0.12
1515	6	25	8	0.11
1516	7	40	7	0.10
1517	75	66	7	0.15
1518	65	51	7	0.15
1519	86	25	8	0.11
1520	88	30	7	0.15
1521	94	15	8	0.11
1522	161	81	6	0.15
1523	34	61	8	0.11
1524	15	30	8	0.17
1525	27	15	11	0.17
1526	35	15	6	0.11
1527	35	40	8	0.11
1528	34	20	7	0.11

RAINSTORM ANALYSIS ON THE CLIFTON GROVE HOUSING ESTATE, NOTTINGHAM

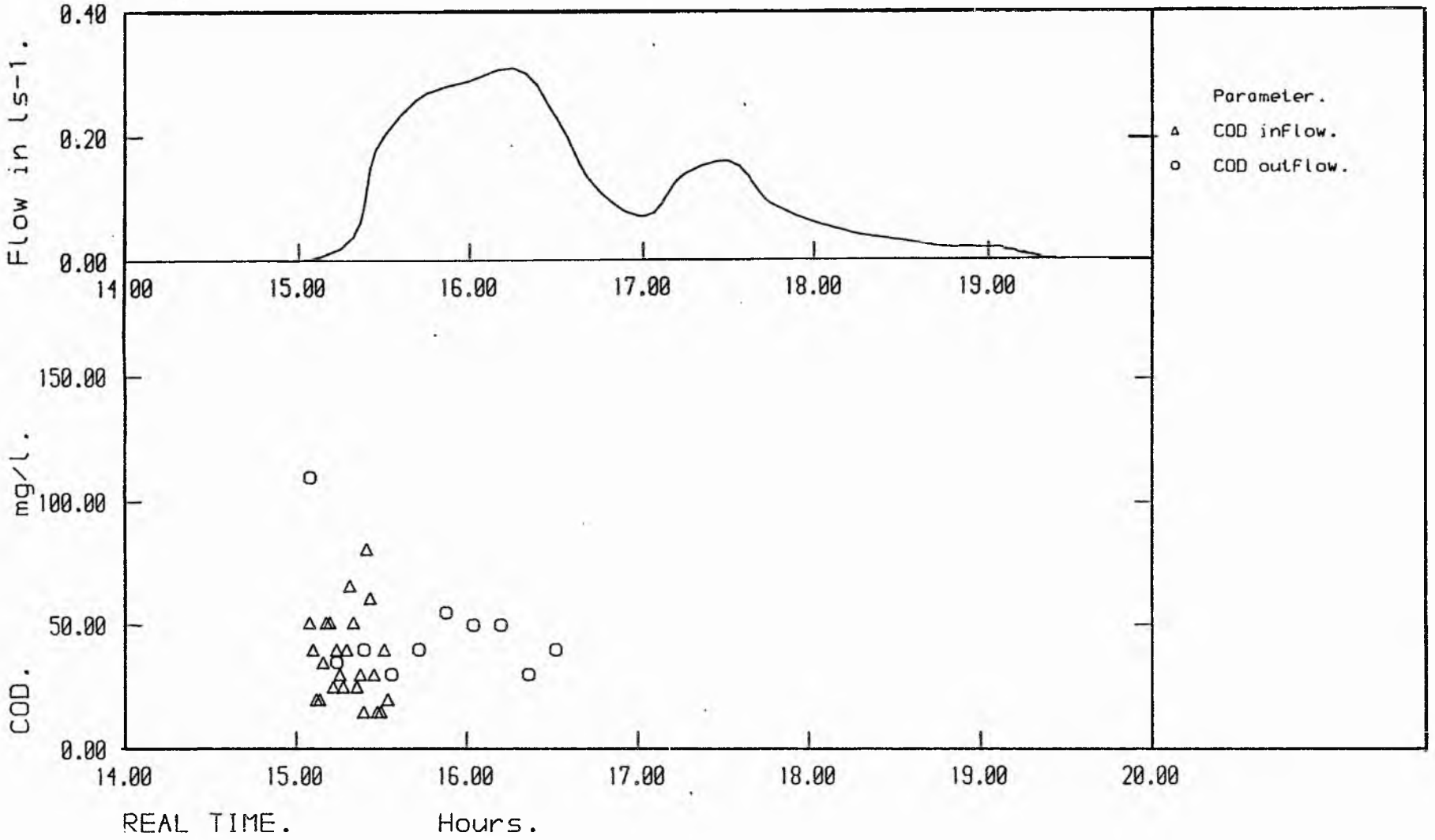
CATCHMENT : Twyford Gardens
DATE OF THE STORM EVENT : 6th. December 1985 (851206)
STORM NUMBER : XV

ANALYSIS OF OUTFLOW WATER FROM THE GULLY POT

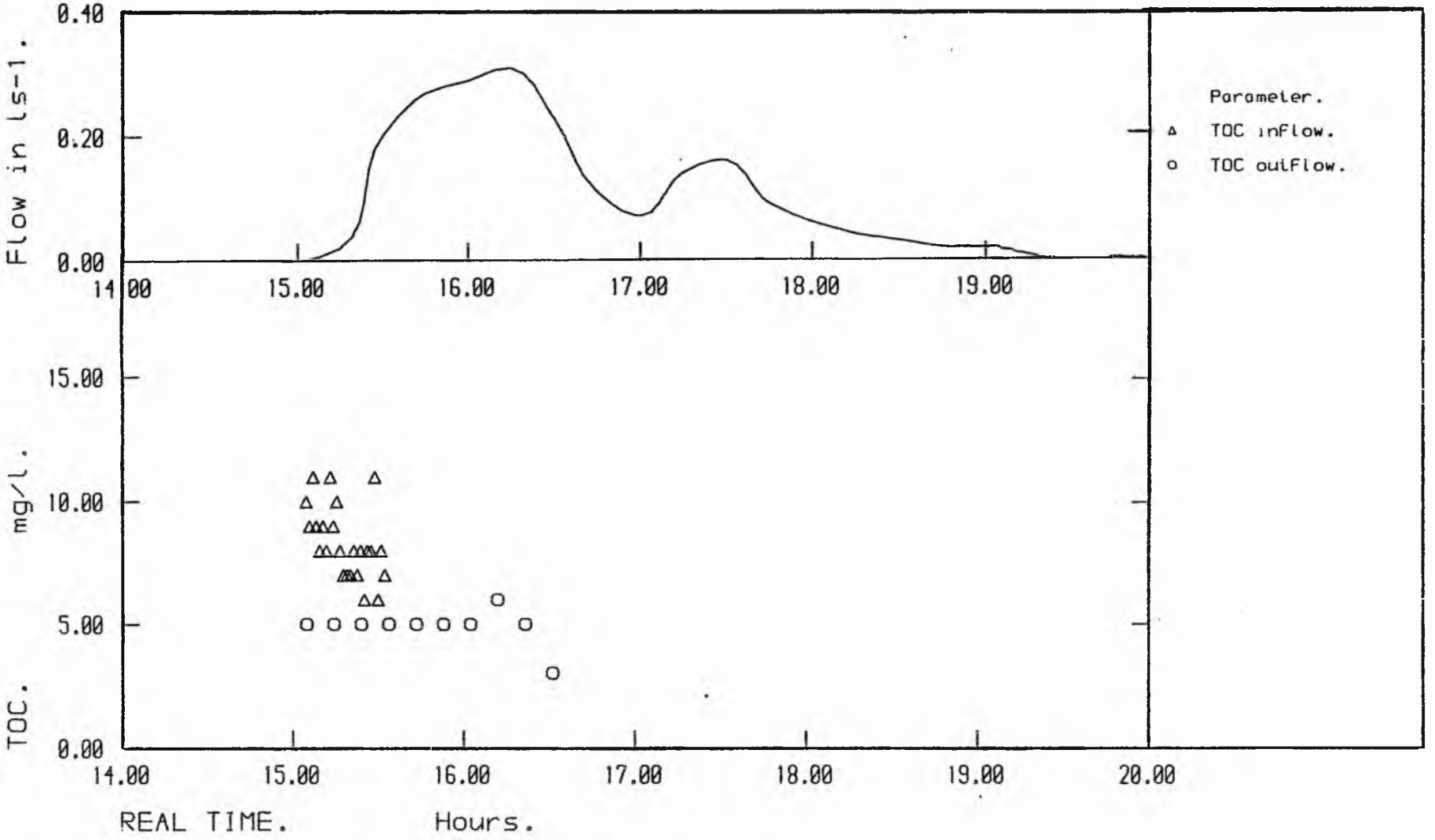
REAL TIME Hours	SS mgl-1	COD mgl-1	TOC mgl-1	Zn mgl-1
1505	10	110	5	0.12
1515	5	35	5	0.08
1525	7	40	5	0.04
1535	6	30	5	0.07
1545	5	40	5	0.03
1555	3	55	5	0.06
1605	6	50	5	0.01
1615	8	50	6	0.03
1625	9	30	5	0.06
1635	5	40	3	0.02



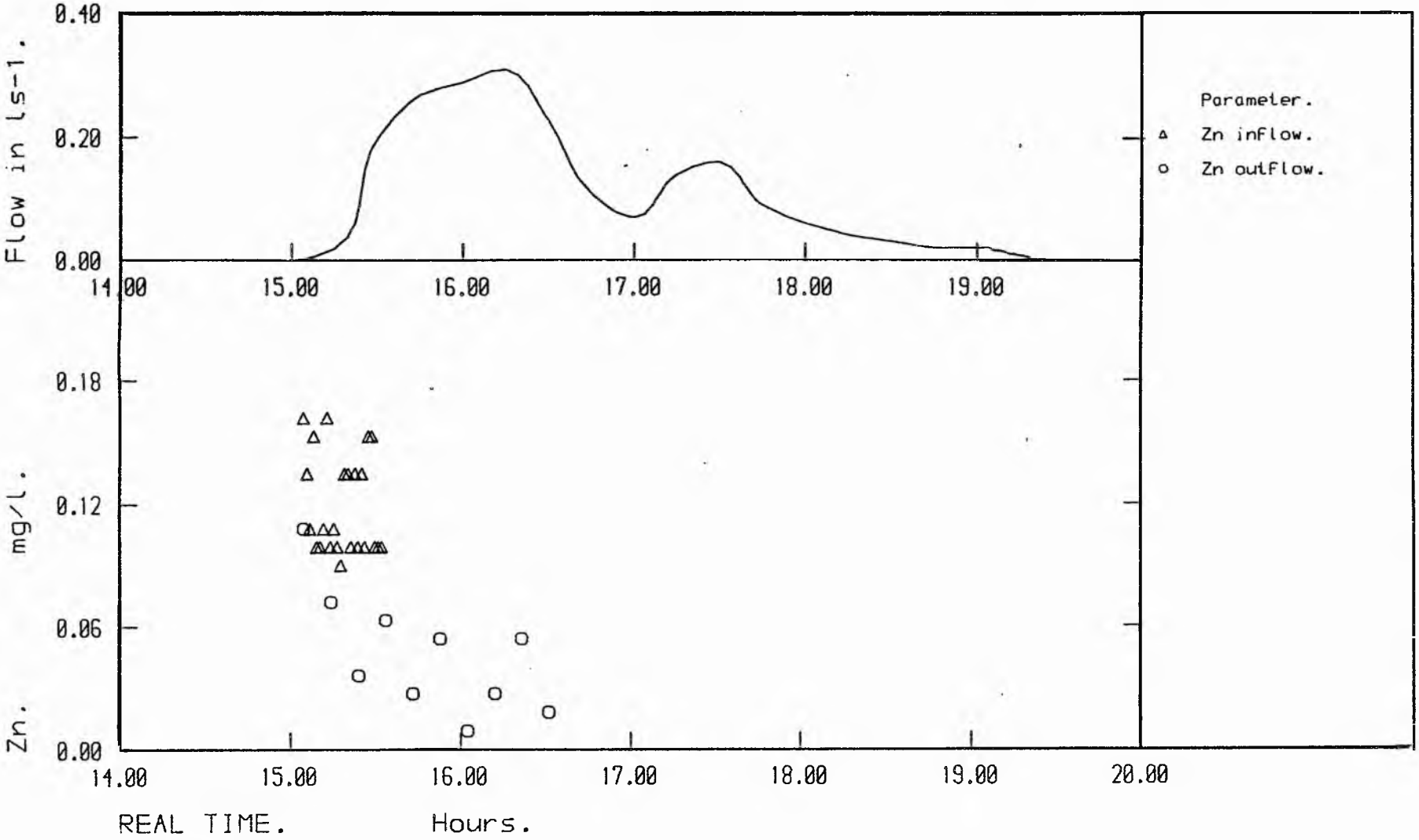
Graph of Suspended Solids for Storm XV on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Chemical Oxygen Demand for Storm XV on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of TOC for Storm XV on Twyford Gardens.
The graph shows inflow and outflow water quality data.



Graph of Zinc for Storm XV on Twyford Gardens.
The graph shows inflow and outflow water quality data.