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GLADMAN DEVELOPMENTS LIMITED

CROSS ROAD, DEAL

HYDROGEOLOGICAL CONCEPTUAL SITE MODEL

MAY 2024

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HYDROGEOLOGICAL CONCEPTUAL SITE MODEL

MAY 2024

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1 INTRODUCTION

1.1 Background

1.1.1 Wardell Armstrong LLP (WA) has been commissioned by Gladman Developments Ltd (the Client) to prepare a Hydrogeological Conceptual Site Model (HCSM) for a site at Cross Road, Deal (the Site) to support monitoring of groundwater levels at the Site which it is understood will be required as a condition of the Planning Permission (Application Reference: 21/01822). The requirement for monitoring is indicated because the site overlies a Principal Aquifer and Southern Water operates a Public Water Supply (PWS) groundwater abstraction located approximately 300 metres east north east of the Site.

1.1.2 The Site refers to a proposed residential development comprising the erection of up to 140 dwellings including affordable housing with public open space, landscaping and vehicular access centred approximately at National Grid Reference (NGR): TR 36041 50521. The location of the site is presented on Drawing Ref. GM12741-001.

1.2 Purpose of Report

1.2.1 The purpose of this report is to present a HCSM for the Site and a design for the groundwater monitoring network required as a condition of the planning permission.

1.2.2 The HCSM presented in this report is the first stage of preparing a Hydrogeological Risk Assessment (HRA) for the proposed development. Southern Water has asked for a HRA to be prepared as a condition of not objecting to the planning application for the proposed development[1]. The HRA will be produced when sufficient monitoring data have been acquired from the site as described at the end of this report.

1.3 Basis of Report

1.3.1 This report is based on data gathered from the Environment Agency (EA), British Geological Survey (BGS), Ordnance Survey (OS), Dover District Council and Southern Water together with the following reports and documents related to the Site:

- Preliminary Risk Assessment: Land west of Cross Road, Cross Road, Deal CT14 9LA, by RSK; dated June 2021 (RSK reference: 52285-R01 (00); referred to as PRA 2021);

[1] Letter ref. DSA000019099 dated 10/01/2023 from Southern Water to Planning Section, Dover District Council.

- Flood Risk Assessment & Outline Surface Water Drainage Strategy by RSK; dated October 2021 (RSK reference: 680074-R1(01)-FRA; referred to as FRA 2021); and
- Southern Water consultation responses to RSK including Southern Water References: DSA000006453 (01 February 2022), DSA000006453 (10 March 2022), DSA000016415 (03 November 2022), and DSA000019099 (10 January 2023).

1.3.2 On 23 November 2023, WA consulted Southern Water on the proposed site investigation, proposed monitoring network and the subsequent proposed development. A Southern Water hydrogeologist indicated that the proposed monitoring network and monitoring programme was sufficient to determine the seasonal change in groundwater depth and elevation at and in the vicinity of the Site. Southern Water provided WA with details of the location of the nearby PWS and its associated adits, one of which intersects the Site at its north east corner.

1.4 Report Structure

1.4.1 Section 2 of this report provides a description of the Site and an overview of the Site setting. Details of the HCSM are provided in Section 3. The proposed monitoring network is outlined in Section 4.

2 SITE DESCRIPTION AND SITE SETTING

2.1.1 The Site is located on land directly north of Ellens Road and directly east of Cross Road, Deal, Kent. The Site location including the Site boundary is presented on Drawing Ref GM12741-001. The Site covers an area of approximately 8.2 hectares. Access can be obtained at the southeast corner and the northeast corner on Cross Road.

2.1.2 The proposed development of the Site refers to a residential development comprising the erection of up to 140 dwellings including affordable housing with public open space, landscaping and vehicular access.

2.1.3 Within the Site, the western corner extending north east and south east is covered by dense semi-mature and mature shrubs and trees. The remainder of the Site comprises arable land divided into two fields; the larger field is located in the central section of the Site and is used for crops. The smaller field is located in the north of the Site and comprises vacant/fallow land. Additionally, semi-mature and mature hedgerows are generally present around the perimeter for the Site.

2.1.4 Based on the Envirocheck Report provided at Appendix C to the PRA 2021, the Site comprised agricultural land and vacant/fallow land from the first available historical Ordnance Survey Plan in 1877 to present.

2.2 Topography

2.2.1 The topography of the Site gradually falls from approximately 30 m above Ordnance Datum (AOD) in the north and northeast to approximately 16 mAOD in the south and south west across the Site.

2.3 Geology

2.3.1 The geology in the vicinity of the Site is described below based on information from the BGS 1:50,000 scale series geological mapping (Sheet 290, Dover, Solid and Drift edition)[2], the online BGS GeoIndex[3] together with the records of 9 boreholes drilled within 500 metres of the Site available from BGS GeoIndex (referred to below as the BGS borehole logs). Copies of the BGS borehole logs are provided in Appendix 1.

[2] BGS, 1:50,000 Scale Series Geological Mapping, Sheet 290, Dover, Solid and Drift Edition. Accessed: 01/11/2023. Available online: https://webapps.bgs.ac.uk/data/MapsPortal/map.html?id=10174300010174

[3] BGS, GeoIndex (onshore). Accessed: 01/11/2023. Available online: https://www.bgs.ac.uk/map-viewers/geoindex-onshore/

Superficial Geology

2.3.2 There are no superficial deposits recorded within the Site. Superficial deposits of Head generally consisting of poorly sorted and poorly stratified angular rock debris, clayey hillwash and soil creep with lenses of silt, clay or peat and organic material[4] is found immediately adjacent to the south western boundary of the Site and curves northwards east of the Site. Head deposits are also located approximately 350 m north east of the Site.

Bedrock Geology

2.3.3 The bedrock geology within the far northern and eastern extents of the Site comprises the Margate Chalk Member which forms part of the Newhaven Chalk Formation. The Margate Chalk Member generally consists of smooth white chalk with little flint. Based on the BGS borehole log (BGS ref: TR35SE51), the Margate Chalk Member has a thickness of up to 4 m in the vicinity of the Site. The Margate Chalk Member is underlain by the Seaford Chalk Formation. The bedrock within the remainder of the Site comprises the Seaford Chalk Formation. The Seaford Chalk Formation generally consists of firm white chalk with semi-continuous nodular and tabular flint seams. Based on the BGS mapping data, the Seaford Chalk Formation has a thickness of approximately 55 m to 60 m in the vicinity of the Site. The Newhaven Chalk Formation and the Seaford Chalk Formation both form part of the White Chalk Subgroup[3].

2.4 Hydrogeology

2.4.1 The hydrogeology at and in the vicinity of the Site is summarised below based on information taken from the online BGS GeoIndex, BGS borehole records, BGS Reports, the online DEFRA Magic Map application and data provided by the EA, Dover District Council and Southern Water.

2.4.2 The superficial Head underlying the land immediately adjacent to the south western boundary of the Site is likely to have a low permeability.[5].

2.4.3 The White Chalk Subgroup underlying the Site is water bearing and is considered to have a low primary permeability and a high secondary permeability. Based on information gathered from the BGS Research Report[6], groundwater flow within the

[4] BGS, Lexicon of Named Rock Units. Accessed: 01/11/2023. Available online: https://www.bgs.ac.uk/technologies/the-bgs-lexicon-of-named-rock-units/
[5] BGS Report, *An appraisal of the early Palaeogene deposits of North Kent,* 2002. Accessed: 09/11/2023. Available online: https://nora.nerc.ac.uk/id/eprint/509480/1/CR02315N.pdf
[6] BGS, Research Report, *The Chalk aquifer of the North Downs*, 2008. Accessed 09/11/2023.

White Chalk Subgroup is concentrated within a few large fractures which are most commonly present at or within a few tens of metres of the water table. These fractures are often further enhanced due to dissolution as a result of the lithology, groundwater flux and the geochemical nature of the aquifer.

2.4.4 Based on data gathered from the EA Catchment Data Explorer[7], the Site is located within the East Kent Chalk – Stour Water Body, which has a catchment area of 593.8 km^2. In 2019 the Overall Water Body classification of the East Kent Chalk – Stour Water Body was 'Poor'.

Aquifer Designations

2.4.5 The superficial Head underlying the land immediately adjacent to the south western boundary of the Site is designated by the EA as a Secondary A Aquifer. Secondary A Aquifers are described by the EA as comprising permeable layers that can support local water supplies, and may form an important source of base flow to rivers.

2.4.6 The White Chalk Subgroup is designated by the EA as a Principal Aquifer. Principal Aquifers are described by the EA as able to provide significant quantities of drinking water and water for business needs. Principal Aquifers may also support rivers, lakes and wetlands[8].

2.4.7 Based on data gathered from the online DEFRA Magic Map Application, the Site is located in an area where Groundwater Vulnerability is High and in a Drinking Water Safeguard Zone for groundwater[9].

Groundwater Abstractions

2.4.8 Based on data provided by the EA, there are four licensed groundwater abstractions located within 3 km of the Site. The details of these are outlined in Table 1 below.

[7] EA (2023). Catchment Data Explorer. Accessed 01/02/2024. Available online: https://environment.data.gov.uk/catchment-planning
[8] EA Guidance, Protect groundwater and prevent groundwater pollution, 2017. Accessed: 09/11/2023. Available online: https://www.gov.uk/government/publications/protect-groundwater-and-prevent-groundwater-pollution/protect-groundwater-and-prevent-groundwater-pollution
[9] Magic Map (2023). Accessed: 01/11/2023. Available at: https://magic.defra.gov.uk/MagicMap.aspx

Table 1 Licensed Groundwater Abstractions within 3 km of the Site					
Licence Holder	**Licence Number**	**Purpose**	**Maximum Daily Quantity (m^3)**	**Maximum Annual Quantity (m^3)**	**Approximate Distance from Site**
Southern Water Services Ltd	9/40/04/0279/GR	Public Water Supply	9092	2273000	280 m ENE
Kingsdown Water	SO/40/0014/003/R01	Food and Drink	120	43800	1010 m SE
Edward Vinson Plants Limited	SO/040/0009/005	General Agricultural	110	17764	2070 m N
Affinity Water Limited	9/40/04/0497/G	Public Water Supply	3700	1158000	Within 3000 m, exact location not supplied-

2.4.9 Based on data provided by Dover District Council, there are no Private Water Supplies within 3 km of the Site.

Source Protection Zones

2.4.10 Based on data gathered from the online DEFRA Magic Map application, the Site is primarily located in a groundwater Source Protection Zone (SPZ) 1. A small area in the south east of the site is located in a groundwater SPZ 2. Based on information provided by Southern Water, a PWS with a maximum abstraction rate of 9092 m^3/day is located approximately 300 m east north east of the Site. It should be noted, however, that following correspondence with Southern Water, it is understood that the Southern Water PWS is not currently operational.

2.4.11 There are two groundwater SPZ1s located approximately 1900 m south and 2600 m south west of the Site, respectively.

Aquifer Properties

2.4.12 Based on information gathered from the BGS Research Report[5] and the BGS Technical Report[8] regional transmissivity values for the Chalk aquifer are typically 1,500 m^2 per day. These values are likely to be increased by large productive fractures which generally develop preferentially along bedding planes and fractures[10]. Within the

[5] BGS, Research Report, *The Chalk aquifer of the North Downs*, 2008. Accessed 09/11/2023.

White Chalk Subgroup at and in the vicinity of the Site, modelling[6] has suggested that specific yield values are approximately 0.015.

Groundwater Elevations and Flows

2.4.13 No groundwater elevation data are available for the Site. Based on data gathered from the online Hydrology Data Explorer[11] and groundwater elevation data at the Southern Water PWS approximately 300 m east north east of the Site, groundwater elevations at and in the vicinity of the Site range between approximately 2 mAOD and 4 mAOD during periods of low rainfall and between approximately 3 mAOD and 5 mAOD during periods of high rainfall.

2.4.14 Groundwater elevations at the Southern Water PWS have ranged between -0.04 mAOD and 4.00 mAOD with a median average of 2.03 mAOD in the period January 2002 to December 2023. It should be noted, however, that the PWS is not currently operational.

2.4.15 Based on the data gathered from the online Hydrology Data Explorer and groundwater elevation data at the Southern Water PWS, it is considered likely that the groundwater flow direction is to the north east. Based on the BGS hydrogeology map[12], it is considered that the English Channel, located approximately 1.8 km east of the Site is a discharge point for groundwater from the White Chalk Subgroup.

2.5 Hydrology

2.5.1 There are no surface water features at the Site. Based on the topography, drainage at the Site is anticipated to be towards the south.

2.5.2 Based on OS mapping, South Stream, a tributary of the River Stour is located approximately 1.3 km north west of the Site. The South Stream generally flows north where it becomes the North Stream which ultimately flows into the River Stour approximately 7.6 km north of the Site.

[10] British Geological Survey & Environment Agency (1997) The Physical Properties of Major Aquifers in England and Wales. *British Geological Survey Technical Report WD/97/34.* Environment Agency R&D Publication 8.
[11] DEFRA (2023) Hydrology Data Explorer. Accessed: 09/11/2023. Available online:
[12] BGS (1970) Hydrogeological Map of the Chalk and Lower Greensand of Kent – Folkestone Beds and Hythe Beds (1:126,720). Accessed 01/02/2023. Available online: https://largeimages.bgs.ac.uk/iip/hydromaps.html?id=kent.jp2

Surface Water Abstractions

2.5.3 Based on EA data, there are five licensed surface water abstractions located within 3 km of the Site. The details of these are outlined in Table 2 below.

Table 2 Licensed Surface Water Abstractions within 3km of the Site

Licence Holder	Licence Number	Purpose	Maximum Daily Quantity (m^3)	Maximum Annual Quantity (m^3)	Approximate Distance from Site
Betteshanger Farms Ltd	9/40/04/0034/SR	General Agriculture	1818	54552	2200 m NW
					2500 m NW
					2750 m NW
CJ Bean & Sons	12/071A	General Agriculture	600	11440	2420 m NNW
Steed	SO/040/0012/002	General Agriculture	800	9092	2500 m NNW
Betteshanger Farms Ltd	12/086/R01	General Agriculture	1527	45454	2530 m NW
Steed	12/074	Aquaculture Fish	800	1705	2530 m NNW

Surface Water Designations

2.5.4 Based on the online DEFRA Magic Map application, the Site is located within the North and South Streams in the Lydden Valley Nitrate Vulnerable Zone. The Site is not located within a Drinking Water Safeguard Zone for surface water.

2.5.5 Based on data gathered from the EA Catchment Data Explorer[13], the Site is located within the South East River Basin District and is part of the Stour Management Catchment. Within the Stour Management Catchment area, the Site falls within the North and South Streams Operational Catchment. The Site is located in the North and South Streams at Northbourne Water Body surface water sub-catchment, which has a catchment area of 40.7 km^2. In 2019 the chemical classification of the North and South Streams at Northbourne Water Body[14] was 'Fail'. In 2022 the ecological classification of the North and South Streams at Northbourne Water Body was

[13] EA (2023). Catchment Data Explorer. Accessed 01/02/2024. Available online: https://environment.data.gov.uk/catchment-planning
[14] EA (2023). Catchment Data Explorer. North and South Streams at Northborne Water Body. Accessed 01/02/2024. Available online: https://environment.data.gov.uk/catchment-planning/WaterBody/GB107040019720

'Moderate', which has been attributed to agriculture and rural land management, mining and quarrying, local and central government and the water industry.

2.5.6 Based on the EA online Flood Map for Planning, the Site is located within a Flood Zone 1, indicating that there is a less than 0.1% annual probability of flooding in any given year.

2.6 Discharges to Groundwater and Surface Water

2.6.1 Based on the EA mapping data, there are six licensed discharges to groundwater or surface water within 3 km of the Site, summarised below in Table 3.

Table 3: Permitted Discharges to Groundwater and Surface Water Within 3km of the Site

Permit Holder	Permit Number	Effluent Type	Site Type	Distance from Site
Ripplevale School Limited	SO/P11654/003	Sewage – not water company	School	990 m S
Mrs Julie Hinkins	SO/EPRDB3690WQ/001	Sewage – not water company	Domestic property	1320 m W
FCC Recycling (UK) Limited	SO/P09021/001	Trade	Waste Collection	2080 m NNE
Mr David Cliff	SO/EPRLP3525GD/001	Trade	Making of beverages	2560 m WSW
Anne Merson	SO/EPRDP3324GX/001	Sewage – not water company	Domestic property	2640 m WSW
Phoenix Care Homes Limited	SO/P11619/002	Sewage – not water company	Care home	3000 m ENE

3 HYDROGEOLOGICAL CONCEPTUAL SITE MODEL

3.1.1 The HCSM is discussed below based in terms of source, pathway and receptor. Following on from consultation with Southern Water, the principal focus of this HCSM is contaminant sources and pathways.

3.2 Source

3.2.1 Vehicular use at the Site may increase sediment mobilisation which can transport from the road material into the Chalk aquifer through surface wash and percolation.

3.2.2 Use of machinery at the Site may cause pollution from spills and leakage of fuels and oils. This pollution may be transported into the Chalk aquifer through percolation.

3.2.3 Cement products used during the construction of the proposed development may come into contact with water to produce a highly alkaline water. This water may percolate into the Chalk aquifer.

3.2.4 The construction of foundations for the proposed development may result in the release of fine sediment or rock flour notably during earthworks or piling. These fine sediments may be transported to the Chalk aquifer through percolation. Rock flour entrained in suspension can adversely alter the turbidity of the groundwater. Particle size and groundwater velocity control whether the chalk flour either settles or remains suspended in groundwater.

3.2.5 Pollution sources may be present during operation of the site. Pollutants present will depend upon the final land use and conditions of use.

3.3 Pathway

3.3.1 There are no superficial deposits at the Site. Therefore, the pathway for any potential contaminants to the receptor is through percolation to groundwater within the White Chalk Subgroup which immediately underlies the Site.

3.3.2 Sustainable Drainage Systems (SuDS) and increased surface water runoff from compacted soil, buildings and paved areas will concentrate groundwater recharge into particular areas of the Site compared with the baseline.

3.3.3 Regional groundwater flow is to the north east, although groundwater flow in the vicinity of the Site may be locally influenced by the Southern Water public water supply located approximately 280 m east north east of the Site. When pumping rates are low/eased at the public water supply, groundwater follows regional trends and flows toward the northeast. When pumping rates are high at the public water supply,

groundwater elevations are drawn down and local groundwater flow is pulled toward the northwest, centred around the abstraction well within a cone of depression.

3.3.4 Groundwater flow in the White Chalk Subgroup is primarily along fractures. Fractures are often enhanced due to dissolution as a result of the lithology of the Chalk, groundwater flux and the geochemical nature of the aquifer which can act as conduits for groundwater flow and therefore increase hydraulic conductivity.

3.4 Receptors

3.4.1 Potential receptors for contaminant sources on site are the groundwater within the White Chalk Subgroup (a Principal Aquifer and WFD groundwater body), the nearby Southern Water public water supply located approximately 280 m north north east of the Site, and the licensed groundwater abstractions listed in Table 1.

3.5 Source – Pathway – Receptor Linkages

Turbidity

3.5.1 The mobilisation of sediment associated with vehicular use and the release of fine sediment or rock flour associated with earthworks or piling works can adversely alter the turbidity of the groundwater of the White Chalk Subgroup. For a source – pathway – receptor linkage to be present, the sediment would need to be entrained and transported by groundwater to the abstractions.

3.5.2 The presence of the linkage between the potential sediment mobilisation associated with the development (the source) and the abstractions will depend on the direction of groundwater flow. Based on the available data there is uncertainty in the direction of groundwater flow around the site and whether the prevailing flow direction provides a linkage between the site and the receptors. Site works and groundwater monitoring will be used to determine local groundwater flow directions as described in Section 4.

Other Potential Contaminants

3.5.3 Fuel and oil spills associated with the use of machinery at the Site can adversely alter the hydrocarbon content of the White Chalk Subgroup. For a source – pathway – receptor linkage to be present, the hydrocarbons would need to transported by groundwater to the abstractions.

3.5.4 Cement products used during the proposed development may come into contact with water which can adversely alter the alkalinity of the White Chalk Subgroup. For a

source – pathway – receptor linkage to be present, the highly alkaline water would need to be transported by groundwater to the abstractions.

3.5.5 These contaminant linkages depend upon groundwater flow direction as noted for turbidity in paragraph 3.5.2. Proposals for monitoring groundwater levels and flow directions are set out in the following section.

4 PROPOSED MONITORING NETWORK

4.1 Introduction

4.1.1 The primary aim of the site investigation is to enable monitoring of the groundwater levels at the Site to determine the seasonal range in groundwater depth and elevation and the direction of groundwater flow. This data will be used to address uncertainties in the hydrogeological conceptual site model and enable risks from the proposed development to the Southern Water PWS and other licensed abstractions to be evaluated.

4.1.2 This specification sets out a description of borehole location and well construction to facilitate planning of the site investigation.

4.1.3 A suitably experienced WA Hydrogeologist will act as the Investigation Supervisor throughout the duration of the drilling and installation works.

4.2 Objective

4.2.1 The objective is to construct three groundwater monitoring wells in the Chalk aquifer at the Site.

4.3 Drilling and Construction

Drilling

4.3.1 Three boreholes (BH1, BH2 and BH3) are proposed, located at points within the Site boundary but outside of the proposed development area to facilitate the establishment of a groundwater monitoring network. Boreholes BH1 and BH2 will be located down-hydraulic gradient of the proposed development in the north and north east of the Site respectively. Borehole BH3 will be located up-hydraulic gradient of the proposed development in the south of the Site. The proposed locations of the boreholes are presented on Drawing GM12741-002.

4.3.2 The diameter of the boreholes will be approximately 150-200mm (or as necessary to accommodate uPVC piping of inside diameter 50mm / 63mm outside diameter). The proposed depths of the boreholes are summarised in Table 4 below.

4.3.3 Borehole BH1 will be drilled through the entirety of the Newhaven Chalk Formation and into the Seaford Chalk Formation to a depth of approximately 28 m below ground level (bgl) and boreholes BH2 and BH3 will be drilled through the Seaford Chalk Formation to depths of approximately 25 mbgl and 14 mbgl respectively. It is anticipated that groundwater will be encountered between 21 mbgl and 25 mbgl in

boreholes BH1 and BH2 and at approximately between 10 mbgl and 12 mbgl in borehole BH3.

4.3.4 Groundwater strike information will be recorded where possible, although it may not be possible to collect groundwater strike information as the proposed drilling method will utilise a water flush. The protocol if a significant inflow or loss of circulation (> 1 litre/second) is detected will be:

i) stop drilling;

ii) record initial water level; and

iii) record stabilised water level after 20-30 minutes of standing time, before deciding to recommence drilling.

4.3.5 Water levels will also be recorded at the start and end of each drill shift.

Logging of Drilling Cuttings

4.3.6 The drilling cuttings will be logged with adherence to the British Standard BS 5930:2015 +A1:2020[15].

Development

4.3.7 The drilling contractor will develop the borehole by air-lifting. Physico-chemical parameters (including suspended solids, pH, turbidity and electrical conductivity) are to be measured every 10 minutes. An estimate of volume purged will be made and this compared to the volume of water used (consumed) during drilling. Development should flush out more water than was introduced.

4.3.8 Suspended solids are to be measured using the 'bucket test': fill a 10-14 litre bucket with the water from the developing borehole and allow suspended sediments to settle; when there is no more than an approximate coin-sized amount of sediment, the water is considered to contain an insignificant amount of suspended sediments.

4.3.9 pH, turbidity and electrical conductivity are to be measured using an Aquaread *AP-2000* physico-chemical probe, or similar.

4.3.10 Development will cease after a minimum 60 minutes when the following conditions have been met by the last three consecutive readings, or as decided by an Investigation Supervisor based on professional judgment:

[15] BSI Standards Publication, 2020. BS 5930:2015 +A1:2020. *Code of practice for ground Investigations*.

- the water contains an insignificant amount of suspended sediments;
- pH is constant; and
- electrical conductivity is constant.

4.3.11 The drilling contractor should anticipate the duration of development to be up to four hours.

4.3.12 All wastewater that is produced during the works will be discharged to a settlement tank to remove fine-grained material from suspension. Following settlement, all wastewater will be transported off-site for disposal. No wastewater is to be discharged to ground.

Construction

4.3.13 Indicative installation details for BH1 are presented on Figure A1.

4.3.14 The boreholes will be screened in the bedrock (White Chalk Subgroup).

4.3.15 A 50mm inside diameter (ID)/63mm outside diameter (OD) unplasticized polyvinyl chloride (uPVC) pipe will be installed to the base of the boreholes. The perforated slotted pipe sections will have a slot aperture of approximately 2 mm with a geotextile wrap. The upper section of plain pipe comprising 50mm ID uPVC will be installed from approximately 0.3 m above ground level to the approximate depths presented in Table 4. The pipework depths in Table 4 are approximate estimates and will likely change depending on the geological and hydrogeological conditions encountered. The plain pipe will be installed to depths between 9 mbgl and 15 mbgl. The remaining length of pipe to the base of the boreholes will comprise 50mm ID uPVC slotted pipe. The installation details are subject to the ground and groundwater conditions which are encountered during the drilling and are likely to change.

4.3.16 The annulus between the borehole and the slotted section of pipe and approximately 1 m of the annulus between the borehole and the base of the base of the plain pipe will be filled with a gravel pack. The volume between the standpipe and the annulus of the borehole will be dependent on the diameter. For a 115 mm diameter borehole the volume will be 0.0337 m^3 per metre length and for a 159 mm diameter borehole the volume will be 0.0628 m^3 per metre length. The estimated mass of gravel per metre length of borehole to fill the annulus between the borehole and the pipe is between approximately 6 kg and 11 kg per metre assuming a density for the gravel of approximately 1.75 Tonnes/m^3. The gravel pack will comprise washed, bagged and dried natural silica gravel at diameters of between approximately 3 mm and 6 mm. As

the gravel pack will comprise loose, granular material only it is considered that the potential for bridging (i.e., filling of the annulus such that the material forms a plug below which there is a void) is minimised. In the unlikely event that bridging occurs it will be identified by monitoring the quantity of gravel used and appropriate action such as manipulating the pipework to free the bridged gravel will be taken to remedy the situation.

4.3.17 The annulus between the borehole and the remaining section of plain pipe above the gravel pack will be filled with coated bentonite pellets and progressively hydrated with clean water to provide a seal to approximately 0.2 mbgl. To prevent the potential for bridging, pellets will be placed initially to a depth of 200 mm above the gravel pack and hydrated progressively in approximately 200 mm intervals to approximately 0.2 mbgl.

4.3.18 The monitoring pipes will be fitted at the base with a push-fit or threaded end cap and at the top with a removable gas tight cap with a gas tap.

4.3.19 The monitoring pipes will be protected by headworks comprising a lockable steel riser pipe extended approximately 0.5 m above ground level and concreted securely at ground level.

4.3.20 The drilling contractor will record the volumes of all construction materials used and provide this record to the Client and Investigation Supervisor.

4.3.21 Following completion of drilling, each borehole location (including any refusals) will be surveyed to provide NGR co-ordinates to 3 decimal places (i.e. mm precision) and elevation to 3 decimal places (i.e. mm precision, relative to Ordnance Datum) including ground level, top of the uPVC standpipe and top of the headworks.

Summary and Subsequent Reporting

4.3.22 Reporting will take the form of daily drill logs (including depth to water measurements) and a drilling and construction report on completion of the works (including drilling and construction logs).

4.3.23 The groundwater monitoring boreholes will be fitted with In-Situ groundwater level loggers, recording automatically at a one-hour interval. The data will be used to understand the temporal and spatial variation in groundwater level across the Site which will inform a Hydrogeological Risk Assessment of the Site. Monthly groundwater monitoring and reporting is proposed.

4.3.24 The indicative scope of work for the groundwater monitoring specifies: Manual groundwater level measurement ('dipping') and automatic logger monitoring, which will involve six monitoring visits to the site to ensure that the groundwater elevation maximum of the year has been recorded. Following each visit, download of logger data, which will then be compensated for atmospheric pressure. The monitoring work will culminate in a Baseline Groundwater Level Monitoring Report and an update of this HCSM Report.

4.3.25 It is considered that this HCSM Report is a 'work in progress' and will be updated as the monitoring and the HRA of the site progresses.

Table 4 – Summary of the Geological and Hydrogeological Conditions Anticipated in the Proposed Groundwater Monitoring Wells					
Proposed Borehole ID	**National Grid Reference**	**Approximate Ground Level (mAOD)**	**Base of the Newhaven Chalk Formation (mAOD)**	**Approximate Groundwater Level (mAOD)**	**Approximate Groundwater Level (mbgl)**
BH1	TR 36084 50781	29.0	25.0	4.5	24.5
BH2	TR 36132 50511	26.5	-	5.0	21.5
BH3	TR 35964 50450	16.5	-	5.5	11.0

Note

- mAOD = metres above Ordnance Datum.
- The ground levels are based on an EA 2022 LIDAR Digital Terrain Model (DTM) with a reported accuracy of 1 metre.

The anticipated approximate groundwater levels are based on groundwater level data gathered from the online Hydrology Data Explorer.

APPENDIX A

Copies of the BGS Borehole Logs

NGRC
BOREHOLE RECORDS
ADJUSTMENT FORM

QUARTER SHEET TR 35 SE

BH REGISTRATION NUMBER 34 - 66

RECORDS ENTERED AND HELD BY WALLINGFORD

BH REGISTRATION NUMBER(S)

TR 35 54 A-G

Thanet Water Board,

290/16 ~~Borough of Deal,~~ Deal Waterworks, St. Richards Road, Deal

(a) W.S.K. p. 212. Surface +108¼. Shaft 111½ x 4. Heading: 149, floor 109 down. Yield 200,000 g.p.d. *1845.*
Hardness: P. 59, T. 204. *July 1869.*
(b) W.S.K. p. 212. Surface +108¼. Shaft 118¼. *1879.*
(c) Surface +108¼. Shaft x 6 x 7 (oval) reduced to x 5¼ at 99 down. Depth 113½. *1883.*
(d) Access shaft. Surface +99¼. Shaft 105 x 6. *1896.*
(e) Access shaft. Surface +117½. Shaft 124 x 6. *1896.*
(f) Surface +108¼. Shaft 116. Headings: floor c.110 down. *1901.*
(g) Access shaft. Surface +117½. Shaft x 6. R.W.L. -2½. P.W.L. -2½. Yield 27,500 g.p.h. *LeGrand, Sept. 1935.*
(a) - (g) Connected by headings: 881 x 6 x 4½. *Before 1896;* extended 225. *1896 - 1897;* extended 364. *1900 - 1901;* extended to 1,750. *LeGrand, 1935;* extended 400 from (g). *1949.*
(a) (b) (c) and (f) R.W.L. +11 (max.). *Feb. 1904;* +c.8. P.W.L. +3¾. *Spring 1907.* R.W.L. +4¼. P.W.L. -2¼. *Apr.* Hardness: P. 60, T. 220. Anal. *July.* R.W.L. +2¾. P.W.L. -3¾. *Aug. - Sept.* Yield 65,000 g.p.h. *1934.* R.W.L. +7½ to +9¼. *1946;* +11¼. P.W.L. +3¼. Recovered to +11¼ in 5 - 6 h. Yield 850,000 g.p.d. *Mar. 1947.* R.W.L. +5½. Hardness: total 270. Anal. *Dec. 1948.* R.W.L. +5¾. Hardness: total 27[illegible]. Anal. *June.* Hardness: total 260. Anal. *Oct. 1949.* R.W.L. +9½. *Feb.;* +6½. *June 1950;* +8¾. *June;* +8¾. *Nov. 1951;* +11. *Apr. 1952;* +7¼. *Sept. 1953;* +4½. P.W.L. +1½. Yield 68,000 g.p.h. *Oct. 1956.* R.W.L. +9¼. Hardness: total 270. *Apr. 1958.* R.W.L. +9¾. P.W.L. +4¼. Yield 66,000 g.p.h. *Oct. 1960.*

(g) Made	...	...	1	1
UCk	...	...	124½	125½

(g)

Top soil	1	1
Broken chalk	3	4
chalk	8	12
chalky flows flints	40½	52½
Bed of flints	1½	53
chalky flints	39	92
Tough y stony chalk	5½	97½
chalky flints	28	125½

A TR 3639 5084
B TR 3639 5085
C TR 3638 5085
D TR 3632 5080
E TR 3637 5078
F TR 3640 5084
G. TR 3631 5067

290/
16
A
TR35/54A

20/4/66. G.C.

Walmer.

Ordn. Map 290, new ser.; Geol. Map 3.

DEAL AND WALMER WATERWORKS, on the northern side of the road to Mongeham, about a quarter of a mile north of Walmer Station. New well. 1880.

About 119 feet above Ordnance Datum.

Communicated by Mr. W. R. HAMMOND, manager. (*S.E. Naturalist*, 1902.)

Shaft, with adit at the bottom.

Chalk, not firm for 70 feet, 118¾ feet.

There is an old well, 22 feet off, with adits about 149 feet long, from which water had been pumped daily for forty years at the rate of about 200,000 gallons a day.

Depth 111½'
Diam. 4'
see letter WQ/290/16/81N dated 10-11-56.

Early in 1907 the Engineer told me, on the ground, that the adits were 1,450 feet long and about a foot above Ordnance Datum; that the rest-level of the water was about 8 feet above Ordnance Datum, which was pumped down to 3¼ feet; that the highest water-level was reached in February, 1904 (11 feet above Ordnance Datum); and that the main fissures ran about north-west to south-east.

The adits were made as follows:
Before 1896 – 881 ft,
1896–97 – 225 ft,
1900–1901 – 364 ft.
see letter WQ/290/16/81N dated 10-11-56.
12-11.56 GW.

"2 access shafts were both constructed with the adit driven in 1896. One is situated in the chalk pit to the S.W. of the works details are 105 ft deep and 6 ft. in diameter. The other is in the field to the S. of the works, known as the 2 acre field, the depth being 124 ft., & the diameter 6 ft."

'The headings were extended to 1750 ft by Le Grande in 1935 at the same time as the 3rd access shaft'.
see letter WQ/290/16/81N. dated 10-11-56.
12-11-56 GW.

The Works also supply the parishes of Great Mongeham, Ripple, Sholden, and Ringwold.

The yearly supply is 172,206,000 gallons. The greatest day's supply 674,000 gallons, in August (Water Works Directory, 1907).

~~Tunbridge Wells, see Pembury, pp. 331, 332.~~

Walmer. DEAL WATERWORKS. (See p. 212.) Well 115 feet.

Three analyses. In first and second water clear, in third slightly turbid, in all palatable. Temperature, in second, 11·3° C. Water from the Chalk. *Rivers Pollution Commission. Sixth Report*, 1874, p. 99.

In parts per 100,000.

	July 24, 1869.	March 1, 1873.	August 28, 1873.
Total solid impurity	33·2	34·06	31·74
Organic carbon	·032	·05	·056
Organic nitrogen...	·013	·007	·024
Ammonia	—	·002	·004
Nitrogen as nitrates and nitrites	·698	·803	·702
Total combined nitrogen ...	·711	·812	·729
Chlorine	2·8	3·	2·9
Hardness, temporary	20·4	18·2	20·2
" permanent	5·9	5·4	6·1
" total	26·3	23·6	26·3

Three analyses, by G. W. WIGNER, *The Water Supply of Sea-side Watering-places*, 1878, pp. 35-37.

1. Sample received from the Surveyor. 2. Taken from a main tap at an hotel near the station. 3. Taken from the reservoir.

	1.	2.	3.
Total solid matter	25·4	26·6	27·4
Loss on ignition after deducting combined carbonic acid	4·7	1·18	2·87
Iron	traces	—	—
Chlorine calculated as chloride of sodium ...	3·51	3·35	3·51
Nitrogen as ammonia	·0015	·0037	·0049
" " albuminoid ammonia	·0029	·0026	·0023
" " nitrates	·535	·374	·346
" " nitrites	·008	·004	·004
Total nitrogen in these four forms	·5474	·3843	·3572
Oxygen absorbed by organic matter... ...	·0144	·008	·02

Hardness, Clark's scale, before boiling, 15·1°, 14·7° and 15°, after boiling 3·5°, 4·2°, and 4°.

1. Water yellowish, from traces of suspended matter. Free from objectionable smell. Taste slightly chalky. Microscopic examination satisfactory.

2, 3. Slight smell and when warmed a taste of chalk, but free from the yellowish colour. Microscopic examination satisfactory.

3. Traces of suspended matter.

"These three samples are very accordant in composition, and are all good."

26.7.49. N2713. Notified 1 adits by G Stow & Co. Ltd. ...000 gph. 120ft P.W.L. 14.6.54. CS.

Published in
'Water Supply
of Kent,'
Page 212

290/16

TR 35/54

By A. HARDEN. From the *Report of the Medical Officer of Health* for 1901. Communicated by Dr. F. PARSONS.

From stand-pipe at Park Street. Sample clear and free from smell. No suspended matter.

Analytical data, in parts per 100,000.

Dissolved solids...	33·15
Chlorine	2·6
Alkalinity, expressed as calcium carbonate ...	21·5
Free and saline ammonia	·0006
Albuminoid ammonia	·0016
Nitrogen as nitrates (none as nitrites)	·63
Oxygen absorbed from permanganate at 80° F. in 4 hours	none

Permanent hardness 5.

"The sample is characterised by the extremely small amount of unoxidised organic matter which it contains. . . A very excellent characteristic of the water is its great constancy of composition from quarter to quarter and from year to year. There is no chemical evidence of pollution from dangerous sources."

Dr. A. MACFADYEN adds the following bacteriologic note:—"This sample of water contained, per cubic centimetre, 88 organisms growing on gelatin at a temperature of 22° C. The *Bacillus Coli communis* was not found in 6 cubic centimetres of the sample. There was therefore no evidence of pollution of intestinal origin."

Ref 9509/50. The two 50 ft borings were made from ground level.
The level of the ground is approximately +108. O.D.

O.D. 1 well top +110'.
3 wells 1 3 access shafts all connected by headings - see diagram
Depth 115'. Brick lined - 4' sump at foot of shaft 7'6" diameter
Headings 4'6" x 6" (N.B. Headings 9' near bottom workings) 17,000' of headings
× Adit floor 100' below well top i.e. O.D. ? — at -500, from graph shown R.W.L. P.W.L. Nov 1934.
Date of wells (a) 1879 } date plant installed
(b) 1883 }
(c) 1901

Powers R.W.L 7'10" above adit floor - Aug 10th 1946
R.W.L varied between 8'- and 10' during 1946
R.W.L 1'9" above adit floor
P.W.L 4'3" " "
Recovery 5-6 hours. 1st 18" quickly then slowly. Never dry since '34
Yield 850,000 g.p.d. pumped as required.
Sited on Kent 58 NE~E

18.3.47

R.W.L. 6'1" above adit floor on 14.12.48.
5'9" above adit floor in summer of 1948. RM. 14.12.48.
6'3" " " " " 8-6-49
9'4" " " " " Jan 1950 - marginal Cork.
10' " " " " 17. 2.50 RM P.S. 7' above adit floor 10,650 P.

R.W.L. 7' above adit floor 15.6.50. RM.
R.W.L. 9'2" above adit floor TKT 21.6.51.
R.W.L. 9'3" " " " TKT 22.11.51
R.W.L. 11'6" " " " Temperature 52.8°F by thermometer TKT 17.4.52
R.W.L. 7'9" " " " after 4 hrs work. 1.9.53. now pumping 24 hrs/day TKT 28.9.53.

R.W.L. 9'9" above adit floor. 11.4.58. RP. TKT.
Visited. R.W.L. 7'10" above adit floor. after 8 hr. rest. Sample taken. 29.11.62. BH

TR 35/54

290 A-C

(B) UNDERGROUND WATER—(WELLS AND BORINGS).

(In each case please state whether a well and/or boring is in question.)

I. GENERAL.

Deal Waterworks
formerly Deal & Walmer Joint Water Board's Works
Municipal Offices, Deal

1. Exact site of well or boring ... ... Wells at Deal Waterworks: Waterworks Road. Deal.

(A map or sketch showing position would be useful.)

2. Surface level of ground above Ordnance Datum ... ... 110 ft.

3. Date of construction ... ... A Original works about 1845 as far as can be ascertained.
B First Beam Addition 1879.
C Second Beam Addition 1883.
Tandem Compound. Addition 1902

WELLS.

4. Depth of well from surface level of ground (i.e., 2 above). If top of well is below the surface level of the ground (*i.e.*, 2 above) state how much ... ... 120 ft.

5. Depth of floor of galleries at site of well: also dimension and direction of galleries ... ... 115 ft.

6ft high x 4ft. 6 ins wide. principally S & S.W. direction

BORINGS.

6. Depth of boring from surface level of ground (*i.e.*, 2 above). If boring is in bottom of well, state depth of well ... ... – ft.

7. (*a*) Diameter of top of boring ... ... – in.

(*b*) Diameter of bottom of boring ... ... – in.

8. Tubed from top of boring to ... ... – ft.

9. Lining tubes perforated at depths of ... ... – ft.

10. Water struck during boring at depths of ... ... – ft.

11. What was rest level on completion of boring? ... ... –

WELLS AND BORINGS.

12. Is the water raised by pump or air lift? ... ... 3 pumping units

13. Depth from top of well or boring to bottom of suction pipe ... 118 ft.

5

II. If systematic measurements of water levels are made, state whether these include :—

(*a*) Pumping levels..... Yes. .....(*b*) Rest levels ... ... Yes.

(*c*) Time of recovery to rest level on cessation of pumping ... ... Approx 10 hours

(*d*) Changes in pumping level, if rate of pumping is altered. ... ... No records.

Also state : (*e*) at what intervals records are taken (*i.e.*, daily, weekly, etc.) ... ... Monthly.

Please furnish a specimen graph of records taken over as long a period as available (up to 1 year). Copy herewith.

III. If measurements are made only occasionally, please indicate what is, or has been, done in this respect and furnish examples of any graphs or figures available. —

IV. YIELDS.

(1) Number of gallons pumped per hour ... ... 65,000.

(2) Is pumping continuous? ... ... Yes. over 12 hours.

(3) If not, how many hours pumping per day? ... ... 12 hours.

(4) Maximum daily yields available ... ...

Estimated ... ... Approx 1,000,000.

Based on actual tests ..... —

V. If a section or record of strata can be given please attach to this form. —

VI. (1) If a chemical analysis can be given please attach. Copy attached.

(2) If not state hardness ... ... Domestic & all purposes

(3) For what purpose is the water used? ... ...

(8CY).

290/16

TR35/54

COUNTY OF KENT

COUNTY ANALYST'S LABORATORY,
Sessions House,
Maidstone.

3rd September 1934.

Lab. Ref. 7439c.

To Mr. W. Mantle.

Description of Sample Deal & Walmer Waterworks supply, taken from tap on main in Meter House. 27. 8. 34.

	Parts per 100,000
Total solid residue.	37.0
Chlorine	3.0
Free Ammonia	0.0
Albuminoid Ammonia	0.0
Nitrogen as Nitrates	0.4
Oxygen absorbed, ½ hour at 80° F.	0.005
" " 4 hours at 80° F.	0.010
Nitrites	Absent

Remarks - This water is of excellent organic quality.

F. W. F. ARNAUD.

Public Analyst for the County of Kent.

290 A 16

(COPY)

LISTER INSTITUTE OF PREVENTIVE MEDICINE.

Chelsea Bridge Road, London, S.W.1.

July 24th 1934.

Report on Examination of....A sample of Water... TR35/54

Received from...M.Roberts Gibbon, Water Engineer, on July 12th 1934.

Description of Sample. The sample was marked:-

"Tap on Well Supply, Council Town Yard, 12/7/34, 7.30 a.m.

Chalk, 115 feet 0 inches."

General characteristics.

Clear and free from smell.

Analytical Data.

Chemical

	Parts per 100,000
Suspended matter	..
Dissolved Solids	36.6.
Chlorine	3.2
Alkalinity	20.0
Total hardness	28
Permanent hardness	6
Free and Saline Ammonia	0
Albuminoid Ammonia	0.0030
Nitrogen as Nitrites	None
Nitrogen as Nitrates	0.451
Oxygen absorbed from Permanganate at 37°C in 3 hours	0.004
Metals: Lead, Zinc, Copper, Iron.	None.

Bacteriological

No. of colonies per c.c. growing on agar at 37°C in 48 hours = 8

No. of colonies per c.c. growing on agar at 22°C in 4 days = 10

The smallest quantity of water in which organisms of the coliform group were found = 100 c.c.

THE SAMPLE IS BACTERIOLOGICALLY SATISFACTORY.

(Signed) J. MASSON GULLAND,

D. B. STEABBEN.

(COPY)

KENT COUNTY COUNCIL

290 Ly 16

Sessions House,
Maidstone.
Sept. 1st. 1934.

TR35/54

Dear Sir,

The following report shows the result of the examination of the sample of water recently received at the laboratory.

Yours faithfully,
ALFRED GREENWOOD.

To Dr. Hughes.

Sample received 27/8/34 2.30 Result forwarded Sept.1st. Lab.No.Y21442

Description Water from tap on main on Meter House.

Result of examination:

Number of Organisms per c.c. capable of growth	On Agar at 37·5° C.	On Agar at Room temperature in 4 days	
	18	Liquefying	Total 16

McConkey's Bile Salts Lactose Broth.

Number of tests			No. Growth	Acid	Acid & Gas.
	tubes	0·01 c.c.water			
10	"	0·1 c.c. "	10		
10	"	1·0 c.c. "	10		
4	"	10·0 c.c. "	2	2	
1	"	50·0 c.c. "			1

Other tests.

B. coli present in 50 cc of this water.

B. enteritidis sporogenes

Streptococci

Report.

CONSTANT PONDER.
Pathologist.

290/16

TR35/54

COPY.

THE LISTER INSTITUTE OF PREVENTIVE MEDICINE.

January, 19th. 1935.

REPORT ON EXAMINATION OF a Sample of Water

RECEIVED FROM M.Roberts Gibbon, Walmer U.D.C. on January 15th. 1935.

DESCRIPTION OF SAMPLES. The Sample was marked:-
"Tap, Town Yard, Walmer, 8 a.m., 15th. January, 1935, Chalk, 115 feet."

GENERAL CHARACTERISTICS.

Clear and Free from Smell.

ANALYTICAL DATA.

Chemical.	Parts per 100,000		Parts per 100,000
Suspended Matter	-	Nitrogen as Nitrites	None
Dissolved Solids	36.5	Nitrogen as Nitrates	0.533
Chlorine	3.3	Oxygen absorbed from Permanganate at 37°C. in 3 hours. ...	Less than 0.001
Alkalinity	21.3		
Total Hardness	29		
Permanent Do.	7		
Free & Saline Ammonia	0.0005	Metals. Zinc, Lead, Copper, Iron.	None.
Albuminoid Ammonia.	0.0020		

Bacteriological.

Number of colonies growing on agar at 37°C in 2 days. = 5
Do. Do. Do. at 22°C in 4 days. = 10

Organisms of the coliform group were not found in 100 ccs or less.

The Sample is bacteriologically satisfactory.

(Signed) J. MASSON GULLAND.
D. B. STEABBEN.

290 TR35/54
16

DATE	Alkalinity p.p.m. $CaCO_3$.	Total Hardness p.p.m. $CaCO_3$	Chloride p.p.m. Cl.	Conductivity m/mhos/cm^3	p.H.
Dec. 1948	223	270	35	550	
June 1949	228	275	35		7·7
Oct. 1949	228	260	35		7·5
Jan. 1950			36	600	
Feb. 1950			35	550	
June 1950			35	550	
June 1951			38·5	600	
Nov. 1951			35	550	
Feb. 1953			43 *		
Dec. 1957					
Apr. 1958	215	270	39	550	7·3
29·11·62		T.D.S. at 180°C mg/L 385	chloride as Cl mg/L 41	590	

* Determination by Margate Corporation

290/16 TR35/54 A-F

Borough of Deal,
Deal Waterworks.

(a) Surface + 108·55. Depth 109ft to floor of heading — Floor at −0·45.
(b) Surface + 108·36
(c) Surface + 108·36
(d) Surface + 99·87
(e) Surface + 117·52
(f) Surface + 108·38. Main heading at (f) has a floor level of −1·51.

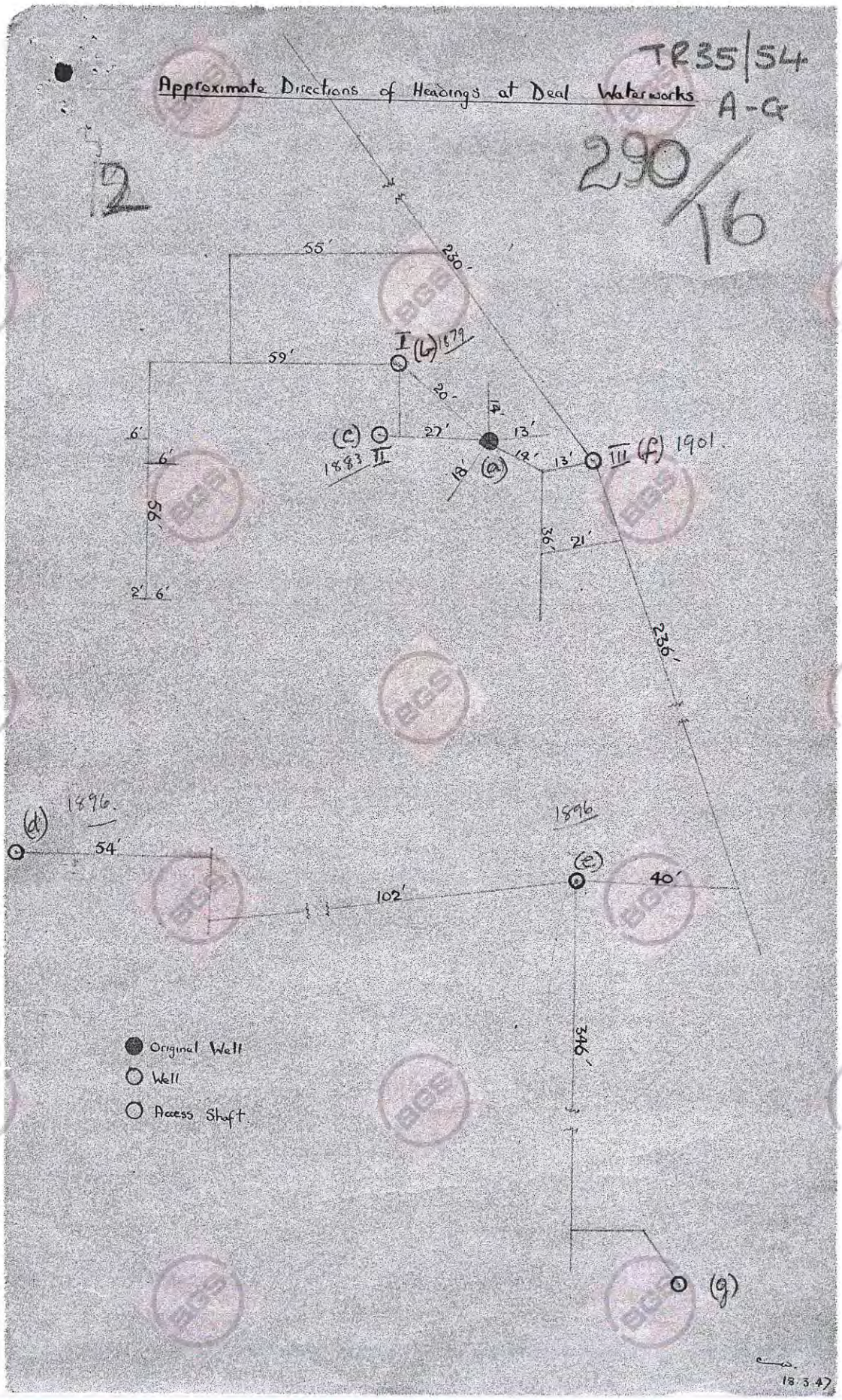
Headings were extended by a further 400 ft in 1949. Heading is straight from shaft (g) + lies under a field at Cross Road after passing under house no. 65.

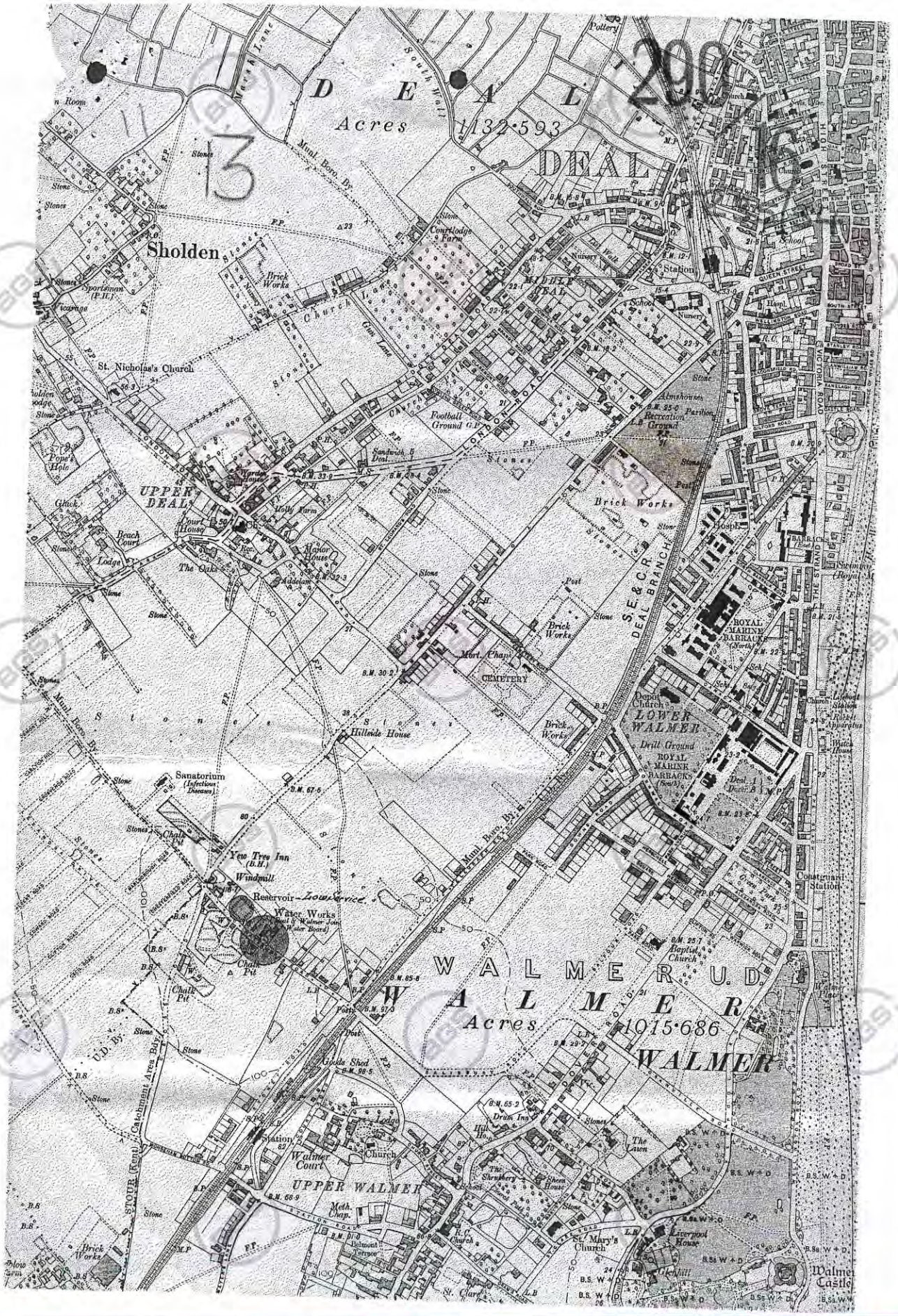
Water levels are measured from shaft (a) and shaft (a) is used to give access to wells (b), (c) and (f).

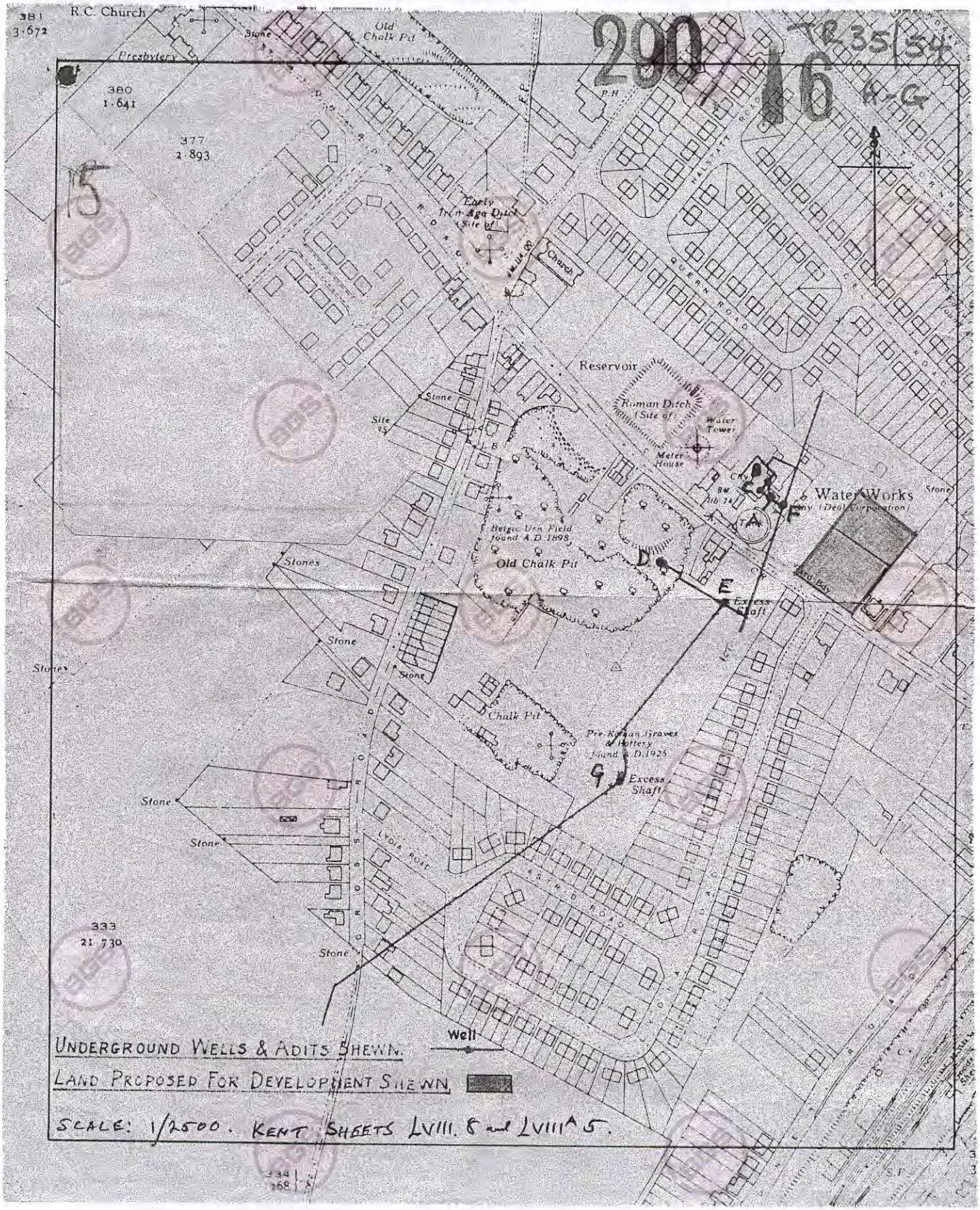
Shaft (c) dimensions :- 88ft × 6'×7' (oval);
4ft × 6'×7' (rect.);
4 × 5'×7' (rect.);
14½ × 5½' (diameter)
Total depth 113½ ft

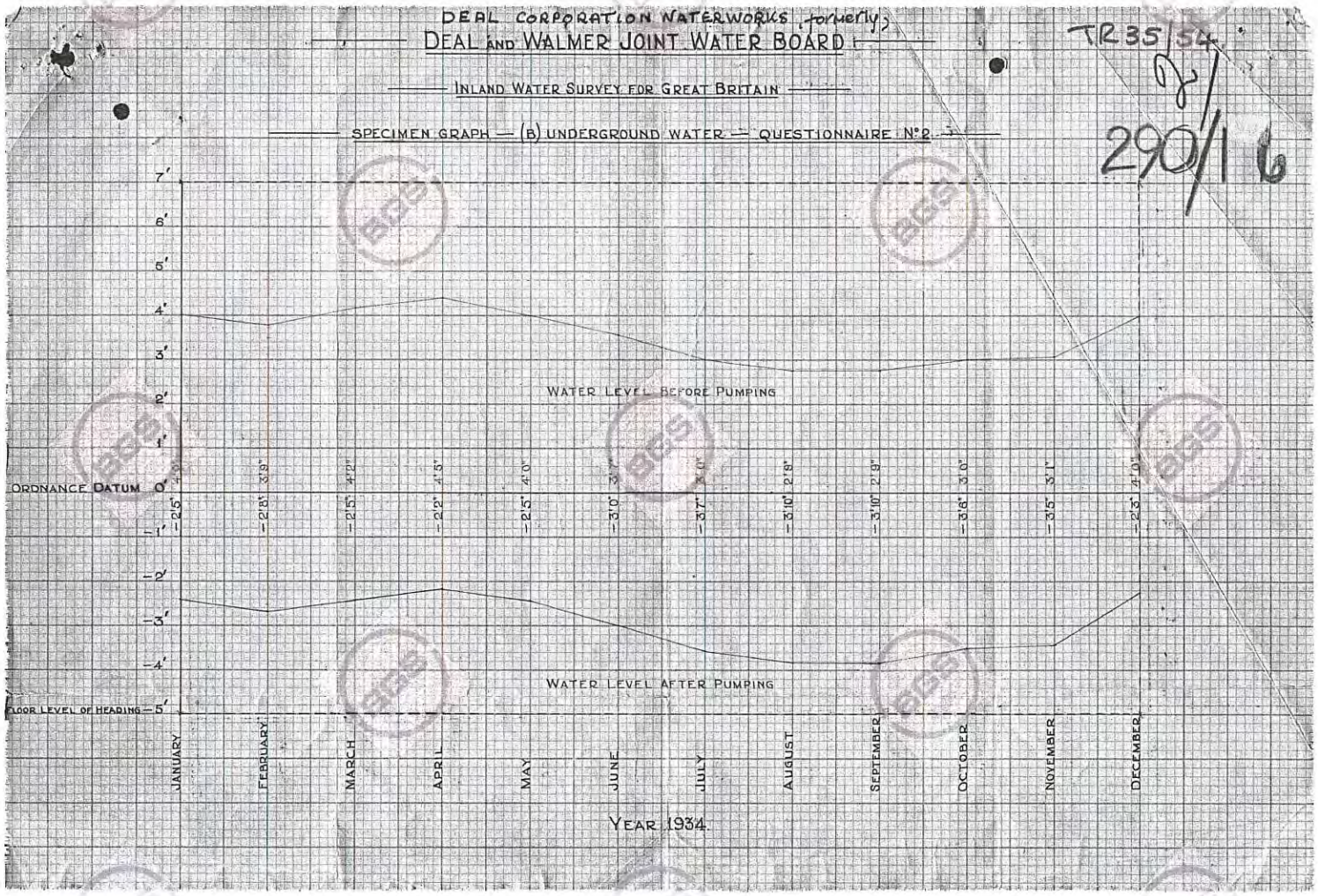
Shaft (f) 116ft deep.

Information received from Water Engineer. See WQ/290/16 dated 21/3/61.



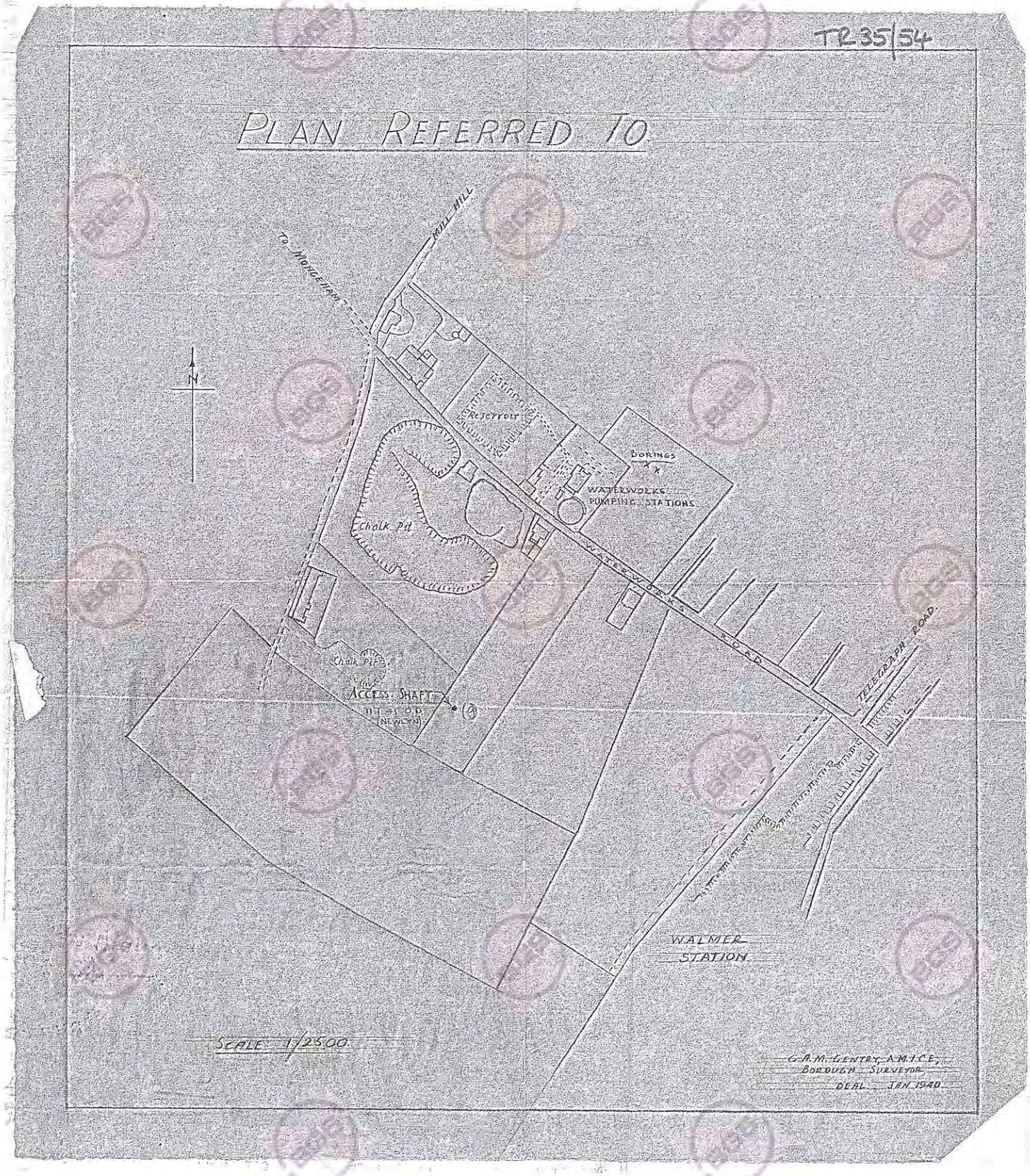






TR 35 54

PLAN REFERRED TO



G.A.M. GENTRY, A.M.I.C.E.,
BOROUGH SURVEYOR
DEAL JAN 1940.