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NITRATE POLLUTION DUE TO AGRICULTURE, PROJECT REPORT No. 3: SHOULD THE POLLUTER PAY?

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NITRATE POLLUTION DUE TO AGRICULTURE, PROJECT REPORT No. 3: SHOULD THE POLLUTER PAY?

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Abstract
The Polluter Pays Principle is a well-established guiding force behind the regulation of polluters in the OECD. Agriculture, however, has frequently been exempt from this principle. This paper considers the reasons for this exemption, with particular reference to the control of nitrate pollution. After outlining the problems in applying many standard pollution control policies to nitrates, we move on to analyse the Nitrate Sensitive Areas scheme in the UK, which is a voluntary subsidy scheme. Reasons for differential take-up rates, and evidence on the effectiveness of the scheme are investigated. Finally, we consider the applicability of this approach to other forms of agricultural pollution.

Keywords: non-point pollution; nitrates; pollution subsidies; Polluter Pays Principle.

1. INTRODUCTION

The Polluter Pays Principle has been a guiding force behind environmental regulation in the OECD for many years (Pezzey, 1988). However, the principle does not seem to have been applied to environmental regulation in agriculture: rather, there are many instances of a 'pay the polluter' principle (Baldock (1992); Seymour, Cox and Lowe (1992)). By this we mean that, in many instances, farmers are compensated for the control costs they incur in reducing water and air pollution, and other examples of negative environmental externalities, to socially-mandated levels. In this paper we examine this phenomenon with particular reference to the control of nitrate pollution in water. Baldock (1992), in explaining why the Polluter Pays Principle (PPP) has not been applied to farmers generally, uses the argument that '..agriculture is a special case'. Baldock suggests four reasons why this is so:

a) agricultural source pollution is usually non-point in nature, making the identification of polluter with pollution impact very difficult. What is more, pollution impacts may be felt much later than the date of emission, creating an 'identification over time' problem;

b) special features of the agricultural sector, such as the fragility of rural incomes and implied property right suggesting that farmers have the right to mange land in the manner they think best (implying that they should not pay for any subsequent adjustments to pollution levels);

c) problems on international competitiveness due to increased production costs if the PPP is applied to its farm sector by one country unilaterally (although this will be true for other sectors too);

d) special features of agricultural policy whereby subsidies form a central part of supply regulation and income support policy. This sets a precedent for the use of subsidies in pollution control.

In the rest of this paper, we first outline the nature of the nitrate problem, and describe some possible policy responses to this problem. Next, the main elements of legislation regarding nitrate pollution are outlined. Section 4 discusses the Nitrate Sensitive Areas scheme in the UK, a clear example of 'paying the polluter'. Finally, section 5 asks whether this approach could be applied to other forms of agricultural pollution control, especially the control of pesticide use.

2. THE NATURE OF THE NITRATE PROBLEM

Agricultural use of nitrogen, like pesticides, is associated with possible adverse impacts on human health and environmental quality. For human health, high nitrate levels[2] can cause oxygen starvation in bottle-fed infants, although the number of cases of this occurring in the UK, for example, is very small: the UK Department of Health report 14 cases attributable to excess nitrate water since 1951 (POST, 1993). Nitrates have also been implicated in stomach cancer, although here the link is much more controversial (Hanley, 1990). Government figures in the UK show that in 1990, 4.8% of all drinking water samples nationally violated the EC 50 mg/l standard, implying that about 5 million water consumers were in receipt of excess-nitrate water (POST, 1993). High nitrate levels in groundwater used for drinking water supply are a major environmental concern in many EC countries such as Germany, The Netherlands and Denmark, despite this scientific uncertainty (LEI, 1993).

With regard to environmental quality, high nitrate levels can result in a decrease in plant diversity in grassland communities; and in eutrophication. Eutrophication occurs when nutrient

[2]The World Health Organisation recommended upper limit for nitrates in drinking water is 45 mg/l.

levels in water bodies rise sufficiently for algal growth to adversely affect water quality. In many water bodies (such as the Baltic Sea, and rivers such as the Ythan in Scotland), nitrogen is the limiting nutrient. Algal growth and subsequent decay results in decreases in dissolved oxygen levels in water, causing fish deaths; some algae also exhibit high levels of toxicity. Algal decay can also cause offensive smells, and algae can change the appearance of mud banks (turning them green). Declining oxygen levels in mudflats reduce the growth of certain worms, cockles, mussels, and snails, with consequent adverse affects on wading birds which feed on these invertebrates. Eutrophication is thus associated with a declining quality of the aquatic environment (Silvander and Drake, 1991; Atkins, Caudwell and Herbert, 1992). Figure 1 illustrates trends in nitrate levels for four rivers in Eastern England, a region particularly affected by nitrate pollution.

The main source of increased levels of nitrates in groundwater is agriculture (MAFF, 1993b). The losses from agriculture are dependent upon the farming system. This in turn determines the balance between nitrogen inputs (fertilisers and feedstuffs) and the level of nitrogen outputs (harvested crops or animal products). The factors known to determine the source of nitrate and influence its relative importance are identified as:

i) mineralisation of soil organic matter;

ii) effects of cultivation;

iii) mineralisation of organic nitrogen from residues of the current crop;

iv) fertiliser residues;

v) organic manures;

vi) atmospheric inputs.

Schleef and Kleinhanss (1993) have compiled data on nitrate inputs and uptake for most regions of the EC: for the UK, net balances (that is, nitrogen inputs less uptake) are particularly high for Humberside, Leicestershire, Lincolnshire, North-West and Cheshire.

Regarding groundwater, nitrate-bearing water passes most quickly through well structured rock types such as limestone whilst rock types with a less fissured structure such as chalk and sandstone reduce the movement of water. This implies a slower movement of nitrate into groundwater and drinking water. The map in Figure 2 details the location of chalk, sandstone and limestone rock types in England and Wales. Rainfall levels are an important factor in the dilution of N inputs and hence nitrate concentrations. In particular the winter levels of rainfall are crucial. High concentrations of nitrate occur in the drier eastern and central areas of Britain. Thus the 'nitrate problem' can be identified as being dependent upon three factors:

i) farming practice;

ii) climate affecting the volume of precipitation passing through the soil and therefore effecting the concentration;

iii) subsequent processes affecting the quantity and rate at which nitrate reaches the abstraction point.

What this implies is that the marginal impact of one kg of nitrogen fertiliser applied to land varies very substantially across farmers. This is due to variations in the physical impacts (the percentage of nitrogen applied which eventually leaches out), determined by the factors outlined above; and on the valuation of these physical impacts. This latter will be dependent largely on the relative scarcity of low-nitrate water in any region. Given that marginal damage costs vary to such an extent, uniform controls on nitrate use are likely to be very inefficient, as Moxey and White (1993) have pointed out. Since rainfall is a stochastic process, then nitrate leaching rates contain a stochastic element as well. Finally in this section, we note that as nitrate pollution is an example of non-point pollution, controls or incentives must either be targeted at inputs or at estimated emissions, since actual emissions from any producer are not observable to any practical extent.

Possible Controls on Nitrate Use

Environmental economists typically think of options for pollution control in terms of command and control instruments versus economic incentives. For the former, a number of possibilities emerge for nitrates.

Uniform upper limits on application rates are one command-and -control option. However, these suffer from five problems:

i) Farms with very low contributions to nitrate pollution per kg nitrate applied are punished as heavily as those with high contributions;

ii) Because of this lack of spatial control, there is no guarantee that local standards will not be violated;

iii) The system would be hard to enforce, due to monitoring problems;

iv) UK farmers would be competitively disadvantaged if the UK applied these controls unilaterally;

v) The system is inefficient, since the marginal control costs are not equalised across farmers.

A second command-and-control option is that of **uniform farm management standards** across the country. For example, these might require winter cover crops to be sown or autumn cereal crops to be planted. However, as Shortle and Dunn (1986) point out, such policies suffer from an information asymmetry, namely that the control agency is much less informed about the impacts of localised farm management practices than is the farmer.

Amongst the range of economic instruments, **nitrate taxes and tradeable nitrate quotas** are frequently suggested (eg Hanley, 1990). Taxes, however, suffer from a number of problems:

i) Whilst a tax system differentiated according to marginal pollution impacts of applying nitrate fertiliser might be efficient, a uniform system would not. A perfectly differentiated system would be relatively costly to administer. In addition it might be regarded as unjust, in that some farmers would face high marginal tax rates due to weather patterns and soil types over which they have no control.

ii) Due to the very low price elasticity of demand for nitrogen fertilizers, taxes would have high income effects which would be politically undesirable.

iii) Taxes would not necessarily affect farm management practices in a favourable way; for example, farmers could substitute out of crops such as cereals into higher-leaching potential crops such as roots, whilst taxes would have little direct bearing on whether farmers sowed winter cover crops.

iv) Taxes would encourage a black market in tax-free nitrogen fertiliser;

v) Taxes would also have to apply to livestock manures, but the nitrogen content and leaching potential of manure is very difficult to assess on a farm-by-farm basis, due to the highly heterogenous composition and condition of manure.

Tradeable nitrogen permits avoid the income effects of taxes if they are initially grandfathered, but suffer from a similar lack of targeting, whilst the formulation and enforcement of adequate trading rules to govern permit exchanges would be difficult.

Perhaps because of these difficulties with the policies outlined above, the UK government has followed a 'pay the polluter' policy for the control of nitrate pollution. This is essentially a highly targeted subsidy scheme, with payments for profits foregone for those farmers who voluntarily agree to join the scheme, and who agree to abide by restrictions in farm management practices. Potter et al (1993) discuss targeting of schemes to achieve environmental effectiveness, through the paying of private groups (especially farmers) to produce public environmental goods. The Nitrate Sensitive Areas (NSA) scheme is described in section 4. First, however, we provide an account of the policy background to the scheme, which outlines some of the political economy issues involved.

3. THE POLICY BACKGROUND

UK Environmental Policy and Agricultural-source Pollution

Regulation on environment matters in the UK has..'moved from a largely informal and decentralised approach to an increasingly formal, legalistic and centralised one' (Seymour, et al.,1992: 86). The Control of Pollution Act (COPA) 1974 and the Environmental Protection Act (EPA) 1990 established general principles of pollution control and enforcement. These principles are regulation by performance and design standards; and the polluter pays principle. Agriculture has historically been largely exempt from pollution controls. In recent years this position has been slowly legislated away. The disposal of agricultural waste is exempt from COPA (1974) and EPA (1990) unless it contravenes the legislation, say in terms of water pollution. General operations, such as manure spreading, can be performed, since it is deemed a '..conditioning or otherwise beneficial improvement of land..' (EPA, 1990). The Control of Pollution (silage, slurry and agricultural fuel oil) Regulations included under COPA (section 53) as amended by schedule 23 of the Water Act 1989, incorporate powers to enter farm premises to anticipate possible pollution problems. The legislation also includes power over the design, construction, and installation of new slurry and silage storage systems, and the substantial enlargement (defined as more than 10 per cent increase in volume) in existing systems. The River Purification Agency (Scotland) or National Rivers Authority (England and Wales) can serve notice on the farmer to improve the storage system to prevent pollution.

MAFF also issues Codes of Good Agricultural Practice for the Protection of Water and Air (for example see MAFF (1991)). The code provides guidance on the way farmers can avoid causing water pollution. Codes with similar guidance were introduced in Scotland and Northern Ireland (Countryside Management Code). These codes were strengthened in October 1991 with the Water (Prevention and Pollution) Code of Practice Order giving a statutory basis. The statutory basis of the codes implies that violation of the code could be taken into account in legal proceedings, but violation of the code is not itself an offence.

EU Policy

With regard to nitrate pollution from farming, however, the main pieces of legislation are three EC Directives and the UK's Nitrate Sensitive Areas scheme. The EC Directives on Drinking Water (80/778), Nitrates (91/676) and Urban Waste Water Treatment (91/271) are detailed in this section and the NSA scheme is described in section 4. The EC Directive on Drinking Water (80/778) sets standards for the quality of water to protect human health. The Directive contains some sixty two water quality standards. The standard for Nitrates was set at 50mg/l, which compares with the WHO recommended safe level of less than 50mg/l (although the range 50-100 mg/l was considered safe). The 50mg/l limit has been criticised as imposing costs which are excessively greater than the benefits of avoided health risks by several bodies (POST, 1993; Royal Commission,1992; Royal Society, 1992). Compliance in the UK has delayed and deferred. By March 1987 derogations had been made for 197 water supply zones in England of which 48 were concerned with nitrates. Available figures indicate that the number of abstraction sites exceeding the 50 mg/l limit of the Drinking water directive continues to rise. In 1989, 154 sites exceeded the limit; by 1990, 192 did. (MAFF, 1993b).

The EC Nitrates Directive (91/676) seeks to protect waters against pollution by nitrates from agricultural sources. Protection will be through the designation of Nitrate Vulnerable Zones (NVZs). In NVZs limits on the application of inorganic nitrogen and the storage and spreading of manure will be applied. The directive provides standards for the identification of polluted waters and stipulates that Member state governments must have carried out the following provisions;

1) By December 1993 all waters must be monitored by state environmental agencies, and Nitrate Vulnerable Zones (NVZs) established.These zones are defined as land areas contributing to drinking water quality problems (the limit of 50 mg/l of nitrates) or eutrophication due to nitrates. In addition a 'Code of Good Agricultural Practice' to minimise nitrate leaching must have been produced.

2) By December 1995 action programmes dealing with the measures contained in the new Code must be in place. These should include a number of extra criteria aimed at minimising nitrate leaching. These programmes are mandatory and must be established by December 1995 and implemented by December 1999.

The designation of Nitrogen Vulnerable Zones (NVZs) will be enforced where 'polluted waters' exist i.e., where:

i fresh water, estuaries, and coastal marine waters are eutrophic or may become so, where eutrophication is principally caused by nitrates (as opposed to phosphates);

ii surface water intended for the abstraction of drinking water contains more than 50mg of nitrates;

iii ground water contains, or could contain, more than 50mg/l nitrates unless protective action is taken.

The Urban Waste Water Treatment (UWWT) Directive (91/271) sets certain minimum standards for the treatment of sewage effluent, according to population size and the sensitivity of receiving waters. It has a bearing on nitrate pollution in that nitrates from non-agricultural sources such as sewage works are covered by the directive. There is currently considerable overlap between the implementation of the UWWT directive and the Nitrates Directive. The UWWT directive sets priorities for the treatment of sewage according to the size of discharge and the sensitivity of the receiving water. It sets out as the required standard a secondary treatment level but allows for primary treatment in less sensitive areas and more rigorous treatment (such as nutrient removal) in some cases. Whilst the Nitrates Directive only seeks to protect water against pollution by nitrates from agricultural sources, the UWWT directive is more embracing in scope. Sensitive Areas are so designated where:

i) freshwaters, estuaries and coastal waters are eutrophic (due to either nitrate or phosphate levels, regardless of source) or may become so in the near future if protective action is not taken;

ii) surface freshwater intended for the abstraction of drinking water could contain more than the concentration of nitrate laid down in the Surface Water Abstraction Directive (75/440/EEC) of 50mg/l nitrates, irrespective of the source of this nitrate;

iii) the requirements of other directives necessitates more stringent treatment than the standard secondary level required in the UWWT Directive.

This allows action to be taken where eutrophication problems exist where the main cause has been shown to be nitrate emissions from agriculture.

4. NITRATE POLICY PROGRAMMES IN THE UNITED KINGDOM

The Pilot Nitrate Sensitive Areas Scheme

UK Government nitrate policy stems from the European Commission's draft directive

(4136/89 COM(88) 708). The draft proposal was followed by the introduction of the Pilot Nitrate Sensitive Areas (NSA) scheme in 1990. The Pilot NSA scheme contained two elements: the establishment of Nitrate Advisory Areas (NAAs) and of Nitrate Sensitive Areas (NSAs). Ten sites were chosen and receive compensation as NSAs, with nine areas subject to an advisory campaign through the NAA Scheme. The 10 NSAs cover some 10 700 hectares and the NAA some 24 000ha. The location of each of these areas is illustrated in Figure 3, whilst Figures 4a and b and 5a and b show nitrate levels in abstraction sites located in two of the pilot NSA areas. As can be seen, these areas show very high nitrate levels, considerably in excess of the EEC upper limit of 50mg/l. The policy aimed to tackle the problem of unacceptable levels of nitrate leaching from farmland into water sources (MAFF 1990). In the advisory areas, farmers were asked to voluntarily undertake restrictions on their agricultural practices. However, no payments were offered for any profits foregone by meeting these requirements since they were deemed to be within the Code of Good Agricultural Practice.

The NSA scheme was a voluntary one, containing two payment tiers: the Basic rate scheme and the Premium rate scheme. Both schemes could be entered into for a minimum of five years. The scheme contained a degree of inflexibility since in order to qualify for the compensatory payments a farmer participating in the scheme had to enter the entire farm area included in the designation of the Nitrate Sensitive Area.

The basic rate scheme demanded the following changes to farming practise;

(i) a reduction in the application levels of N fertiliser;

(ii) no N fertiliser applications in the autumn and with a maximum of 120kg/ha to be applied at any one time;

(iii) all N applications to be recorded;

(iv) the maintenance of a winter cover crop to avoid leaving the ground bare during periods of high rainfall resulting in possible Nitrate leaching;

(v) the drawing up of a manure plan to demonstrate adequate storage and spreading capacity;

(vi) a limit of manure applications to 175 kg/ ha, and

(vii) a ban on slurry or poultry manure applications between 1 September and 1 November for grassland and between 1 July and 1 November for fields cropped annually.

For inclusion in the Premium rate scheme two conditions had to be met. First, all eligible land had to be entered in the basic scheme, and second, arable land had to be taken out of intensive production and switched to one of the following four grassland options:

(i) unfertilised and ungrazed;

(ii) fertilised and grazed;

(iii) limited fertiliser and optimal grazing;

(iv) grassland with woodland.

Payment rates were calculated as an average profit foregone plus an additional payment to cover extra items such as the cost of establishing a cover crop (where applicable) and the cost of management time for work directly associated with the scheme. There are indications that payments were set slightly in excess of MAFF's estimate's of this total for each NSA, in order to persuade more farmers to sign up. However, as will become clear, the payments were only partially successful in this respect. The Nitrate Sensitive Areas and payment rates are illustrated in Table One. Variations in payment rates across NSAs are attributable to variations in the *ex ante* levels of farming profits across the different areas.

Table 1: Pilot nitrate sensitive areas and payment rates (£ / ha)

Nitrate Sensitive Area (NSA)	Basic scheme (£/ha)	Premium scheme (£/ha) (% of total area)		
		0 - 25	25 - 75	75 - 100
Sleaford (Lincolnshire)	85	380	290	200
Branston Booths (Lincolnshire)	95	380	290	200
Ogbourne St. George (Wiltshire)	55	380	290	200
Old Chalford (Oxfordshire)	55	330	265	200
Egford (Somerset)	55	380	290	200
Boughton (Nottinghamshire)	75	280	240	200
Wildmoor (Hereford and Worcestershire)	70	280	240	200
Wellings (Staffordshire and Shropshire)	65	280	240	200
Tom Hill (Staffordshire)	70	280	240	200
Kilham (Humberside)	55	330	265	200

Effectiveness of the pilot NSA scheme

Table 2 reports the areas that actually entered into the Pilot NSA schemes' basic and premium tiers. The total areas within the NSA scheme extended to some 10 700 ha of which 9300 ha or some 87% was entered in the scheme. Of this area some 7800 ha qualified for the basic tier payments, representing 73% of the total area in the scheme, and 1550 ha entered the premium payment scheme, representing some 14%. The take-up of the individual schemes can be seen to vary quite substantially, ranging from a take-up rate of 36% in Kilham to 100% in Sleaford and Branston Booths. The number of farms entering the NSA scheme was 163,or 80 % of the total eligible number.

Table 2: Areas and take-up rates under the Pilot NSA scheme

Nitrogen Sensitive Area (NSA)	Basic (hectares)	%	Premium (hectares)	%	Agricultural area (hectares) (est.)	Overall takeup (%)
Sleaford	1930	67.1	945	32.9	2875	100
Branston Booths	1380	86.8	210	13.2	1592	100
Ogbourne St. George	580	58.8	130	13.2	984	72.0
Old Chalford	415	66.8	165	26.6	621	93.4
Egford	175	41	42	9.8	427	50.8
Boughton	1610	97.4	16	1.0	1652	98.4
Wildmoor	668	92.4	15	2.1	723	94.5
Wellings	315	60.2	10	1.9	523	62.1
Tom Hill	450	78.9	20	3.5	570	82.4
Kilham	275	36.4	0	0	756	36.4
Total	7798	100	1553	100	10723	87.2

Source:Environmental Protection Division, MAFF.

In order to examine the reasons for variations in take-up, we conducted a series of interviews with farmers in two NSAs, Wellings and Kilham. Wellings NSA is characterised by intensive livestock/dairy production systems and Kilham by a simple arable system. In each case, farmers who did and did not join the scheme were interviewed. In addition, we interviewed the local MAFF officers responsible for the administration of the two areas. The sign-up rates in Wellings and Kilham were 62% and 32% respectively. The following reasons were given by those farmers who <u>did not</u> join the schemes:

* payment rates were too low (the main reason in Kilham, only a minor reason in Wellings);

* the ban on slurry spreading during the autumn caused problems, due to insufficient storage

capacity; the maximum level of spreading permitted was set too low (this was the major reason given by both non-joiners in Wellings)

* uncertainty over the interaction of the NSA restrictions and payments with current and future reform of the CAP;

* a reluctance to have their farming activities restricted by government.

For those farmers who <u>did</u> join the scheme, payment rates were deemed to cover income losses and additional costs imposed by the scheme (including inconvenience costs) in three out of four cases, whilst for these farmers costs of building new slurry stores (to meet timing restrictions on spreading) were covered by scheme payments. That the costs of capital investment to reduce pollution (ie by constructing a slurry store) should be met by the subsidy in Wellings but not in Kilham reflects differences in payment rates and also in local factors such as stocking levels. One farmer indicated that he would still have joined if payments had been reduced by 50%, as few changes were necessary on his farm to meet the scheme's requirements. Fear that a compulsory scheme with lower payment rates would be introduced if the voluntary scheme did not achieve a high enough sign-up rate was given as a reason for joining by 75 % of the farmers in our survey.

As part of the assessment of the scheme, measurement of nitrate concentrations has been undertaken by MAFF at selected monitoring sites in each of the ten NSAs (MAFF,1993c). This has been carried out over the 3 winter periods starting from 1990. The runoff from the soil is collected across each catchment in porous pots at a depth of 90-100cm: no data is available yet on changes in nitrate concentrations below this depth, since time lags imply that reductions in leaching will not show up as falling N concentrations in groundwater supplies (boreholes) for at least ten years. The rainfall for the winter of 1991/92 was well below average and insufficient to leach out all the nitrate in the soil. This lead to a reduction in the total loss of nitrate, and also to an increase in the average nitrate concentration. Rainfall for the winter of 1992/93 was close to the average for the first time since the scheme commenced, however the distribution was not uniform, with higher than average rainfall during the autumn period and lower than average from January to April. The autumn rainfall resulted in an early start to water leaving the soil and resulted in good cover crop establishment. Nitrate concentrations were reduced because of the greater volume of water passing through the soil, but the total losses of nitrogen were at the same level or slightly increased. This was in part due to near complete leaching of nitrate from the soil.

Table 3 details the average fertiliser reductions by crop subject to NSA agreements. The large reductions in fertiliser use can be clearly seen. Two factors determine the magnitude of the change; firstly reductions due to adherence to the NSA policy, and secondly reductions in payment levels for many crops due to CAP reform.

Table 3: Reductions in average fertiliser applications to crops subject to NSA agreements (1990-1992)

Crop	Percentage reductions in nitrogen fertiliser
Grass (except Premium)	16.4
Winter Wheat	5.5
Winter Barley	14.2
Spring Barley	7.1
Potatoes	8.4
Sugar Beet	14.7
Winter Oilseed Rape	6.67
Overall (includes Premium Grass)	27.0

Overall across the whole of the ten NSAs, four areas complied with the EC limit and a further two were within ten per cent. The areas with the highest nitrate concentrations were predominantly arable areas in Eastern England. For the Premium grass option nitrate concentrations were found to be significantly reduced and lower than for land under arable cropping. In around 50 per cent of cases peak concentrations were below the EC limit of 50mg/l nitrate. Large reductions in nitrate losses were initially achieved by the cessation of manure spreading at the very high rates, and reductions in nitrate loss continued in monitoring sites. The expected role of cover crops, to reduce the nitrate concentrations of water leaving the root zone in late winter, was reduced due to poor crop establishment in the first year of the scheme. However in the second year of the scheme the favourable weather conditions permitted good establishment of cover crops. This was effective in reducing nitrate losses. Cover crops were estimated to halve the nitrate loss when compared with fields sown to winter cereals.

The expected reduction in nitrate from cereals under this scheme are assessed to be potentially small. This is especially so if farmers were previously operating near to the economic optimum, in terms of the yield response curves. The nitrate losses were greater in the second year of monitoring at sites which had had high nitrate concentrations in the previous year. An explanation forwarded for this was that the dry winters in the preceding two years had not allowed all the nitrate to be leached from the soil profile; the cereal crop had not been able to take up sufficient nitrate and this was then leached with the increased rainfall volume in the winter of 1992/93.

For the root crops, especially potatoes and sugar beet, the nitrate losses continued to be low. Factors which contributed to this phenomena include:

i) reduced fertiliser inputs;

ii) a good growing season resulting in high yields;

iii) drainage of water from the soil profile occurring before the beet harvest, thus the combination of nitrate removal by plant uptake and leaching by rainfall left little nitrate in the soil.

Although the scheme has only been in operation for a short period of time and the winter weather conditions have been atypical, some reductions in nitrate losses have already been observed. A number of critical changes in agricultural practice have been shown to work in reducing nitrate losses and concentrations: reductions in excessive fertiliser applications combined with careful timing in application, and the avoidance of bare land in the autumn period through the establishment of a cover crop. Initial conclusions thus suggest that compensating farmers for changing their agricultural practices' beyond the code of good agricultural practice is reducing the concentrations of nitrate leaving these sensitive areas and moving towards compliance with the EU limit.

The New Nitrate Sensitive Areas Scheme

As an extension of the pilot NSA scheme MAFF have implemented, under the EC Agri-Environment Regulation, a new Nitrate Sensitive Areas scheme. More than 56 000 hectares in England, were originally identified as part of 30 candidate areas under the NSA scheme. These areas were identified through sampling exercises performed by the regional National River Authority (NRA). The areas were selected on a number of criteria: they are predominantly agricultural in nature; exhibit medium to high nitrate concentrations; and designation under the NSA scheme has been judged to provide a cost efficient method of reducing the nitrate concentrations to the EC limit. The actual area designated following the consultation period extends to 35,059 ha covering 28 sites. The aim of the scheme is to protect selected groundwater sources used for supply of drinking water where nitrate levels exceed or are expected to exceed 50 mg/l. These boreholes identified as being affected by rising nitrate levels will be designated as Nitrate Vulnerable Zones (NVZs) under the EC Nitrates Directive. These areas will form the central-zones and larger surrounding areas will be designated inter-zones within the catchment. The new NSA scheme will become operational in October 1994 and will operate for five-year agreement periods with payment rates reviewed after three years. Unlike the pilot scheme the new NSA scheme offers farmers a high degree of choice. Land may be entered into the scheme on a field-by-field basis and into a combination of options. Greater flexibility is extended to the farmer through the time horizon of the scheme. The scheme can be entered into during any of the five years and each agreement will then run for five years, so in theory a farmer joining the scheme in 1999 could have an agreement with MAFF until 2004.

All participating farmers are subject to two general requirements of the scheme:

1) Organic manure applications will not exceed 250 kg of total nitrogen per hectare within any 12 month period.
2) Organic manure will not be applied within 50 metres of a spring, well or borehole intended for human consumption and within 10 metres of any water course.

5. DISCUSSION

In this paper, we have tried to explain why the polluter pays principle has not been applied to the control of nitrate pollution in the UK. The major reasons were argued to be (i) a tradition of subsiding farmers, and treating farm-generated pollution differently to other forms of pollution in legislation; (ii) the non-point and highly-spatially variable nature of nitrate pollution, causing (iii) major problems in applying either tradeable permits or pollution taxes to the control of the problem. Any control option faces additional problems of a partly-stochastic process linking farmers' activities to nitrate levels in water (due to the influence of the weather); and a large information asymmetry between farmers and the regulator, in terms of a lack of knowledge by the regulator of on-farm conditions at the farm level. For these reasons, the UK government has introduced what is essentially a voluntary subsidy scheme, with farmers being paid in excess of profit foregone for enrolling in the NSA scheme and agreeing to restrictions on their farming practices. We also note that a voluntary subsidy scheme is less likely to provoke opposition from the farming lobby, which is important given the influence which the farm lobby has exerted on agri-environmental policy in the UK in the past (Lowe et al., 1986). This approach to agri-environmental policy is now dominant in the UK: the Environmentally Sensitive Areas (ESA) scheme is also essentially a voluntary subsidy scheme, producing environmental goods in terms of desirable farm landscapes and wildlife habitats.

The decision to extend the pilot NSA scheme, as outlined in the preceding section, is indicative of a MAFF view that the pilot scheme has been successful. This judgement has been reached by observing that sign up rates in most NSAs have been high, whilst nitrate leaching has been reduced according to the initial results again described above. Total payments to farmers participating in the pilot NSA scheme have been estimated at £1.6 million p.a. (MAFF, pers. comm.), and for the new scheme at £6.7 million p.a.. Administrative costs of the two policies are unknown at present. Also unknown at present is the cost-effectiveness of the pilot NSA programme, relative to alternative means of reducing nitrate levels such as nitrogen taxes or tradeable nitrogen permits. However, given the highly spatial nature of nitrate pollution in the UK, any policy which imposed restrictions or cost penalties (such as a tax) at a national level are likely to be very inefficient.

The NSA sets payments rates that vary across NSAs but not within each NSA, like the ESA scheme. It is not thus a perfectly-differentiated subsidy scheme, whereby subsidy rates are adjusted to take account of variations in marginal damage costs across individual farms. Payment rates are set for each NSA slightly in excess of average profit foregone. It is inevitable, then, that some farmers who join will be over-compensated for profits foregone by agreeing to the NSA restrictions, while others will not join since they could be under-compensated. Within a given NSA, payment rates rise with the level of restrictions chosen (so that payment rates are higher in the premium scheme than in the basic scheme). Farmers should not, however, be envisaged as making adjustments along a smooth, continuous marginal abatement cost curve. Rather this is likely to be kinked, since agreeing to premium-rate restrictions may entail large changes in the *type* of farming operation being run; for example, away from intensive arable cropping and towards extensive livestock grazing. Uncertainty about a farmer's own ability to successfully manage such changes in their production systems will discourage many from signing up to the premium-rate restrictions.

Finally, it is interesting to consider whether NSA-type policies could be extended to other forms of pollution control in agriculture. Obvious parallels can be drawn with the Conservation Reserve Programme (CRP) in the US, which offers payments to farmers who abandon farming on highly-erodible land, and who undertake soil conservation measures. Heimlich (1991) reports an Economic Research Service study which found that the CRP had positive net economic benefits, when impacts on food prices, farm incomes, water quality and maintenance of soil productivity were taken into account. It seems plausible that a voluntary subsidy approach could also be used to tackle pesticide pollution. Farmers could be offered profit-foregone payments for agreeing to reductions in the frequency of pesticide applications, and changes in the types of pesticides used. Payments could vary regionally to take account of variations in the marginal revenue product of pesticide use, possible adjusted for risk: the latter would involve quantifying the difference in risk from moving to a new pesticide regime. Such as policy would probably achieve principled acceptance from the farm lobby, and there is no particular reason to suppose it would be ineffective in reducing pollution problems linked to pesticides. Indeed, by implementing the 'pay the polluter' principle, such a policy would be in accordance with most agri-environmental policy in the UK.

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Figure 1: Trends in Nitrate Levels in 4 Anglian NRA Rivers

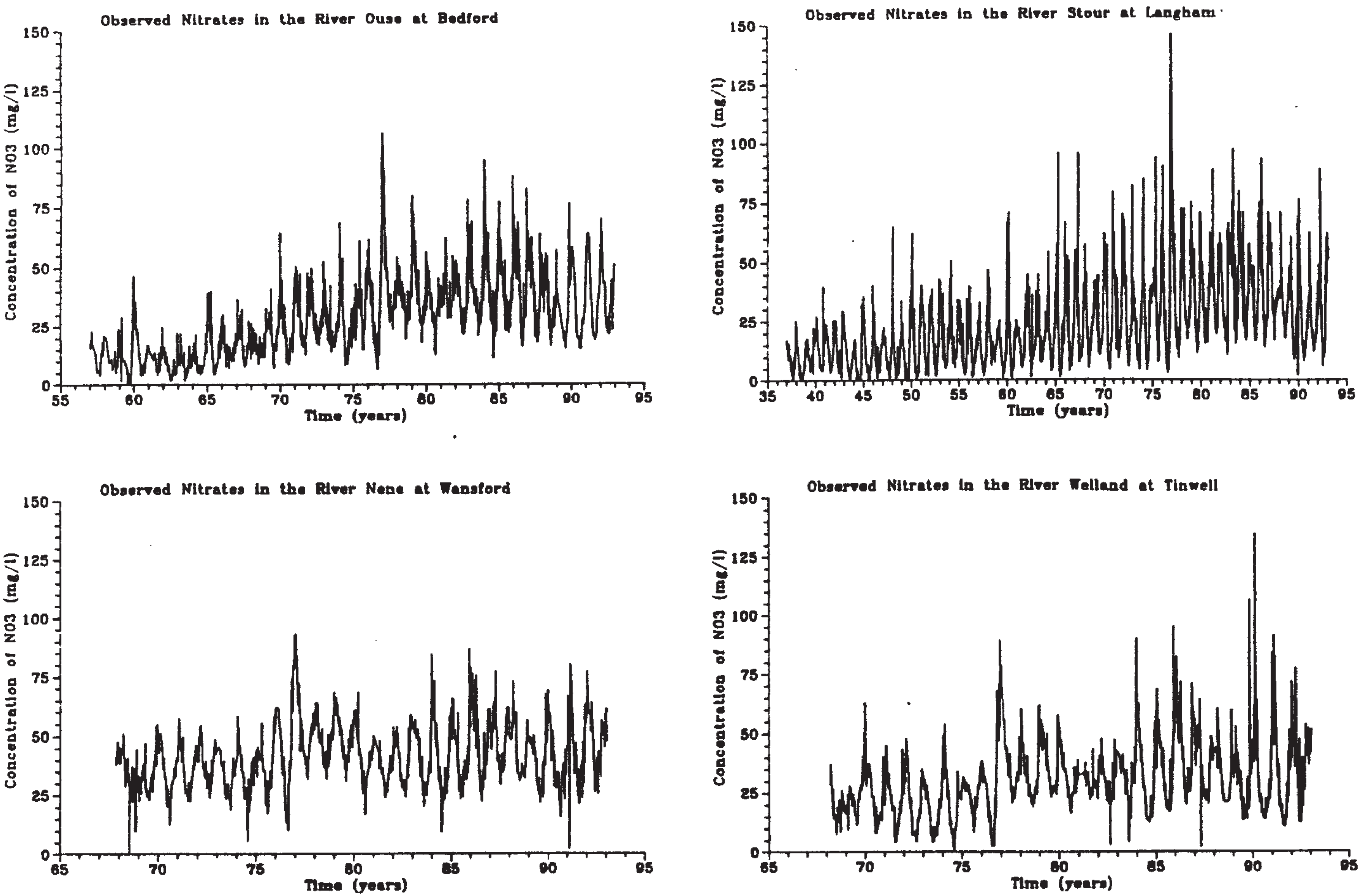


Figure 2: Illustration of the location of principal rock types in England and Wales

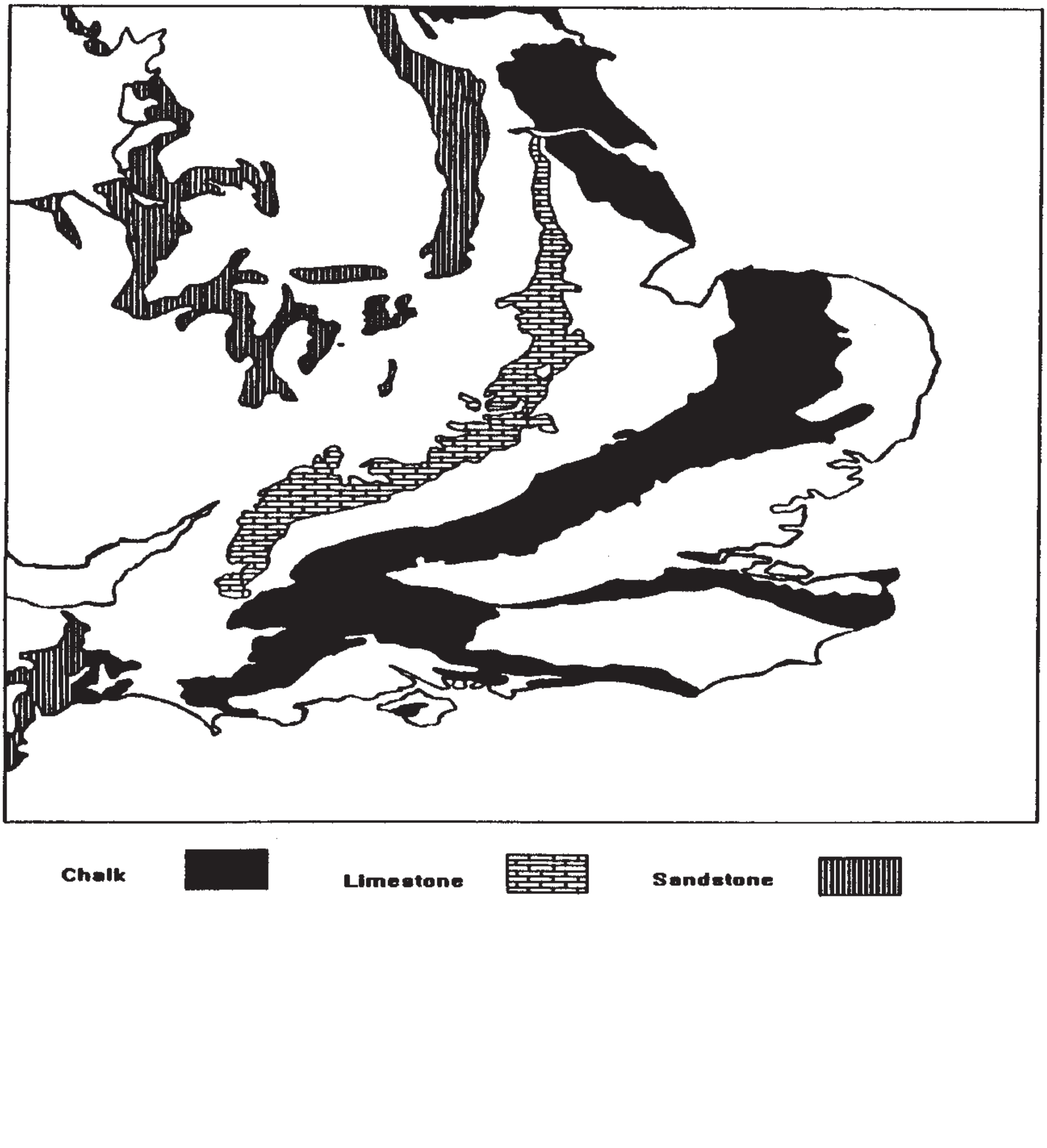


Figure 3: Location of existing and candidate NSAs under the Nitrate Sensitive Areas Scheme

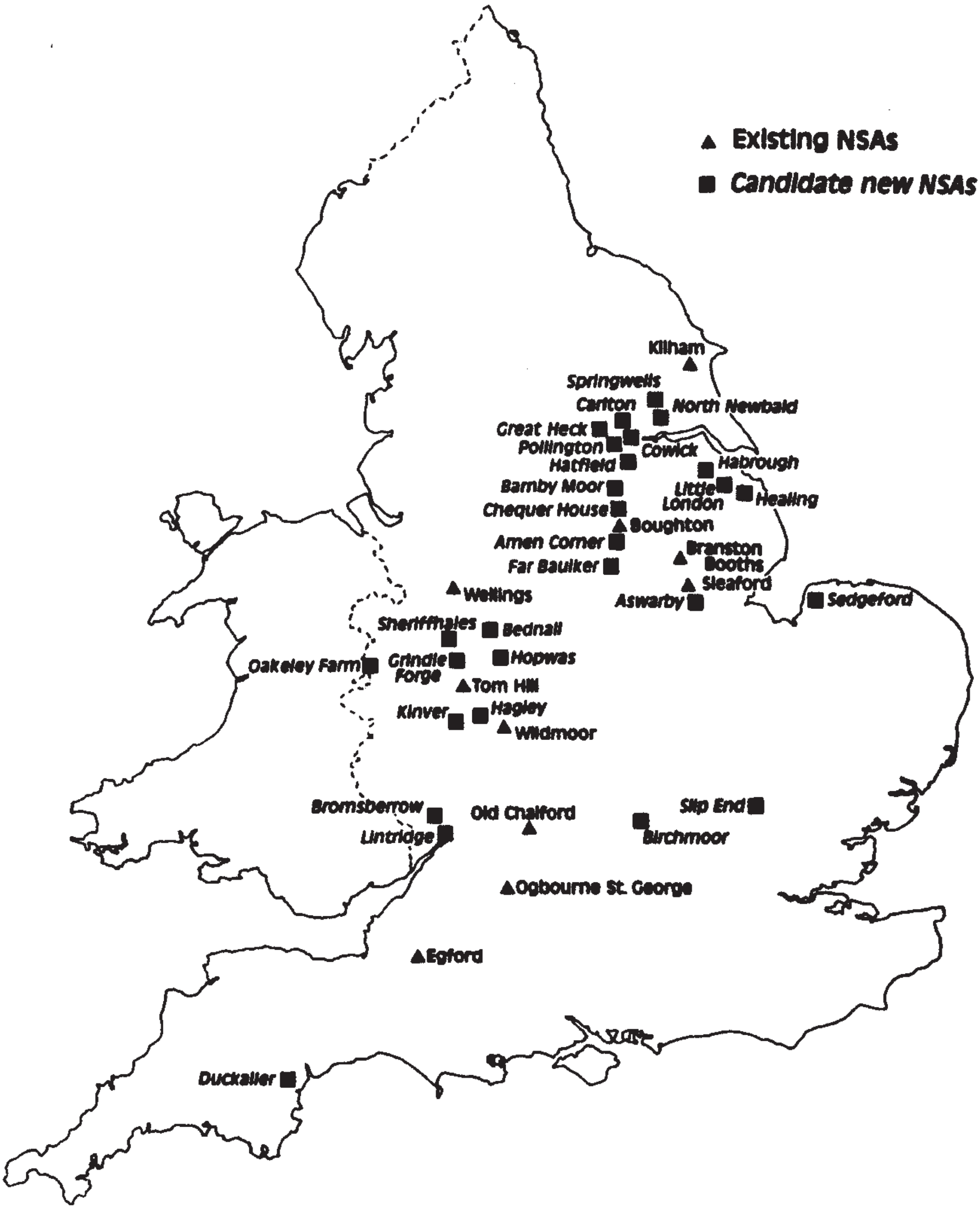


Figure 4a: Sleaford NSA
Century Plantation (Spring)

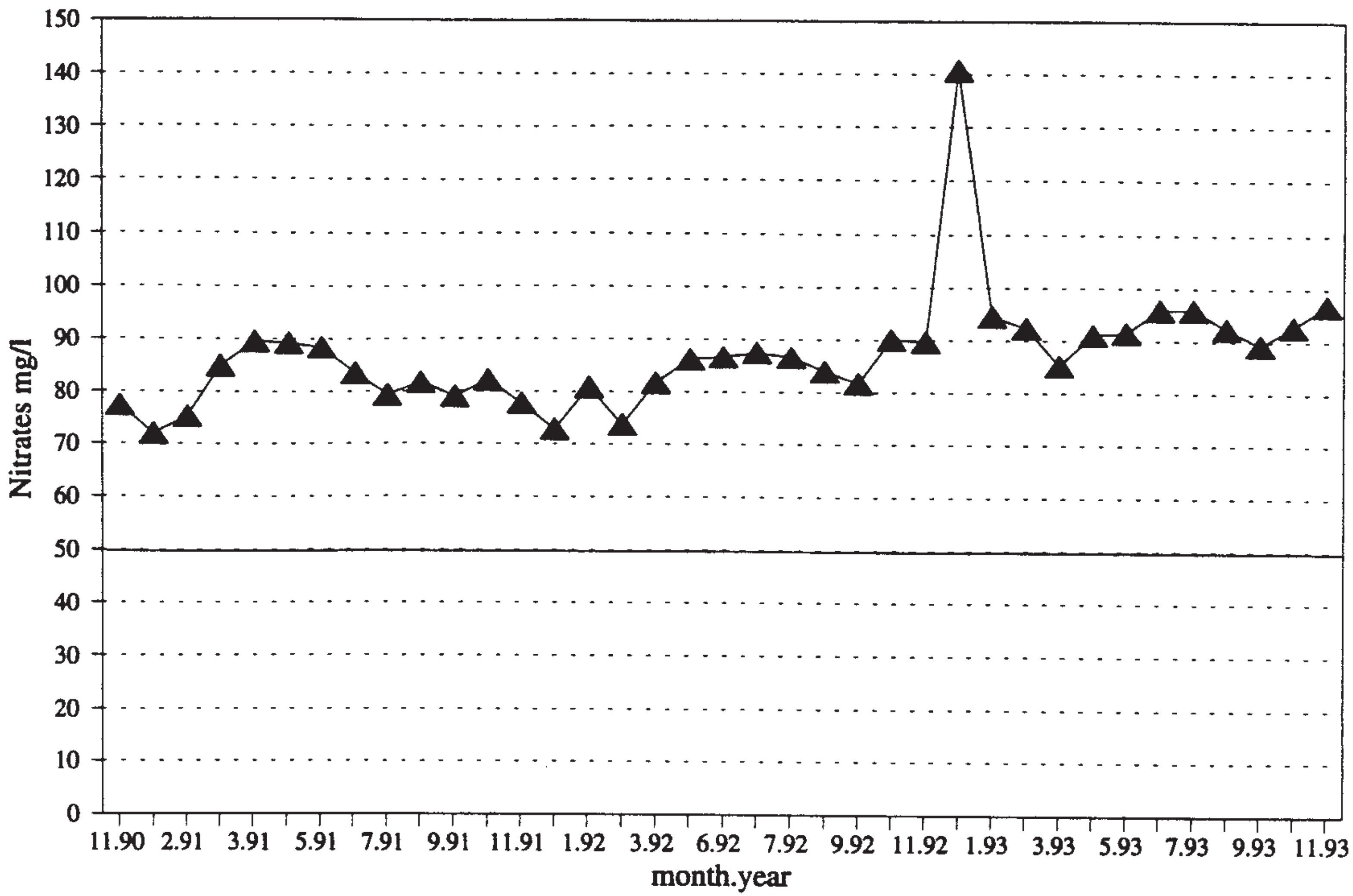


Figure 4b: Sleaford NSA

Wilsford No. 1 (borehole)

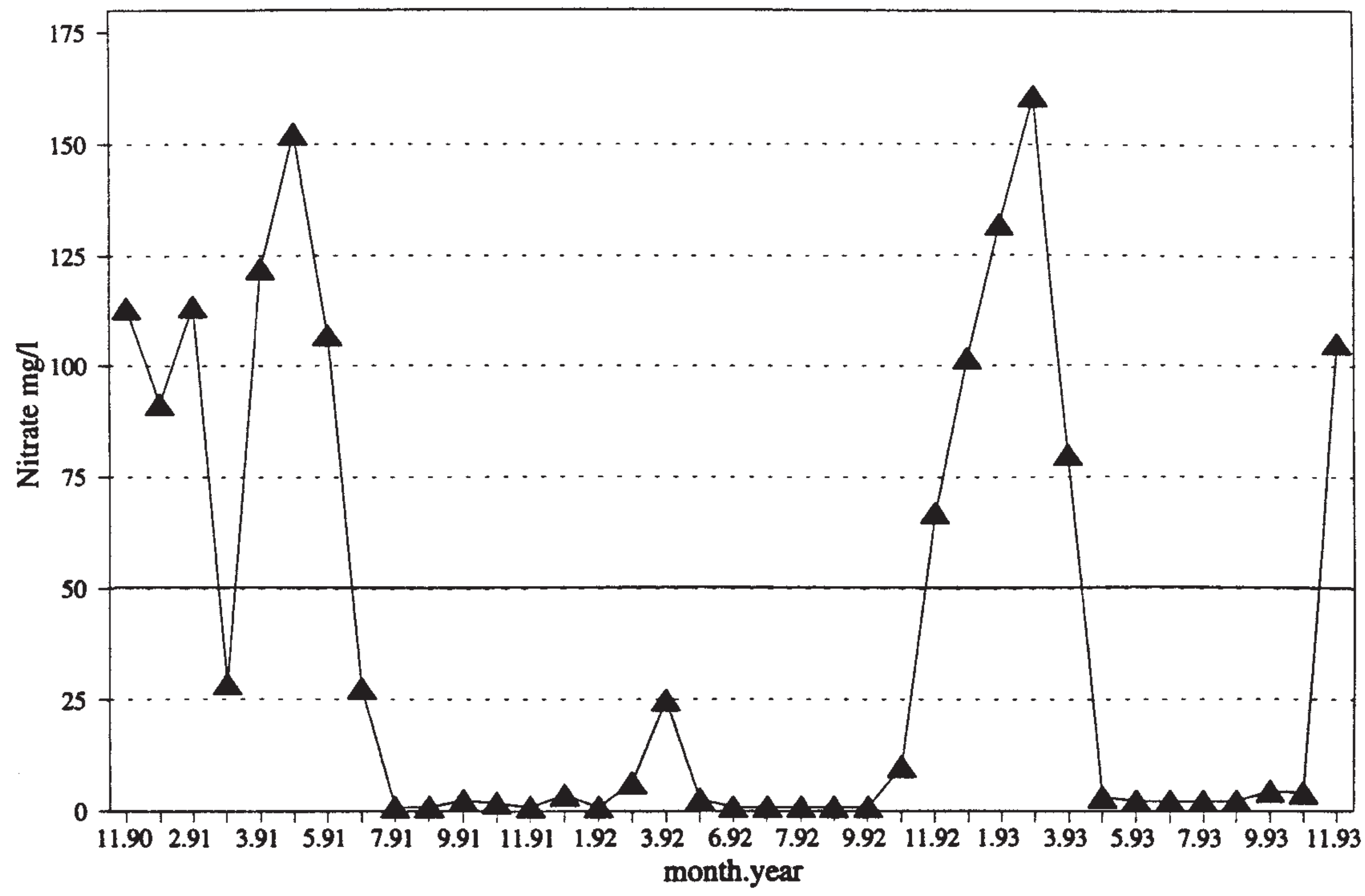


Figure 5a: Branston Booths NSA

Branston borehole

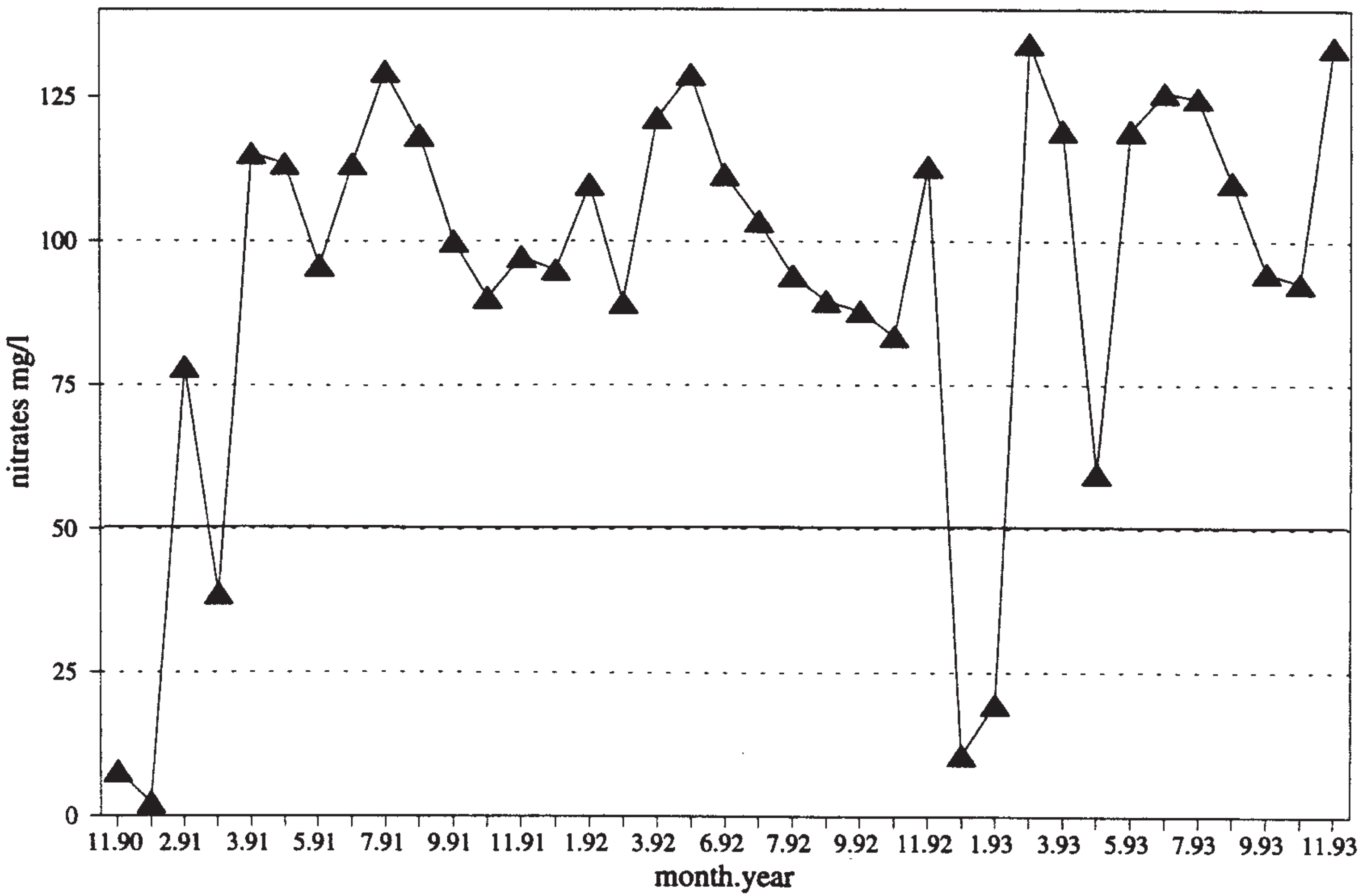
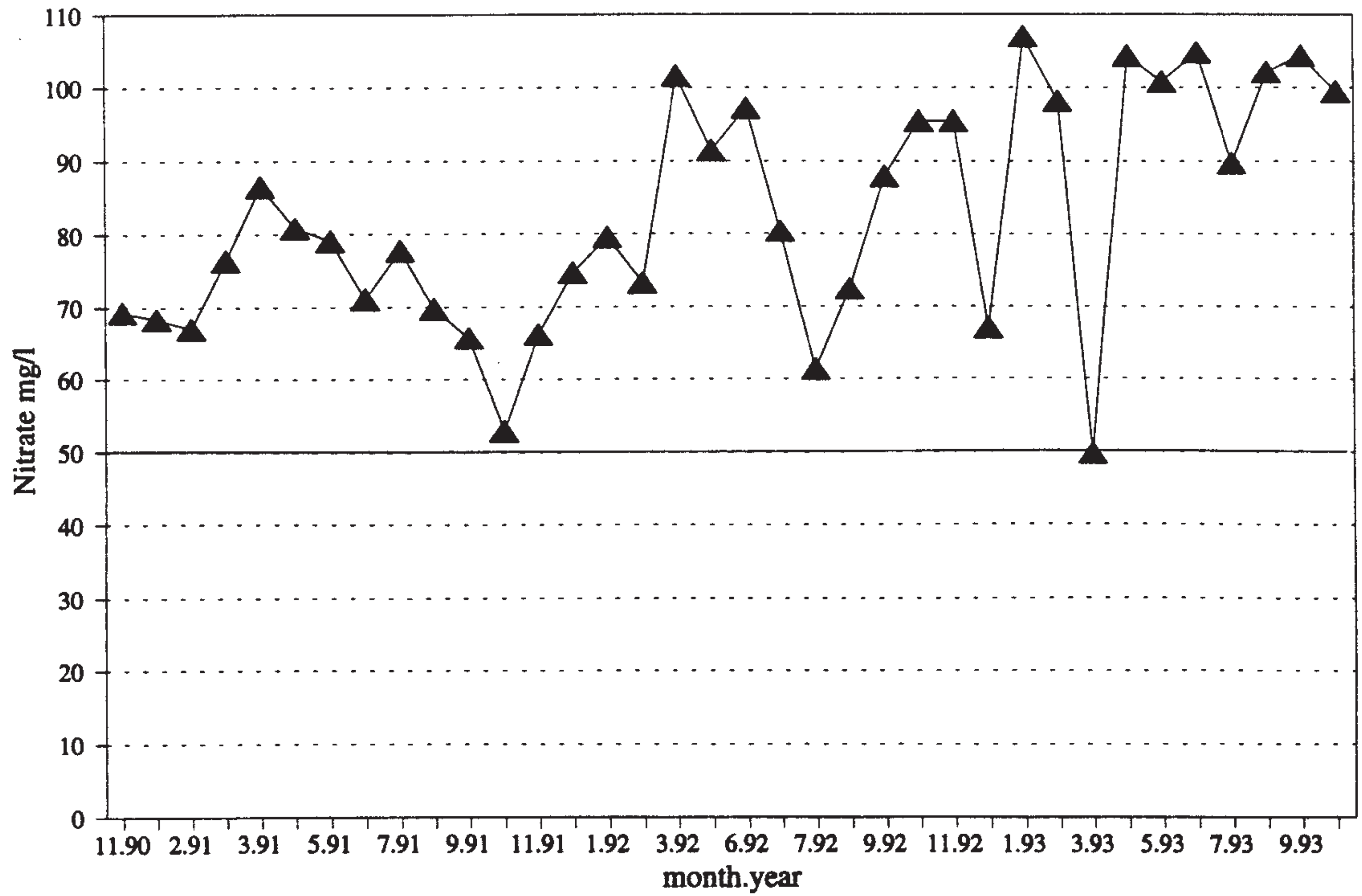


Figure 5b: Branston Booths NSA

Cliff Lane borehole



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