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A review of the available data on the hydrology and a discussion of the impact of proposed drainage works

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Abram Flashes SSSI - A Review of the available data on the hydrology and a discussion of the impact of proposed drainage works

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ABSTRACT

Abram Flashes SSSI is located south of Wigan and near to the village of Abram. The flashes have been formed as the result of mining subsidence, where the land surface has progressively sunk below the water table. They now form relatively stable wetland features along the banks of the Hey Brook. Information available from the National Rivers Authority suggests that the wetlands act as a significant buffer attenuating flood flows along Hey Brook. There are more data available for water quality in the Abram Flashes area. These data would suggest that Hey Brook and Abram Flashes themselves are subject to a rising nutrient load and to sewage contamination.

Little information is available as to the extent of the proposed drainage works on the flashes, but it would appear that while ponding caused by close proximity to the water table will decrease with drainage, inundation by flood waters will continue to be a frequent occurrence. The benefits to the farmer(s) concerned would be small unless considerable works are carried out to prevent further flooding. Were the drainage works to be of a significant scale there would be impacts beyond the loss of seasonal and perennial wetland. These impacts would almost certainly involve a further decline in water quality parameters in the Abram Flashes and Pennington Flashes area.

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TABLES

1. ABRAM FLASHES : DEVELOPMENT AND MORPHOLOGY

Abram Flashes SSSI is located south of Wigan and near to the village of Abram. The flashes have been formed as the result of mining subsidence. One of the effects of removing coal or other mineral matter from a seam is to create a basin-like depression at the surface, unless measures to prevent subsidence are taken. The depression is caused by the strata overlying the seam settling into the space which was occupied by the material extracted. The settlement varies from zero at the limits of the basin to a maximum over the centre of the workings, but owing to the bulking of the strata over the seam, the maximum settlement is never as great as the thickness of the seam. The area affected, however, is greater than the area of the underground workings. The subsidence moves outwards from the centre of the depression affecting an increasingly large area. The subsidence may be progressive or in some cases extremely dramatic. Abram suffered a severe incident in April 1945, when an old shaft which had been plugged opened up and a train of mining wagons which were reversing over the area disappeared into the hole. Although the engine driver braked hard, the weight of the wagon pulled him and his engine down into the pit.

The effect of this subsidence is frequently to cause areas of flooding along low lying areas where the subsidence causes the land surface to fall close to, or below the water table. Such lakes are usually described as flashes. They are associated with salt workings as well as coal and they are a common feature in north west England. The subsidence accompanying coal mining over 300 to 400 years is responsible for the generation of Abram Flashes. Subsidence today has largely ceased although some structural damage to buildings is still apparent in the area.

Abram Flashes lie alongside Hey Brook. Beginning 30 to 40 years ago subsidence affected all of the region now designated as a SSSI. A combination of subsidence and poor drainage has caused extensive flooding in winter from Hey Brook. In the last 5 years there has been some concern that sewage contamination of Hey Brook has affected the SSSI.

2. HEY BROOK FLOW REGIMES

Hydrographic data for Hey Brook are extremely limited; there are no permanent gauging stations within the catchment and only limited spot gauging has taken place. Such data as are available are held by the National Rivers Authority, in the South Flood Defence Area office.

Hey Brook has a catchment area of 33.6 km^2 and a catchment length of 13.6 km. The principal tributaries of Hey Brook are Borsdane Brook and Brookside Brook (Figure 2.1). The catchment area is predominantly lowland below 100m with a number of small settlements. The geology is predominantly westphalian coal measures overlaid with boulder clay. The area contained a number of faults.

Spot gauging were carried out in 1981 and 1982 at three locations along Hey Brook. The data recorded are shown in Table 2.1:

Table 2.1 Spot Gauging along Hey Brook

Location	Date	Discharge (m^{3}sec^{-1})
SD 609023	11.5.81	0.279
	12.5.81	0.18
SD 608030	11.5.81	0.346
	5.10.82	1.415
SD 605015	5.10.82	1.144

Some estimates have been carried out into flood hydrographs likely to be generated in the Hey Brook catchment. These estimates were made by North West Water although the exact dates are not known. For a storm with a 5 year recurrence interval, that is a 24 hour storm with an hourly intensity of 2.16mm (51.84 in 24 hours) the estimated total flow is 690,000m^3. NWWA have made some estimates as to the storage of water held within the Flashes area, but this was carried out some time ago and the data are indicative rather than authoritative. The volume estimate of 231,000m^3 is based on predictions of the attenuation of a flood event , and is therefore, necessarily a crude estimate. It would appear to be rather high

a

may be more a measure of the maximum possible storage in a storm

event

rather than the normal volume of flood storage

3. HYDROLOGY OF THE WETLAND AREAS

The estimate of the volume of storage by North West Water, represents a maximum short-term storage available in the Hey Brook catchment for a storm with a five year recurrence interval, It is likely that the normal surface winter storage in the flash wetlands is considerably less.

Abram Flashes SSSI has components of seasonal and perennial water storage. The variation in water levels within the flashes is a factor closely governed by the flow regime of Hey Brook. For this reason it is unlikely that any control of water level at a small scale, or more generally within the SSSI could be achieved without considerable structural works. These works would involve the prevention of flooding, through bunds, levees or channel routing schemes. Clearly these would be undesirable from English Nature's point of view.

The variability of water table levels is driven primarily by the flood regime of Hey Brook rather than local groundwater variations. This has a number of implications for water quality within the wetland areas: the extent to which nutrients accumulate in a waterbody is crucially influenced by the flushing rate of that waterbody. The flash wetlands have a relatively high flushing rate overall, though individual wetland areas may be influenced only by the highest flows on Hey Brook. Whilst a high flushing rate may be seen to be beneficial , (and might well ameliorate any decline in water quality brought about by drainage, in that nutrients from agricultural land are diluted and removed) it does make the wetland system very dependent on the water quality of Hey Brook itself. Any deterioration in water quality in Hey Brook is likely to be transferred very rapidly into the wetland areas and have a direct influence on them.

There is a need to quantify the storage and release of water in Abram Flashes. This would involve:

(i) a characterisation of the flow regime of Hey Brook, with particular regard to the frequency of flood events;

(ii) some quantification of the depression storage available for floodwaters. This would involve some measurement or estimation of the water table : volume of storage table for at least some of the wetland areas;

(iii) a consideration of the volume of water entering the wetland areas from sources other than Hey Brook. At present this would appear to be low but some quantification is essential;

(iv) a consideration of recession rates in the wetland areas through
- groundwater losses, and
- return flow into Hey Brook

It would appear that groundwater losses are very low, but it should be noted that this report covers an analysis of the wetland areas over two months in winter.

4. WATER QUALITY

Whilst hydrometric data for the Abram flash complex is scarce, Wigan Metropolitan Borough Council do collect water samples for analysis by Greater Manchester Scientific Services. Data are collected on:

pH
Ammoniacal nitrogen
Albuminoid nitrogen
Nitrous nitrogen
Nitric nitrogen
Oxygen absorbed (4 hours @ 27 degrees Celsius)
Total hardness ($CaCo^3$)
Alkalinity ($CaCo^3$)
Chloride
Sulphate
E. Coli

Samples are collected from three sites around Pennington Flash:

1) Hey Brook at Slag Lane, Lowton
2) Leigh Sailing Club Jetty
3) Pennington Brook at Pennington Park

A small number of samples exist at Wigan Sailing club Jetty and at a site between the two jetties. A summary of the data supplied by Wigan MBC is provided in table 4.1.

Figures 4.1 to 4.12 show the levels found at each site of the parameters measured throughout the recording period. It should be noted in examining these graphs that the lower axis is compressed, due to the spread of sampling dates, so that part of the axis representing 1991 is considerably longer than that representing 1992.

It is difficult to draw firm conclusions about the overall water quality regime without the availability of flow data to match the water quality data, as concentrations of dissolved material vary with the amount of water present, thus the same input of material to a stream will give different concentrations depending on whether low or high flow conditions dominate.

It would also be unwise to extrapolate a precise water quality regime for the entire complex on the basis of three sampling points and a poorly stratified sampling regime. Although the data are presented as a temporal continuum, there is always the possibility that, because of the spread of sampling dates, each day's data may simply be a 'snapshot' of unique conditions on that date, rather than part of a general trend.

Having made these reservations, the following features can be observed from table 4.1 and figures 4.1-4.13.

4.1 pH

The pH range experienced suggests very alkaline water, surprisingly so considering the nature of the local geology. pH is nearest to neutral in Hey Brook. Hey Brook pH fluctuates much less than the Leigh jetty and Pennington Brook sites and peaks in early summer and winter. Annual pH distributions are much less well defined for the other two sites, except for a general fall in pH towards neutral from summer 1991 onwards.

4.2 Conductivity

Conductivity can indicate the content of ionizable salts in river waters due to e.g. oil and chemical waste. As with pH, conductivity levels in Hey Brook are lower than at the other two sites, although with a similar range. The pattern of conductivity readings at Leigh Jetty and Pennington Brook are almost identical, and show discernible, but not marked, Spring and Autumn peaks in 1991. Any seasonal patterns in Hey Brook, other than a general upward trend between March and June 1991 (possibly from decreasing flow in the summer dry period), are obscured by wide fluctuations between readings during the remainder of the period of record.

4.3 Ammoniacal Nitrogen

Ammoniacal nitrogen is generally derived from the decomposition of nitrogenous organic matter. Values greater than 0.2 mg/l are a good indication of sewage contamination, and values larger than 5 mg/l may prove dangerous to fish. Most values are less than the 5 mg/l danger level, but are frequently larger than those indicating sewage contamination. Values for Hey Brook are consistently higher than those at the other two sampling sites, with Pennington generally the lowest of the three. This feature may indicate the role of Pennington Flash in attenuating water quality, although it should always be borne in mind that a much better indication of the quality of the Flash would be from readings in open water and at various depths, away from the immediate influence of lake-shore contributions of nutrients.

Two other features are of interest. Firstly, there is a marked rise in levels at all three sites in June/July 1991, which may indicate a serious pollution incident. Secondly, there is an apparent trend towards increasing levels throughout 1992, but previous caveats should be applied.

4.4 Albuminoid Nitrogen

As with ammoniacal nitrogen, values of albuminoid nitrogen greater than 0.2 mg/l are a good indication of sewage contamination, although decaying vegetation may give seasonally high values, and it is clear from the graph that almost all values are above this level. Albuminoid nitrogen levels show a different pattern to ammoniacal nitrogen levels.

Up until July 1991, Hey Brook experiences higher levels of albuminoid nitrogen than at the other two sites, with a marked peak in that month not exhibited elsewhere, although Leigh Jetty and Pennington Brook show maxima some two months later. All three sites exhibit suspiciously similar values after the Hey Brook maximum, and if this is ignored then levels in Hey Brook fall to values mid-way between Leigh Jetty and Pennington Brook levels, with all three sites showing a general decline throughout 1992.

4.5 Nitric Nitrogen

Nitric nitrogen measures all oxidised nitrogen, and values give little indication of any overall patter. Hey Brook values are generally, although not universally higher, than those at the other two sites, showing a small peak in early Autumn 1991, with a marked peak in early 1992. Pennington Brook values reach a maximum in late Spring 1991 and begin to rise again in late 1992.

4.6 Ammoniacal:Albuminoid Nitrogen

Where sewage has contaminated water, ammoniacal nitrogen forms a greater proportion of total nitrogen than does albuminoid nitrogen, so that the ammoniacal:albuminoid ration will be high. Vegetable based organic contributions, e.g. from peaty waters, contributes relatively more albuminoid nitrogen and thus values of the ratio will be low.

The pattern of data is very similar to the pattern for ammoniacal nitrogen, indicating its relative importance to total nitrogen in Pennington Flash. The ratio in Hey Brook shows a general rising trend in the early part of 1991, with a marked peak in July 1991. This, again suggests a serious sewage contamination event upstream of the flash, but the concentrating effects of Summer low flow cannot be discounted.

Pennington Brook shows a prolonged rise in the ratio in late Spring 1991, and this may result from an earlier input from Hey Brook passing through the flash, or sewage contamination immediately upstream of the sampling point. Apart from this rise, Leigh Jetty and Pennington Brook samples are very similar, showing Spring and Autumn minima consistent with dilution by higher flow levels. The Autumn decline in the ratio may also result from inputs from decaying vegetation. There is a general rising trend in ratio at all sites throughout 1992 that may indicate increasing contamination since January 1992.

4.7 Oxygen uptake

This value should not exceed 3-5 ppm in stream water, and streams can be considered clean where values fall between 0-3 ppm. With the exception of one reading from Hey Brook in March 1991, all readings from all sites fall below 5 ppm, and most fall into the 'clean' category.

Hey Brook again shows the mid-summer peak found in other quality indicators, indicating an increase in organic load to Hey Brook. Levels begin to rise again in late Autumn 1991, reaching a peak in November 1992. Leigh Jetty and Pennington Brook samples are consistently lower than Hey Brook, again indicating a possible attenuating effect of the Flash. Leigh Jetty and Pennington Brook samples also seem to follow the general upward trend in oxygen absorption capacity of the water.

<u>4.8 Total hardness</u>

Total hardness is the sum of the concentrations of magnesium and calcium ions, and represents the ability of water to absorb soap, the higher the hardness value, the more soap needed to produce a froth.

All samples fall into the 'hard' category, and the majority fall into the 'very hard' category, a surprising feature given the nature of the local geology. Increased hardness in groundwaters may indicate the presence of oxygen consuming organic matter, but the applicability of this work to Pennington data is not clear.

There are few discernible patterns to total hardness data. Hey Brook data fluctuate considerably but seem to begin to show a general decline from late 1991 onwards. Leigh Jetty and Pennington Brook samples are very similar, more stable, and also show a declining trend from late 1991 onwards.

<u>4.9 Alkalinity</u>

Alkalininty measures the actual quantity of alkali present in a sample, rather than the intensity of alkalinity given by a pH value. Alkalinity can be used as an indicator of sewage contamination, with oxidation of organic material decreasing the alkalinity of the water by converting oxygen in bicarbonate ions, leaving carbonate ions. Examination of figure 4.9 in conjunction with figure 4.7 does suggest a coincidence of oxygen uptake peaks with alkalinity troughs.

Alkalinity in Hey Brook shows a rising trend in Spring 1991, peaking in May, before declining again, entering a period of extreme flux in September. Leigh Jetty and Pennington Brook samples are generally lower in alkalinity than Hey Brook throughout 1991 and correspond well with each other. The generally lower level (indicating organic processing) may indicate algal activity within the Flash, although this suggestion is made with caution.

All three sites show a general decline throughout 1992.

4.10 Chloride

Chloride occurs in urine as sodium chloride, hence its presence in water indicates sewage or farm waste contamination, and values in Klein (1959) suggests that the chloride content of Pennington flash is equivalent to that of medium to strong sewage (100-500 ppm), compared to that found in unpolluted river water of up to 15 ppm. Data in Bond & Straub (1973) suggests that lake water should never exceed 15 ppm of chloride.

Pennington data are clearly very high, and suggest either that the data is in error or that there is serious effluent contamination within the Flash. The former may in part be true as the maximum chloride (324ppm) value was recorded only 15 minutes after a previous sample at Pennington Brook with a more representative 134 ppm, but even so the general chloride level seems excessive.

Hey Brook chloride levels are much lower than at Leigh Jetty and Pennington Brook, and apparently much more stable. Ignoring the April maximum for Pennington Brook, the other two sites are consistently four times greater than Hey Brook for most of 1991, but begin to decline through 1992 towards the Hey Brook value.

4.11 Sulphate

Data for sulphate content are less frequently available than for other parameters, and it would therefore be unwise to draw precise conclusions. That said, it does seem that sulphate levels are declining at all sites, although they are still considerably higher than the 50 ppm permissible limit suggested in Bond & Straub (1973).

4.12 E. Coli

Escherichia Coli is the only indicator organism accepted as being of solely foecal origin, in the UK. The EEC guideline for recreational waters is 100 FC $100ml^{-1}$. E. Coli counts are a direct indication of the presence of sewage in water. Data in Bond & Straub (1973) suggest a maximum permissible limit of 2500, and counts of over 1000 would seriously affect the suitability of the water for recreation.

Data for all sites suggest that E. Coli counts were at acceptable levels until September 1991, after which recorded levels apparently begin to increase sharply. Levels in Hey Brook seem particularly high, and should give cause for concern. Leigh Jetty levels are also higher than desirable, particularly given that this is a point where regular human contact with the water by sailing enthusiasts is unavoidable.

4.2 Conclusions

All water quality parameters measured by Greater Manchester Scientific Services on samples taken by Wigan Metropolitan Borough Council confirm observations on record sheets that sewage contamination is occurring in the Hey Brook catchment, particularly upstream of Pennington Flash, and probably from disused sewage treatment works. There are grounds for suggesting that Pennington Flash is acting as a buffer, moderating a number of water quality parameters as water passes through the system.

These data are of direct relevance to Abram Flashes and to Pennington Flash itself. A decline in water quality standards in Hey Brook and Abram Flashes is certainly of immediate concern to English Nature. Under the governments proposals for river quality (DOE , 1992) Abram Flashes would be classified under the special ecosystem use class. Standards for this class are being developed by English Nature and NRA, according to the special requirements of sites requiring protection for nature conservation reasons. It is likely that these standards will cover organic pollutants and nutrient levels and take the form of a matrix of possible standards, from which individual standards would be selected on a site-specific basis. English Nature has, in consultation with the Countryside Council for Wales and the Joint Nature Conservation Committee, undertaken studies into water quality aspects of rivers and wetlands of nature conservation importance, and standards are being finalised. When these standards become available it should be clear as the extent of the deterioration of water quality in Hey Brook.

5. Impact of Proposed Drainage.

Discussions with English Nature suggested that there are plans to drain land within the Abram flashes, There are numerous impacts of such proposals that have a direct impact on the area to be drained and on downstream sites.

5.1 Hydrological impacts on the flash.

The localised depressions created by mining subsidence act as surface water storage sites within the Abram Flashes complex. The ponds, and their associated wetlands, act as flood peak moderators for the Hey Brook basin. The poorly defined channel network and large catchment area combine to generate large volumes of surface run-off, with associated nutrient and sediment loads, focusing into relatively small areas. Surface depressions store this run-off, gradually reducing the flood peak as the run-off is carried downstream to the basin outlet.

It must be stressed that, while ponding caused by close proximity of the water table to the surface will decrease with drainage, inundation by floodwaters will continue to be a regular occurrence. This is because the focusing of run-off into small areas, with associated flooding, is an inevitable consequence of the current topography of the region (Kittelson, 1988). Any drainage works will serve only to render the current permanent ponding temporary, so that severe rainfall events will continue to flood the fields in question. Such flooding will occur as run-off from the adjacent fields focuses in the depression, and from Hey Brook. Visual evidence at Hey Brook does suggest sufficient channel adjustment to cope with quite high flow levels, but flattened vegetation and strand-lines indicate breaches in the channel on a regular basis.

Ditches and drains reduce the moderating impact of such depressions by speeding water removal from the soil surface (Seuna, 1980). If the desired end result is to completely drain the flash on a permanent basis then all fields will need boundary ditches, and probably under-drainage, with levees along the affected part of Hey Brook, as have been constructed elsewhere, to contain all levels of flow. Many fields adjacent to the flashes do have ditches, but site records indicate that many of these ditches have become blocked and are presumably inactive.

The draining of the flash concerned would have secondary impacts on water quality. In addition to their role as floodwater buffers, wetlands are extremely efficient natural water treatment areas (Bastian & Benforado, 1988). As inflowing water is stilled, associated nutrients and contaminants are removed by:

- Increased aquatic and standing biomass

- Oxidation and reduction processes

- Adsorption to sediment surfaces

These processes are aided by prolonged contact with a large sediment body, and even distribution of inflowing water by the network of dense vegetation over a wider area. The end impact of these processes is that outflow from wetland areas is considerably less enriched by agricultural and other contaminants than inflows. This buffering role of the wetland areas in the Abram flashes is likely to be of particular significance given the large area of arable land adjacent to them.

A number of post-drainage impacts are also likely within the currently ponded area. As the water subsides, sediment (with its associated organic component and nutrient complexes) is likely to be released. Anaerobic decay of newly exposed organic material will release nitrogen and sulphur compounds downstream (Hornung & Adamson, 1987). If a stream channel is maintained through the wetland and ponded area then chemicals previously locked within the sediments, and by-products from the decay of biomass, will pass downstream, ultimately to Pennington Flash.

The additional nutrient load to Pennington Flash may well prove insignificant if a small area is to be drained, but wholesale drainage of a number of the flashes may well lead to excessive levels of organic compounds in Pennington Flash. The site file at English Nature's Blackrod office notes examples of pig slurry being added to Dover Flash to encourage bloodworms for angling, and the drainage impacts described above would be particularly important where this has occurred. Such slurry additions may also have a bearing on water quality levels downstream of the flashes, given the data presented in section 4.

Additional drainage channels, in the form of ditches, may also add to the nutrient load of Pennington Flash by increasing flow levels in Hey Brook. Maps obtained from the National Rivers Authority indicate that most, if not all, of the bed of Hey Brook consists of soft material deposited due to the shallow gradient. A more speedy dispersal of flows from the flashes will increase the erosive power of Hey Brook, removing this sediment towards Pennington Flash and eroding channel banks. Additional sedimentary material will be provided by spoil from the ditching process until the new ditch banks stabilise (Asken & Williams, 1984). Again, it must be stressed that if only one flash is to be drained then the net impact may not be great, but a large-scale programme of drainage works will alter the flow characteristics of Hey Brook and pass current channel bed and bank material towards Pennington.

6. Conclusions and Recommendations

1. Abram Flashes SSSI has a significant role in the amelioration and attentuation of flood events on Hey Brook.

2. The benefit of any drainage scheme to the farmers owning land on the Abram Flashes SSSI would be minimal unless significant action was taken to prevent flooding during winter. This would involve some considerable cost to the farmer.

3. The impact on the SSSI of proposed drainage schemes would involve a deterioration in water quality.

4. Sampling would indicate that water quality is declining generally in the Hey Brook, Abram Flash and Pennington Flash region. Any further decline should represent a significant concern to English Nature. In fact the evidence for sewage contamination of Hey Brook and therefore Abram Flashes is possibly a more immediate concern than the proposed drainage schemes.

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Organizations & Persons Contacted

English Nature - Blackrod and Wakefield offices site files.

NRA - North West Region South Area - maps, plans, hydrological data.

Wigan M.B.C. - Sheena Cromby (Ecologist)
- Gary Bell (Environmental Health) - Pollution data
- Colin James (Main Drainage Dep't.)
- Dennis McBride (Planning)

British Waterworks Board - Northwich office

Greater Manchester Scientific Services

British Coal - Estates
Archives
Surveyors

Wigan Heritage Service Archives, Town Hall Leigh

Wigan Technical College - S. Hewitt

ABRAM FLASHES CATCHMENT AREA

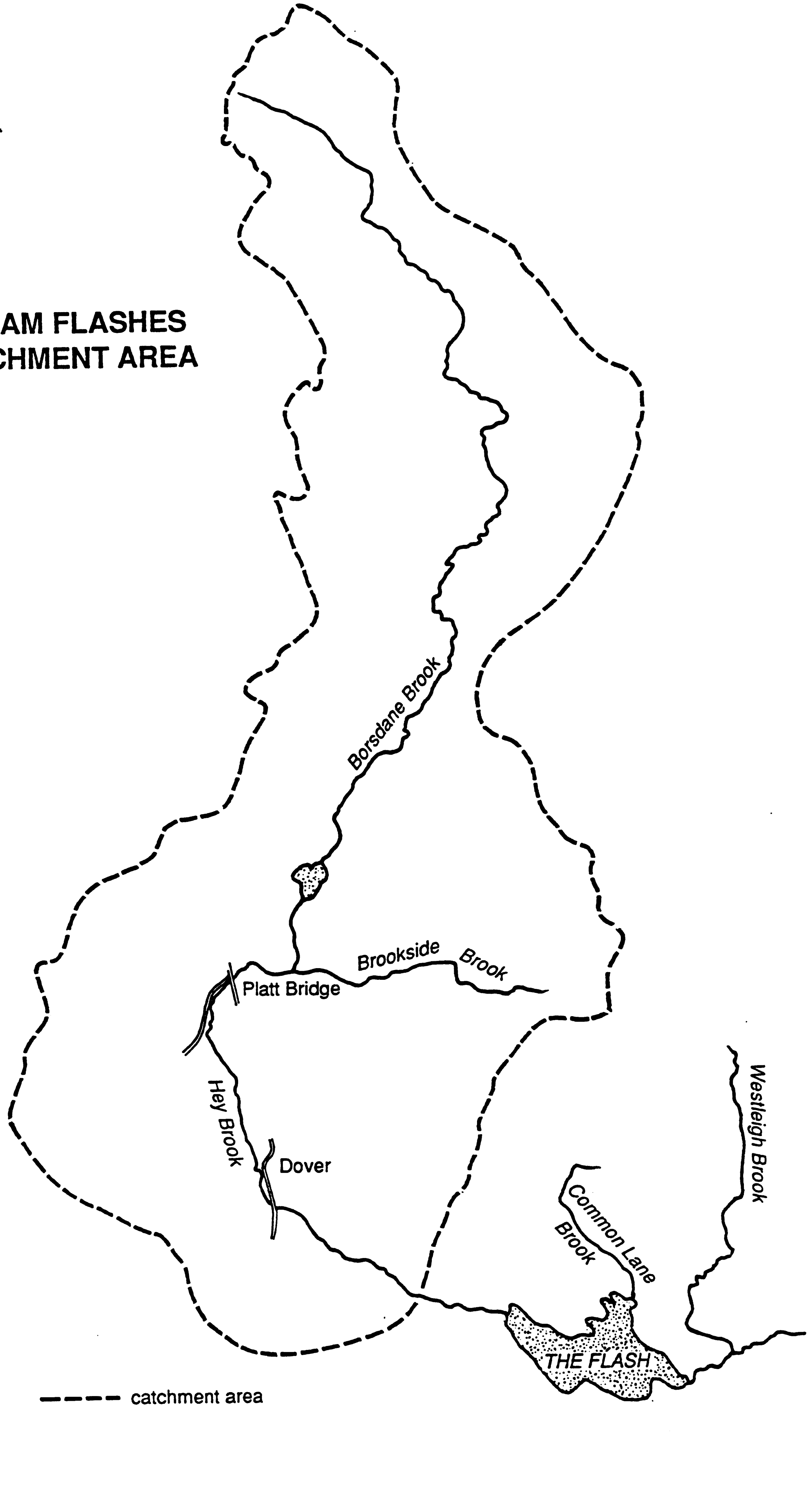


Fig. 4.1

pH at Pennington Flash 1991-1993

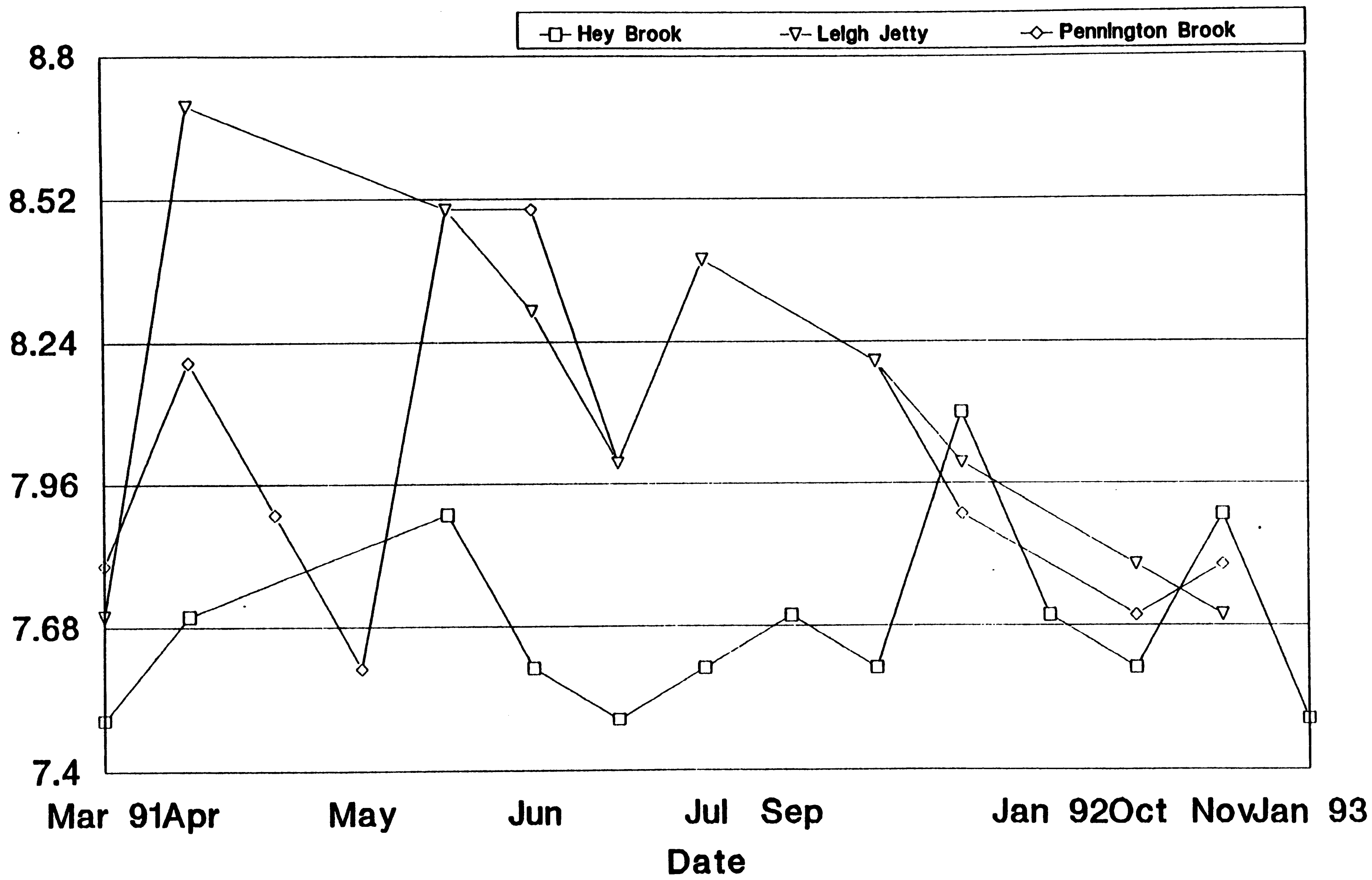


Fig. 4.2

Conductivity at Pennington Flash 1991-1993

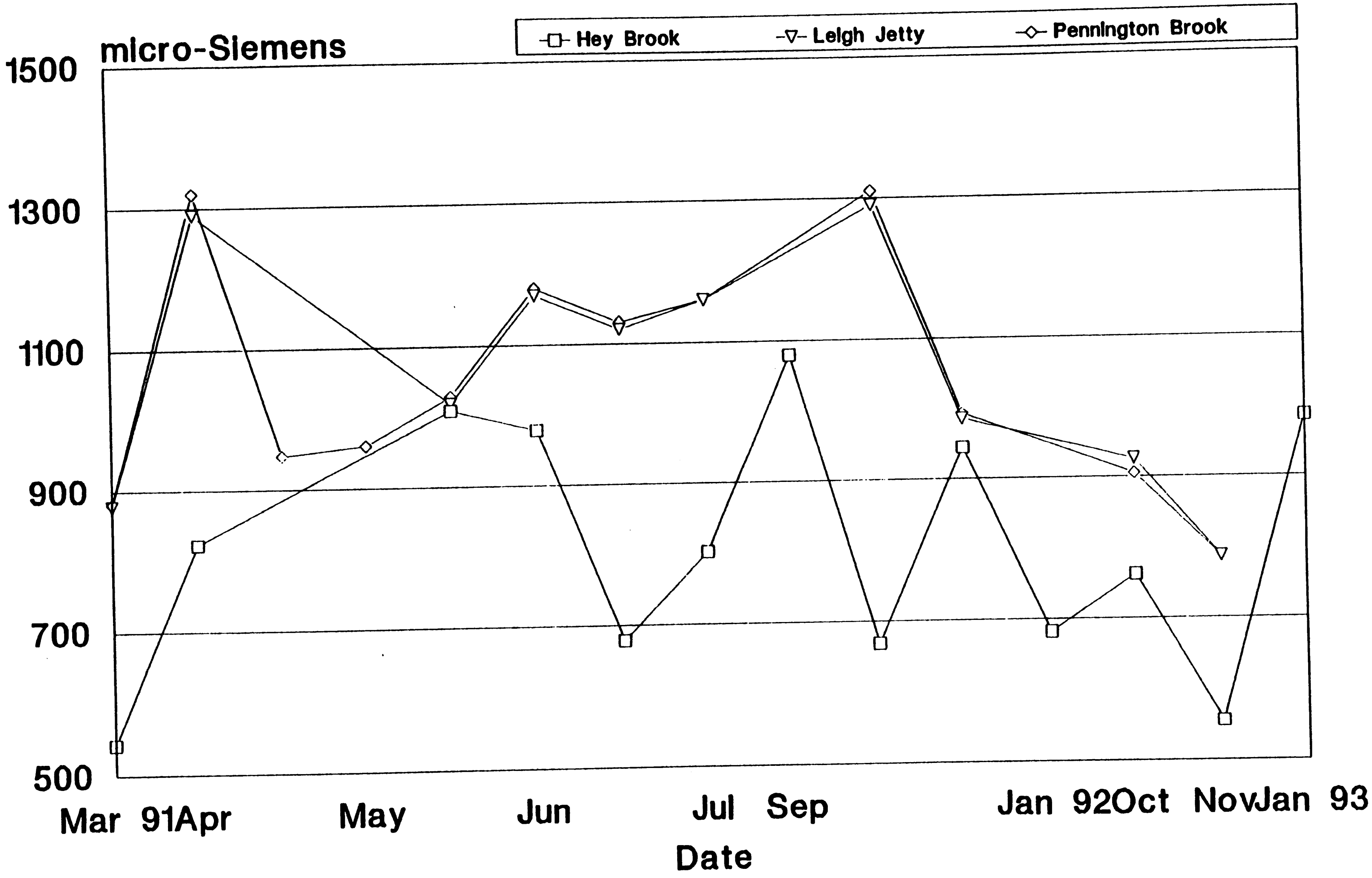


Fig. 4.3

Ammoniacal Nitrogen at Pennington Flash 1991-1993

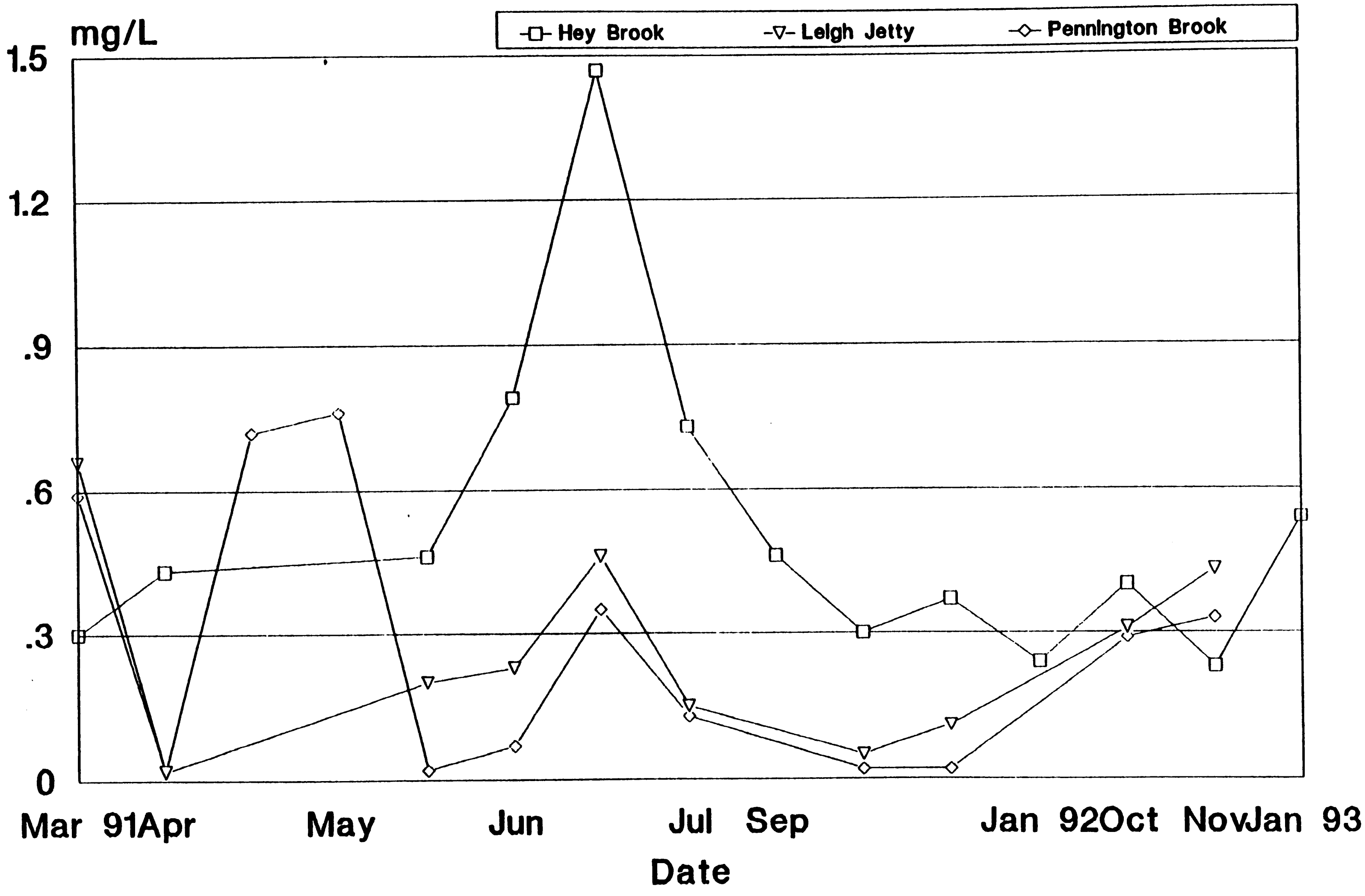


Fig. 4.4

Albuminoid Nitrogen at Pennington Flash 1991-1993

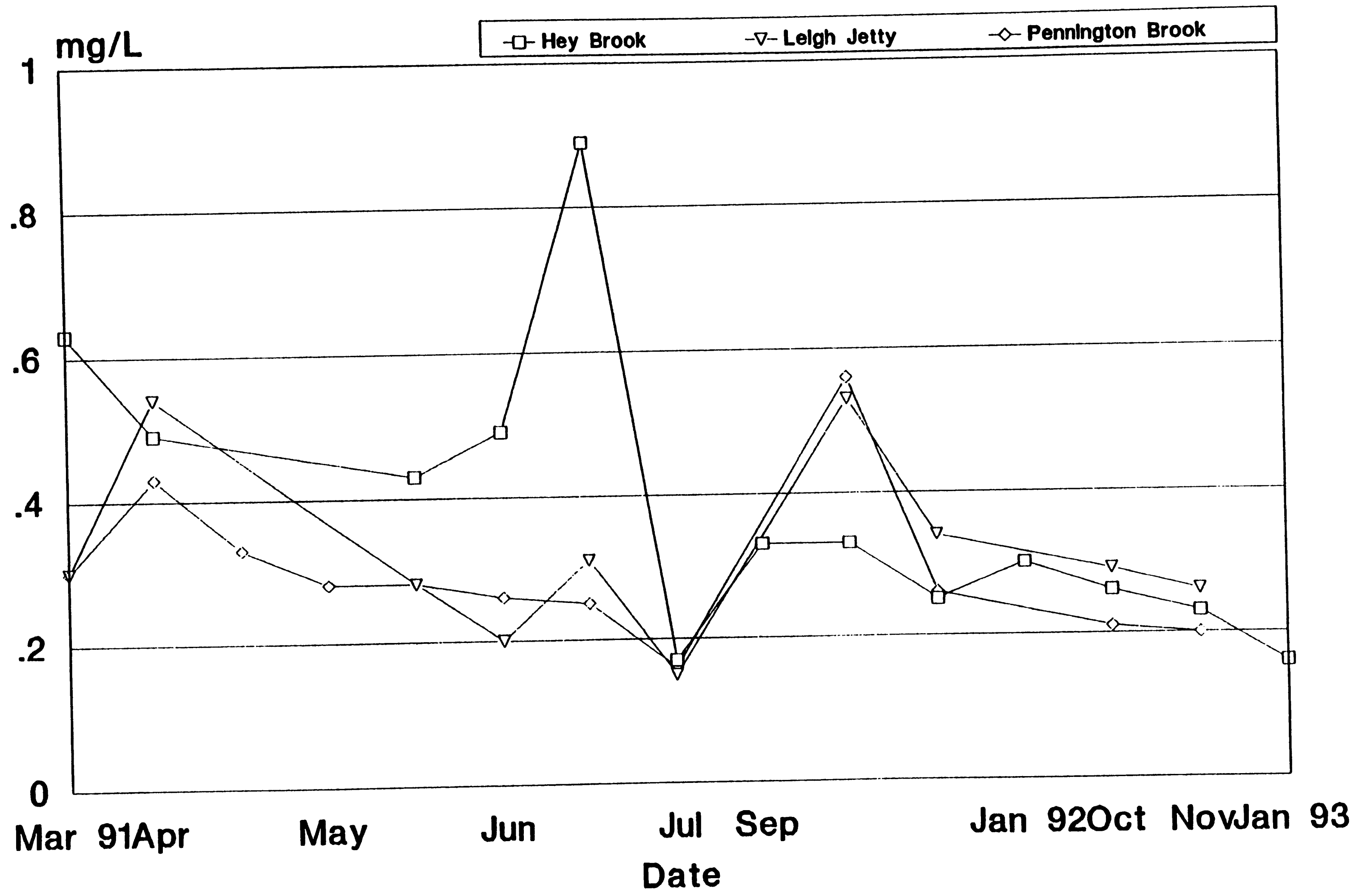


Fig. 4.5

Nitric Nitrogen at Pennington Flash 1991-1993

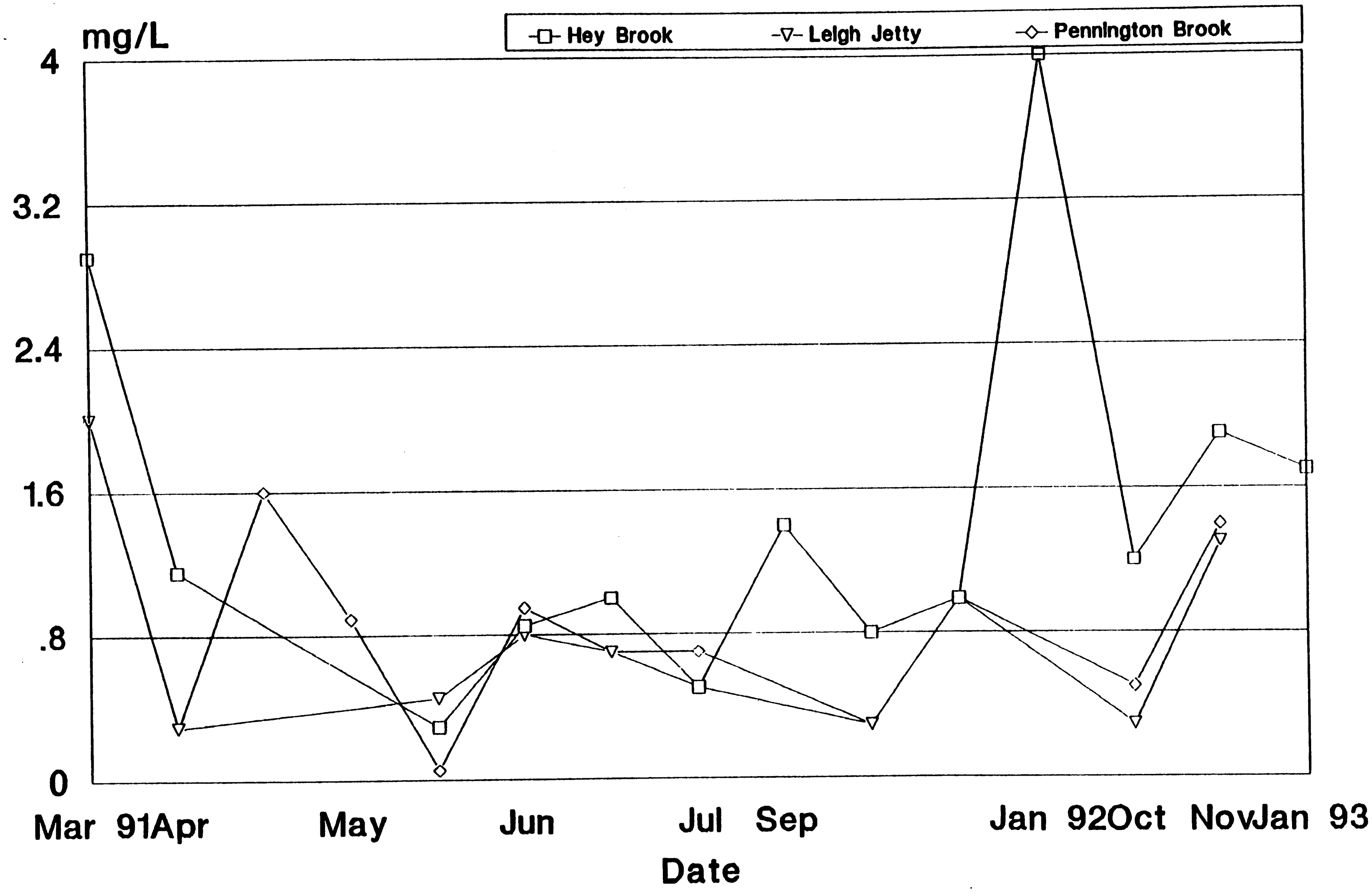


Fig. 4.6

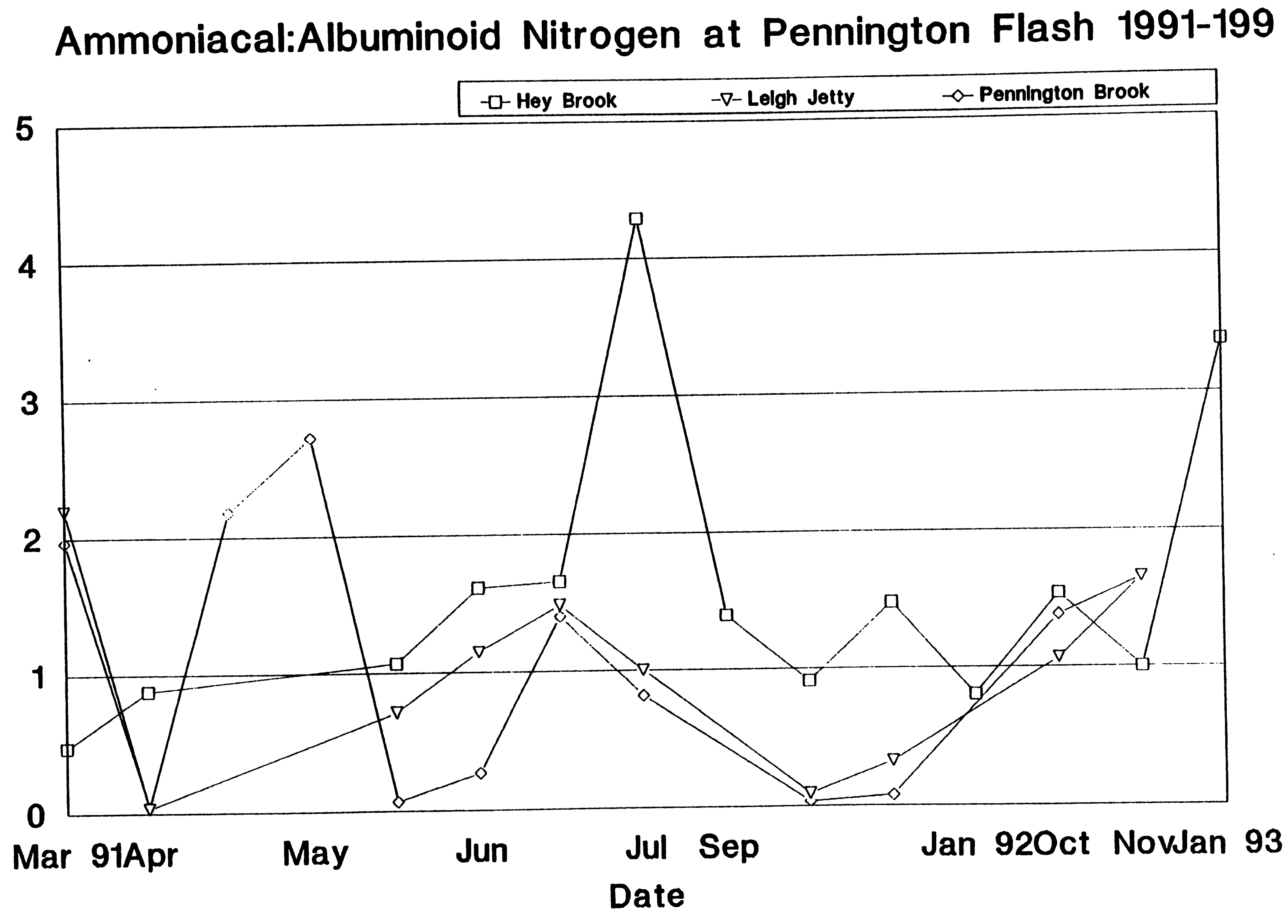

Ammoniacal:Albuminoid Nitrogen at Pennington Flash 1991-199
Hey Brook
Leigh Jetty
Pennington Brook
5
4
3
2
1
0
Mar 91Apr
May
Jun
Jul
Sep
Jan 92Oct
NovJan 93
Date

Fig. 4.7

Oxygen absorption at Pennington Flash 1991-1993

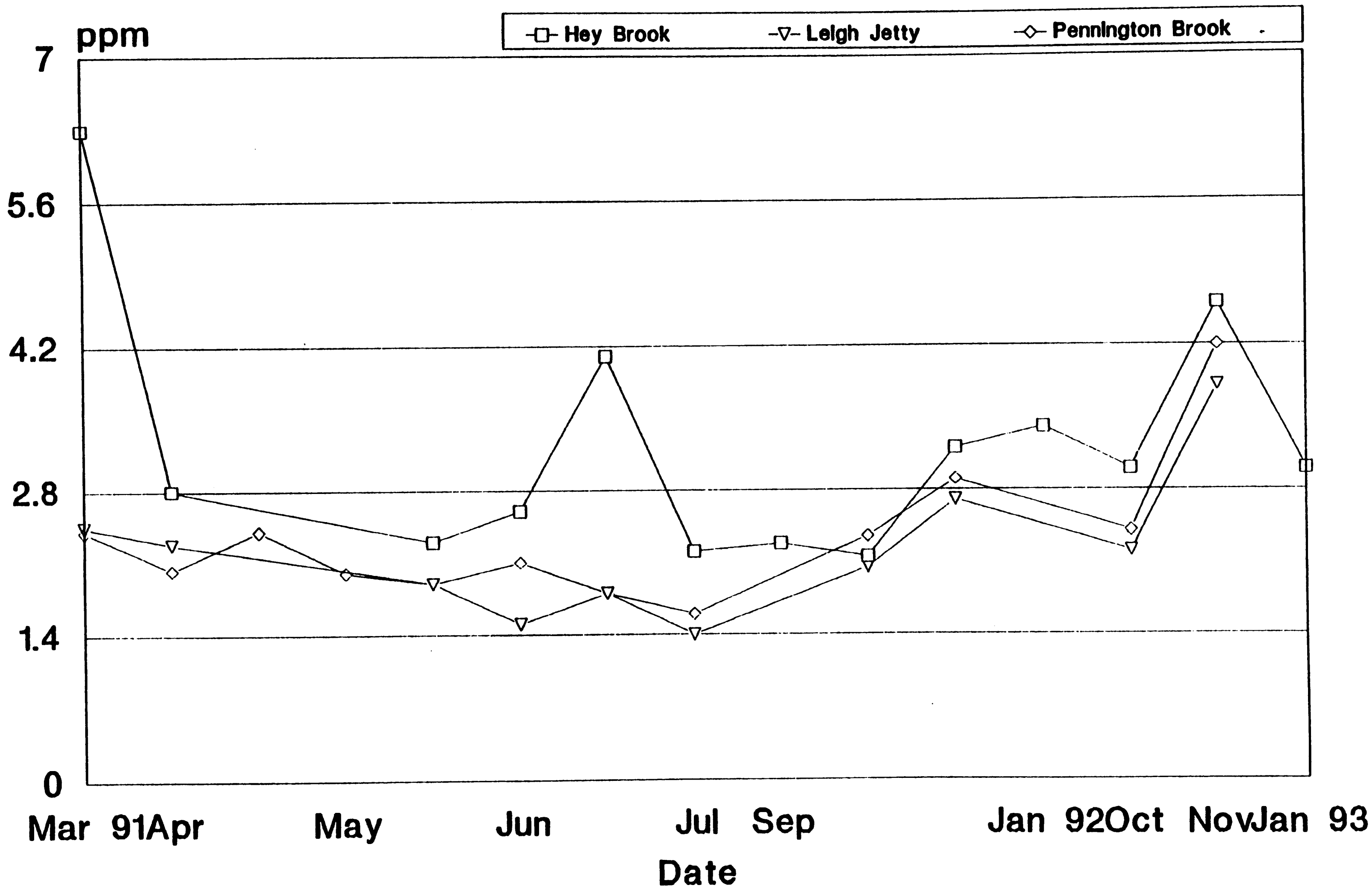


Fig. 4.8

Total Hardness at Pennington Flash 1991-1993

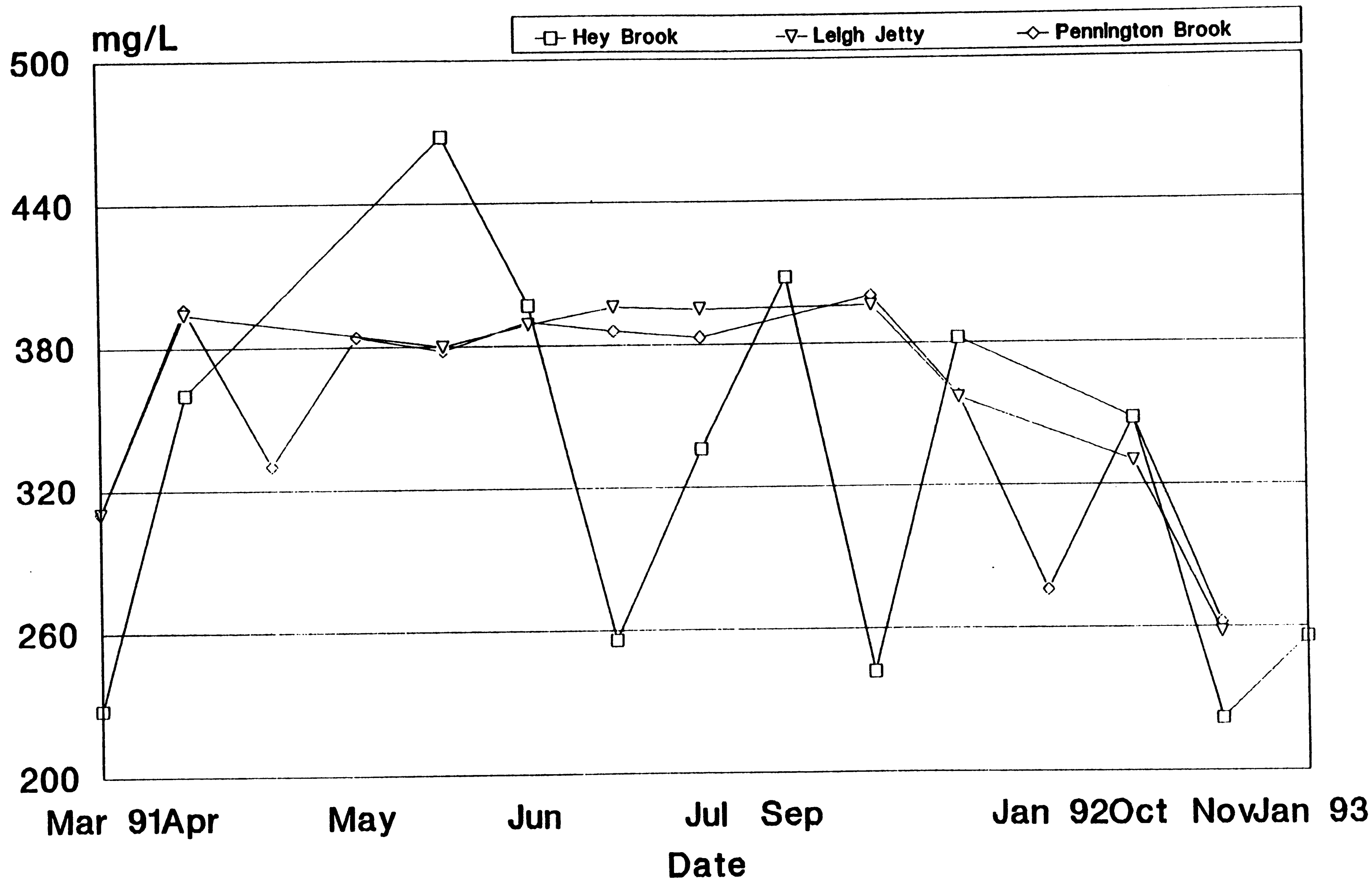


Fig. 4.9

Alkalinity at Pennington Flash 1991-1993

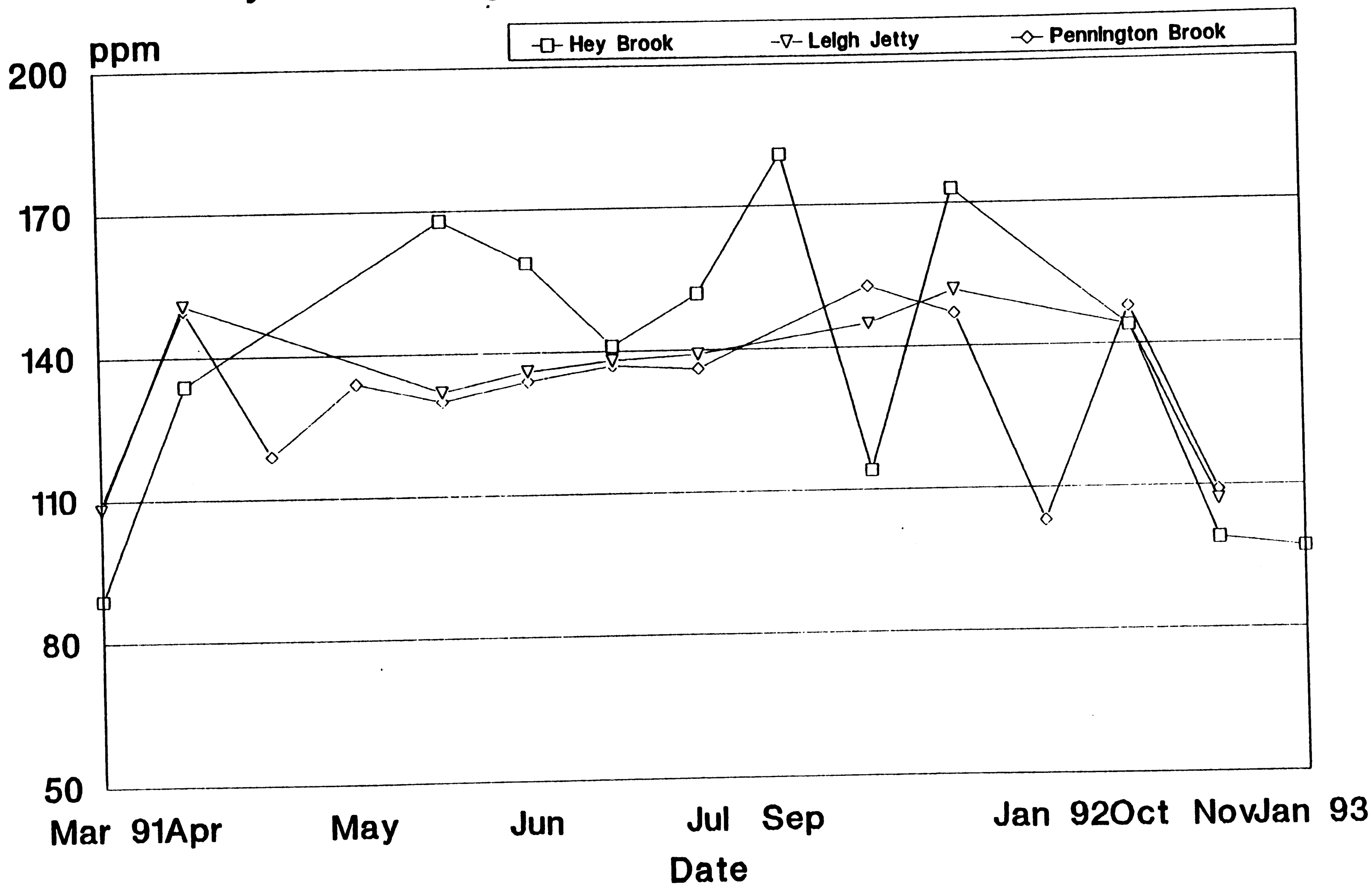


Fig. 4.10

Chloride at Pennington Flash 1991-1993

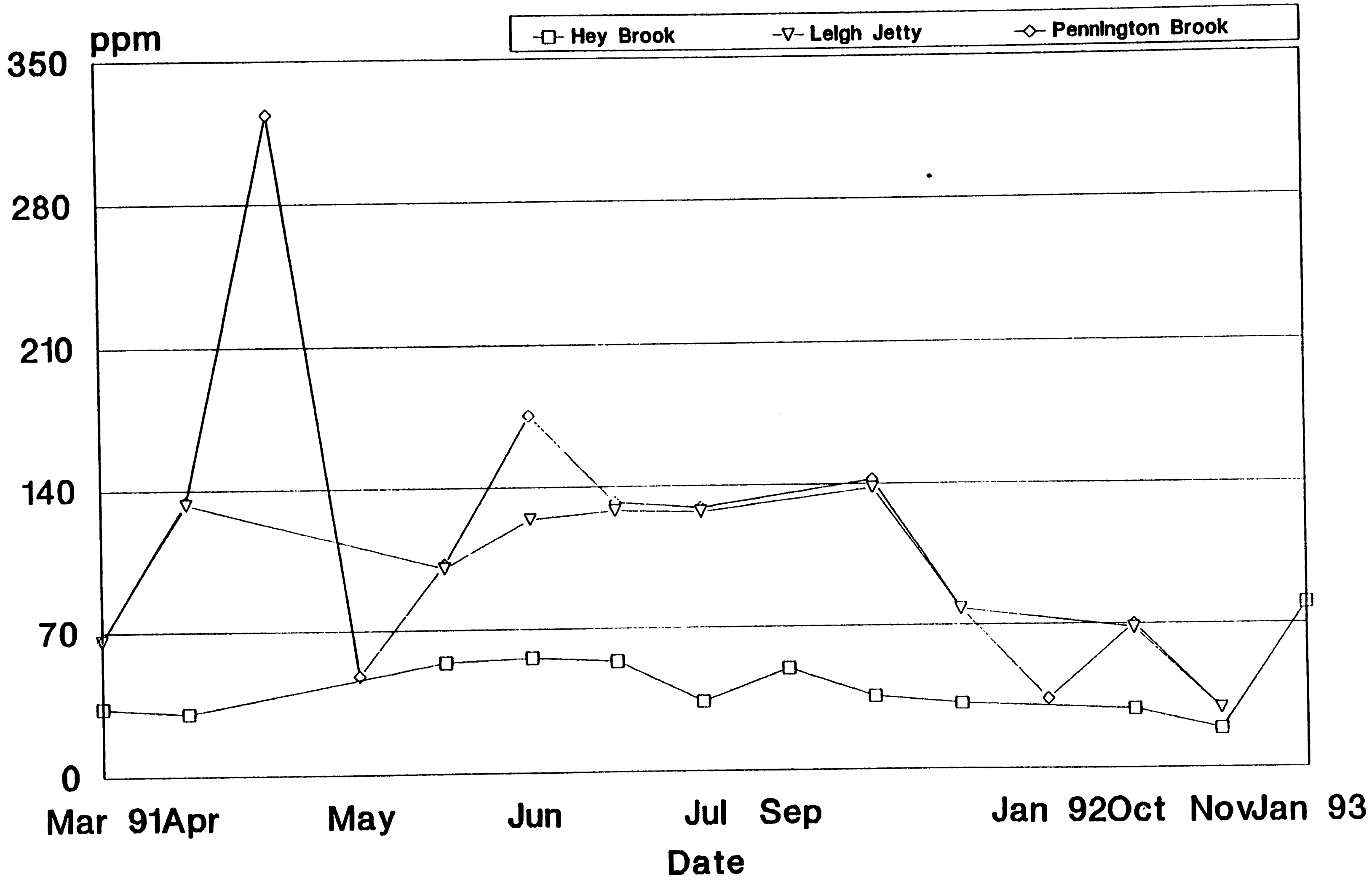


Fig. 4.11

Sulphate at Pennington Flash 1991-1993

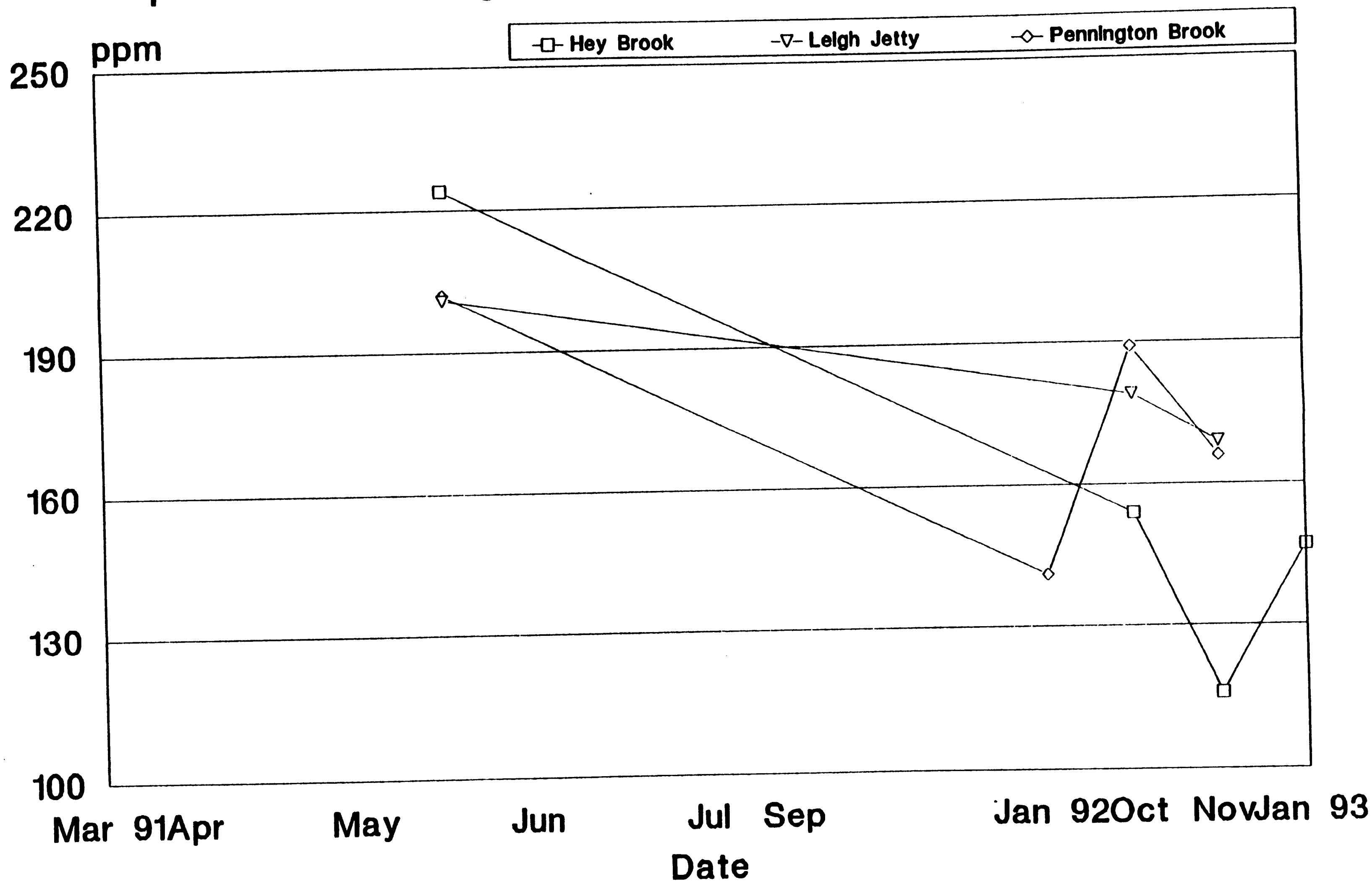
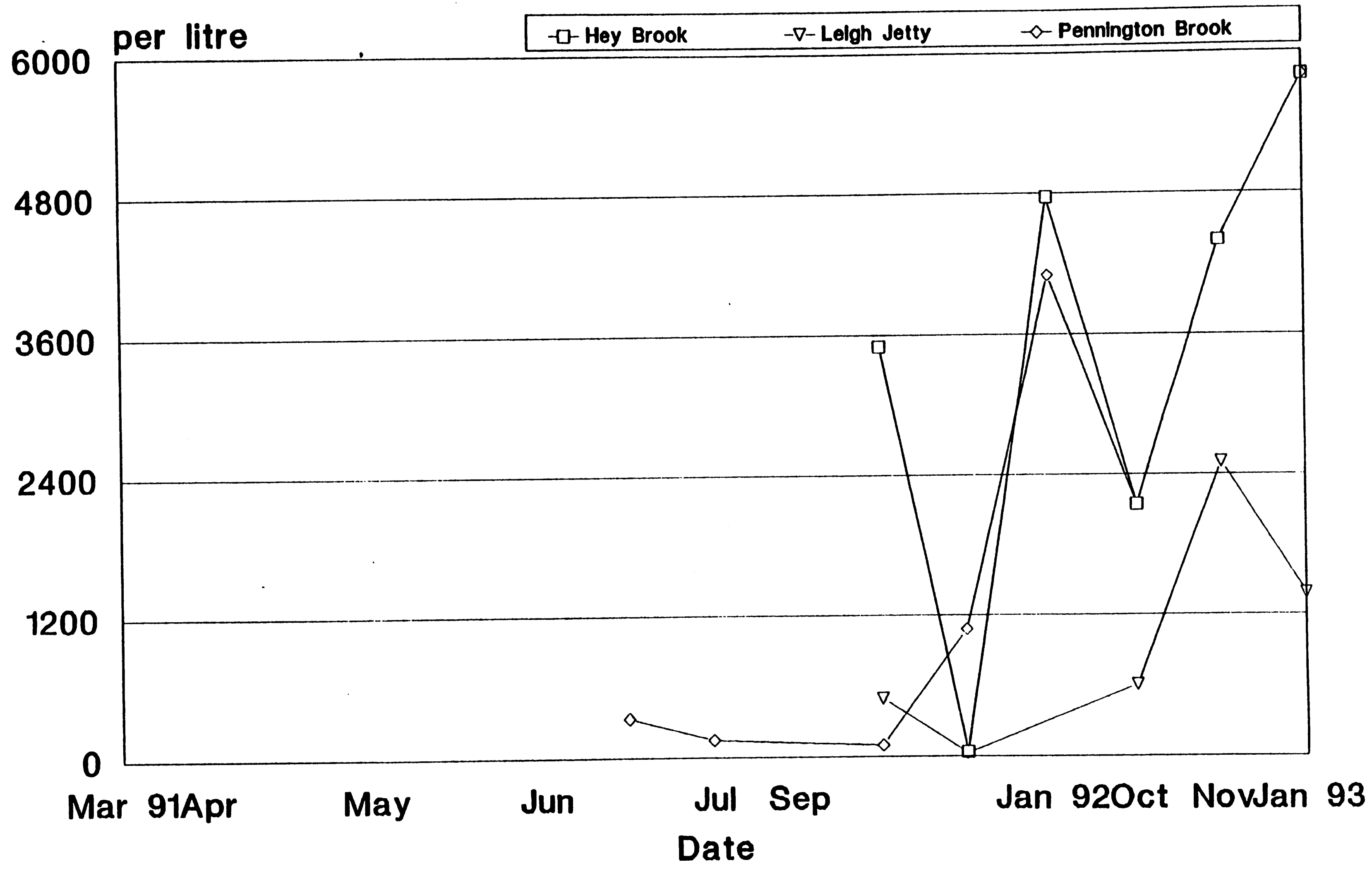


Fig. 4.12

E. Coli at Pennington Flash 1991-1993



Albuminoid Nitrogen	10	0.320	0.15	0.54
Nitric Nitrogen	10	0.761	0.29	2.00
Ammoniacal:Albuminoid	9	0.972	0.034	2.20
Oxygen Absorption	10	2.208	1.40	3.8
Total Hardness	10	360.50	258.00	396.0
Alkalinity	10	135.20	107.00	152.0
Chloride	10	99.10	29.00	138.0
Sulphate	3	183.00	169.00	201.0
E.Coli		1000	30	2500

d) Data from Pennington Brook.

	No. of Cases	Mean	Minimum	Maximum
pH	12	8.04	7.6	8.5
Conductivity	12	1050.5	543.0	1080.0
Ammoniacal Nitrogen	12	0.277	0.019	0.28
Albuminoid Nitrogen	12	0.293	0.16	0.56
Nitric Nitrogen	12	0.863	0.05	2.00
Ammoniacal:Albuminoid	10	1.050	0.036	2.71
Oxygen Absorption	12	2.340	2.15	4.20
Total Hardness	12	353.92	262.0	400.0
Alkalinity	12	131.46	103.0	153.0
Chloride	13	112.54	29.0	324.0
Sulphate	13	174.50	141.0	202.0
E.Coli	5	1963.1	30.0	5800.0

Table 4.1: Summary of water quality data
(Source: Wigan MBC)

a) Data from all sites

	No. of Cases	Mean	Minimum	Maximum
pH	37	7.92	7.5	8.7
Conductivity	37	957.8	543.0	1320.0
Ammoniacal Nitrogen	37	0.577	0.019	4.60
Albuminoid Nitrogen	37	0.364	0.150	1.20
Nitric Nitrogen	37	1.046	0.050	4.0
Ammoniacal: Albuminoid	37	1.448	0.035	6.95
Oxygen Absorption	37	2.697	1.400	6.3
Total Hardness	37	342.5	222.0	468.0
Alkalinity	37	135.16	89.0	181.0
Chloride	37	84.92	19.0	324.0
Sulphate	12	162.1	57.0	224.0
E.Coli	16	1963	30	5800

b) Data from Hey Brook.

	No. of Cases	Mean	Minimum	Maximum
pH	13	7.68	7.5	8.1
Conductivity	13	803.0	543.0	1080.0
Ammoniacal Nitrogen	13	0.517	0.23	1.47
Albuminoid Nitrogen	13	0.382	0.16	0.89
Nitric Nitrogen	13	1.437	0.29	4.00
Ammoniacal:Albuminoid	13	1.575	0.48	4.29
Oxygen Absorption	13	3.225	2.15	4.0
Total Hardness	12	325.25	222.00	468.0
Alkalinity	12	137.58	89.00	181.0
Chloride	12	42.25	19.00	80.0
Sulphate	4	183.00	169.00	201.0
E.Coli	6	1000	40	5800

Table 4.1: Summary of water quality data (Cont'd)
(Source: Wigan MBC)

c) Data from Leigh Sailing Club jetty.

	No. of Cases	Mean	Minimum	Maximum
pH	10	8.13	7.7	8.7
Conductivity	10	1062.7	787.0	1290.0
Ammoniacal Nitrogen	10	0.262	0.019	0.66