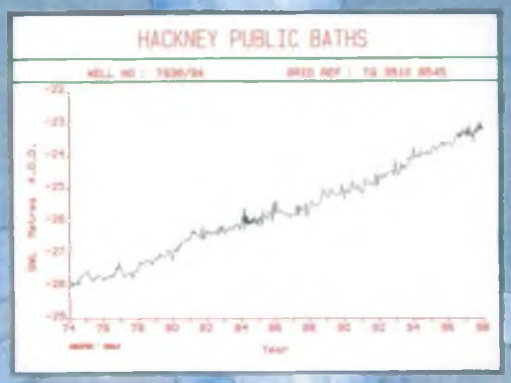
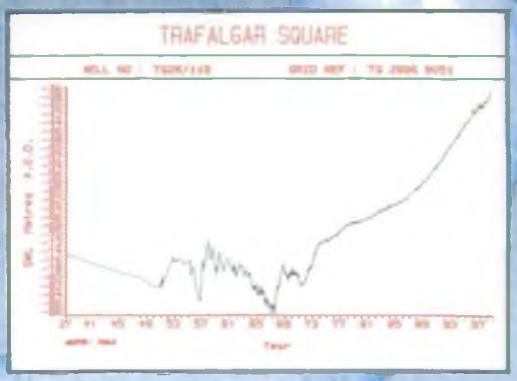
EA-Thames Box 2

ENVIRONMENT AGENCY

[redacted]





RISING GROUNDWATER LEVELS IN THE CHALK-BASAL SANDS AQUIFER OF THE CENTRAL LONDON BASIN

-- May 2002 --

CONTENTS

1. Introduction

This 2002 report is the eleventh annual report that the Environment Agency (and previously the National Rivers Authority) has produced on rising groundwater levels in the Chalk aquifer beneath London.

The rising groundwater levels are the result of a significant reduction in groundwater abstraction from the Chalk aquifer beneath London since the mid-1960s. Prior to this the Chalk aquifer had been increasingly exploited through the development of groundwater sources during the 19th and first half of the 20th centuries. By the time abstraction peaked in the 1960s, groundwater levels below central London had dropped to 88 metres below sea-level, creating a large depression in the water-table. The subsequent reduction in abstraction has resulted in groundwater levels recovering by as much as 3 metres per year in places in the early 1990s. This has led to a gradual re-filling of the water-table cone of depression. It should be understood that the Chalk aquifer is confined over most of London by a layer of London Clay, up to 80 metres thick in places. This prevents the water table actually bursting through at ground level but causes artesian pressure to build up underneath the London Clay as levels rise, slowly increasing its saturation. It is this re-saturation which could affect the stability of certain foundations and tunnels in the London Clay.

The consequences of rising groundwater have been discussed in detail in previous reports. The extent to which the stability of buildings and tunnels could be compromised by continuing re-saturation of the Chalk and London Clay has not been quantified, but the potential disruption and damage is such to merit preventative action.

The GARDIT (General Aquifer Research, Development and Investigation Team) five-phase strategy to control London's rising groundwater was published in March 1999 and is now being implemented. Thames Water Utilities Ltd (TWUL) are project managing the strategy to control the rising groundwater level by developing additional means of abstracting groundwater for public water supply. See section 5.

The Environment Agency has the responsibility to manage groundwater resources in an appropriate and sustainable manner. This is achieved by licensing abstraction as required by the Water Resources Act 1991. The Agency regards the rising groundwater beneath London as an available resource that should be utilised, where possible, for suitable potable and non-potable purposes.

2. Monitoring Network

The Environment Agency has a long term commitment to monitor and report on the state of groundwater levels beneath London. The Agency collates data from a network of nearly 200 observation boreholes to keep track of absolute groundwater levels and rates of change of levels in the Chalk aquifer. These are reported annually in this report.

Many of these data are obtained from other organisations, particularly water companies, and the availability of data could be compromised in the future by

modifications to these monitoring networks and by previously monitored boreholes becoming unavailable. Several longstanding monitoring boreholes have been lost in central London in recent years and any knowledge or, or data from, alternative boreholes would be very helpful to the Agency. People and organisations are requested to contact the Environment Agency Thames Region Groundwater and Licensing Group, Tel. 0118 9535311, if Chalk groundwater level information can be made available. Similarly, where redevelopment and ground investigations offer the opportunity of obtaining 'one-off' or short-term groundwater data, these data will be utilised wherever possible.

3. Groundwater Levels and Rate of Rise

3.1 Chalk Groundwater Levels at January 2002

Groundwater levels in the Chalk aquifer beneath London for January 2002 are shown in Figure 1. An enlarged map of Central London groundwater levels is also included (Figure 2). For comparison, January 2001 groundwater levels are included as Figure 3.

The lowest part of the cone of depression around the Regents Park area has risen slightly with the water level being at approximately –38 metres above Ordnance Datum (mAOD). However, water levels on the southern limb of the depression are falling. The lowest water levels were recorded in the observation boreholes at Grove Hall Court (TQ28/61) and at Ashley Gardens (TQ27/88). The water levels were –38.78 mAOD and –38.86 mAOD respectively.

The groundwater level at Trafalgar Square observation borehole (TQ28/119) (Figure 6) is currently –35.11 mAOD which is very similar to last year's level of –35.13 mAOD. For the last 3 years the water level has been fairly static, although the hydrograph can be interpreted to show a slight continued increase in water levels of 0.04 m/year, see 3.2 below.

The water level within the Essex cone of depression, centred between Wanstead and Romford, has decreased to below –30 mAOD at the centre. Essex and Suffolk Water have continued to abstract at Roding pumping station (TQ 4155 8910) but TWUL have also started to abstract from Wanstead pumping station (TQ 4153 8822) as part of Phase 1 of the GARDIT strategy. This operation has increased the actual abstraction in the area by a significant percentage in 2001 (>30%). Figure 8 shows the groundwater level at the Wanstead observation borehole (TQ48/12B).

Due to continued abstraction for public water supply, a cone of depression continues to develop in the area of TWUL's Merton (TQ 2960 7095) and Streatham (TQ 2686 7001) pumping stations (see Figures 9 & 10). This cone of depression also includes Sutton and E. Surrey Water's sources at Hackbridge (TQ 2801 6624, TQ 2787 6634, TQ 2807 6615). These pumping stations in south London are associated with Phase 1 of the GARDIT strategy

to control rising groundwater levels. A cone of depression is also evident around Honor Oak (TQ37/32B).

The borehole at Grove Hall Court showed the lowest water level last year but the water level at Ashley Gardens has decreased since last year. Ashley Gardens is 5 km to the south east of Grove Hall Court so the decrease in water level could be associated to the decrease of water levels in south London. The hydrograph for Ashley Gardens is shown in Figure 7.

3.2 Current Rate of Rise / Fall of Chalk Groundwater Levels

The current rate of rise of Chalk groundwater levels in the London Basin is shown by the contour map in Figure 4. The previous rate of rise map for the January 2001 is also shown, Figure 5.

For many boreholes in last year's report the rate of rise was analysed over the previous 18 months as there had not been a constant rate of rise over the previous 2 years. This is the case again this year. In many boreholes there has not even been a steady rate of rise compared with 2001. Therefore, the rate of rise which is reported is the rate of rise which is considered to be representative of a continuing current trend. The periods over which this rate of rise is taken vary from 6 months to 2 years and is contoured in metres rise/fall per year.

As last year, the maximum rate of rise in central London is no longer in the Trafalgar Square area. The rate of rise of now only 0.04 m/year could be interpreted from the data. Rate of rise as recorded in the Trafalgar Square borehole (TQ28/119, Figure 6) has reduced from 1.7 m/year as published for January 2000 to 0.24 m/year during 2001 and now 0.04 m/year. Overall, the water level across central London has not changed much since last year, which indicates that some control of the water levels in this area has been attained.

The maximum rate of rise of water levels is in the Greenford–Wembley area of north-west London. Groundwater levels here continue to rise in excess of 1.5 metres per year (Figures 11 & 12).

The fall in levels that has been apparent in recent years across a large area of south London is continuing. This is due to abstraction by Sutton and East Surrey Water Company at their Hackbridge source, and Thames Water Utilities Limited (TWUL) at their Streatham and Merton Abbey sources. Groundwater levels have been seen to fall in this area by as much as 15 metres per year, as observed in the Herlwyn Gardens observation borehole (TQ 27/342, Figure 10). Levels in this area are very responsive to abstraction so they vary considerably as the pattern of abstraction changes. The influence of abstraction now extends from Surbiton in the west to Dulwich in the east, and northwards as far as the City.

In north east London a significant fall of water levels is seen in the Stratford area (TQ38/59B, Stratford Goods Yard, Figure 13). This is due to the

commencement of dewatering in that area for the development of the Channel Tunnel Rail Link (CTRL) and the "Stratford Box" which is the location of a new station and may require permanent dewatering. Further temporary dewatering will occur along the alignment of the tunnel over the next few years.

Water levels are now falling at around the River Roding by up to 2 metres per year but the trend within the Essex depression to the east is still a slight increase in water levels. Further north east, at Stanford Rivers STW observation borehole (TQ59/16) 3 km south of Chipping Ongar, groundwater levels continue to rise at 0.31 m/year. (Figure 14)

In south east London along the Ravensbourne Valley, where significant new resources are being developed by TWUL, levels are generally stable. The hydrograph of TQ37/34, Ladywell Centre (Figure 15) is included as, in future years, the trend in this borehole should show the effects of resource development in the Ravensbourne Valley area.

4. Groundwater Abstraction Trends in London Since 1990

Figure 16 shows the total licensed and actual abstractions in the area contributing to rising groundwater in central London for each year from 1990 to 2001. The area for over which abstractions are taken has been increased this year to include the Roding and Wanstead pumping stations so the volumes for previous years have been adjusted accordingly. The area is shown in Figure 18.

Licensed abstraction quantities had been gradually increasing over the last few years but there has been a decrease of licensed quantities in 2001. However, there has been a significant increase in actual abstraction of approximately 5400 Ml/a during this year. Most of this additional abstraction has been at the pumping stations at Merton, Streatham and Hackbridge.

Much of the increase in licensed quantity since 1990 is due to the development of TWUL's North London Abstraction Recharge Scheme (NLARS) in 1994/5. This group of boreholes is operated only to meet peak demands, typically in dry years. At times when surplus mains water is available, it is recharged back to the Chalk aquifer, utilising it as a natural reservoir.

The quantities of water abstracted and recharged each year through the NLARS scheme are shown in Figure 17. The highly variable operation of the scheme means that it does not have a major impact on rising groundwater levels. In 2001 NLARS may have contributed to some localised decrease in water levels as the scheme has been used mainly for abstraction of water, only 10% of the abstracted volume has been recharged back into the aquifer. Only after extensive abstraction in a dry year would significant quantities be recharged.

5. Progress with the GARDIT* Strategy

*(General Aquifer Research, Development and Investigation Team)

Thames Water Utilities Ltd (TWUL) are project managing the 5 phase strategy to develop, with other companies, the infrastructure to abstract more of London's rising groundwater for public water supply and to control levels (see EA Report for April 2000).

Phase 1 of the Strategy is now complete with sources at Merton, Streatham, Honor Oak and Wanstead back in operation. The first two sources, together with the source at Hackbridge (south Merton), operated by Sutton and East Surrey Water (SES), are having a substantial effect in south London along a corridor from the River Thames to the boundary of the Tertiary Strata and the Chalk of the North Downs.

Phase 2 of the Strategy is still on going. Between late September 2000 and early May 2001 a very large combined pumping test was carried out by TWUL at two new sources, Battersea and Brixton. A combined rate of just over 20 Ml/d was achieved for much of this period. The source at Brixton has now been licensed for a volume of 10 Ml/d. The Battersea licence is currently being determined for a volume of 7 Ml/d and testing is still ongoing at New River Head in conjunction with a new site at Barnard Park. It is expected that one or more of these new sources will be operated on a near continuous basis. This will cause substantial reduction in levels over the next few years. The Brixton source is already in operation.

Phase 3 is defined as abstraction developed by organisations other than TWUL. Only three new groundwater abstractions were granted during 2001 for a total of 0.77 Ml/d but applications for abstraction proposals are continuing to be received.

The testing at Phase 4 site, Porchester Square, was not successful but plans for drillling and testing at Barrow Hill, Holland Park and Mile End are being progressed.

6. Additional Abstraction Proposals

6.1 Roding Valley

In Essex, along the valley of the middle River Roding and in the Chigwell area, Essex and Suffolk Water are carrying exploration drilling into the deep Chalk aquifer with a view to developing a groundwater abstraction and possible recharge scheme based around the treatment works at Chigwell.

6.2 Dewatering Water

Both permanent and temporary dewatering sites required for the construction of the Channel Tunnel Rail Link are currently being constructed by Rail Link Engineering (RLE). These sites are around the "Stratford Box" and along the tunnel alignment. There is interest from Thames Water to utilise the dewatering location for public supply after the tunnel construction. The sustainability of these proposals needs to be carefully assessed but there is

probably considerable potential for intermittent (peak load) abstraction. These proposals will have only a marginal effect on the central London cone of depression. They will however add to the overall ability to utilise and control the Chalk aquifer resource under London over a very wide area.

6.3 The Ravensbourne Valley

TWUL have developed two additional sources in the Ravensbourne Valley at Catford and Bell Green in NW Kent. The combined yield of these is around 20 Ml/d. Whilst these have only a marginal effect in the central London area, when combined with the proposals north of the River Thames in Essex, they represent a considerable usage of Chalk groundwater which would have drained naturally into the Thames Tideway.

7. Additional Combined Abstraction / Recharge Proposals

The North London Abstraction Recharge Scheme (NLARS) has now been in operation for eight years. It consists of 35 abstraction borehole sites, many of which are also capable of recharging treated mains water back into the Chalk aquifer to utilise this as a natural reservoir. The scheme is used in times of peak demand and has the potential to supply 150 Ml/d for periods of several months at a time. There are currently proposals to increase the peak daily deployable output of the scheme by upgrading existing boreholes and constructing new boreholes at some additional locations. The subsequent reduction in resource is made up by recharging treated water back into the aquifer in the following winter when demand is lower and surface water resources are abundant. This operation has no long term effect on rising groundwater levels.

A similar scheme is being proposed for South London (South London Abstraction recharge scheme, SLARS) in the corridor north and south of Merton. Recharge/abstraction testing is already taking place at Streatham. The potential for the GARDIT Phase 1 and Phase 2 sites to cause very large drawdowns in this area means that the potential to utilise the area for recharge will increase. Similar recharge potential is also being considered in the Ravensbourne Valley.

8. Balancing Groundwater Level, Abstraction and Recharge

The TWUL led, 5 phase GARDIT programme is now well underway and a number of key abstraction sites are now established or are due to be commissioned. There is now no doubt that these, plus the remaining proposals will enable sufficient water to be abstracted to control London's rising groundwater in the long term. It is useful at this point to re-state the objective of the GARDIT strategy which is "To control groundwater level in the Chalk aquifer under London in order to maintain the integrity of underground structures and foundations in the London Clay".

Once the infrastructure is in place to do this, the operation of this should be with a view to maintaining levels below an upper level needed to protect underground structures. Any additional abstraction and additional drawdown will enable the

aquifer to be used in a more versatile way, limited by a lower level which is the point where the Chalk aquifer starts to be dewatered to an unacceptable level. This is considered to be the point beyond which the abstraction rate is unsustainable, yields would fall and protected rights to abstract would be derogated. This level is a complex surface based on the situation locally. Because response times in the aquifer are measured in years, the Agency is confident that it can manage the situation through the abstraction licensing process, specifically through issuing time limited licences. Because of the pace of development in London, abstraction licences are frequently lapsing. The current situation is that requests for new licences can usually be agreed. Under Water Resources legislation, however, the rights of existing abstractors must be protected. As new development of the resource increases, the increasing issue of derogation of protected rights will make new proposals more difficult. Prospective applicants need to realise that large proposals will result in having to protect other abstractors over a radius of several kilometres. Large proposals, particularly for environmental control of buildings i.e. (heating and cooling) frequently fail at the design stage because unrealistic quantities of groundwater are sought which the aquifer will not yield and the derogation issues become very difficult to deal with.

The key player, however, is TWUL. When the majority of abstraction infrastructure is licensed to this major water company, the controlling ability to maintain levels will lie with them. The Agency's role is to continue to monitor levels and advise the major abstractors on the current situation so that abstraction can be slowly adjusted to achieve the required balance.

The concept of using the aquifer as a reservoir to be abstracted and refilled by recharge up to an agreed level is already an established operation in North London by the NLARS. The extension of this concept over much of the London Basin is now becoming feasible.

Eventually, the whole of the London Basin Chalk aquifer will become a highly managed entity, like many other natural systems in the UK. The great advantage of controlling the London Basin Chalk aquifer is that there is no negative environmental side to it. No ecosystems depend on a specific groundwater level under London and therefore, provided levels are kept below that required to protect structures, the aquifer represents a very secure, stable and sustainable water resource.

9. Conclusions

- The lowest groundwater levels are beneath Regents Park and also to the south of the park at around –38m.
- The rate of groundwater level rise in central London has reduced to less than 0.5 metres/year with the water level to the south beginning to fall.
- The maximum rate of rise continues to be approximately 1.5 metres/year in the area between Ealing and Wembley where there are very few structures with very deep foundations.
- In south London, abstraction from the GARDIT Phase 1 sites is having a substantial effect in reducing and controlling levels and this effect appears to be spreading north of the Thames into the central London area.

- Later phases of the GARDIT Strategy now being put in place, plus the other resource development options described in Section 5 above, are now sufficiently advanced to indicate that the control of levels is a reality.
- If groundwater abstraction by the major players in the Strategy actually builds up to serious utilisation of this water resource, then rising groundwater levels will be controlled. This utilisation is beginning to be indicated by the increase in actual abstraction from 2000 to 2001.
- The protection of existing abstraction rights will become more of an issue as increasing abstraction lowers water levels. This will eventually become the dominant factor affecting future development of the resource, demonstrating that the limit of sustainability has been reached.

VKR/ACH/JS 05/2002

Figure 1 London Basin Chalk Groundwater Levels, January 2002 (metres OD)

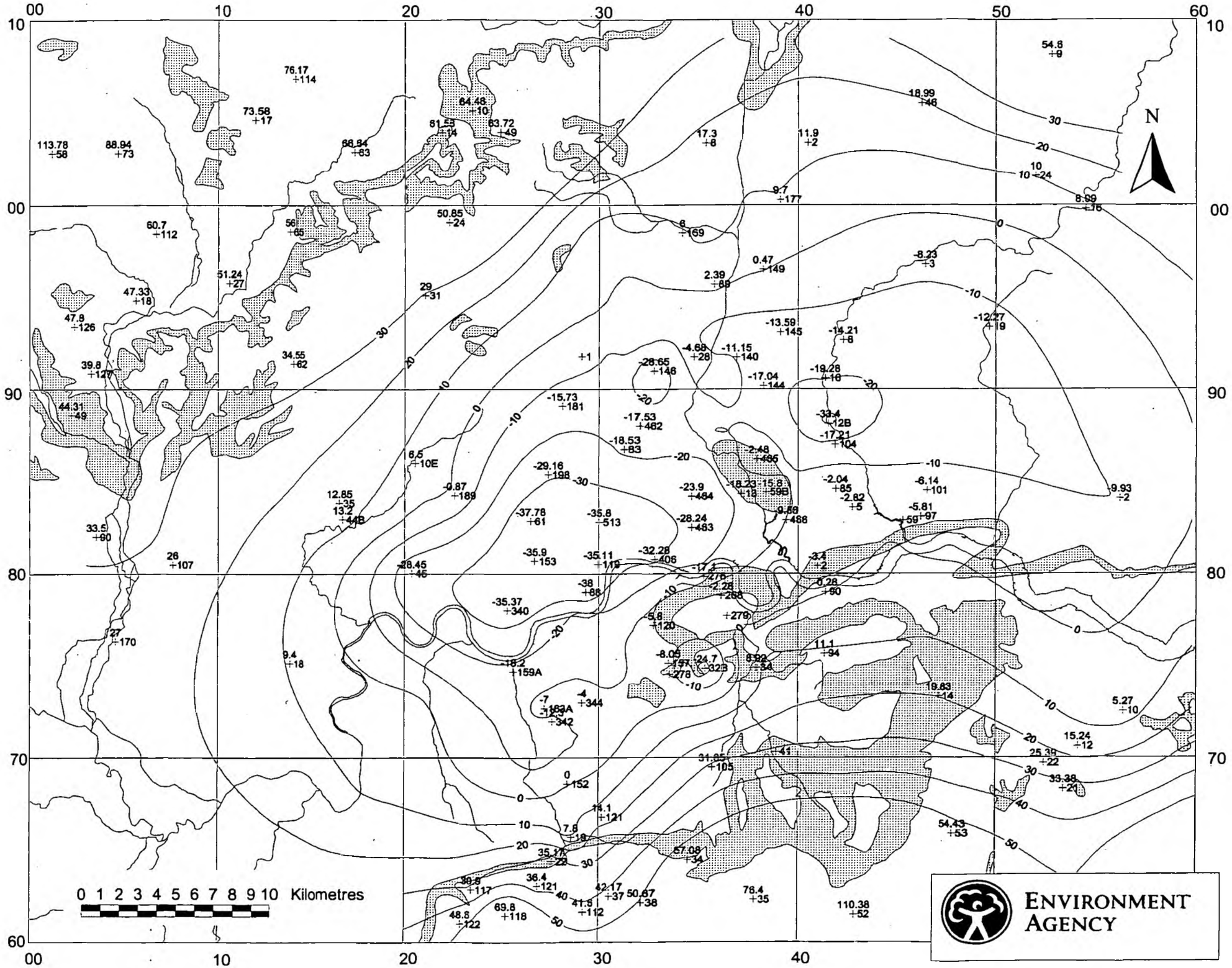


Figure 2 - Central London Chalk Groundwater Levels, January 2002 (metres OD)

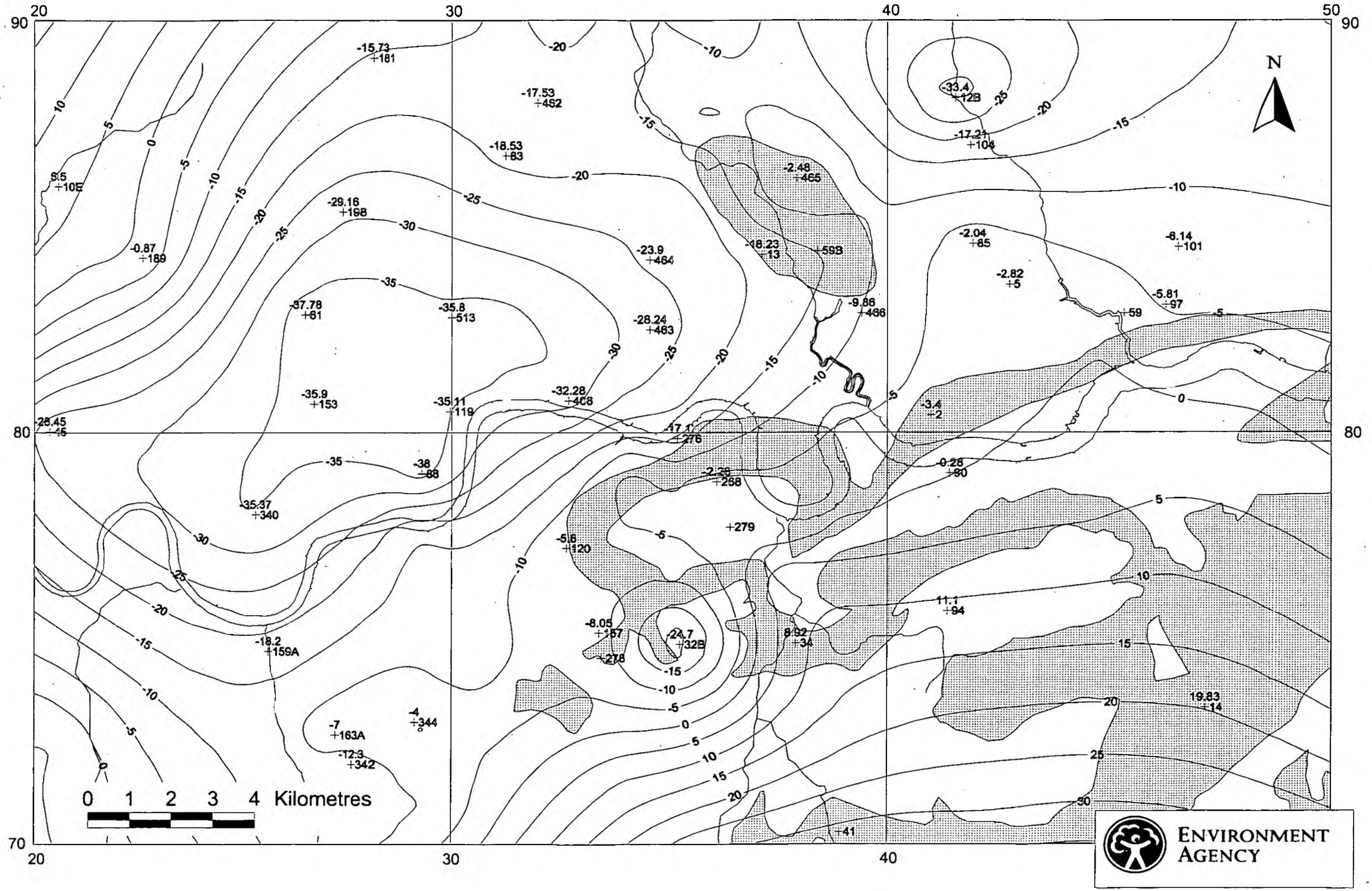


Figure 3 London Basin Chalk Groundwater Levels, January 2001 (metres OD)

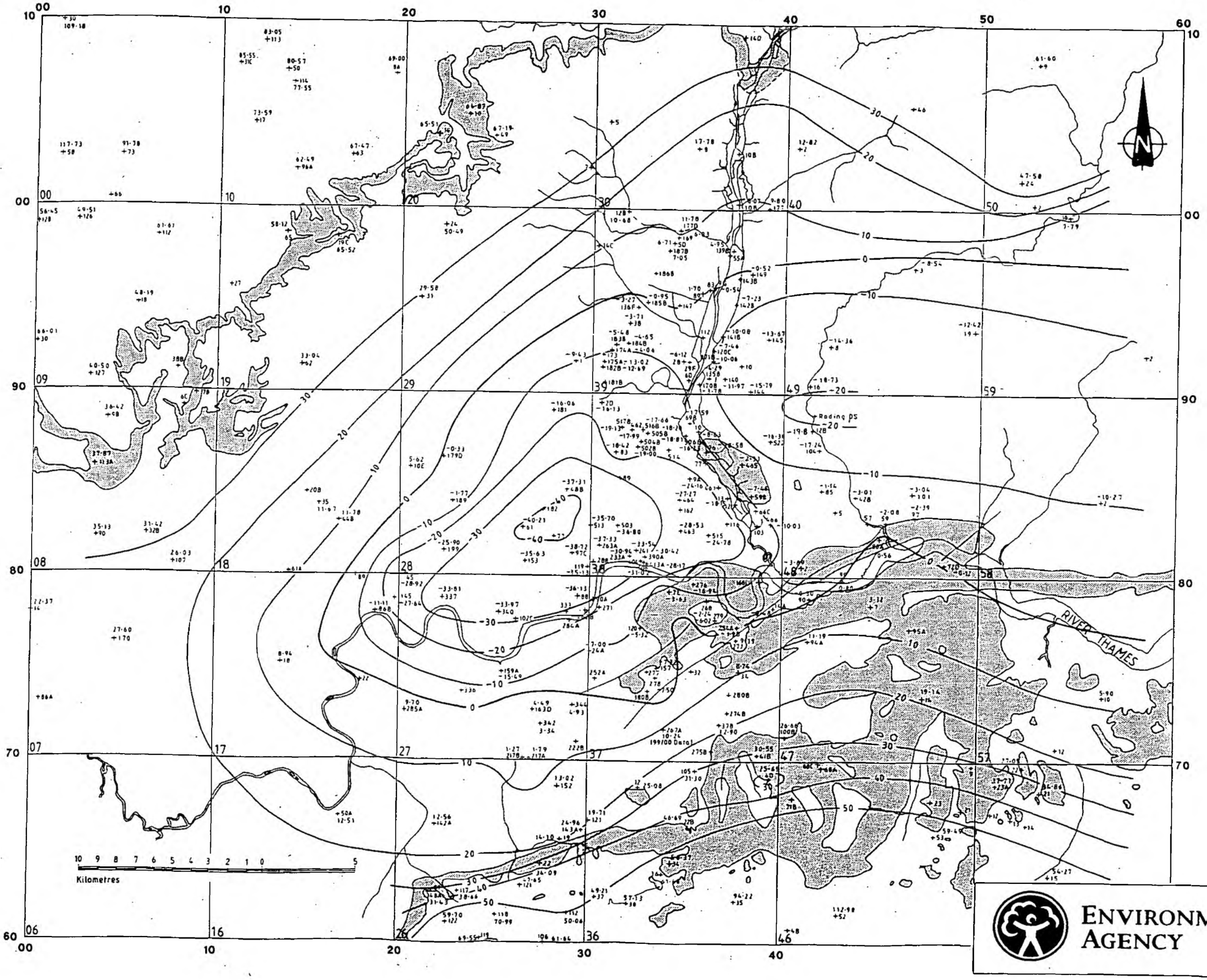


Figure 4 London Basin Rate of Rise of Chalk Groundwater Levels, January 2002 (metres / year)

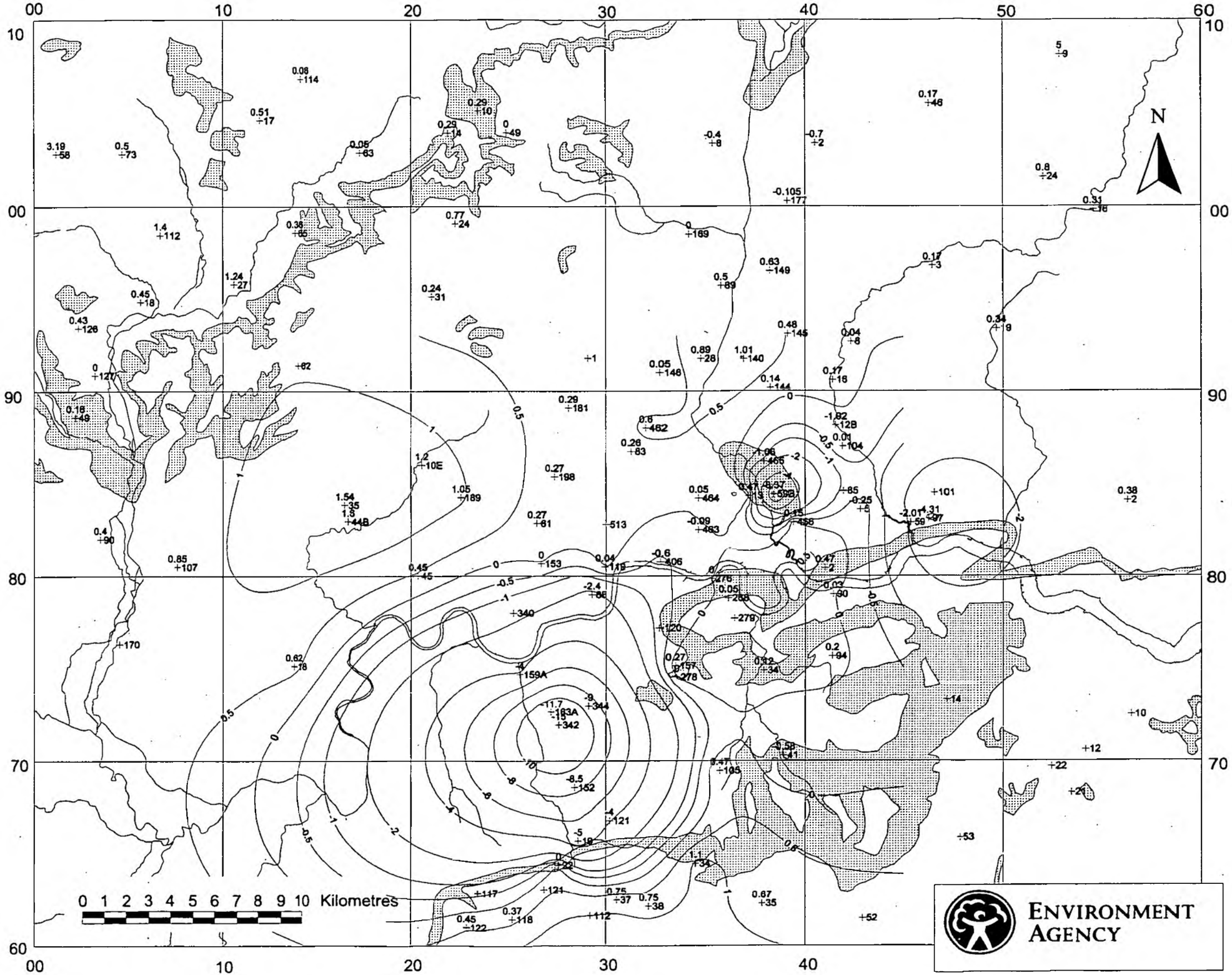
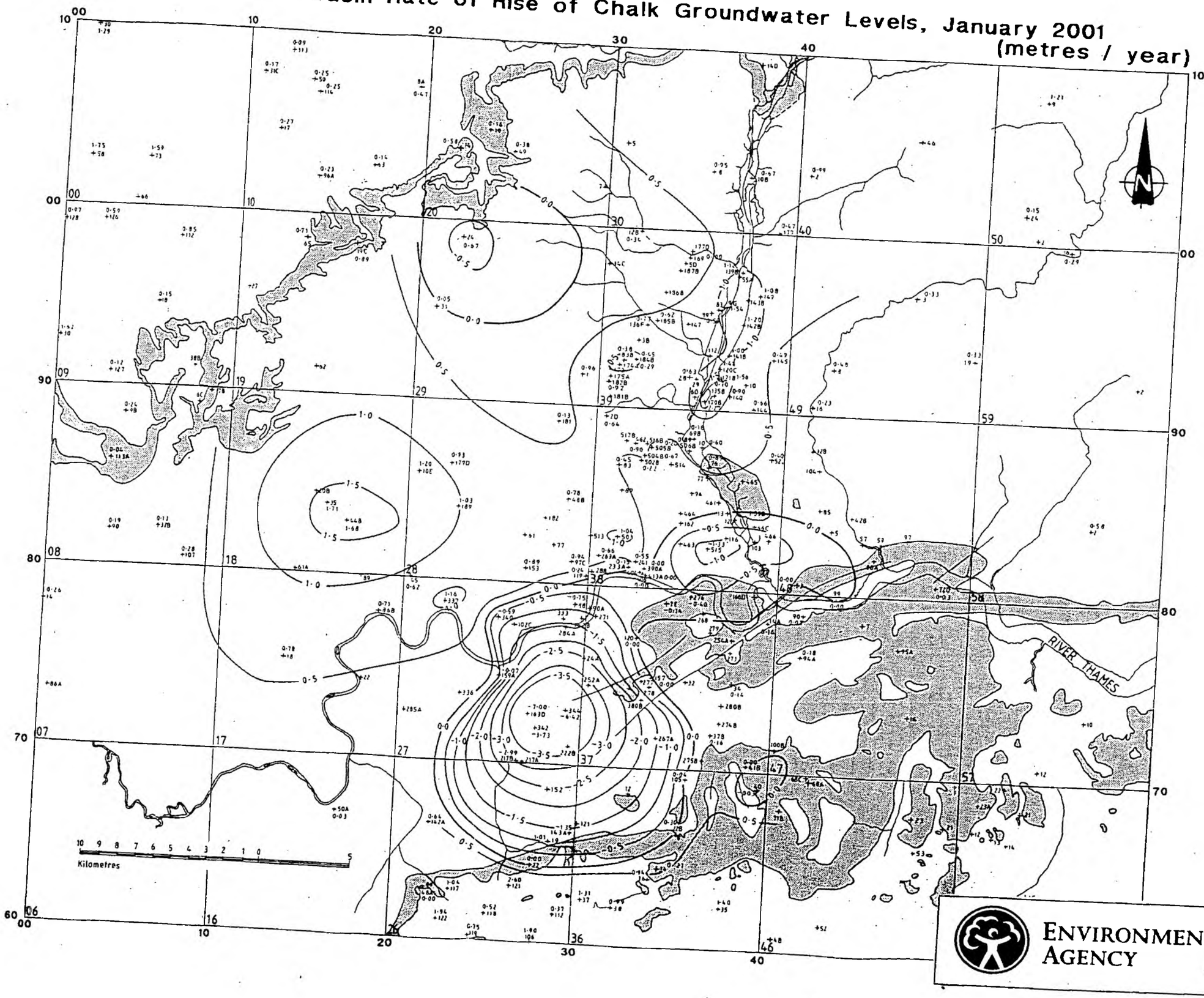


Figure 5 London Basin Rate of Rise of Chalk Groundwater Levels, January 2001 (metres / year)



ENVIRONMENT AGENCY

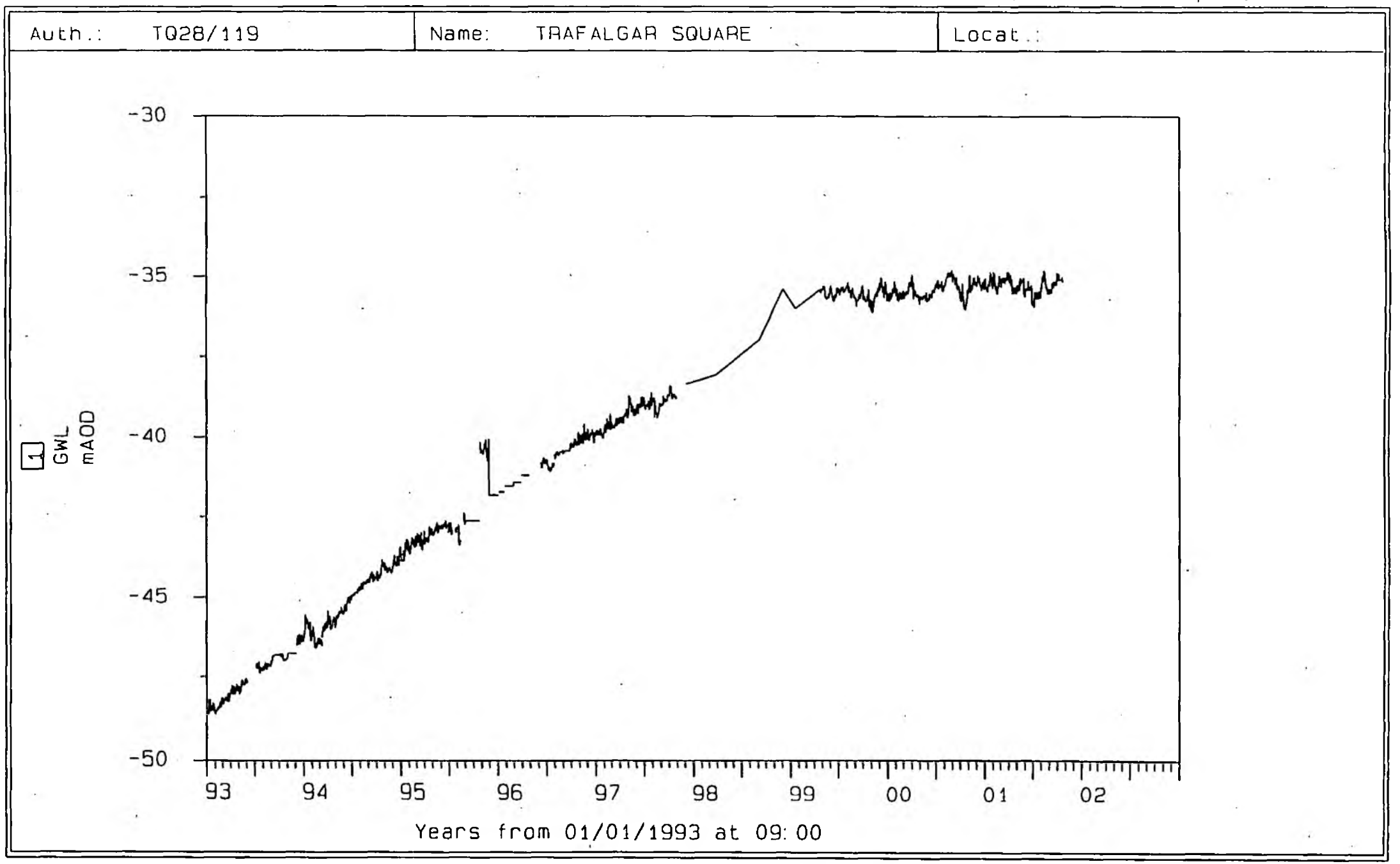


Figure 6 Trafalgar Square OBH, TQ28/119

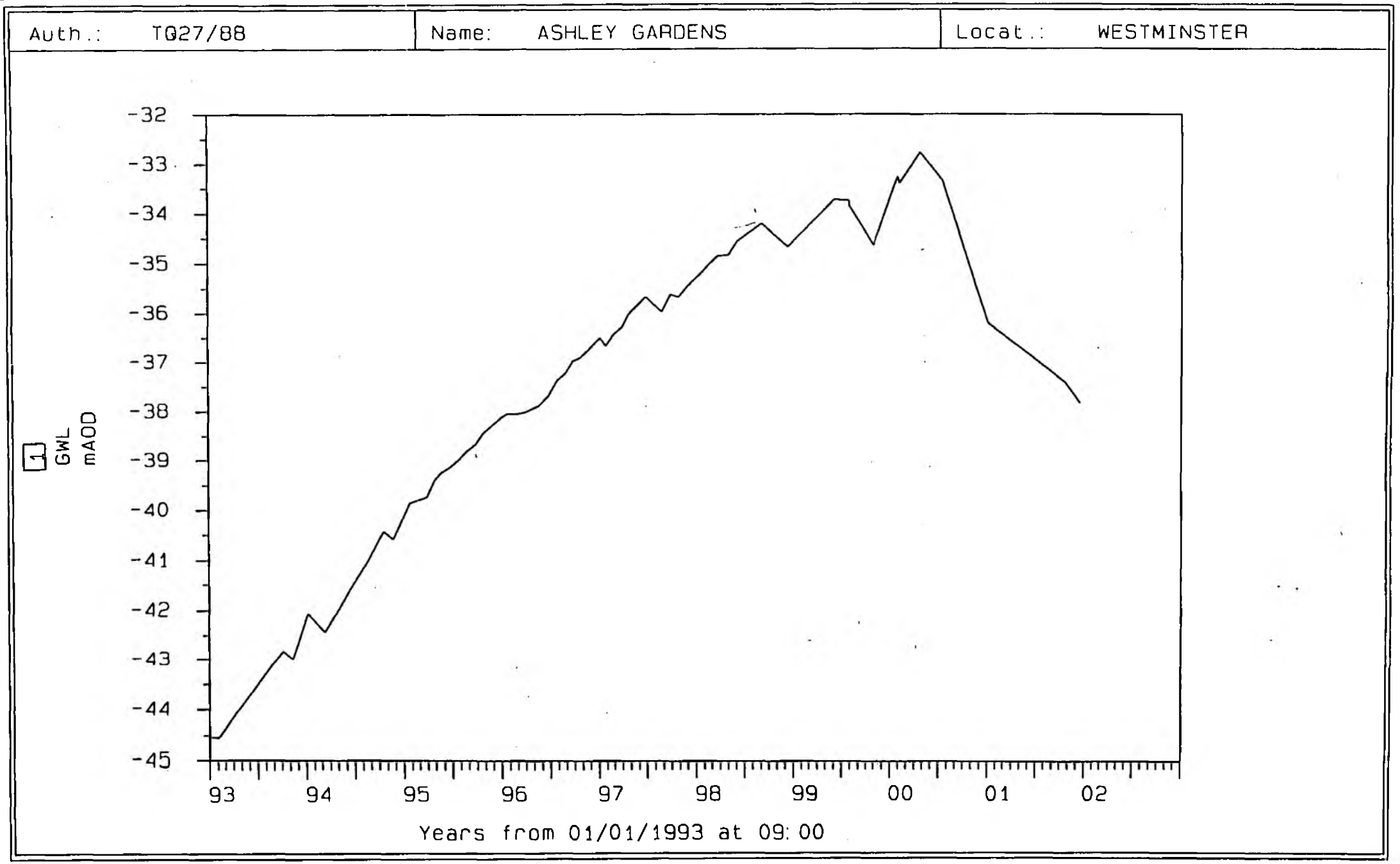


Figure 7 Ashley Gardens OBH, TQ27/88

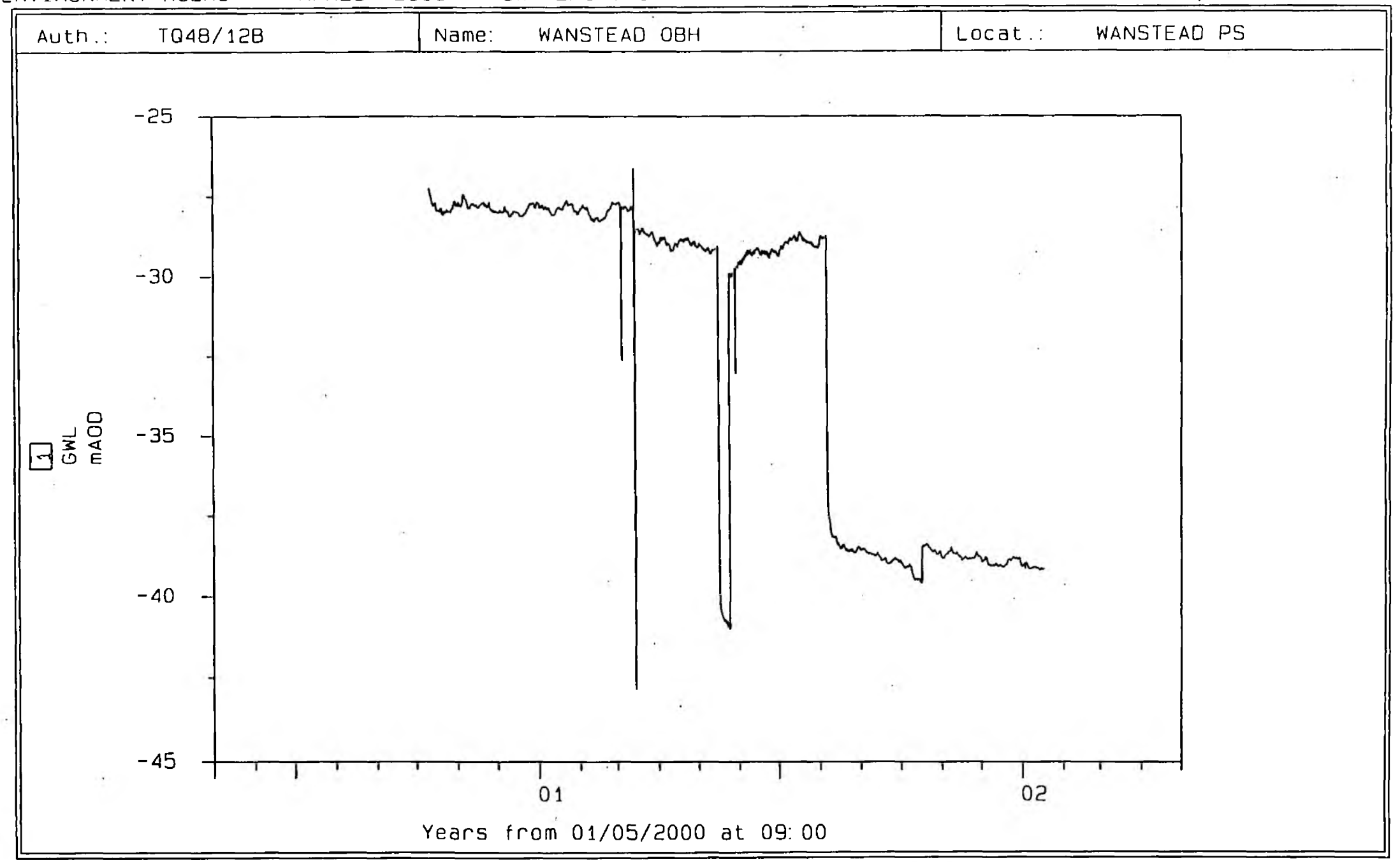


Figure 8 Wanstead OBH, TQ48/12B

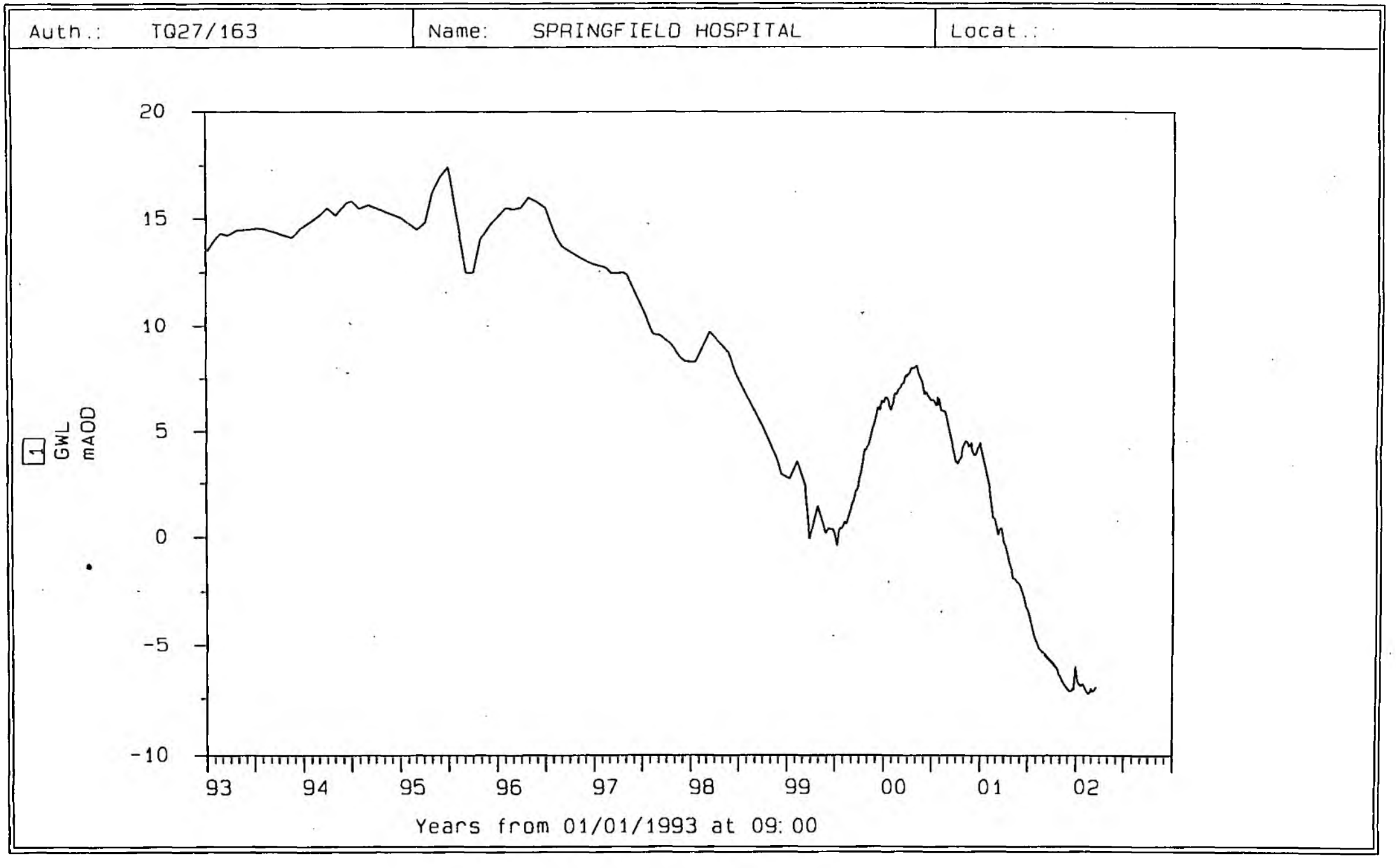


Figure 9 Springfield Hospital OBH, TQ27/163

Auth.: TQ27/342	Name: HERLWYN GARDENS	Locat.: TOOTING, STH LON

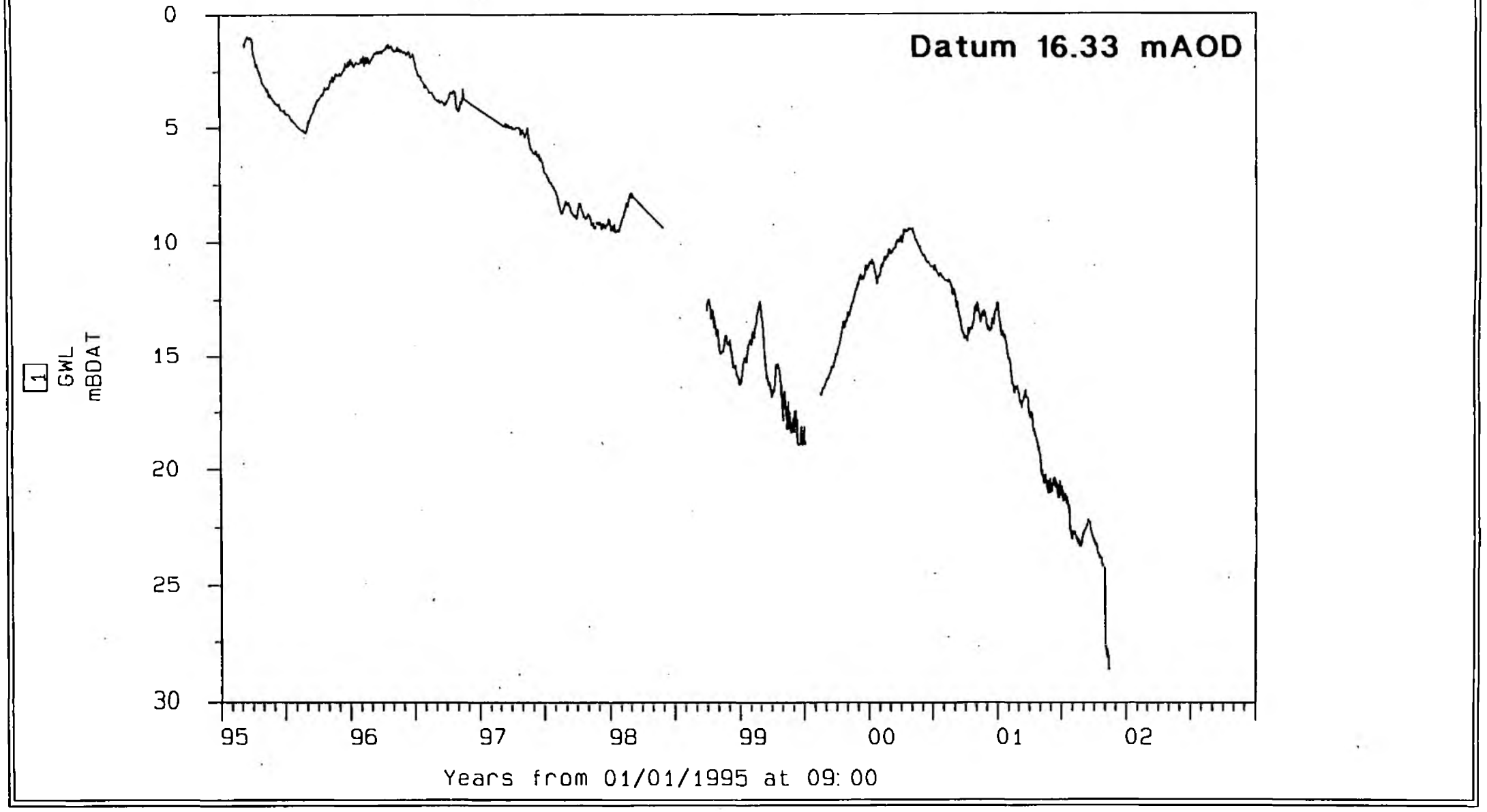


Figure 10 Herlwyn Gardens OBH, TQ27/342

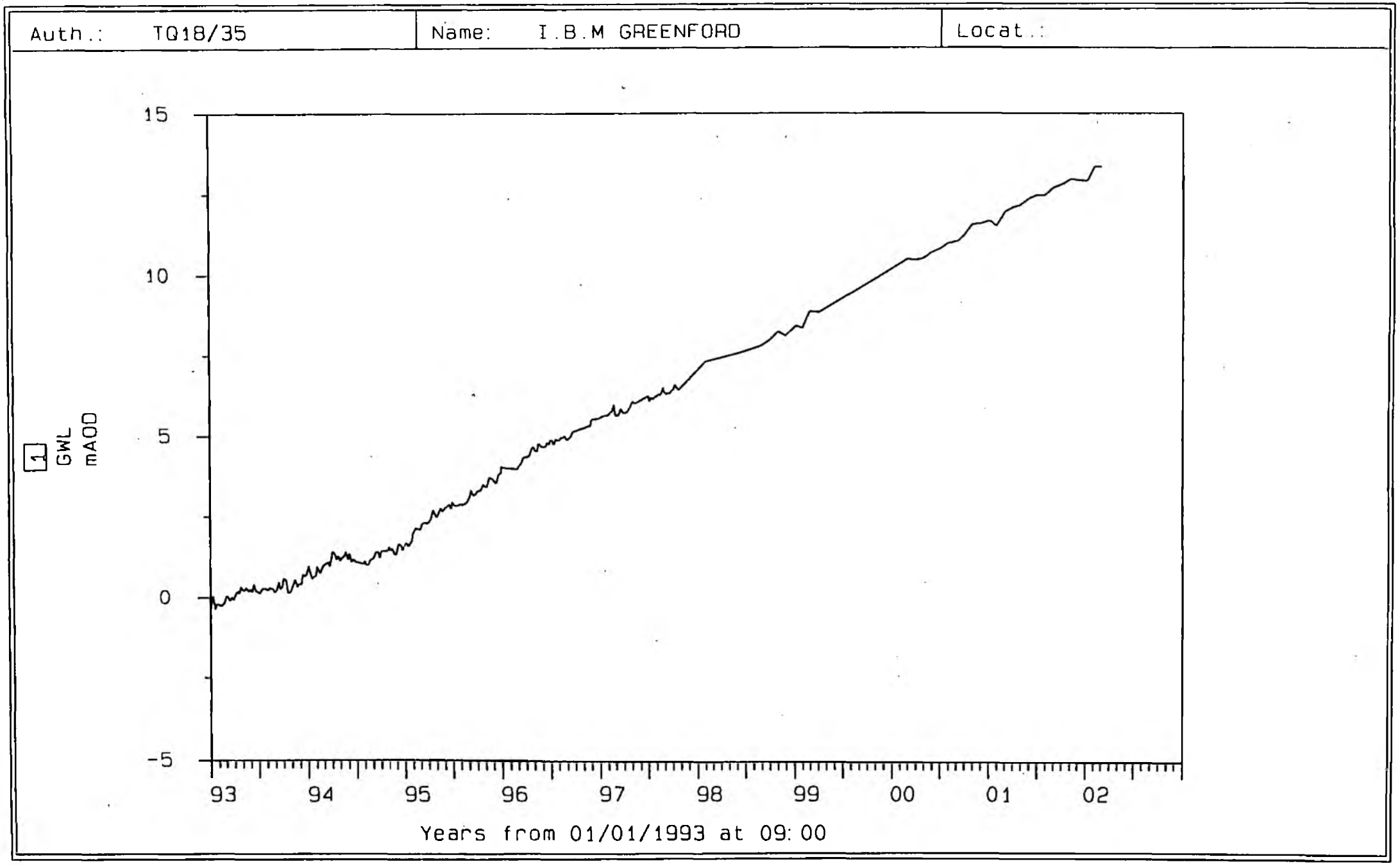


Figure 11 I.B.M Greenford OBH, TQ18/35

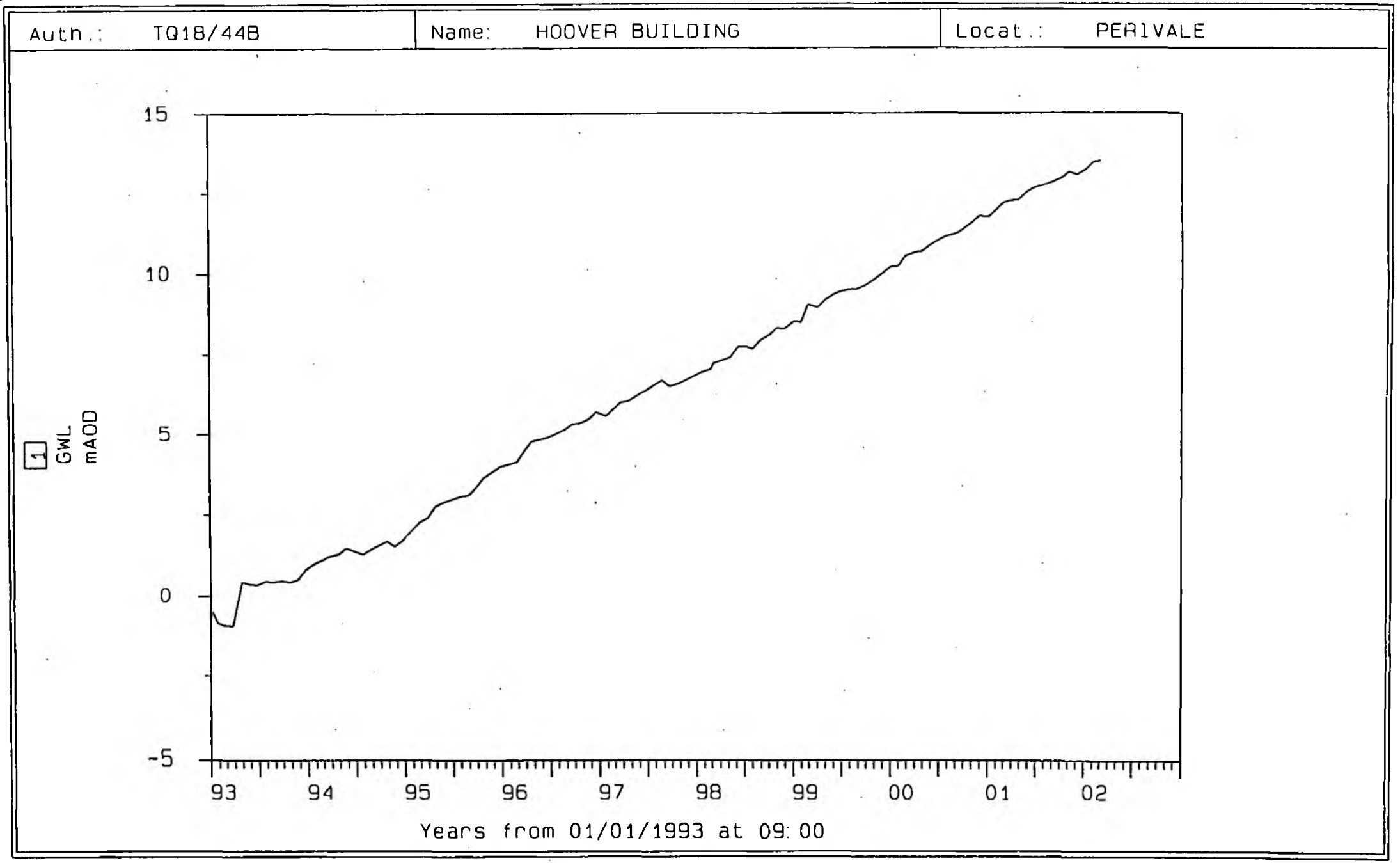


Figure 12 Hoover Building OBH, TQ18/44B

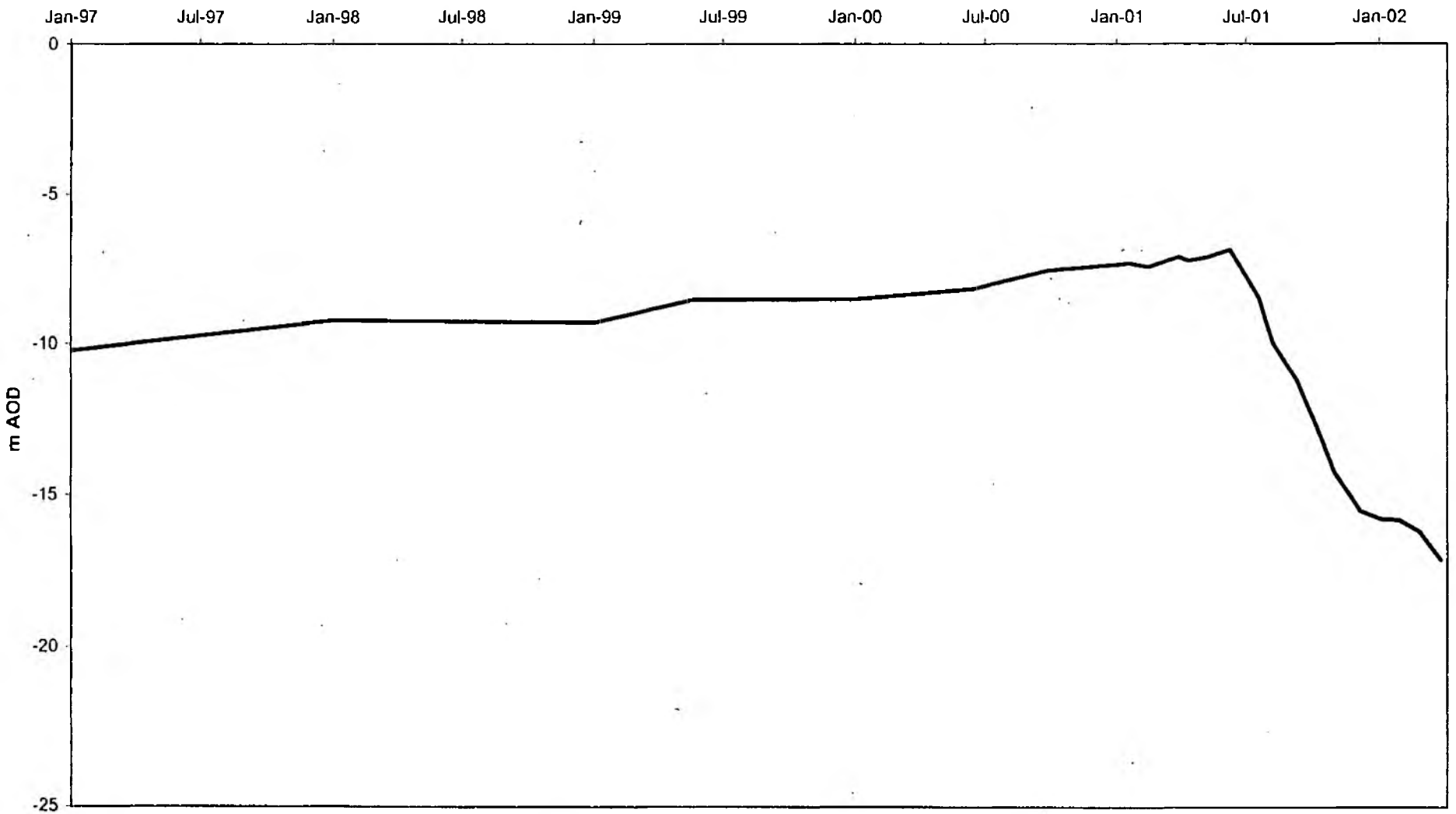


Figure 13 **Stratford Goods Yard OBH, TQ38/59B**

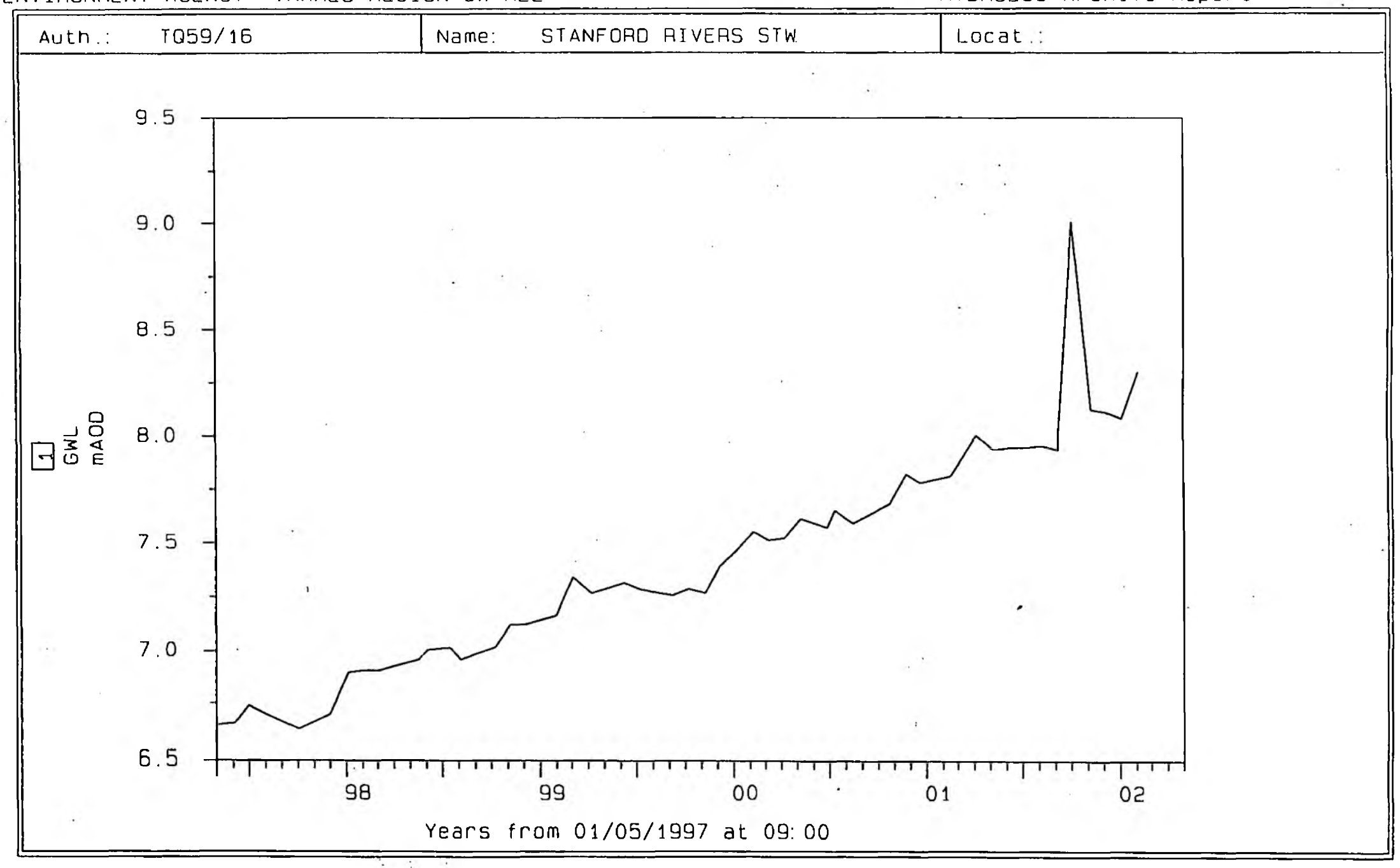


Figure 14 Stanford Rivers STW OBH, TQ59/16

Auth.: TQ37/34	Name: LADYWELL	Locat.: SPORTS CENTRE

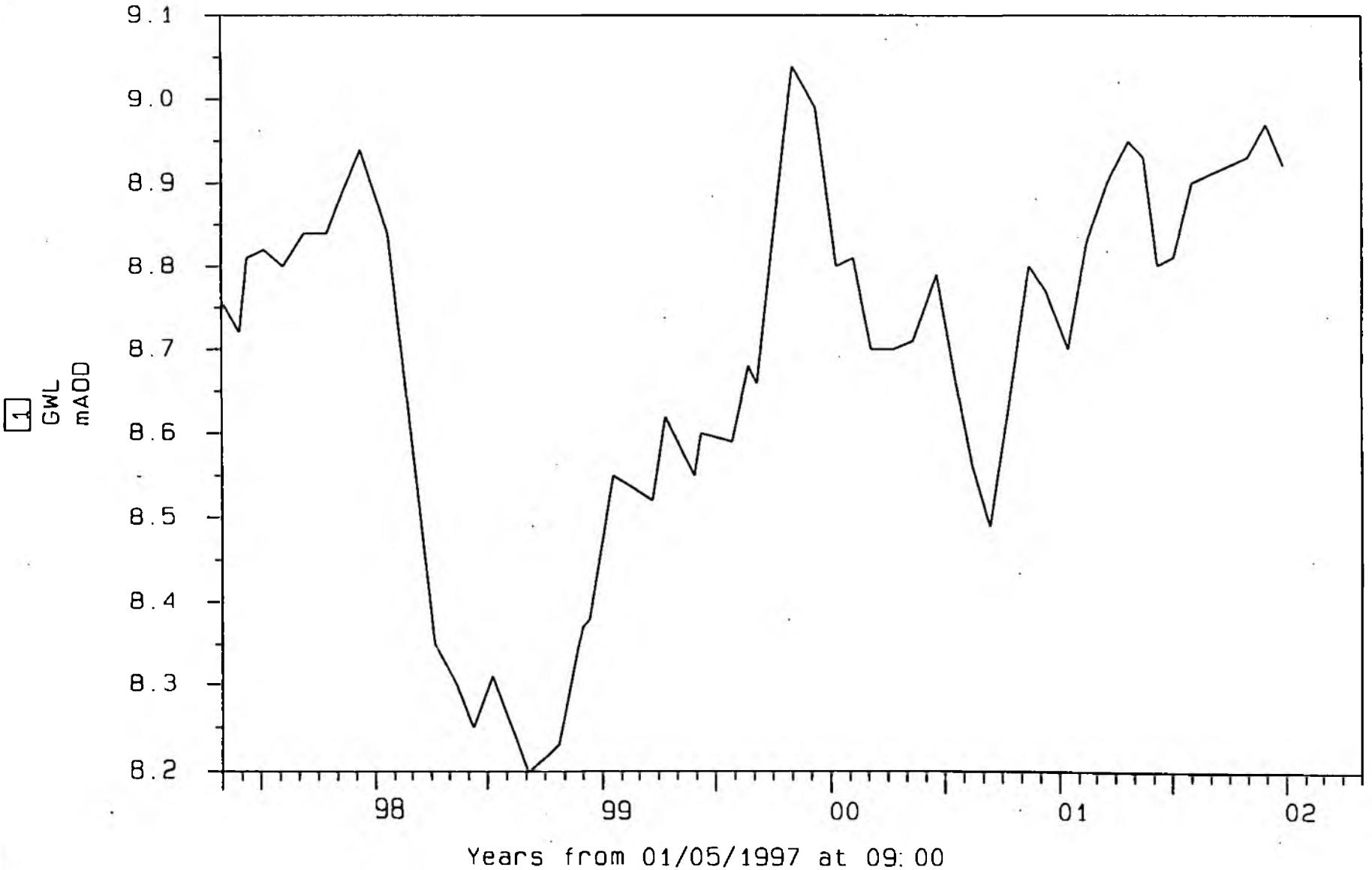


Figure 15 Ladywell OBH, TQ37/34

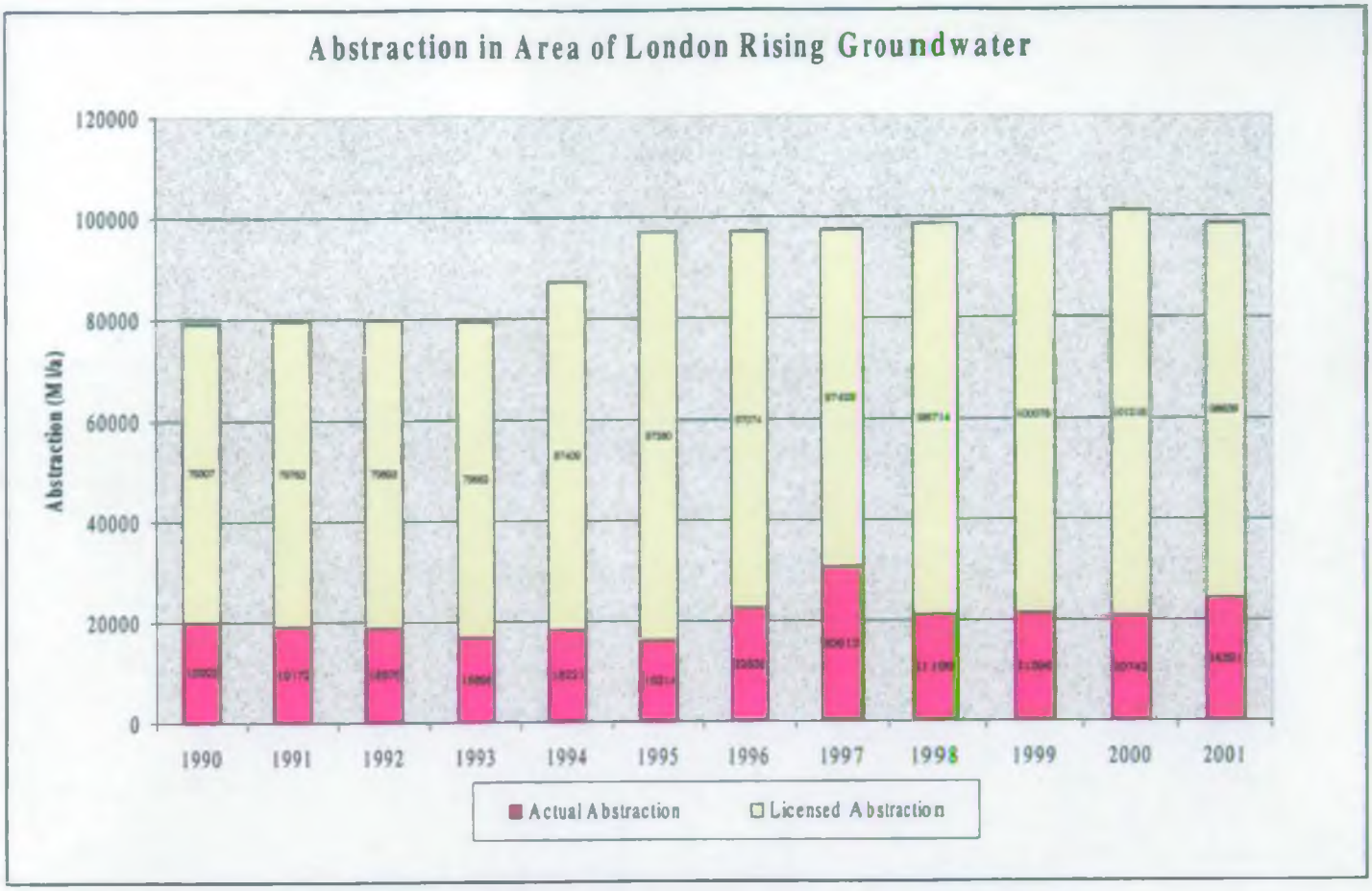


Figure 16 Licensed and Actual Abstraction in the Area Contributing to Rising Groundwater, 1990 to 2001

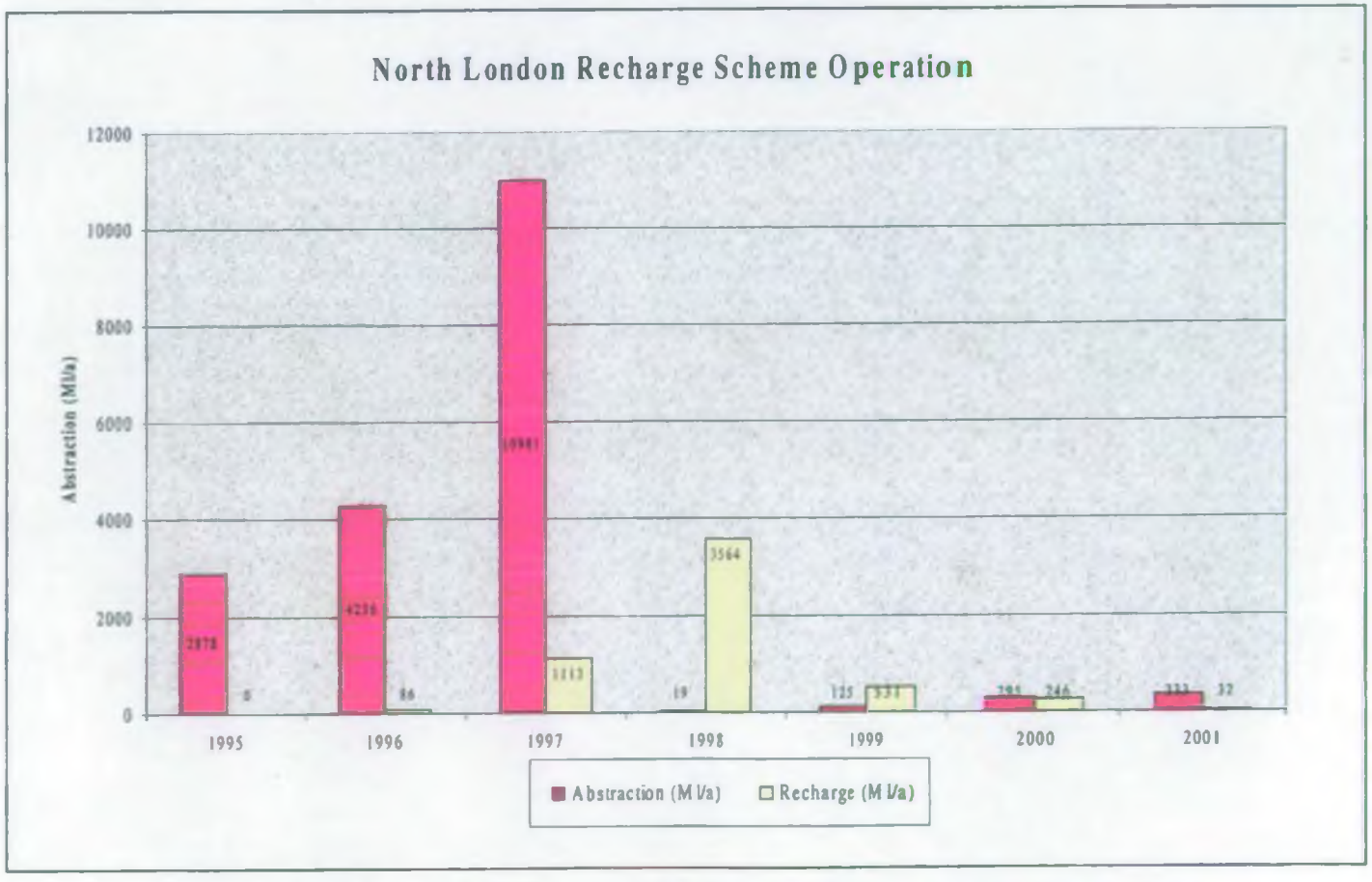


Figure 17 Operation of North London Abstraction Recharge Scheme, 1995 to 2001

Figure 18 - Area used in Calculating Abstraction in the Central London Basin