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

--April 2000--

CONTENTS

1. Introduction

This 2000 report is the ninth 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 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 98 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, and has led to a gradual re-filling of the water-table depression.

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) strategy to control rising groundwater beneath London, published in March 1999, is now operational (GARDIT, 1999). The first phase of this Thames Water Utilities Ltd (TWUL) co-ordinated five-phase strategy to increase abstraction from the Chalk aquifer is now partly active. Large-scale test abstractions at three new TWUL sites are planned for this summer as part of the development of the phase 2 sources (see Section 6).

The Environment Agency has the responsibility to manage groundwater resources in an appropriate and sustainable manner. The Agency regards the rising groundwater beneath London as an available resource that should be utilised, where possible, for suitable potable and non-potable uses.

2. Monitoring Network

The Environment Agency will continue to monitor and report on the state of groundwater levels beneath London. The Agency collates data from a network of over 200 observation boreholes to keep track of absolute groundwater levels and rates of change of levels in the Chalk aquifer.

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 defunct. Several longstanding monitoring boreholes have been lost in central London in recent years and any knowledge of, 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 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

i) Chalk Groundwater Levels at January 2000

Groundwater levels in the Chalk aquifer beneath London for January 2000 are shown in figure 1. For comparison, January 1999 groundwater levels are included as figure 2. An enlarged map of central London groundwater levels is also included (figure 3).

The centre of the cone of depression in the Regent's Park area of central London is still believed to be below –40 M aod (metres above ordnance datum), although inaccessibility to the Abbey House (TQ28/77) borehole at the assumed centre of the cone prevents confirmation of this.

The deepest recorded level in January 2000 was -39.74 M aod at Walmer House, Regent St (TQ28/97C), immediately south-east of the assumed centre of the cone. The groundwater level at Trafalgar Square observation borehole (TQ28/119) (figure 6) is currently -34.90 M aod.

Elsewhere, the Essex cone of depression remains with groundwater levels below –20 M aod at the centre. A shallower cone of depression has developed in recent years in the Merton-Streatham area of south London due to increased abstraction for public water supply associated with Phase 1 of the GARDIT strategy to control rising groundwater levels.

ii) Average Annual Rate of Rise of Chalk Groundwater Levels

The average annual rate of rise of Chalk groundwater levels in the London Basin for the period January 1998 to January 2000 is shown in figure 4. It should be noted that where abstraction has caused a significant change in groundwater levels in the past year, the change in level shown on the map is for that year only. The previous rate of rise map for the period January 1997 to January 1999 is shown in figure 5.

The maximum rate of rise in central London is currently at 1.7 metres per year in the Trafalgar Square area, Figure 6, and the marked reduction in the rate of rise, noticeable since the mid-1990s, remains evident. The current rate of rise over most of central London is now between 0.5 and 1.5 metres per year.

A slightly increased rate of rise is evident in the Greenford-Wembley area of north-west London. Groundwater levels here are rising in excess of 1.5 metres per year.

The fall in levels that has been apparent in recent years across a large area of south London due to abstraction by Sutton and East Surrey Water Company at their Hackbridge source, and TWUL at their Streatham and Merton Abbey sources, has continued. The rate of fall has, however, reduced in the past year as groundwater levels appear to be equilibrating to a new steady-state condition. The influence of abstraction, however, now extends from Surbiton in the west to Dulwich in the east, and northwards to the River Thames. The effects of abstraction in this area in recent years can be seen by the response of the Springfield Hospital observation borehole, TQ27/163, in figure 7.

Dewatering of the Chalk for engineering works associated with the construction of the London Underground Jubilee Line extension and the Channel Tunnel Rail Link has caused a reduction in levels of up to 2 metres in the Docklands and Stratford areas of east London.

At the centre of the Essex cone of depression, groundwater levels are currently rising by between 0.25 and 0.50 metres per year.

4. The Current Situation

The current rate of rise beneath central London continues to decline from the peak rate of the early and mid-1990s. With TWUL about to undertake an 8-month test of their GARDIT phase 2 boreholes it is likely that the rate of rise will decline still further during the remainder of 2000.

Groundwater levels across much of south London are being controlled by the GARDIT phase 1 abstractions that are now operational in the Mitcham-Streatham area. The influence of these abstractions now extends as far north as the River Thames at Wandsworth and will significantly reduce the flow of groundwater towards central London, thus contributing to the control of groundwater levels in that area.

TWUL are still to begin abstraction at their GARDIT phase 1 source at Honor Oak. When operational, this should further restrict the flow of groundwater to central London from the south.

The use by Essex and Suffolk Water Company of their Roding source in recent years has constrained rising groundwater levels in the Essex cone of depression. These will be constrained still further should TWUL bring their GARDIT phase 1 source at Wanstead into operation.

5. Groundwater Abstraction Trends in London Since 1990

Figure 8 shows the total licensed and actual abstractions in the area contributing to rising groundwater in central London for each year from 1990 to 1999. Although the quantity of water licensed for abstraction has risen by approximately 20000 Ml/a (55 Ml/d) since 1990, the quantity actually abstracted has remained fairly constant at about 19000 Ml/a.

Much of the increase in licensed quantity is due to the development of TWUL's North London Abstraction Recharge Scheme (NLARS). This group of boreholes is operated only to meet peak demands or in dry years. At times when surplus water is available, treated water 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 9. The highly variable operation of the scheme means that it does not have a major impact on rising groundwater levels.

In general, abstraction from the London Chalk aquifer has remained fairly constant since the beginning of 1990. Constant base load abstraction is required to effectively control groundwater levels. The GARDIT strategy incorporates this principle, but a substantial increase in actual abstraction is still required for the strategy to become effective.

6. Progress on the London Basin Groundwater Model

The London Basin Groundwater Model was completed in December 1999. It was a jointly funded 12-month project by the Environment Agency Thames Region and Thames Water Utilities Ltd (TWUL) and was constructed by consultants Mott MacDonald at Cambridge. The model boundaries are shown in figure 10. It will be seen that the whole of the North Downs area of unconfined Chalk aquifer south of London is included in the model. This area is heavily utilised for groundwater abstraction for public water supply and management of the water resources of this aquifer unit cannot be separated from the management of the south London area of confined Chalk aquifer. As well as extensive calibration of the model, the contract specified a number of predictive scenarios. These looked at various abstraction regimes from the end of the model calibration period (1997) to 2027 (ie. a 30-year prediction period). Figure 11 shows an example hydrograph at Trafalgar Square from the final calibration run. Figure 12 shows the hydrographs at Trafalgar Square for the following predictive scenarios:

i) Run PR01 - this assumes abstractions continue at the 1997 level until 2027, ie. no changes to the current level or pattern of abstraction.

ii) Run PR02 - this is the worst case scenario in that it assumes all abstraction in central London ceases, particularly in the central fault block.

iii) Run PR03 - this run simulates the full GARDIT strategy. The 5 phases envisage a proposed increase of 70 Ml/d above the 1997 abstraction.

The model report provided comparative hydrographs for 51 observation boreholes in the London Basin. Most show a similar response to Trafalgar Square for the 3 scenarios. A large number of predicted groundwater contour maps were also produced. Figure 13 shows the contour maps for PR03, for the year 2027, ie 30 years into the GARDIT strategy. The figure indicates that 70 Ml/d additional abstraction is probably excessive in that levels in 2027 have fallen to below -80m in central London and continue to fall at a steady rate beyond this time.

As a result of this the Agency has run an additional scenario (PR05b) in which the GARDIT strategy abstractions amounted to an additional 50 Ml/d (instead of 70 Ml/d). Figure 14 shows the resulting hydrograph at Trafalgar Square and figure 15 shows the groundwater contour map for 2027. These show a more realistic steadying of groundwater levels.

A significant outcome from constructing the London Basin model has been the development of a map showing the distribution of Chalk aquifer transmissivity (ie. permeability multiplied by effective aquifer thickness) (figure 16). As the productive zone of the confined Chalk aquifer is assumed to be of constant thickness, the map can be taken as representing the permeability of the Chalk, which is a good indicator of the likely yield of a borehole. It can be seen that there are large areas or blocks of low permeability Chalk, particularly to the west of London, separated by corridors of higher permeability Chalk.

This map is remarkably similar to the map published by the Water Resources Board, 1972, but now has much greater detail. This map is a major step forward as it enables prospective users to target the higher yielding areas which will be more effective in controlling rising

levels and will reduce the number of proposals abandoned due to low yields.

7. Progress with the GARDIT Strategy

The GARDIT 5-phase strategy is being co-ordinated by TWUL with most of the proposed abstraction being carried out by TWUL for public water supply but with significant abstraction from other water companies and from a number of non-public water supply sites (GARDIT 1999). Phase 1 involves the bringing back into operation of four disused sources at Merton, Streatham, Honor Oak and Wanstead. The first two are fully operational and are in use sporadically. These two sources together with the Sutton and East Surrey Water Company (SES) source at Hackbridge are steadily reducing levels in south London.

Phase 2 of the Strategy comprises three new sources at Brixton, Battersea and New River Head. Initial testing of these sources has indicated very high short term yields. The total combined yield for the three sources has been initially assessed in the Strategy at 12 Ml/d. However, an eight month combined pumping test at rates of up to 24 Ml/d is planned for this year, which will result in the yields being re-assessed more accurately and, possibly, considerably higher. There is no doubt that these three sources will have a major impact on the main area of rising groundwater beneath central London. Therefore, when licensed, and if used for steady base load pumping, these three sources are likely to be crucial in controlling levels and may reduce the proposed quantities identified for Phases 3 to 5. (GARDIT 1999)

TWUL have started work on Phases 3 and 4 of the Strategy and have identified sites for three new boreholes to be included in Phase 4.

Elsewhere, abstraction proposals by other companies are progressing. In south London, SES have drilled a new borehole at Goatbridge that will be added to the Hackbridge source. A small licence increase is proposed after 2002. Metropolitan Water have a number of small projects which are distributed throughout the London region. Drilling and test pumping of a substantial abstraction has taken place for the new Greater London Authority offices to be constructed near London Bridge. The position of this abstraction complements the TWUL proposals previously mentioned.

Current impressions are that with the GARDIT Phase 1 and 2 proposals fully implemented, the Phase 3 to 5 proposals (some of which are beginning) may not need to be as large as previously thought. It would appear that the means for controlling London's rising groundwater is steadily being designed, tested and put in place. As always, control will only happen if substantial abstraction actually takes place and continues steadily at the required rates over and above the 1997 rate.

The recently developed London Basin groundwater model suggests 50 Ml/d may be a more realistic increase than the 70 Ml/d identified in the GARDIT strategy. Despite the effort and knowledge put into the model, only continued monitoring of both abstraction and groundwater levels will provide an accurate assessment of progress. At present there is still plenty of scope for new proposals and the Agency's policy continues to be one of licensing abstraction in this area, subject to the requirements of the 1991 Water Resources Act.

8. Applications to Abstract Groundwater from the London Basin Confined Chalk.

Although the principal objective is to stabilise groundwater levels and in some areas to lower them to previous levels, a longer-term means of controlling and adjusting levels is required. The Agency's main mechanism for long-term control of abstraction in the London Basin to ensure that no unacceptable trends in groundwater levels develop, is to impose time limits on new proposals. These time limits are generally of between 5 and 10 years duration with review dates at 'common' five yearly intervals.

9. Derogation

The Water Resources Act, 1991, states that in considering an application for a licence the Agency may not grant permission if the new proposal will derogate from any existing protected rights to abstract. Derogation is defined in the Agency's Licensing Manual and is taken to include the situation where an abstractor would have to lower the pump level in order to continue abstracting. As with all applications to abstract groundwater, applicants in London will be required to assess the effect of the proposal on local abstractors and if necessary, lower pumps or obtain 'agreement to derogate.' Care must be taken, however, since in some circumstances a licence holder could be taken to be unreasonable by setting the level of his/her pump too high, making it liable to be affected. Individual cases must be considered on their own merits.

It is hoped that levels will be stabilised, and in many areas, reduced to levels similar to those of 10 or more years ago, but not lower than the top of the Chalk aquifer. Bearing this in mind, it has to be accepted that this general reduction in level will not be attributable to specific sources, sites or organisations. All existing abstractors should therefore ensure that pump depths are adjusted to lower levels over the next few years to cope with the expected fall.

Where new licences are granted, the minimum depth of the pump may be specified as a licence condition. Failure to comply with this would remove the protected status of this licence with regard to future derogation from other abstractions.

The Agency will provide, on request, advice on expected groundwater levels and suitable pump depths.

10. Proposed Approach to Licensing

The following policy does not apply to the area of Merton, Streatham and Hackbridge, south of the Wimbledon fault, where groundwater levels are falling steadily at present. In this area there is essentially an embargo on new licences until levels have stabilised under the current pumping regime, or until 2004, when several licences come up for renewal.

For all enquiries for abstractions up to an annual quantity that averages 1Ml/d, the following policy applies:

There is no objection in principle to licensing such abstractions subject to the normal statutory requirements (ie. consideration of existing protected rights, availability of resource etc.)

TWUL Phase 2 GARDIT proposals at Brixton, New River Head and Battersea, and other water company proposals do not affect this policy. These large proposals may not be licensed for some considerable time into the future, but will eventually, if fully implemented, have a substantial effect on levels. The Agency will, however, continue to accept other abstraction proposals until such time as it can be demonstrated that levels have been reduced and are stabilising under the abstraction regime that persists at that time. These smaller proposals will be subject to the minimum pump depth licence conditions mentioned above in order to cope with the large long-term effects on levels that would occur due to various water company proposals.

References

Water Resources Board, 1972. The Hydrogeology of the London Basin.

GARDIT, 1999. Controlling London's Rising Groundwater, GARDIT Strategy Proposal.

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Figure 1 London Basin Chalk Groundwater Levels, January 2000

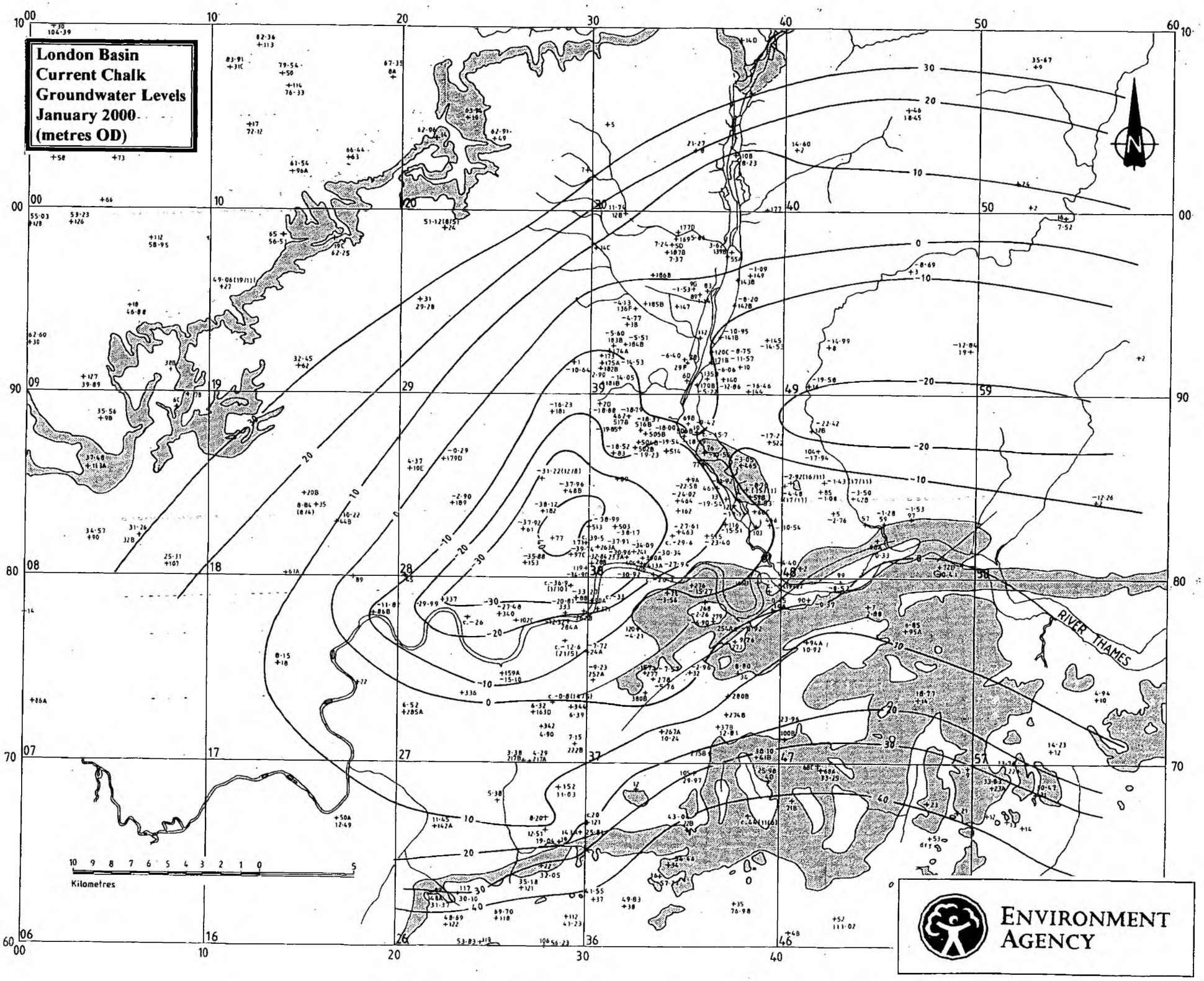


Figure 2 Central London Chalk Groundwater Levels, January 2000

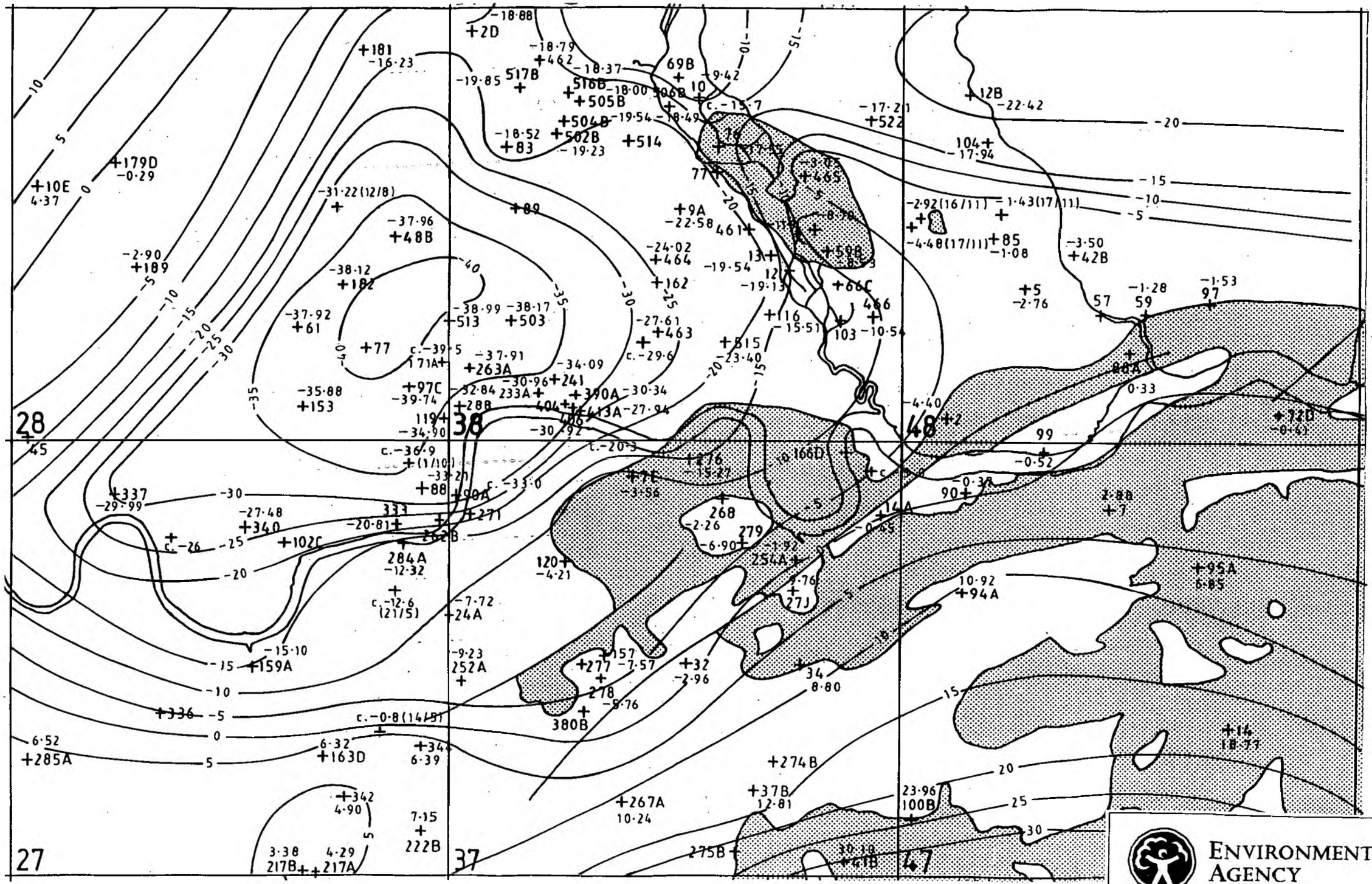


Figure 3 London Basin Chalk Groundwater Levels, January 1999

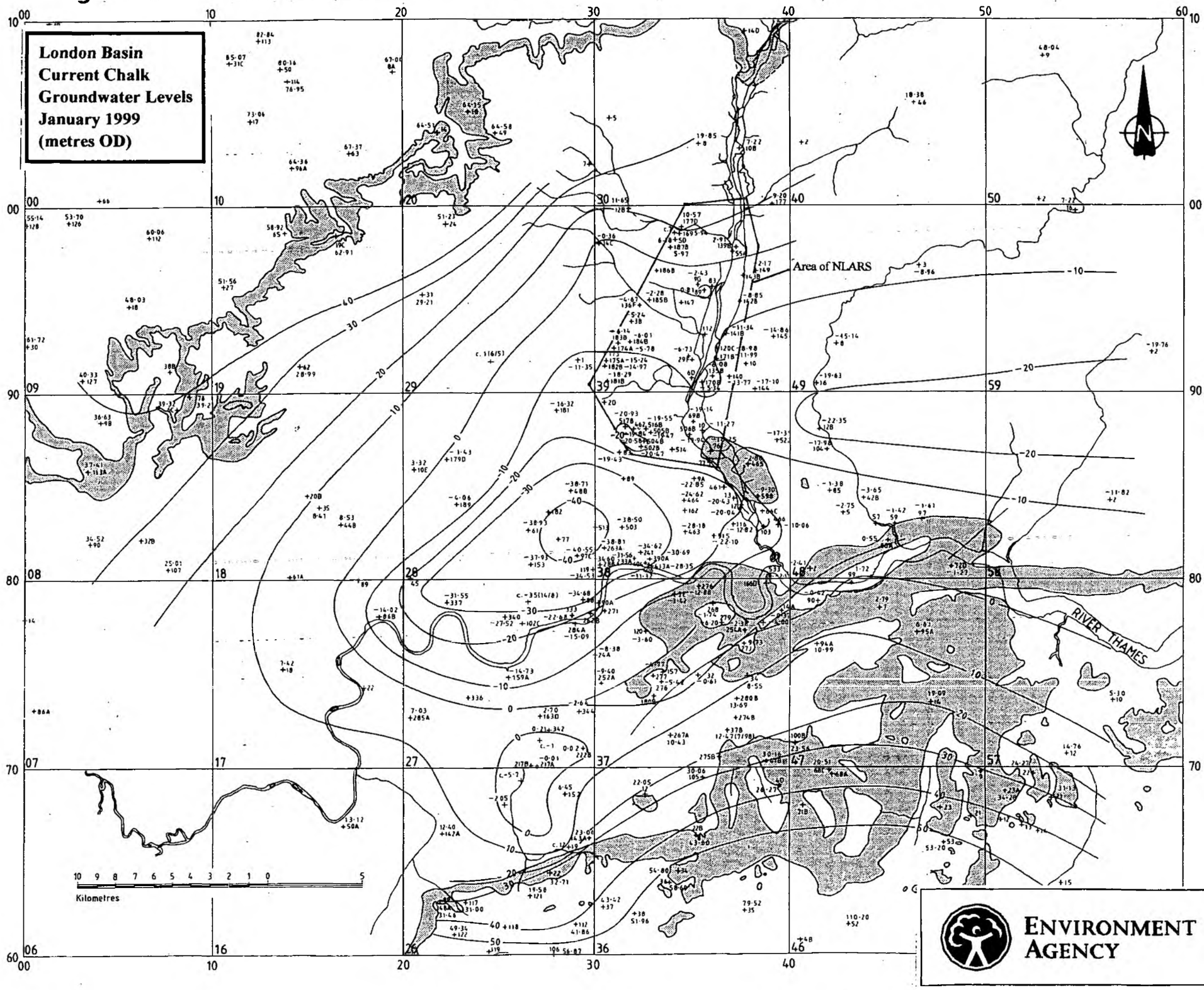


Fig. 4 London Basin Average Rate of Rise of Chalk Groundwater Levels, January 1998 to January 2000

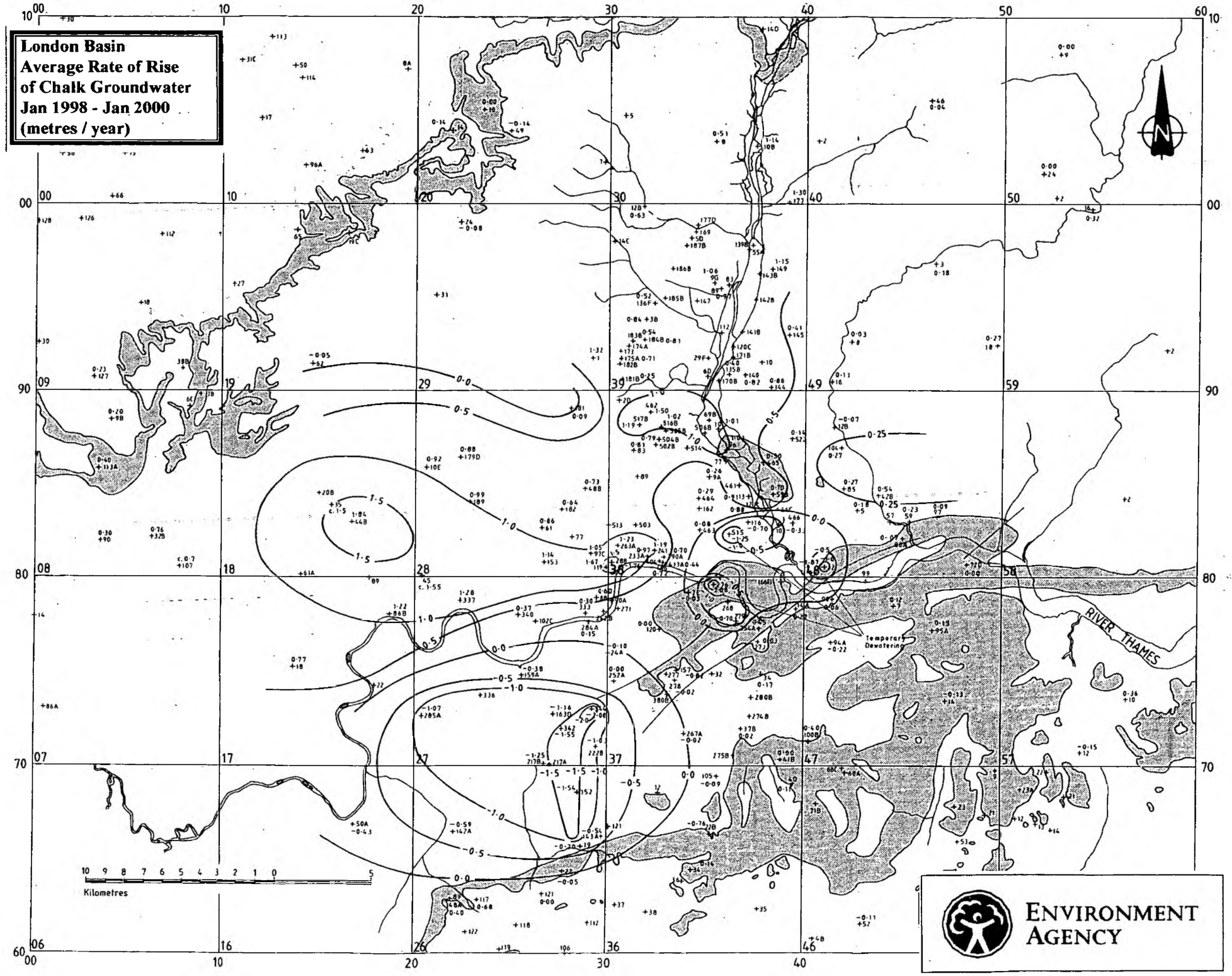
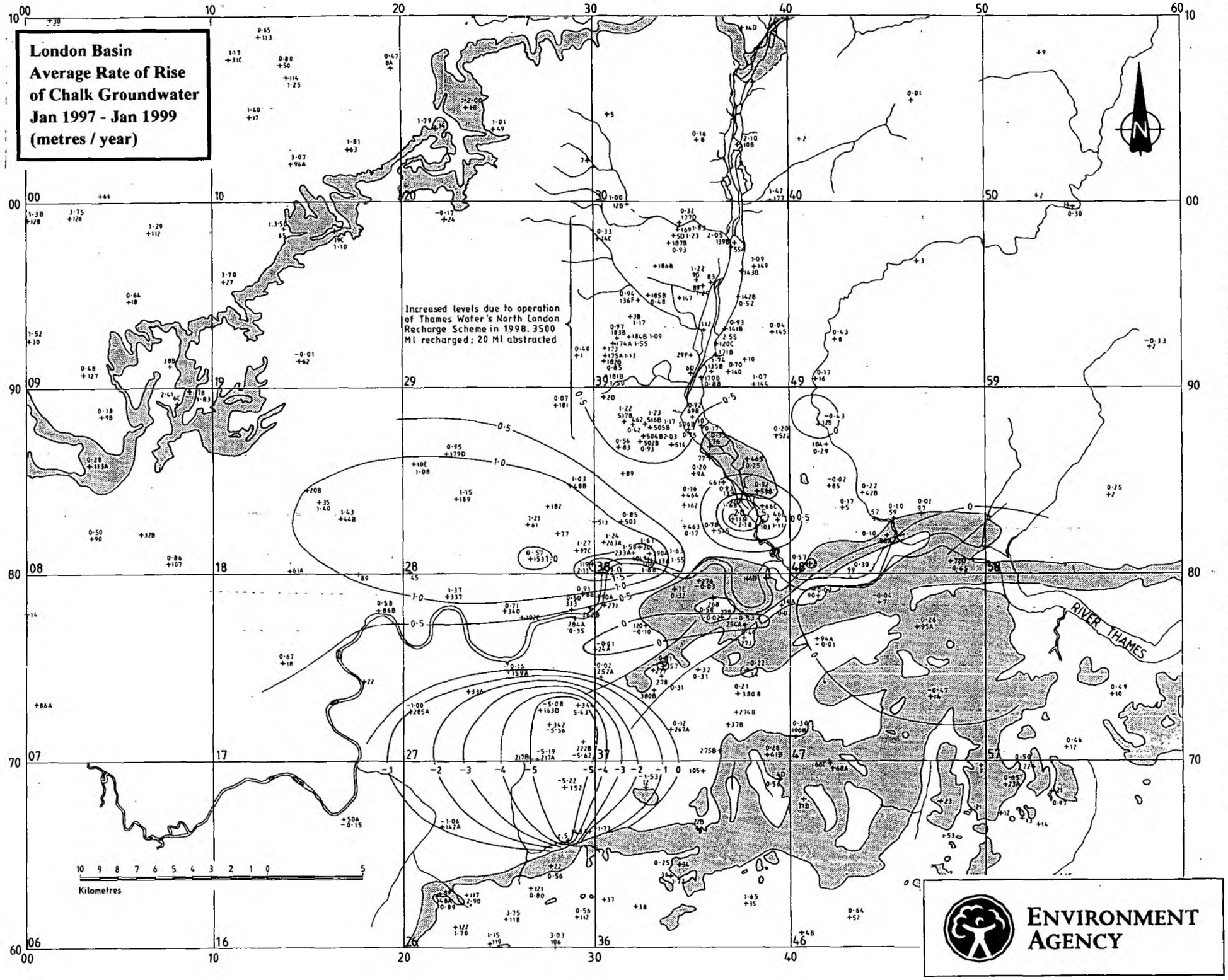


Fig. 5 London Basin Average Rate of Rise of Chalk Groundwater Levels, January 1997 to January 1999



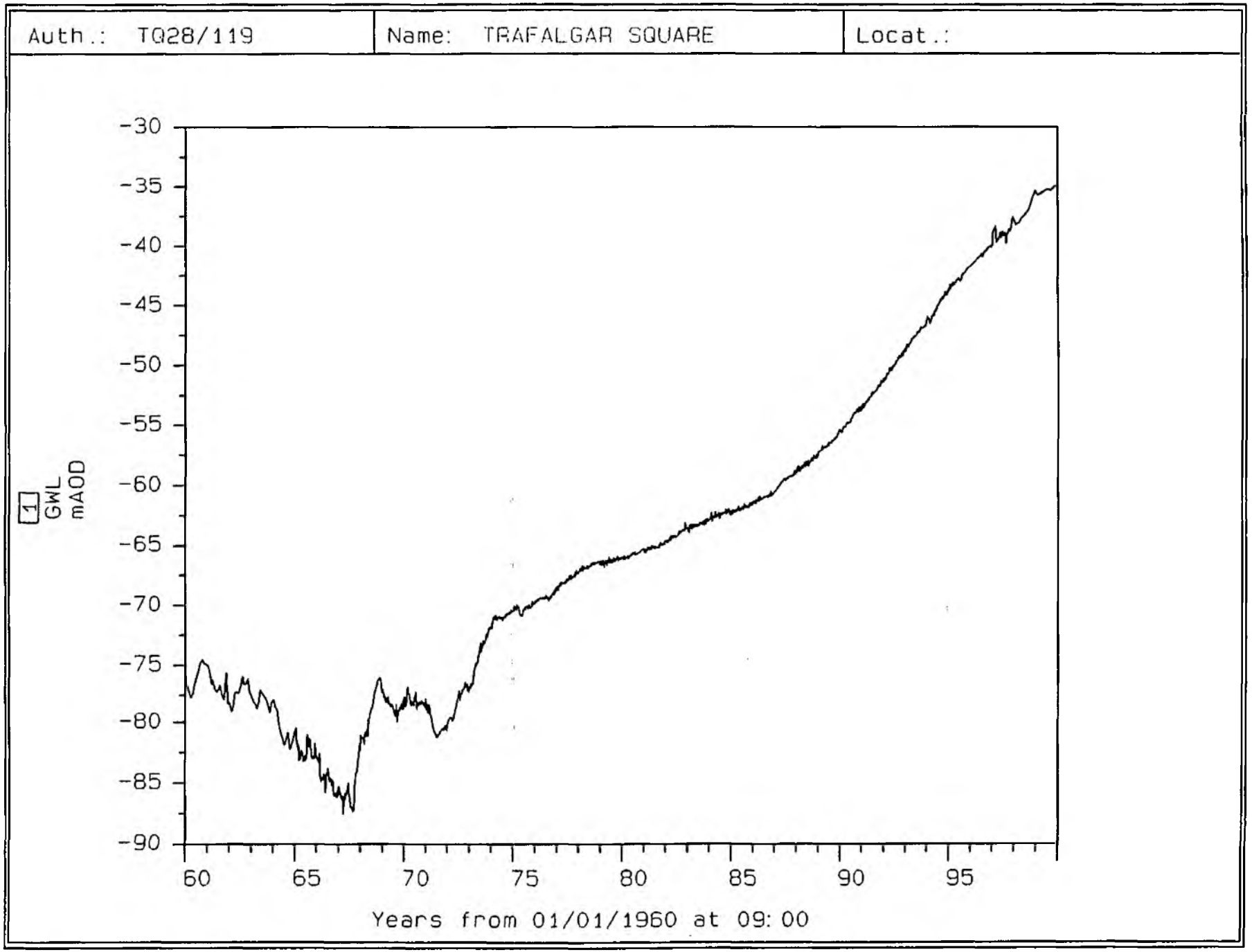


Figure 6 Trafalgar Square OBH, TQ 28/119

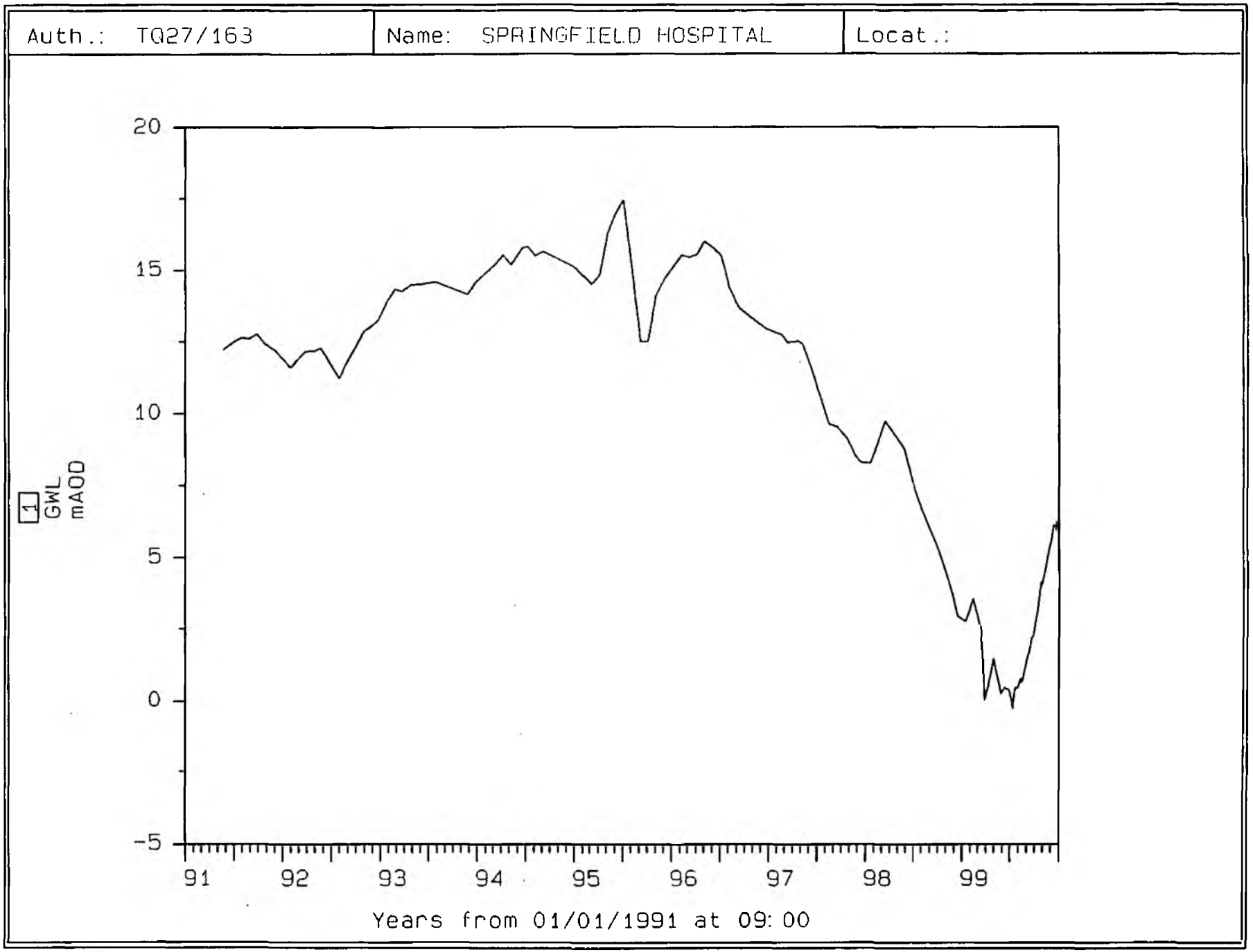


Figure 7 Springfield Hospital OBH, TQ 27/163

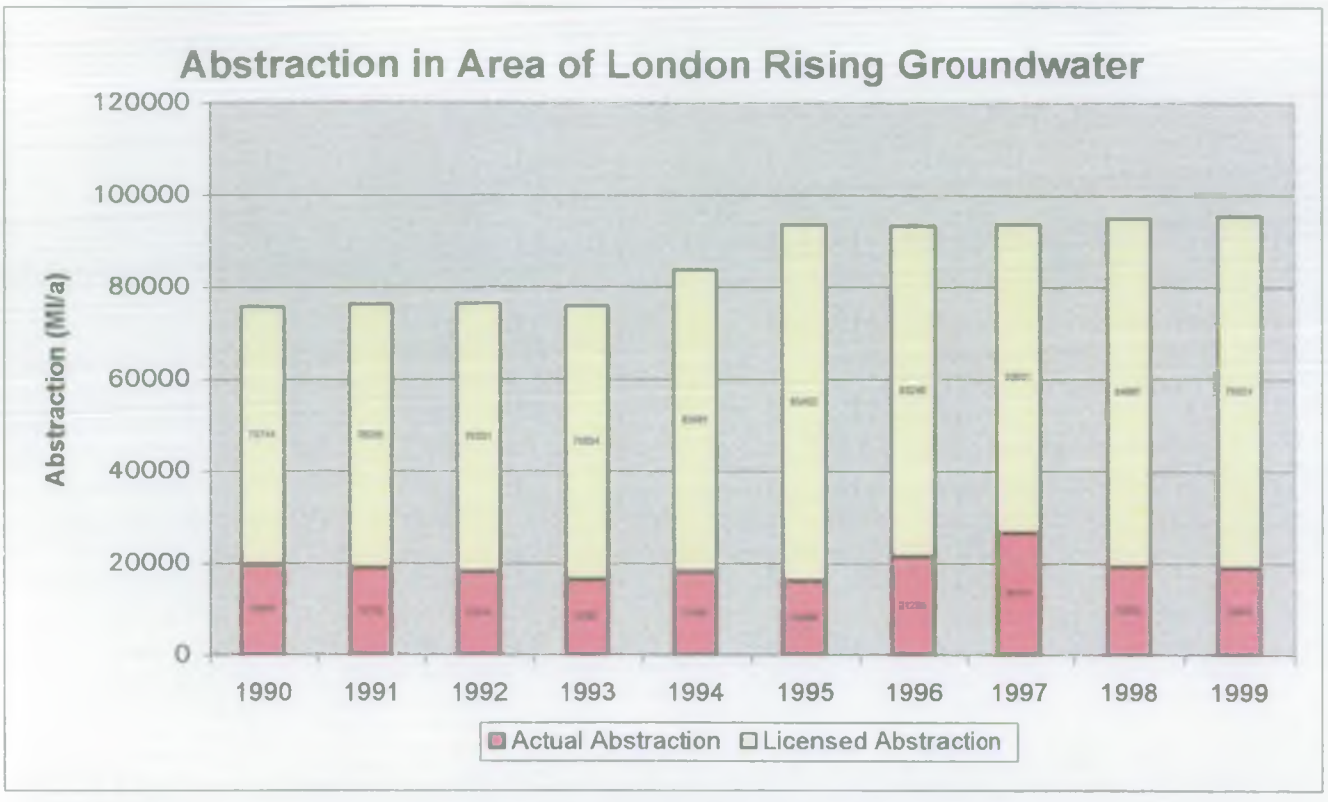


Figure 8 Licensed and Actual Abstraction in the Area Contributing to Rising Groundwater, 1990 to 1999

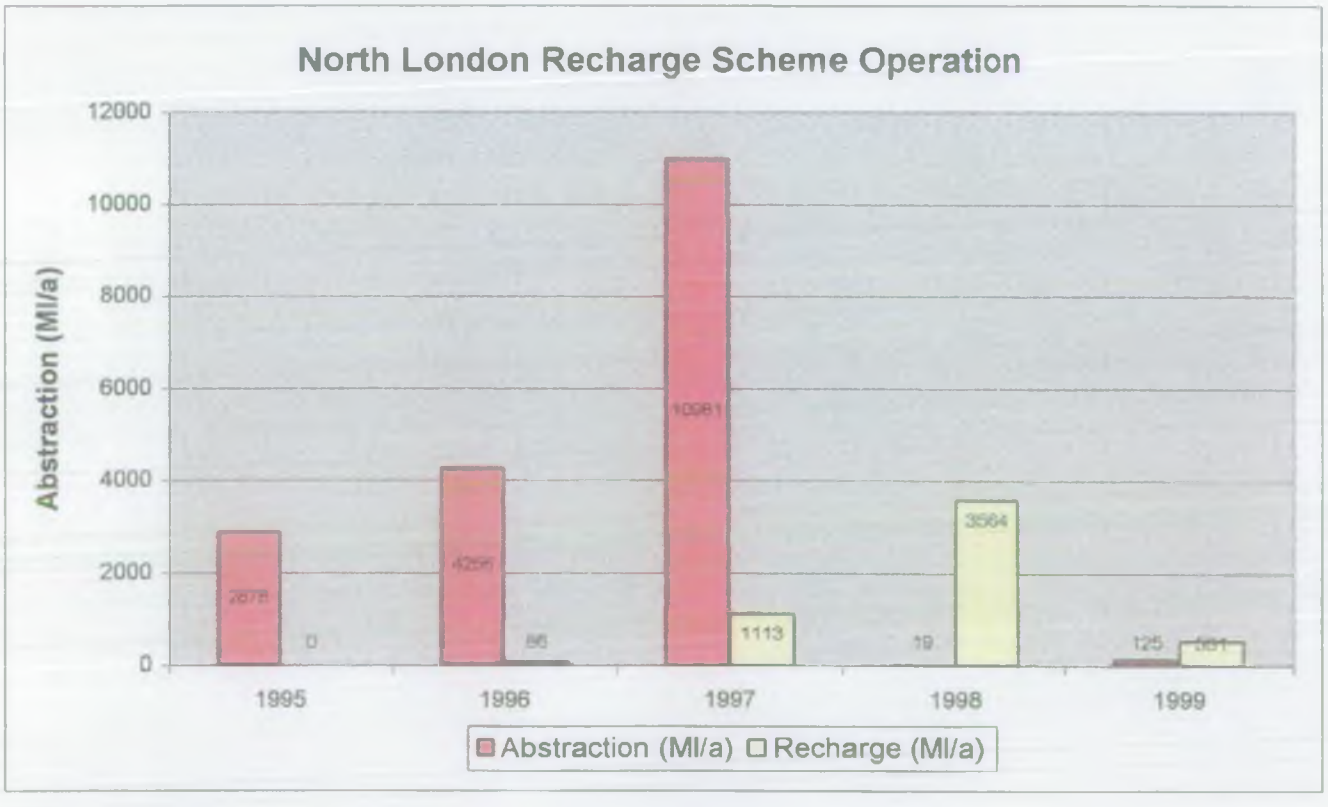
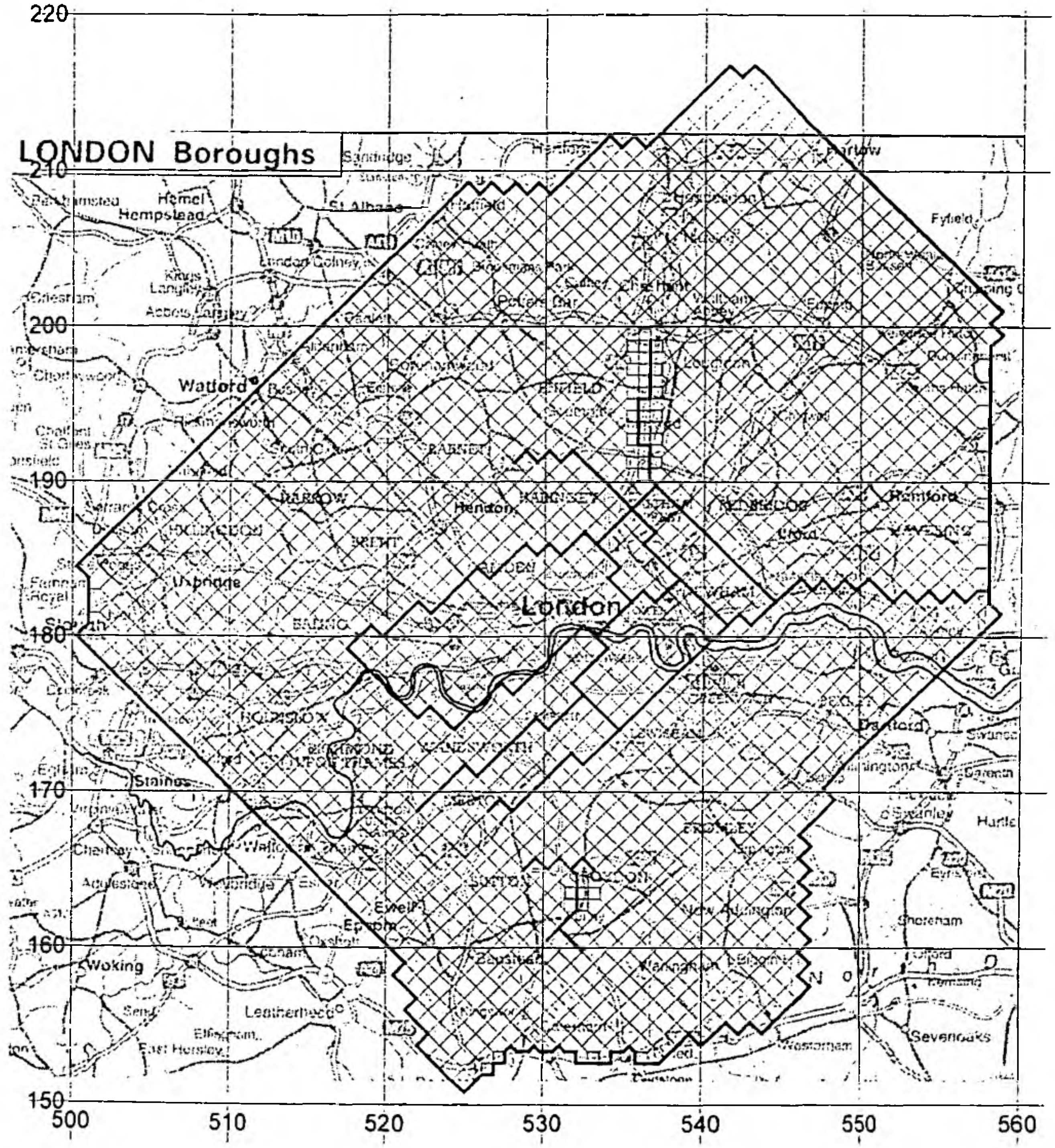


Figure 9 Operation of North London Abstraction Recharge Scheme, 1995 to 1999

Fig. 10 London Basin Groundwater Model Boundaries

Geographical Location of Study Area



Low permeability barrier

River element

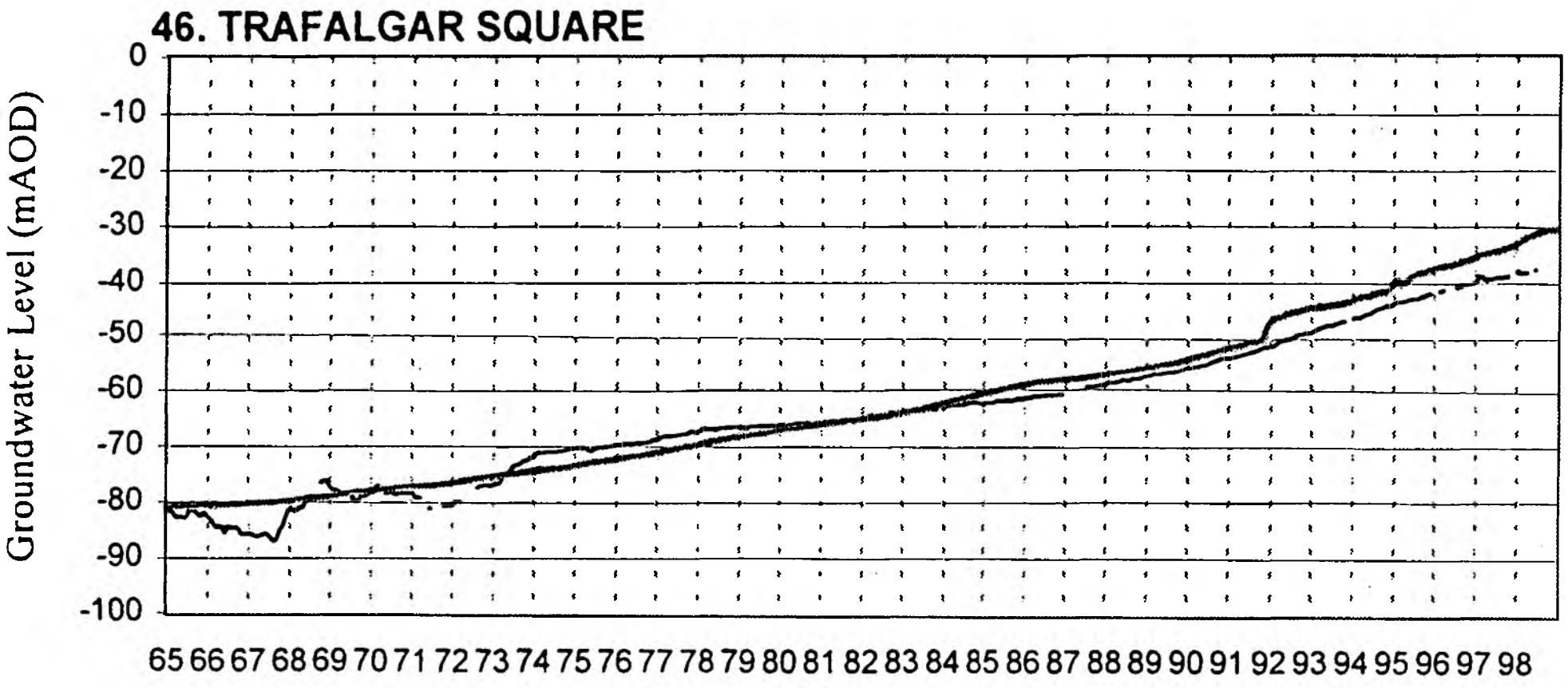


Figure 11 Trafalgar Square Hydrograph for Final Model Calibration Run,TR37

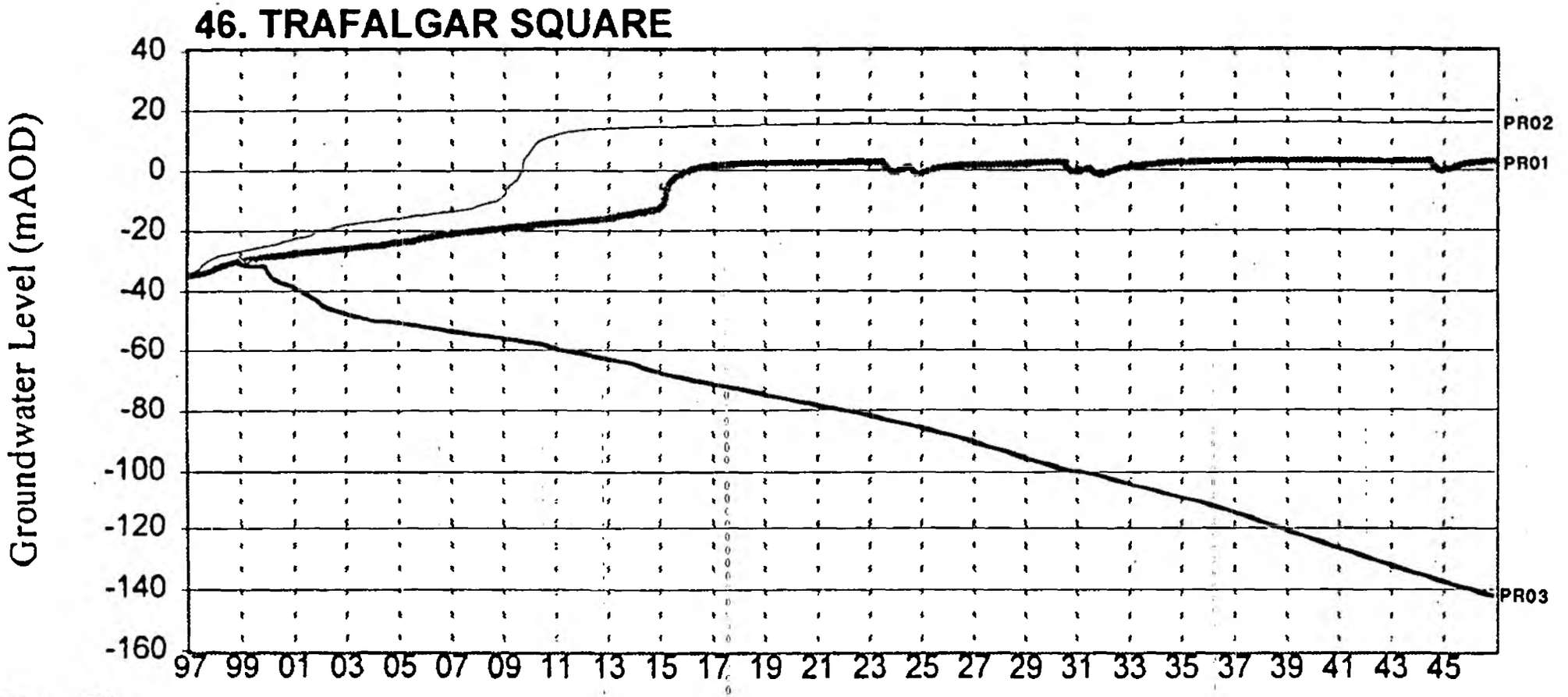


Fig. 12

Trafalgar Square Hydrographs for Model Prediction Runs, PR01, PR02 and PR03

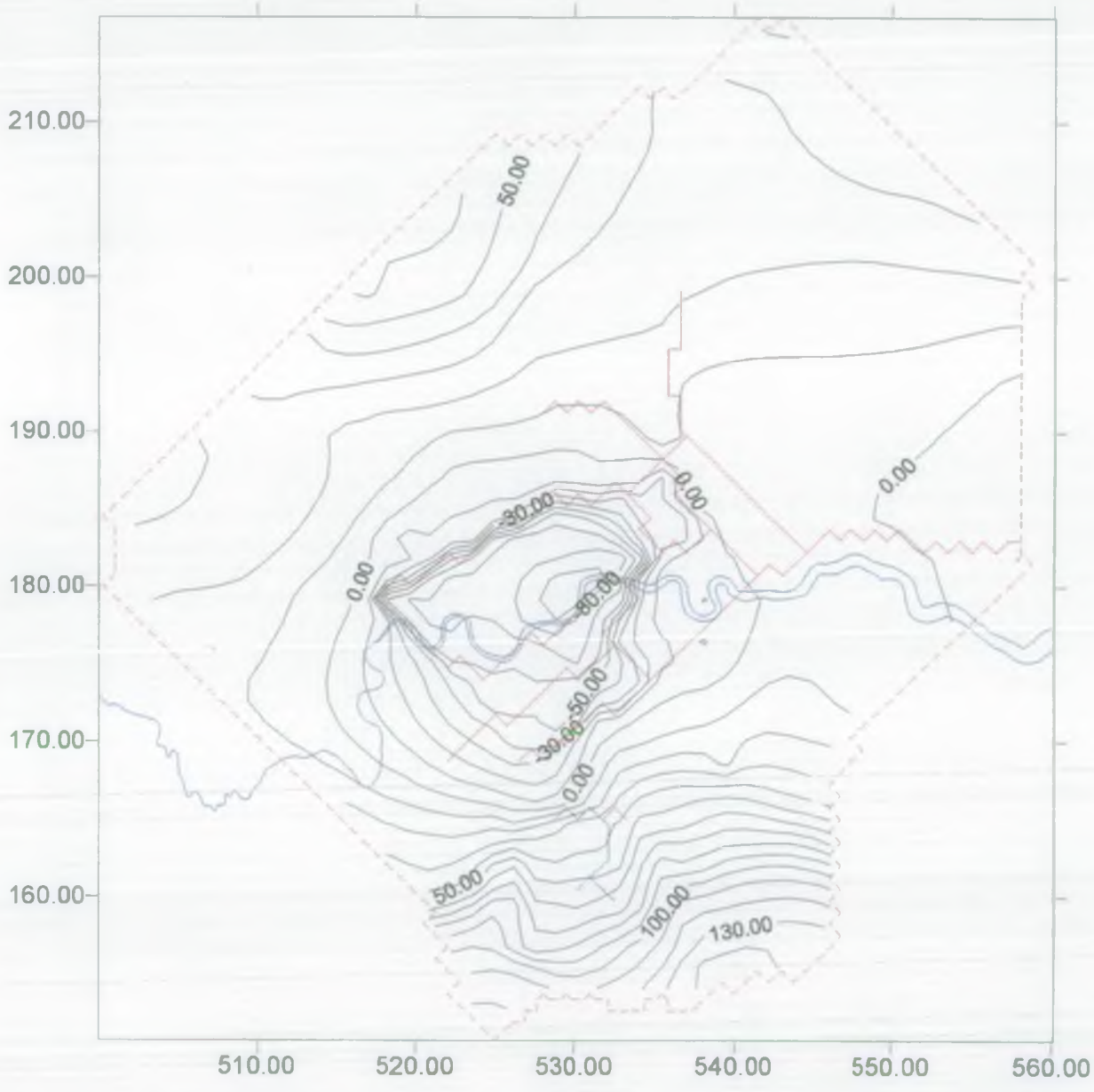


Fig. 13

Run PR03, Modelled Groundwater Levels for 2027

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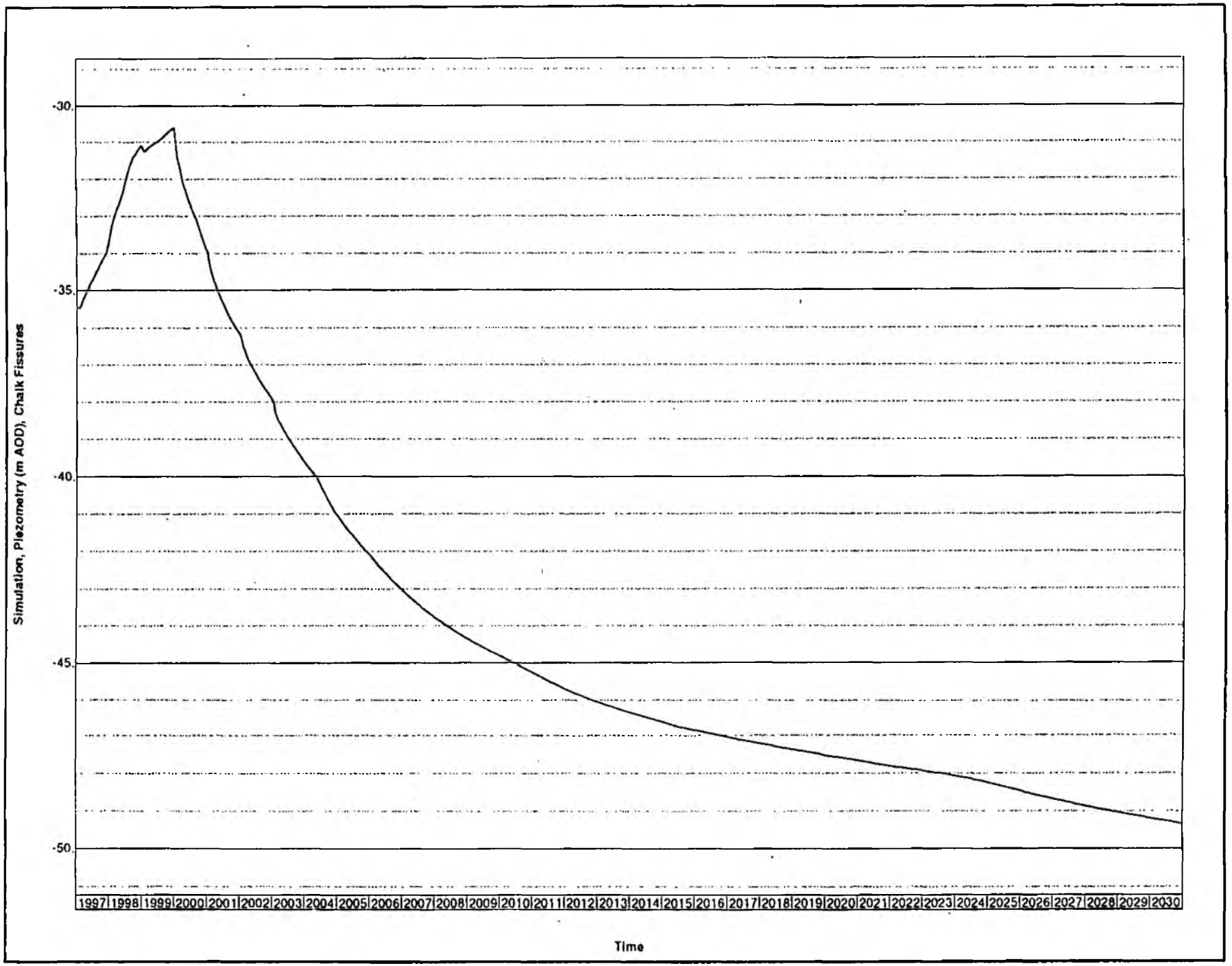

PR5B Node: 888 Simulatio n, Piezometry (m AOD), Chalk Fis

Figure 14 Trafalgar Square Hydrograph for Model Run, PR05B

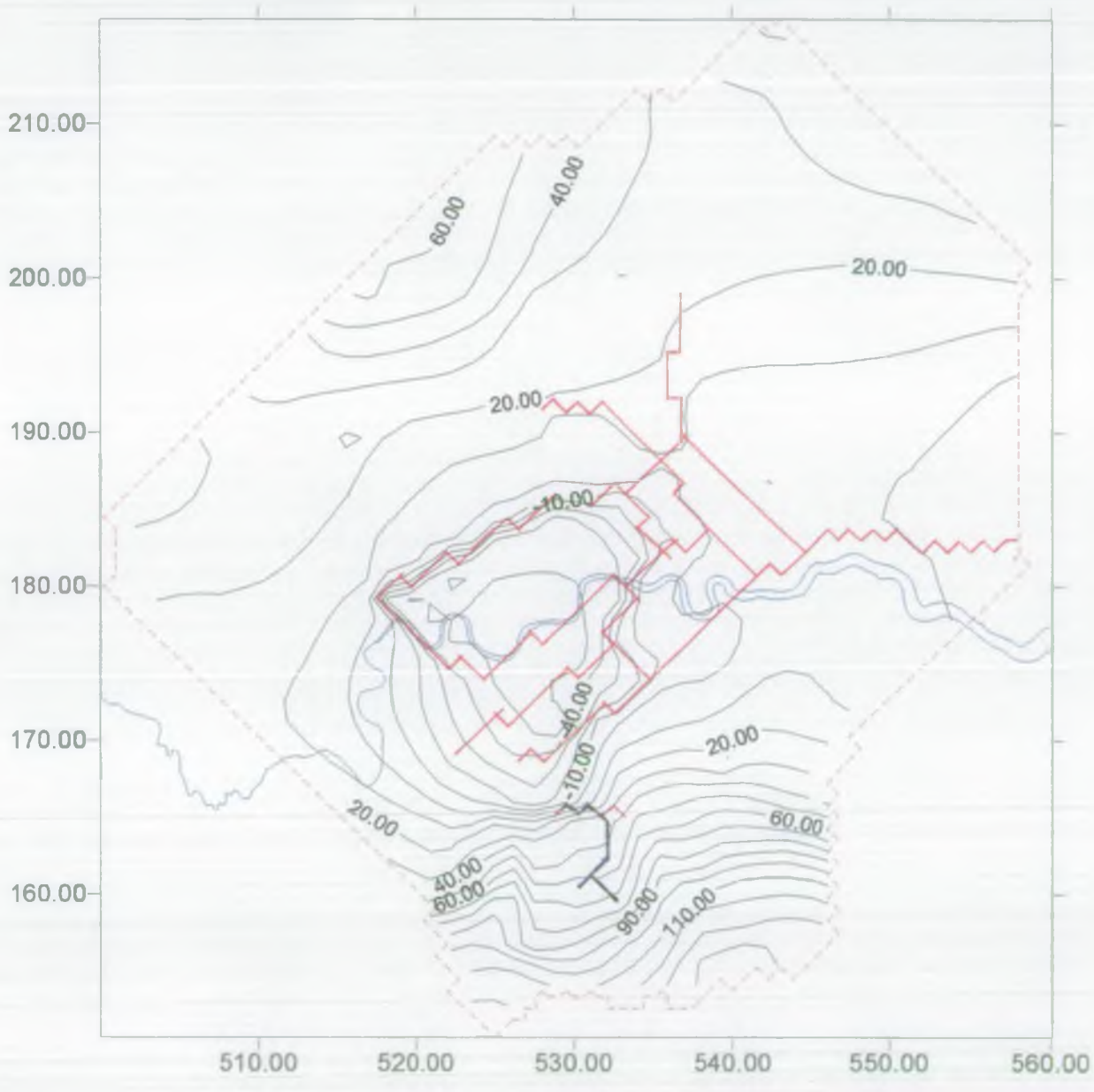

Fig. 15

Run PR05B - Modelled Groundwater Levels for 2027

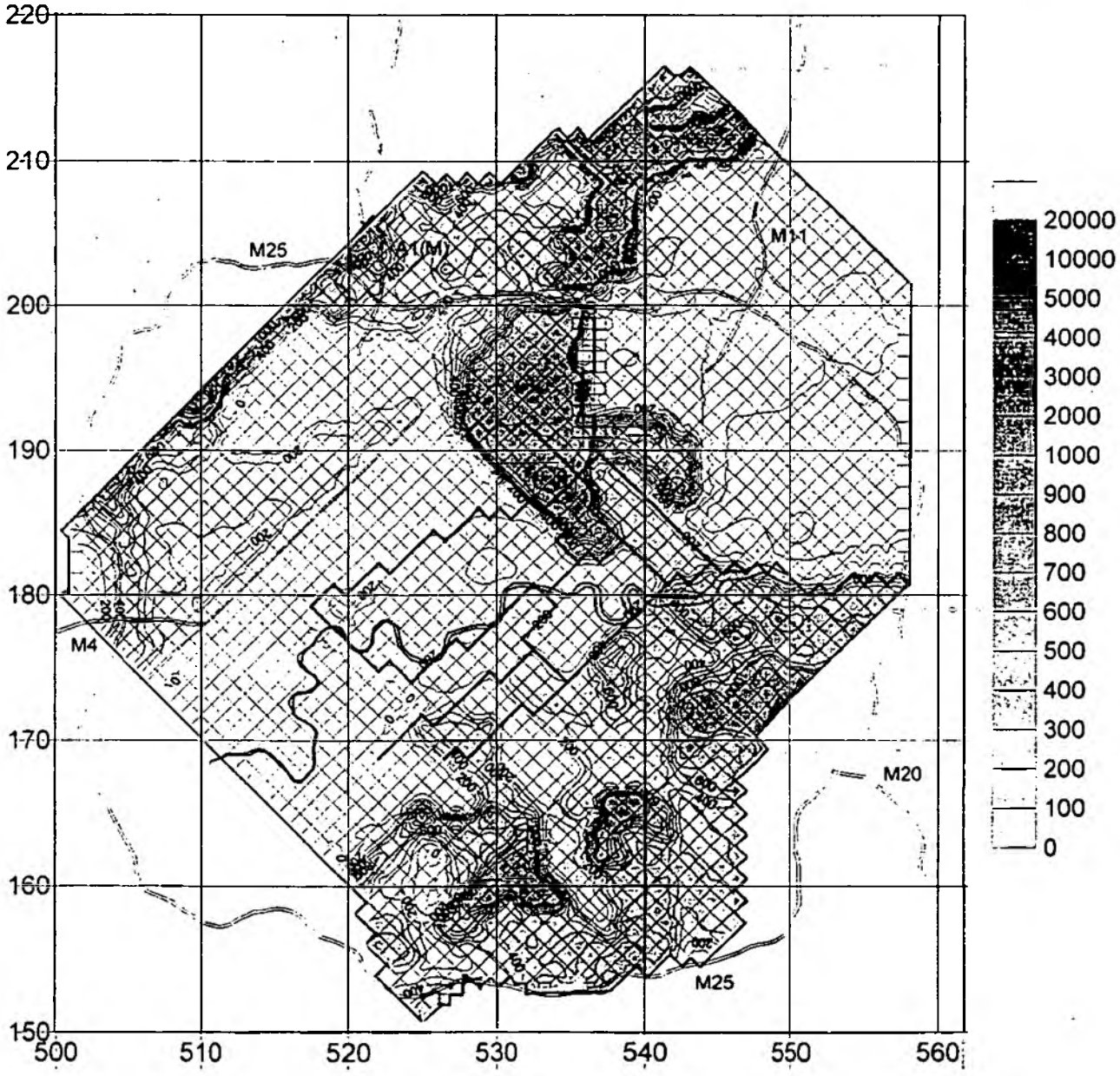

Figure 16 Chalk Aquifer Transmissivity