

Groundwater Monitoring Report

Land East of Westergate



CALA Homes (South Home Counties) Limited

June 2017 – Version 3

Document Control Sheet

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PO20 3QR

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Version 3 – Groundwater monitoring and precipitation data included July 2016 to
February 2017.

	Name	Position	Signature	Date
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For and on behalf of Bingham Hall Associates				

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Executive Summary

This Report is provided in accordance with requirements set out by Arun District Council policy to assess groundwater conditions for new developments. Groundwater monitoring is required over a six month winter season to assess the risk of groundwater flooding to the development, and to inform the surface water drainage strategy. To facilitate long term groundwater monitoring at the Site five (BH1-5) groundwater monitoring wells were installed. Groundwater monitoring was undertaken between March 2016 and February 2017.

Geological Cross Sections have been prepared and illustrate that groundwater lies within the Superficial Deposits sitting above the impermeable London Clay cap. Cross sections of the wider Barnham – Eastergate – Westergate area show that the site is some distance from the possible groundwater emergence zones located to the north and south of the Site, i.e north of Eastergate and further to the south towards Bognor Regis, that coincide with the Chalk outcrop. Therefore, the groundwater regime within the Site is not connected to the deeper Chalk Aquifer.

The groundwater monitoring results indicate groundwater levels are consistent and within an expected range considering the underlying geology and the proximity of the monitoring wells to nearby watercourses.

All development will be undertaken within Flood Zone 1.

The monitoring undertaken indicates groundwater levels within BH1, BH2 and BH5, located within Flood Zone 1, were between 0.60m and 2.40mbgl. Groundwater levels within BH1 remained relatively constant throughout the monitoring period indicating a low responsiveness to intense rainfall events. Groundwater levels within BH2 and BH5 showed a steady decrease during the summer months but were influenced by intense rainfall events.

Groundwater levels within BH3 and BH4 reflect their proximity, and hydraulic continuity, with the Lidsey Rife and Westergate Stream, and position within Flood Zone 2.

There is no indication that high rainfall events result in groundwater flooding.

No flooding above existing ground level was noted during this monitoring period.

Groundwater levels within the Superficial Deposits are separated from the underlying Chalk Aquifer by a significant thickness of London Clay which acts as an aquiclude.

Groundwater levels will be a factor in the design of surface water drainage systems which must provide a 1m unsaturated zone beneath the base of any infiltration structure and the maximum recorded groundwater level.

This report demonstrates that the risk from groundwater flooding impacting upon the Site is negligible.

1 Introduction

General

- 1.1 Bingham Hall Associates has been commissioned by CALA Homes (South Home Counties) Limited to assess the groundwater regime in support of a hybrid planning application for a development of 350 dwellings on land east of Westergate, referred to hereafter as 'the Site'.
 - 1.2 Groundwater monitoring is required to assess annual fluctuations in groundwater levels to assess the risk of groundwater flooding, and to inform drainage design.
 - 1.3 The Site is currently greenfield land located to the east of the developed area of Westergate.
 - 1.4 The scope of works comprised:
 - Installation of 5 long term groundwater monitoring wells
 - 12 months groundwater monitoring*
 - Interpretative report assessing the impact of groundwater on the development
- * Installation was carried out in February 2016 and monitoring commenced at the beginning of March 2016. The initial monitoring did not encompass the full six months winter monitoring season therefore monitoring continued until February 2017 to cover the required period.

Limitations

- 1.5 This document has been prepared for the titled project and should not be relied upon or used for any other project. Bingham Hall Associates accepts no responsibility or liability for the consequences of this document being used for a purpose other than that for which it was commissioned. The assessments and judgments contained herein should not be relied upon as legal opinion.
- 1.6 The findings and opinions are relevant to the dates of the site visits and it should be noted that groundwater conditions will change over time due to natural variations and may be affected by human activities. The opinions included herein are based on the information obtained from the assessments undertaken at the site and from our experience. If additional information becomes available which may alter our conclusions, we request the opportunity to review the information, reassess the potential concerns and modify our opinion, if warranted.

2 Background

- 2.1 Arun District Council Emerging Local Plan notes that parts of eastern area of Barnham are prone to foul and surface water sewer flooding with this potentially due to high groundwater levels.
- 2.2 The British Geological Survey defines groundwater flooding as “the emergence of groundwater at the ground surface away from perennial river channels or the rising of groundwater into man made ground (e.g. property situated below ground level), under conditions where the ‘normal’ ranges of groundwater level and groundwater flow are exceeded”. Given the nature of groundwater flooding this is sometimes difficult to fully establish without the use of long term groundwater monitoring data. The geology and inherent hydrogeology has a significant influence on flood risk as it has direct bearing on rates of infiltration, runoff which directly influences groundwater flooding, and groundwater emergence zones.
- 2.3 The West Sussex SFRA, Map G ‘Areas More Prone to Groundwater Flooding’ shows the site to be in an area that is at medium risk of groundwater flooding. There are no recorded areas of groundwater flooding or groundwater flood events within close proximity of the site.
- 2.4 The Lidsey Surface Water Management Plan (SWMP) has identified groundwater infiltration to piped drainage in the 6 villages as the primary cause of sewer flooding in the urban area. High groundwater levels in the 6 villages is attributed to rainfall on the South Downs, particularly in winter, causing groundwater levels to rise in the Chalk aquifer. Sub-standard drainage (private and public) in the 6 villages allows water ingress to pipework hence overloading sewers. This subsequently overloads the downstream Wastewater Treatment Works with significant ‘clean’ water flows through the works taking up a substantial part of the consented outfall from the Works.

Planning Policy Context

- 2.5 Arun District Council Emerging Local Plan Policies relevant to Flood Risk are described below:
 - Policy DM2: identifies the potential for flooding (coastal, fluvial, surface water and groundwater) as being a matter for further assessment in a planning application.
 - Policy DM3: encourages the use of Sustainable Urban Drainage Systems (SUDS) to minimise the impact of urban development on the water environment, reduce flood risk, and provide habitats for wildlife. In particular, to ensure that SUDS discharge water from the development at the same or lesser rate, the policy requires developers to undertake six months groundwater monitoring within the winter months (October – March).

- Policy DM41: further specifies the use of SUDS and the requirement to undertake 6 months monitoring within the winter period.

Lidsey Surface Water Management Plan

- 2.6 Lidsey SWMP (Section 4.6.6) details appropriate SuDS drainage for areas prone to groundwater flooding. It states that only two methods (green roofs and rainwater harvesting) are considered appropriate in areas where groundwater flooding or high groundwater levels occur as other methods all seek to utilise capacity in the ground to remove surface water. There may be potential to use other methods such as ponds & wetlands; swales, detention basins; bio-retention basins; car parking areas; permeable paving; and soakaways. Prior to considering these monitoring needs to be undertaken to establish groundwater conditions during periods of prolonged wet weather (the winter period).

Stakeholder Consultation

- 2.7 Appropriate consultees in respect of this report are:
- Arun District Council
 - West Sussex County Council – Lead local Flood Authority
- 2.8 The groundwater monitoring undertaken for this report has been carried out in accordance the scope of work agreed with Arun District Council. Correspondence with Arun District Council is provided in **Appendix A**.

3 Site Appraisal

Site Setting

- 3.1 The site is currently undeveloped arable land covering approximately 18.4ha as shown in Figures 3.1 and 3.2:

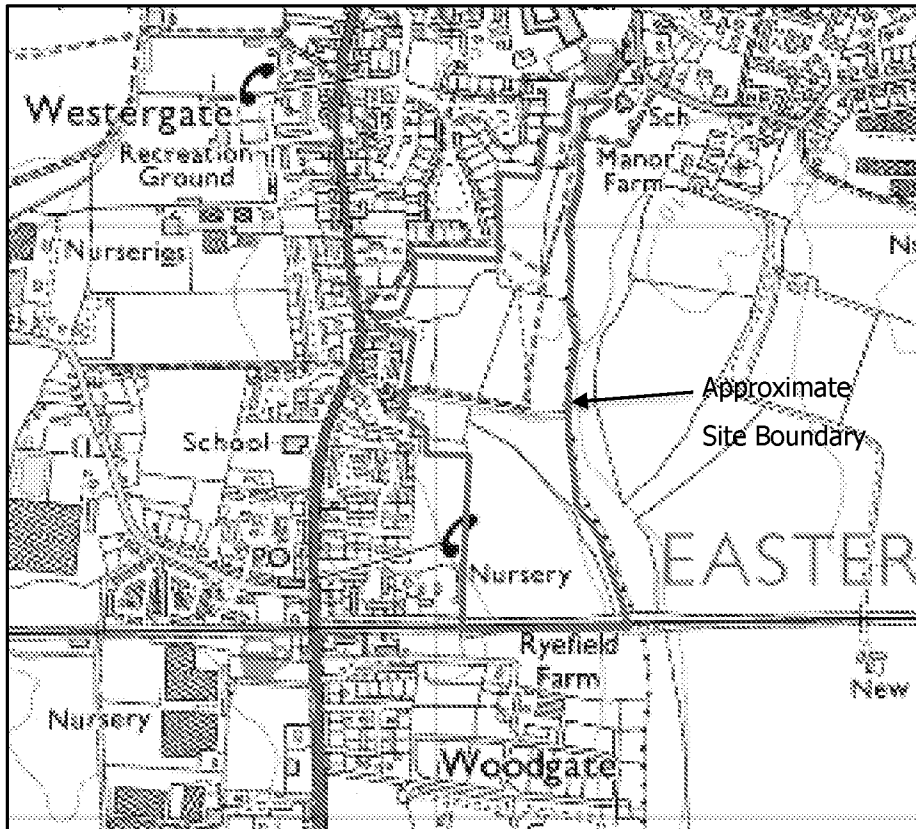


Figure 3.1: Site Location Plan



Figure 3.2: Site Location Plan: Aerial View

Topography

- 3.2 A detailed topographic survey has been carried out and is provided in **Appendix B**. The land falls from west to east and towards Lidsey Rife forming the eastern boundary. The west part of the site is relatively level at an elevation of around 8m–10m AOD and falling to between 5m–3.5m AOD along the lower edge adjacent to Lidsey Rife.

Geology

- 3.3 The British Geological Survey (BGS) 1:50,000 map for Chichester/Bognor (sheet 317/332) indicates the site lies on bedrock of the London Clay Formation. This is largely masked by superficial deposits of Head (Gravel, Sand Silt & Clay) in the northern part of the site and River Terrace Deposits (Sand, Silt & Clay) in the southern part of the site, with the river valley comprising Alluvium (Clay, Silt, Sand & Gravel) and Raised Beach Deposits (Sand and Gravel).

- 3.4 The London Clay Formation and Lambeth Group strata (clay, silt & sand) is known to be in excess of 100m thick beneath the Site, and lies upon the Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation and Culver Chalk Formation (Chalk – undifferentiated).

Hydrology

- 3.5 The Site is located in an area of agricultural land that is bounded to the east by Lidsey Rife which flows from the north to the south and is culverted underneath the railway line. An unnamed tributary from the west joins the Lidsey Rife through the Site from Westergate, to assist in identification this watercourse is termed Westergate Stream in this Report.

Hydrogeology

Aquifer Characteristics

- 3.6 The superficial deposits are designated as Secondary A Aquifers (i.e. permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers). Groundwater within these deposits will be perched upon the Unproductive London Clay Formation (i.e. low permeability layers with negligible significance for water supply or river base flow) which is known to be in excess of 100m thick beneath the site.
- 3.7 Considering the topography and underlying impermeable geology it is likely that groundwater within the superficial deposits is in hydraulic continuity with the Lidsey Rife and Westergate Stream located along the eastern boundary and through the centre of the site, respectively.
- 3.8 Groundwater movement in the Superficial Deposits will generally be down the slope and towards Lidsey Rife hence resulting in a slow decline in groundwater levels between rainfall periods.

Groundwater Vulnerability

- 3.9 The vulnerability of groundwater at a location is based on the hydrological, geological, hydrogeological and soil properties within a one kilometer square grid and is expressed at high, medium or low vulnerability, as defined by the Environment Agency. Typically this information is used to assess the exposure of groundwater to pollution hazards, however it can also be a useful tool in judging the likely permeability, flow and storage characteristics of the underlying strata.
- 3.10 The Secondary A aquifers beneath the Site are designated as high vulnerability and therefore, likely to have good permeability, flow and storage properties.

Source Protection Zones

- 3.11 Groundwater provides a third of the drinking water in England and Wales. The Environment Agency has defined Source Protection Zones around protected groundwater sources such as wells, boreholes and springs used for public drinking water supply. The zones are defined by the groundwater travel time from a point below the water table to the source. Zone 1 is defined by a travel time of 50 days, Zone 2 by a travel time of 400 days and Zone 3 by the total catchment area within which all groundwater recharge is presumed to be discharged at the source.
- 3.12 The Site is not within a Source Protection Zone, therefore the groundwater beneath the site is not used for public drinking water supply.

4 Fieldwork

- 4.1 Ground investigation works were carried out on 22 February 2016 to install five 50mm diameter monitoring standpipes to depths of 5mbgl (below ground level) using window sampling apparatus.
- 4.2 The exploratory borehole locations were chosen to provide a spread across the site, as shown in Figures 4.1. Borehole locations are dictated to some extent by presence of below ground utility apparatus; land use (presence of crops); field boundaries; and accessibility.
- 4.3 The exploratory holes (BH1-5 (WS1-5)) were logged on site, by an engineer, to BS5930:1999+A2:2010 'Code of Practice for Site Investigations' and are provided in **Appendix C**.
- 4.4 Return monitoring visits, to record groundwater levels, were carried out at regular intervals from March 2016 to February 2017.

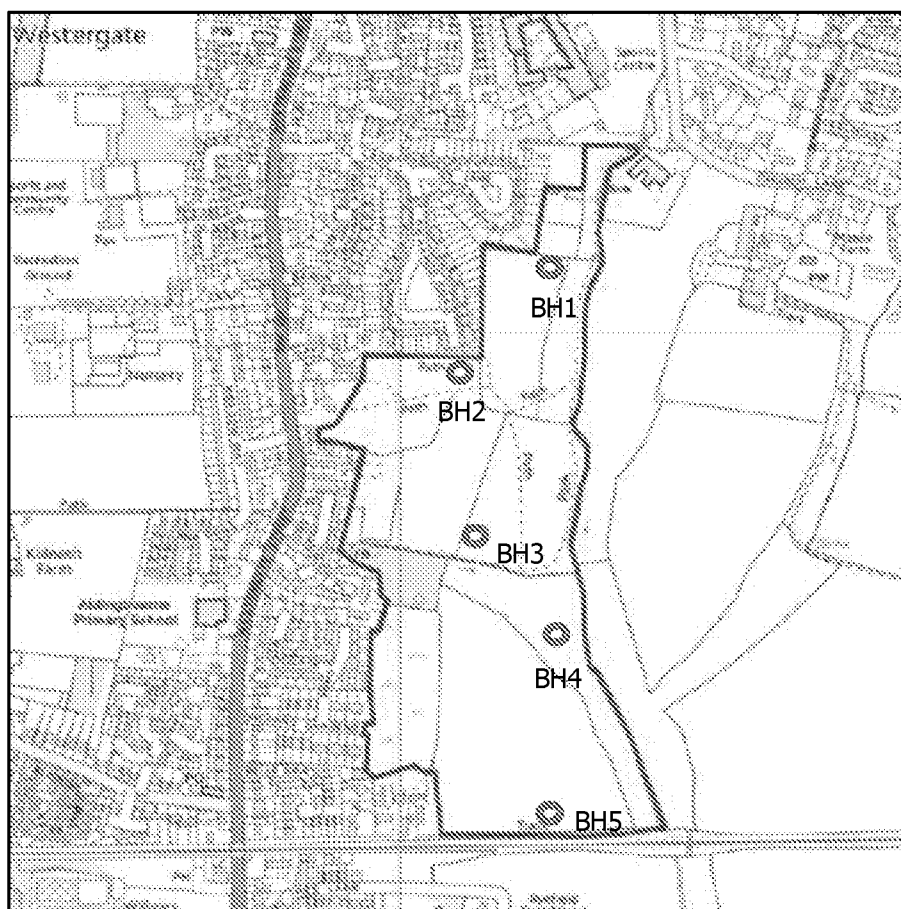


Figure 4.1: Groundwater Monitoring Well Locations

5 Groundwater Monitoring

General

- 5.1 Groundwater levels were recorded using either a manual dip tape or via water level dataloggers, installed within the monitoring standpipes. Dataloggers are regarded as the most reliable way of recording long term continuous water levels, however, the standpipes were vandalised in April and October which compromised their data and therefore manual readings were deemed more reliable.
- 5.2 Where datalogger readings were available, the groundwater levels have been interpreted using average values, ignoring any significant short term spikes that are attributed to localised vibration or disturbance. Groundwater monitoring data is provided in **Appendix D**.

Groundwater Assessment

- 5.3 The groundwater monitoring results indicate groundwater levels are consistent and within an expected range considering the underlying geology and the proximity of the monitoring wells to nearby watercourses.
- 5.4 Geological Cross Sections have been prepared and illustrate that groundwater lies within the Superficial Deposits sitting above the impermeable London Clay cap. Cross sections of the wider Barnham – Eastergate – Westergate area show that the site is some distance from the possible groundwater emergence zones located to the north and south of the Site, north of Eastergate and further to the south towards Bognor Regis, that coincide with the Chalk outcrop. Therefore, the groundwater regime within the Site is not connected to the deeper Chalk Aquifer.
- 5.5 Geological Cross Sections are provided in **Appendix E**.

Precipitation Data

- 5.6 Weekly precipitation data for the same period has been obtained from RP5.co.uk. The records are taken from the Meteorological Office weather Station at Thorney Island. This weather station is located to the west of Chichester and hence rainfall rates are not necessarily directly comparable with weather conditions at the Site. However, this data does give an indication of weather patterns in the area. The data is presented graphically in **Appendix F**.
- 5.7 The records show significant rainfall in weeks commencing 24 March 2016, 16 June 2016, 23 June 2016, 28 July 2016, 17 November 2016, 12 January 2017, 2 February 2017 and 23 February 2017.
- 5.8 These records have been correlated with the groundwater monitoring data:

- BH1: Groundwater levels have remained relatively constant throughout the monitoring period indicating a low responsiveness to rainfall. BH1 is located within Flood Zone 1 and the well is installed within the River Terrace Deposits.
- BH2: Groundwater levels show a steady decline during the summer months, with a marked increase noted around late June 2016. Levels were at their highest during January and February 2017. BH2 is located within Flood Zone 1 and the well is installed within the River Terrace Deposits.
- BH3: Groundwater levels show a steady decrease during the summer months, with marked increases noted around late June 2016, late July 2016, January and February 2017, in response to rainfall events. BH3 is located within Flood Zone 2 and the well is installed within Alluvium.
- BH4: BH4 indicates a similar trend to BH3. BH3 is also located within Flood Zone 2 and the well is installed within Alluvium.
- BH5: BH5 follows a similar trend to BH2. BH5 is located within Flood Zone 1 and the well is installed within the River Terrace Deposits.

6 Conclusions

- 6.1 All development will be undertaken within Flood Zone 1. The monitoring undertaken indicates groundwater levels within BH1, BH2 and BH5, located within Flood Zone 1, were between 0.60m and 2.40mbgl. Groundwater levels within BH1 remained relatively constant throughout the monitoring period indicating a low responsiveness to intense rainfall events. Groundwater levels within BH2 and BH5 showed a steady decrease during the summer months, however were influenced by intense rainfall events.
- 6.2 Groundwater levels within BH3 and BH4 were between 0.10m and 1.43mbgl. These levels reflect their proximity, and hydraulic continuity, with the Lidsey Rife and Westergate Stream, and position within Flood Zone 2. Development will not be undertaken within Flood Zone 2.
- 6.3 There is no indication that high rainfall events result in groundwater flooding. No flooding above existing ground level was noted during this monitoring period.
- 6.4 Groundwater levels within the Superficial Deposits are separated from the underlying Chalk Aquifer by a significant thickness of London Clay which acts as an aquiclude, preventing any hydraulic continuity between the two, as demonstrated by the Geological Cross Sections.
- 6.5 Groundwater levels will be a factor in the design of surface water drainage systems which must provide a 1m unsaturated zone beneath the base of any infiltration structure and the maximum recorded groundwater level. However, this report demonstrates that the risk from groundwater flooding impacting upon the Site is negligible.

Appendix A: Correspondence with Arun District Council

Andrew Bingham

From: Thomas Callaway [REDACTED]
Sent: 18 February 2016 14:07
To: Andrew Bingham
Cc: Paul Cann
Subject: RE: Land east of Westergate: groundwater monitoring

Andrew

The strategy is acceptable. Groundwater monitoring can be done now but will need to be supplemented by monitoring throughout next winter, from October through to March.

This is required to inform the drainage design before any building work can start.

Regards

Tom Callaway

Thomas Callaway | Drainage & Coastal Engineer, Engineering Services, Arun District Council | Location: Second Floor, Arun Civic Centre, Maltrovers Road, Littlehampton, BN17 5LF

[REDACTED]
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Save the environment - think before you print.

From: Paul Cann
Sent: 18 February 2016 10:21
To: Thomas Callaway
Subject: FW: Land east of Westergate: groundwater monitoring

Paul Cann
Senior Engineer (Drainage & Coastal)

Paul Cann | Senior Engineer (Drainage & Coastal), Engineering Services, Arun District Council | Location: Second Floor, Arun Civic Centre, Maltrovers Road, Littlehampton, BN17 5LF

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Save the environment - think before you print.

From: Andrew Bingham [REDACTED]
Sent: 18 February 2016 08:59

To: Paul Cann
Subject: Land east of Westergate: groundwater monitoring

Paul

I refer to our conversation yesterday.

The proposed land is as shown attached for approximately 320 dwellings to be developed in advance of the wider development with initially a hybrid planning application.

In accordance with policy W DM3 we need to undertake 6 months groundwater monitoring within the winter period – I appreciate we are at the latter end of the period but hope we can obtain a reasonable amount of viable data to inform the planning application, with if required further monitoring next winter.

As discussed as propose to install 4 wells and consider that this will provide a reasonable distribution across the site, approximate locations shown on the attached plan. The geology in this area is shown to be a clay cap in excess of 100m thick overlying the water bearing chalk. It is clear that groundwater flooding will not arise from the deep aquifer but may occur due to perched water tables in the upper strata. Consequently borehole monitoring will target these shallow water tables with well monitoring depth of 5m. Water levels will be monitored continuously using data loggers with data retrieved weekly. At the end of the 6 month monitoring period a report will be produced, if required interim results can be provided.

Can you let me know if you are in agreement with this strategy, and subject to the proviso that additional monitoring may be required post planning.

regards

Andrew Bingham C. Eng.
Managing Director
BHA Consulting Ltd
Oakleigh Connaught Rd
Attleborough
Norfolk NR17 2BW

see our website at www.binghamhall.com

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Appendix B: Topographic Survey

Appendix C: Borehole Logs



Soils Limited
Newton House, Cross Road, Tadworth KT20 5SR

Borehole Log

Borehole No.

WS1

Sheet 1 of 1

Project Name: Land at Westergate

Project No.: 15474

Co-ords:

Hole Type
WS

Location: Land at Wester Gate, St Richards Rd, Westergate, Chichester,
West Sussex PO20 3RD

Level:

Scale
1:50

Client: BHA Consulting Ltd

Dates: 07/03/2016

Logged By
OK

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.10	D		0.20			Grass over very soft grey slightly sandy silty CLAY. Sand is fine. Occasional fine to medium sub-angular flint gravels. Abundant of fine roots and rootlets. TOPSOIL	
		0.50	D					Soft light brown slightly sandy silty CLAY becoming firm yellowish grey with depth. Sand is fine. Very rare fine to medium sub-angular flint gravels becoming frequent at with depth. Frequent fine roots and rootlets becoming occasional fine to medium with depth. ALLUVIUM	1
		0.90	D						
		1.20	D		1.30				
		1.80	D					Yellowish brown slightly clayey fine SAND. A occasional pockets of slightly clayey gravelly fine to coarse SAND. Gravel is fine to medium sub-angular flint. RIVER TERRACE GRAVELS	2
		2.20	D						
		2.80	D						3
		3.20	D						
		3.80	D						4
		4.30	D						
		4.95	D		5.00			End of Borehole at 5.00m	5
									6
									7
									8
									9
									10

General Remarks:

Fine to medium roots and rootlets to 1.30

Borehole Type

CP: Cable Percussive
WS: Windowless Sampler
RC: Rotary Cored

Sample Types

D: Disturbed
B: Bulk
J: Jar
W: Water
U: Undisturbed

In-Situ Testing

SPT: Split spoon - Standard Penetration Test
CPT: Cone - Standard Penetration Test

Groundwater Remarks:

**Soils Limited**

Newton House, Cross Road, Tadworth KT20 5SR

Borehole Log

Borehole No.

WS2

Sheet 1 of 1

Project Name: Land at Westergate

Project No.: 15474

Co-ords:

Hole Type
WSLocation: Land at Wester Gate, St Richards Rd, Westergate, Chichester,
West Sussex PO20 3RD

Level:

Scale
1:50

Client: BHA Consulting Ltd

Dates: 07/03/2016

Logged By
OK

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.10	D					Grass over soft light brown slightly sandy silty CLAY. Sand is fine. Occasional fine to coarse sub-angular flint gravels. Abundant of fine roots and rootlets to 0.10. Occasional fine roots and rootlets. ALLUVIUM	
		0.40	D						
		0.80	D		0.90				
		1.20	D		1.30			Light brown slightly sandy clayey fine to coarse angular flint GRAVEL. Sand is fine to coarse. Rare fine roots and rootlets. RIVER TERRACE GRAVELS	1
		1.50	D		1.60			Light brownish white clayey gravelly fine to coarse SAND. Gravel is fine to coarse angular flint. Frequent fine to coarse sand sized chalk particles. RIVER TERRACE GRAVELS	
		2.20	D					Light brown slightly clayey fine SAND. Occasional pockets of fine to medium sub-angular flint gravels. Rare occasional pockets of firm grey CLAY at depth. RIVER TERRACE GRAVELS	2
		2.80	D						3
		3.30	D						
		3.80	D						4
		4.50	D						
					5.00			End of Borehole at 5.00m	5
									6
									7
									8
									9
									10

General Remarks:

Fine roots and rootlets to 1.30

Borehole Type

CP: Cable Percussive
WS: Windowless Sampler
RC: Rotary Cored

Sample Types

D: Disturbed
B: Bulk
J: Jar
W: Water
U: Undisturbed

In-Situ Testing

SPT: Split spoon - Standard Penetration Test
CPT: Cone - Standard Penetration Test

Groundwater Remarks:

Project Name: Land at Westergate	Project No.: 15474	Co-ords:	Hole Type WS
Location: Land at Wester Gate, St Richards Rd, Westergate, Chichester, West Sussex PO20 3RD		Level:	Scale 1:50
Client: BHA Consulting Ltd		Dates: 07/03/2016	Logged By OK

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.10	D		0.20			Grass over slightly sandy clayey SILT. Sand is fine. Very rare fine to medium sub-angular flint gravels. Abundant of fine roots and rootlets. TOPSOIL	
		0.50	D					Firm light brown slightly silty CLAY. Frequent fine to coarse angular flint gravels at depth. Occasional pockets of fine to medium gravel sized calcareous nodules. Occasional fine roots and rootlets. ALLUVIUM	
		0.80	D		1.00			Stiff light brown mottled orange and grey slightly silty CLAY becoming very stiff with depth. Occasional pockets of fine to medium gravel. Rare pockets of fine sand at depth. Rare pockets of fine to medium sand sized selenite crystal particles at depth. Rare fine roots present till 2.0m bgl. LONDON CLAY FORMATION.	1
		1.30	D						2
		1.80	D						3
		2.30	D						4
		2.80	D						5
		3.30	D						6
		3.80	D						7
		4.30	D						8
		4.80	D		5.00				9
								End of Borehole at 5.00m	10

General Remarks: Fine roots and rootlets to 2	Borehole Type CP: Cable Percussive WS: Windowless Sampler RC: Rotary Cored In-Situ Testing SPT: Split spoon - Standard Penetration Test CPT: Cone - Standard Penetration Test	Sample Types D: Disturbed B: Bulk J: Jar W: Water U: Undisturbed
Groundwater Remarks:		

Project Name: Land at Westergate	Project No.: 15474	Co-ords:	Hole Type WS
Location: Land at Wester Gate, St Richards Rd, Westergate, Chichester, West Sussex PO20 3RD		Level:	Scale 1:50
Client: BHA Consulting Ltd		Dates: 07/03/2016	Logged By OK

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.20	D		0.30			Grass over grey slightly sandy clayey SILT. Sand is fine. Rare fine to medium sub-angular flint gravels. Frequent fine roots and rootlets. TOPSOIL	
		0.50	D					Firm grey sandy silty CLAY. Sand is fine. Occasional fine to coarse angular to sub-angular flint gravels. Occasional fine roots and rootlets. ALLUVIUM	
		0.90	D		1.00			No sample received	1
					2.00			Stiff grey mottled orange CLAY with occasional lenses of silty fine sand. Rare fine roots and rootlets. LONDON CLAY FORMATION	2
		2.30	D					Stiff grey CLAY with occasional silty lenses. A single thin band of fine to coarse sand sized shell fragments observed at 3.50m bgl. LONDON CLAY FORMATION	3
		2.80	D		3.00				4
		3.30	D						5
		3.80	D						6
		4.30	D						7
		4.80	D		5.00				8
								End of Borehole at 5.00m	9
									10

General Remarks: Fine roots and rootlets to 3.0	Borehole Type CP: Cable Percussive WS: Windowless Sampler RC: Rotary Cored In-Situ Testing SPT: Split spoon - Standard Penetration Test CPT: Cone - Standard Penetration Test	Sample Types D: Disturbed B: Bulk J: Jar W: Water U: Undisturbed
Groundwater Remarks:		

Project Name: Land at Westergate	Project No.: 15474	Co-ords:	Hole Type WS
Location: Land at Wester Gate, St Richards Rd, Westergate, Chichester, West Sussex PO20 3RD		Level:	Scale 1:50
Client: BHA Consulting Ltd		Dates: 07/03/2016	Logged By OK

Well		Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description		
			Depth (m)	Type	Results						
			0.20	D		0.40			Grass over grey slightly sandy clayey SILT. Sand is fine. Rare fine to medium sub-angular flint gravels. Frequent fine roots and rootlets. TOPSOIL		
			0.50	D					Soft light brown slightly sandy silty CLAY. Sand is fine. Rare fine to medium angular to sub-angular flint gravels with depth. Occasional decomposed material. Occasional fine roots and rootlets. RIVER TERRACE GRAVELS		
			0.80	D							
			1.30	D		1.00			Stiff light brown slightly sandy slightly silty CLAY. Sand is fine. Occasional pockets of fine to coarse sand sized calcareous nodules. Rare fine to medium sub-angular calcareous gravels. Rare fine rootlets. RIVER TERRACE GRAVELS		
			1.80	D				2.00			
			2.30	D							Stiff light brown mottled grey CLAY with occasional lenses of silty fine sand. Rare decomposed material. LONDON CLAY FORMATION
			2.80	D		3.00					Stiff grey CLAY with occasional lenses of silty fine sand becoming frequent at with depth. Occasional pockets of fine to medium sand observed at depth. LONDON CLAY FORMATION
			3.30	D							
			3.80	D							
			4.30	D		5.00					
			4.80	D							
			End of Borehole at 5.00m								
										6	
										7	
										8	
										9	
										10	

General Remarks: Fine roots and rootlets to 2.0	Borehole Type CP: Cable Percussive WS: Windowless Sampler RC: Rotary Cored	Sample Types D: Disturbed B: Bulk J: Jar W: Water U: Undisturbed
	In-Situ Testing SPT: Split spoon - Standard Penetration Test CPT: Cone - Standard Penetration Test	
	Groundwater Remarks:	

Appendix D: Groundwater Monitoring Data

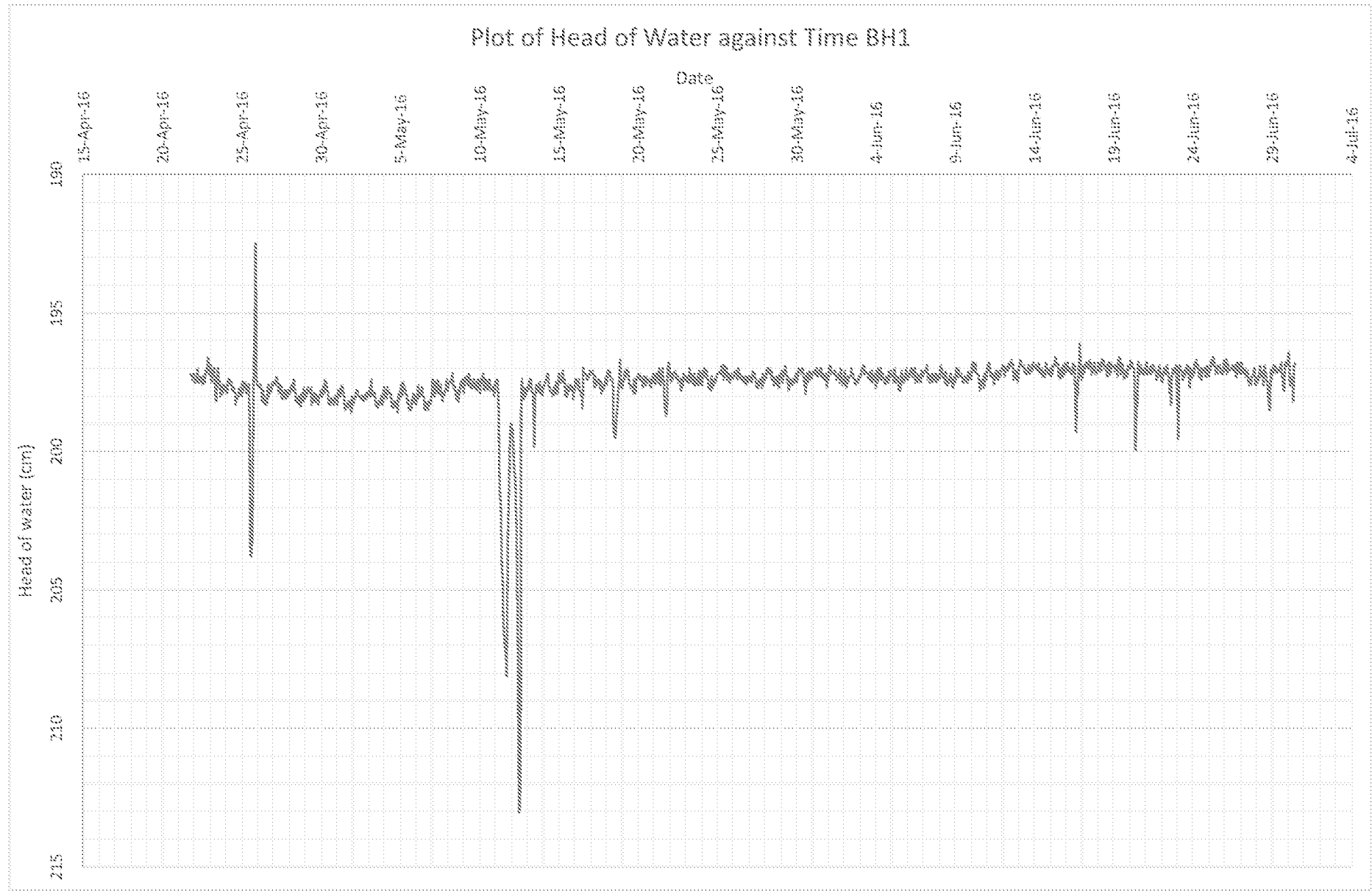
3030 Land East of Westergate - Annual Groundwater Monitoring Data

Monitoring Well Number				BH1	BH2	BH3	BH4	BH5
Depth of well (mbgl) - 22/2/16				5	5	5	5	5
Depth of well (mbgl) - 21/4/16 (reinstated)				2.3	2.18	4.48	4.7	4.54
Groundwater Level (mbgl*)	Reading No.	Method	Date					
	1	Manual	08/03/2016	2.40	1.40	0.50	0.75	0.60
	2	Manual	17/03/2016	2.34	1.58	0.45	0.90	0.98
	Monitoring wells vandalised early April. Covers reinstated & data loggers installed 21/04/16							
	3	Data Logger	25/04/2016	1.98	1.65	0.76	0.57	0.96
	4	Data Logger	02/05/2016	1.98	1.69	0.86	0.52	1.09
	5	Data Logger	09/05/2016	1.97	1.70	0.94	0.52	1.13
	6	Data Logger	16/05/2016	1.98	1.69	0.93	0.52	1.17
	7	Data Logger	23/05/2016	1.97	1.72	0.81	0.52	1.18
	8	Data Logger	30/05/2016	1.97	1.73	0.88	0.54	1.27
	9	Data Logger	06/06/2016	1.97	1.74	0.97	0.58	1.40
	10	Data Logger	13/06/2016	1.97	1.75	1.03	0.71	1.53
	11	Data Logger	20/06/2016	2.00	1.73	0.98	0.68	1.56
	12	Data Logger	27/06/2016	1.97	1.58	0.62	0.40	1.27
	Monthly manual readings instructed over summer monitoring period.							
	13	Manual	19/07/2016	2.30	1.78	1.19	0.80	1.85
	14	Manual	25/08/2016	2.30	1.73	1.41	0.60	1.80
	15	Manual	12/09/2016	2.30	1.72	1.40	0.70	1.75
	16	Manual	07/10/2016	2.30	1.73	1.43	0.72	1.80
	Data loggers installed 31/10/16. Monitoring visit on 29/11/16 found wells had been vandalised and one data logger stolen. No recoverable readings on other data loggers. Weekly manual readings instructed.							
	17	Manual	05/12/2016	2.30	1.70	0.74	0.46	1.21
	18	Manual	14/12/2016	2.30	1.71	0.67	0.54	1.26
	19	Manual	19/12/2016	2.30	1.72	0.64	0.53	1.23
	20	Manual	05/01/2017	2.30	2.00	0.85	0.35	0.95
	21	Manual	12/01/2017	2.30	1.67	0.56	0.30	0.78
	22	Manual	17/01/2017	2.30	1.53	0.40	0.20	0.74
	23	Manual	26/01/2017	2.30	1.62	0.48	0.31	0.85
	24	Manual	02/02/2017	2.30	1.52	0.40	0.22	0.74
	25	Manual	09/02/2017	2.30	1.53	0.10	0.18	0.71
	26	Manual	14/02/2017	2.30	1.55	0.32	0.22	0.75
	27	Manual	22/02/2017	2.29	1.60		0.17	0.88

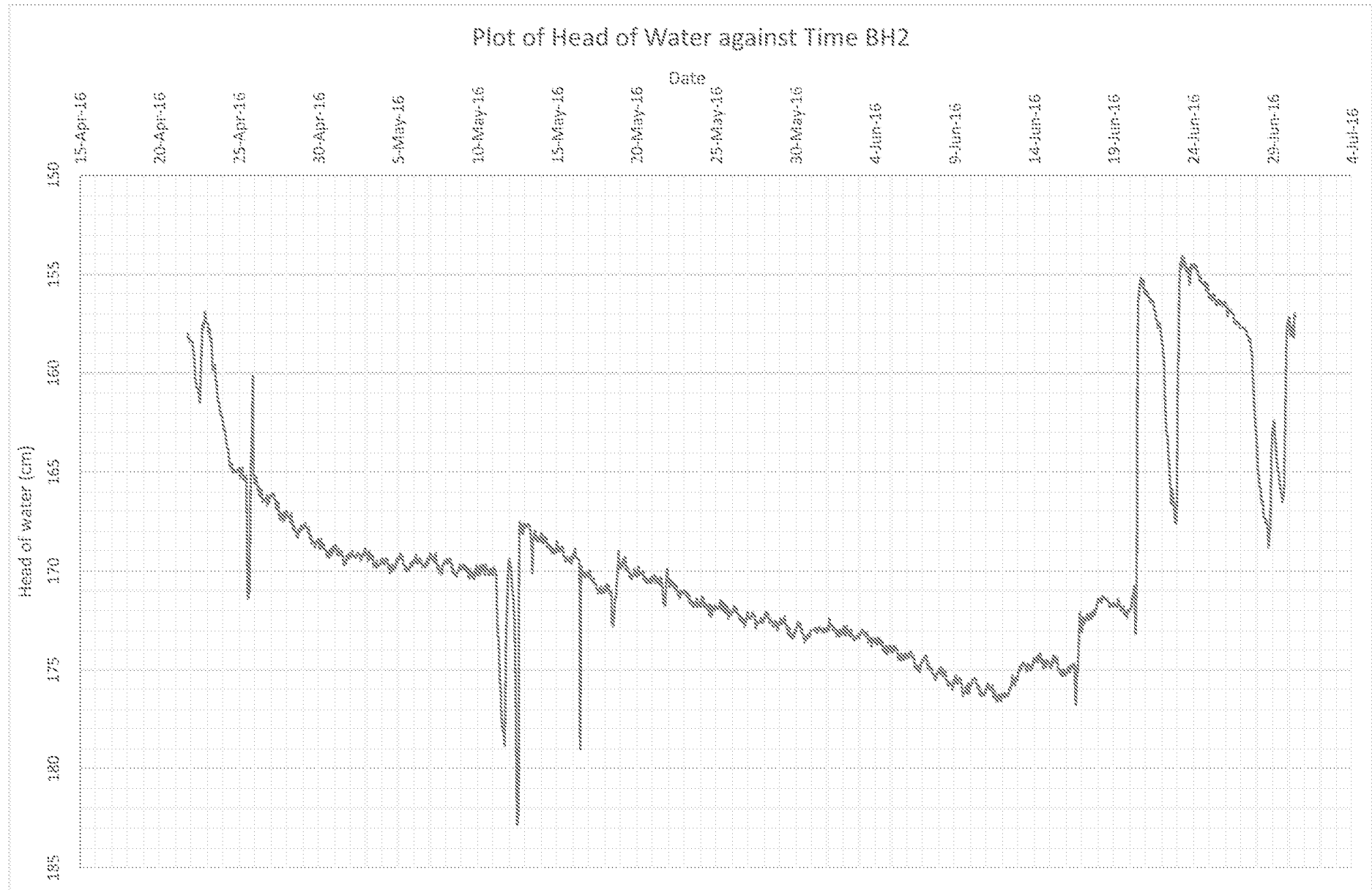
mbgl* = meters below existing ground level

			Bingham : Hall Associates Oakleigh Connaught Rd Attleborough Norfolk NR17 2BW	
Prepared By:	Chcked By:	Apprvd By:	Groundwater Monitoring Data	
GH	AB	AB		

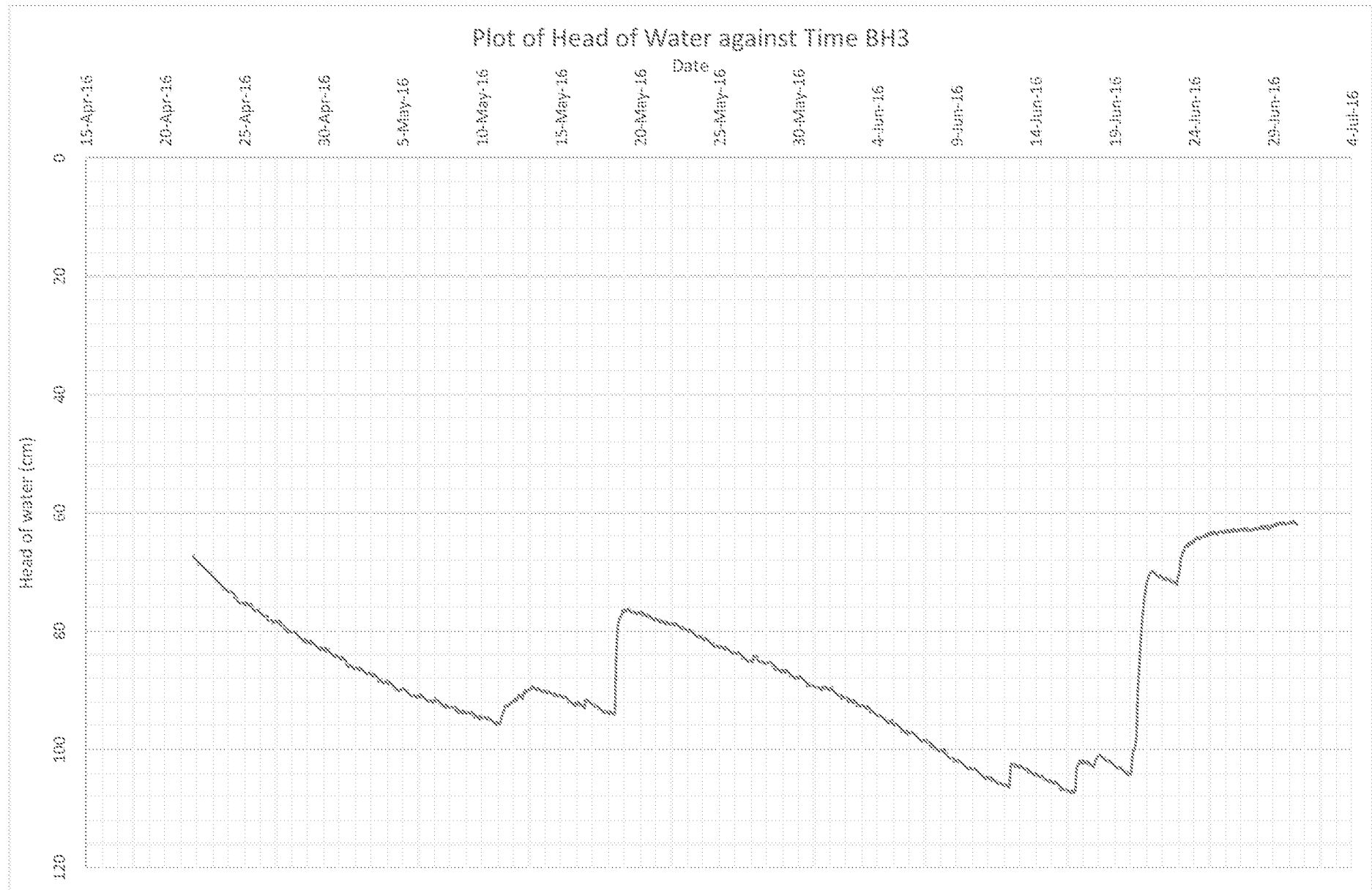
BHI Readings for Head of Groundwater



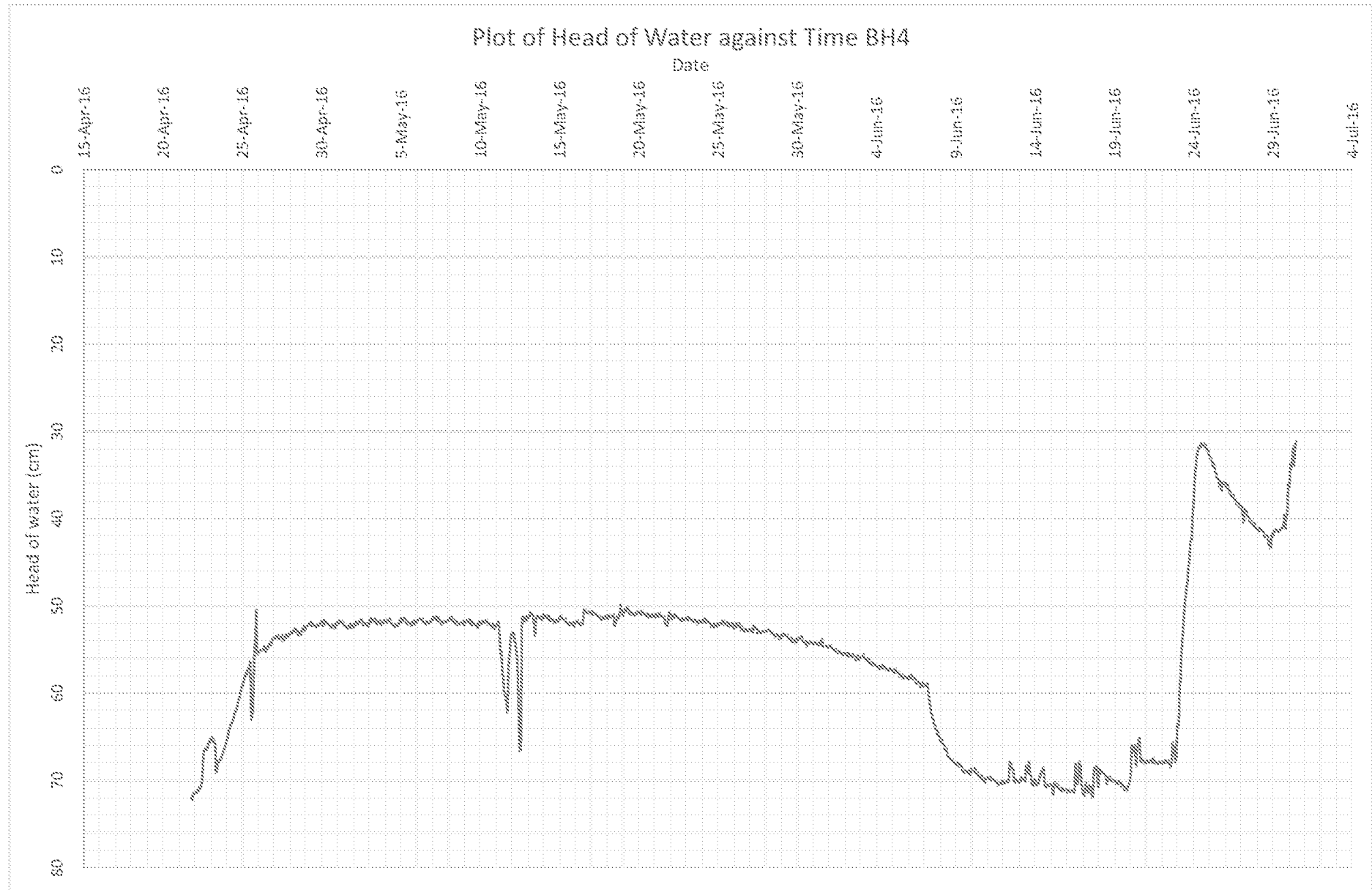
BH2 Readings for Head of Groundwater



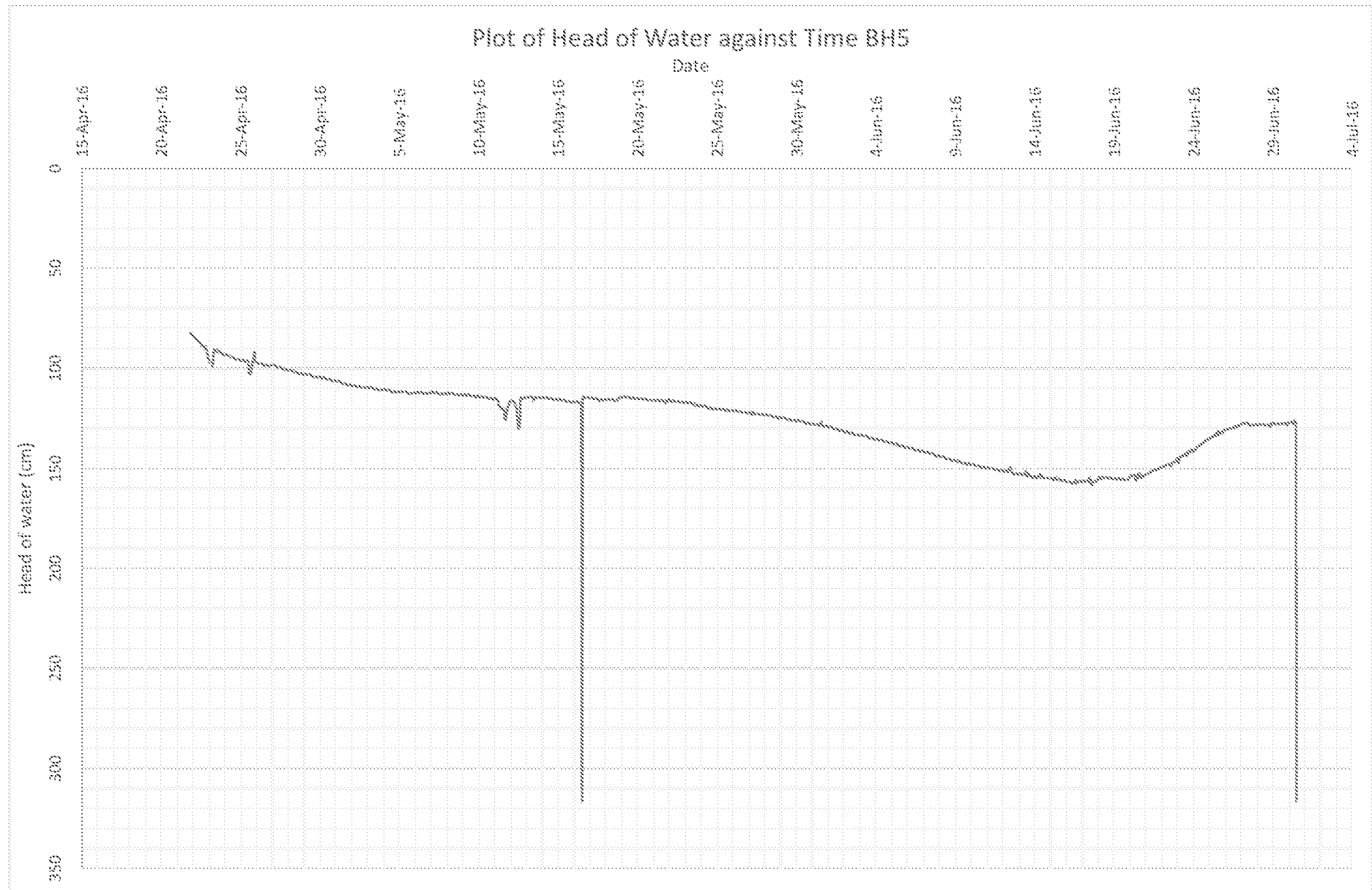
BH3 Readings for Head of Groundwater



BH4 Readings for Head of Groundwater

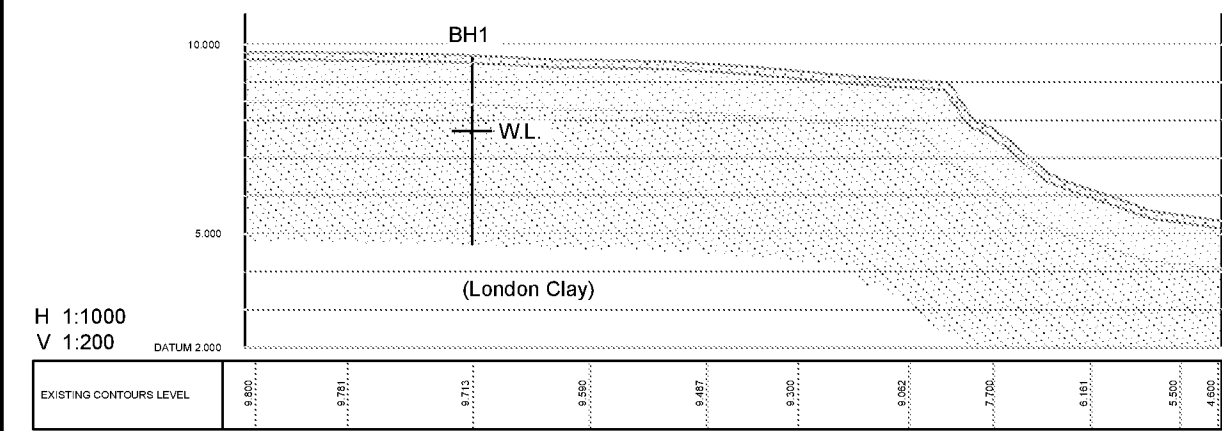


BH5 Readings for Head of Groundwater

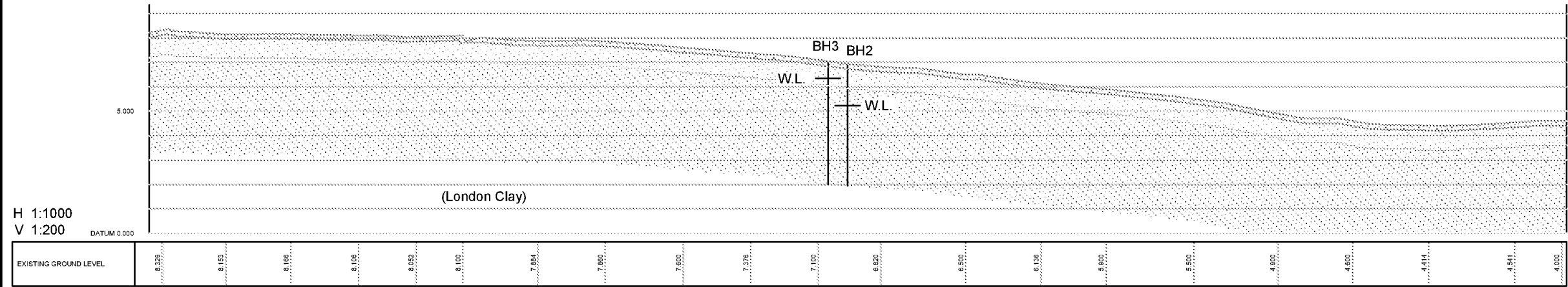


Appendix E: Geological Cross Sections

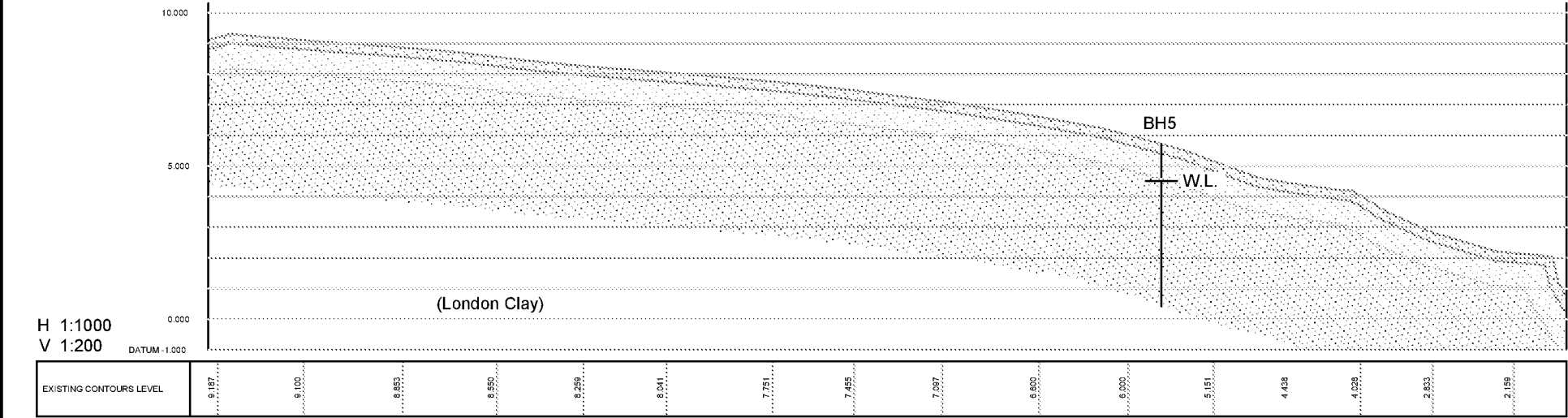
LAND EAST OF WESTERGATE



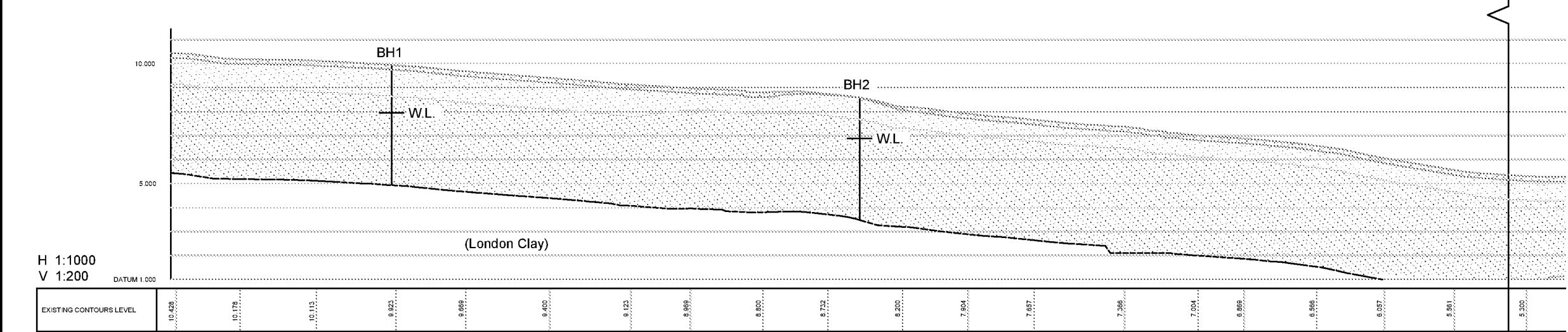
Section A-A



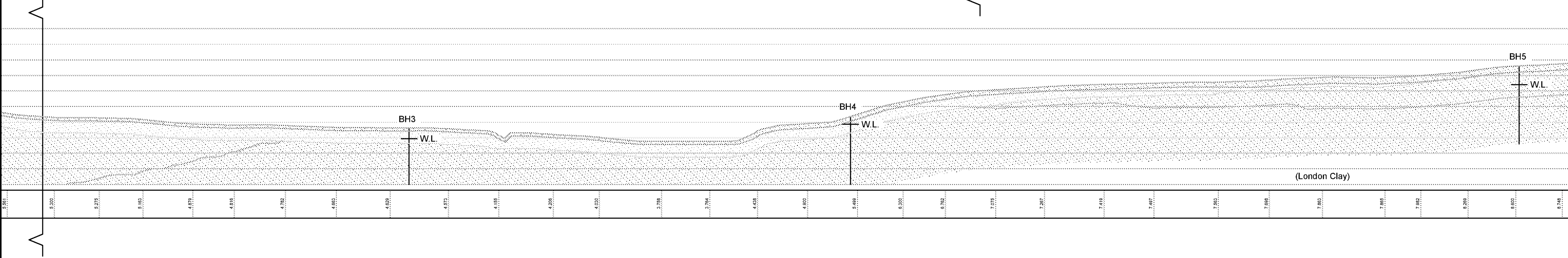
Section B-B



Section C-C



Section D-D



SECTIONS SHOWING GEOLOGY

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Key:

- Major Contour
- Minor Contour
- Borehole Location
- Topsoil
- Alluvium
- River Terrace Gravels
- London Clay Formation

- P - Planning
C - For Construction

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Project Title
Land East of Westergate

Drawing Title
Sections
Showing Geology

Drawn by RB	Checked by GH	Approved By KE
Size A2	Scale As Shown	Date Aug 2016

Drawing No. 3030.100	Rev P1
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Key

- Drift (undifferentiated)
- London Clay
- Lambeth - Reading Beds
- Chalk
- Ground Level
- Borehole Location
- Lateral Flow To Rife

P1	First Issue	16.08.16	JTT	AB
Rev	Description	Date	By	App

P - Planning
C - For Construction

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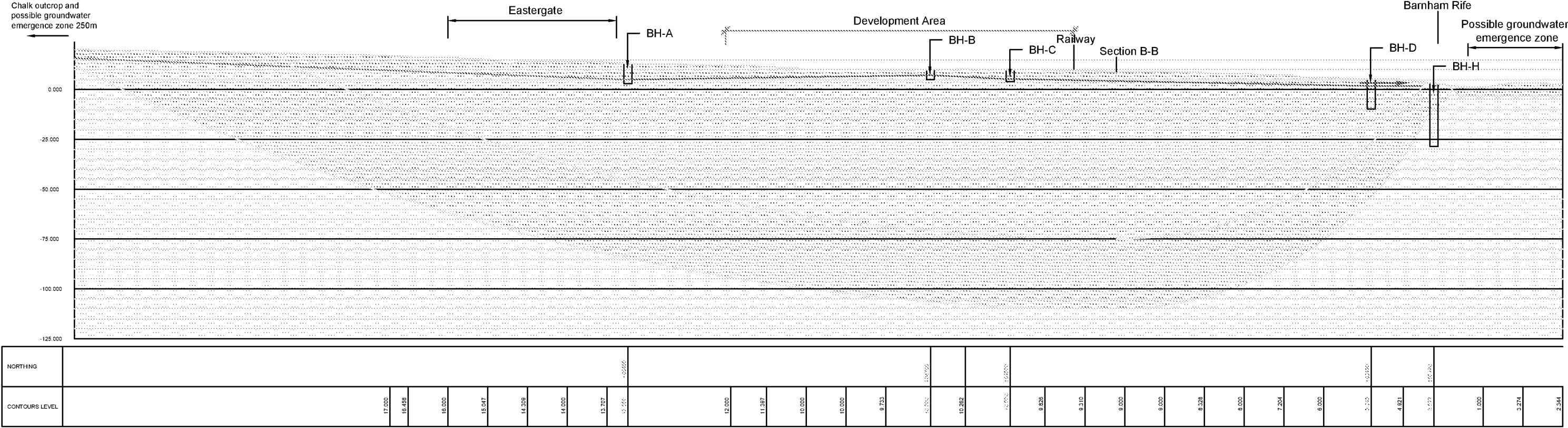


Project Title
Land East of Westergate

Drawing Title
Geological Sections Through Barnham -
Eastergate - Westergate

Drawn by JTT	Checked by GH	Approved By AB
Size A2	Scale As Shown	Date Aug 2016

Drawing No. 3030.101	Rev P1
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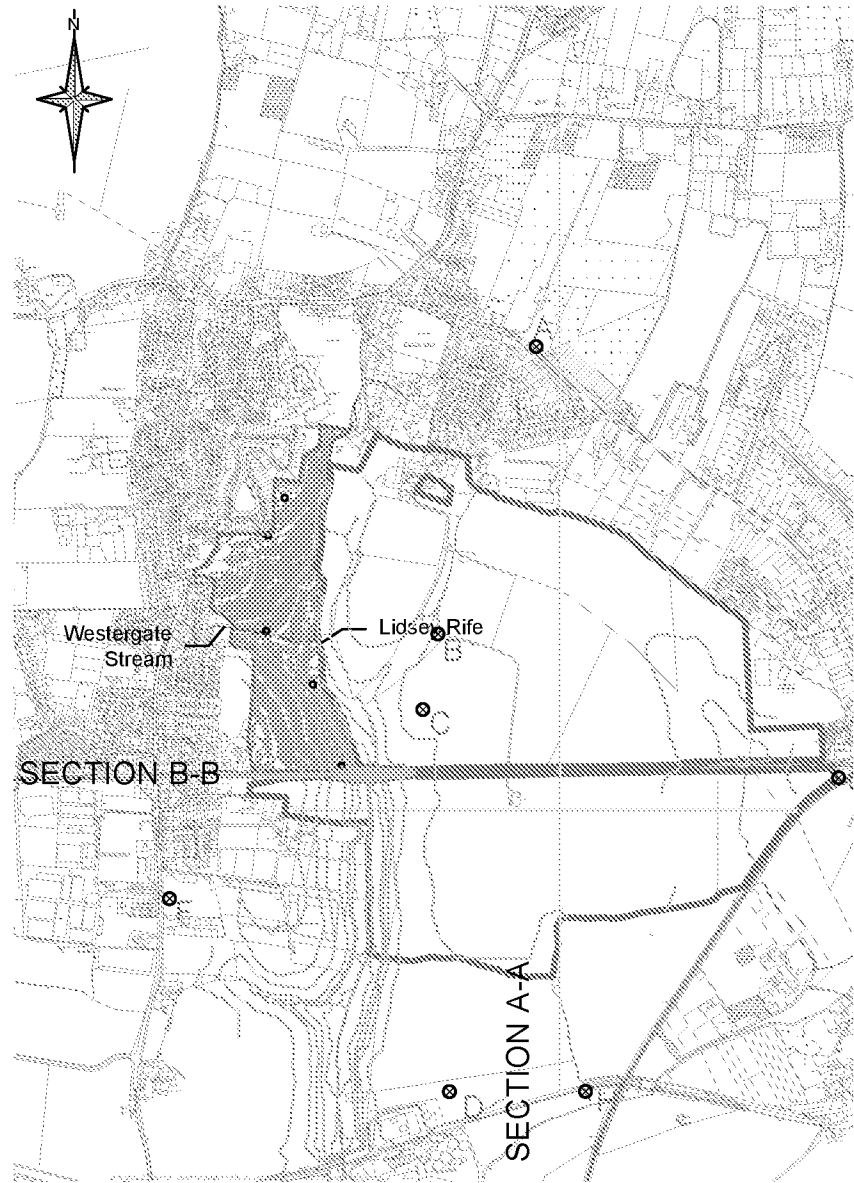


Section A-A

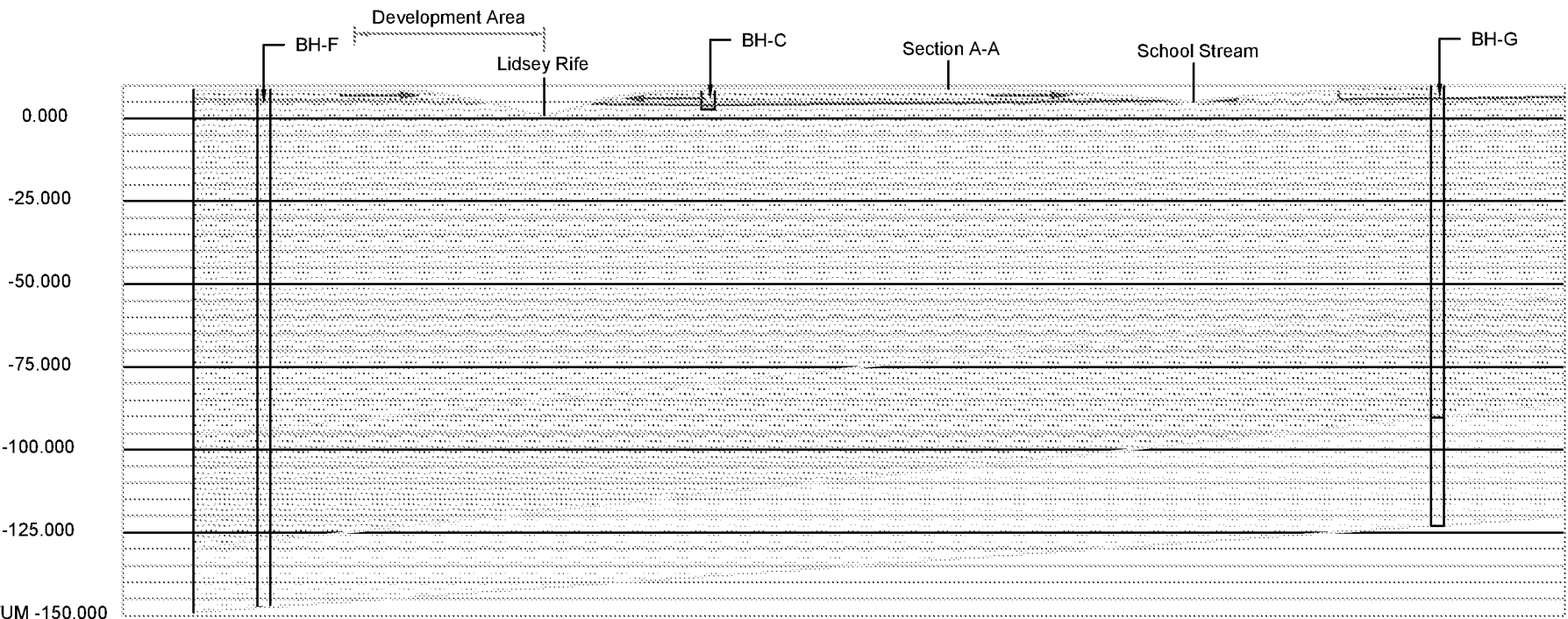
North-South Section					
Section Borehole Name	A	B	C	D	H
BGS Borehole name	SU90NW76 EASTERGATE	SU90SW51 EASTERGATE	SU90SW59 WOODHAM FARM, EASTERGATE 1	SU90SW52 LIDSEY	SU90SW22 SW RAILWAY STATION BARNHAM SUSSEX
Date	Sept. 1981	Sept. 1981		Sept. 1981	1899
Easting	494800	494540	484500	494570	494930
Northing	105460	104700	104500	103490	103490
Depth (m)	10.00	5.00	6	15.00	31.69
GL (mAOD)	13.5	9.3		8.00	16.00
Depth to base of:					
Drift (undifferentiated)	8.00	2.90	4.70	3.40	NONE
London Clay	10.00 End of BH	5.0 End of BH	6.0 - End of BH	15.0 - End of BH	NONE
Lambeth - Reading Beds					14.02
Chalk					31.69 End of BH
Groundwater	4.00	1.50	2.00	2.00	2.20

East-West Section			
Section Borehole Name	F	C	G
BGS Borehole name	SU90SW56 WOODGAT E NEAR CHICHESTER SUSSEX	SU90SW59 WOODHAM FARM, EASTERGATE 1	SU90SE12 RAILWAY STATION BARNHAM EASTERGATE
Date	01.08.1978		24.09.1898
Easting	493830	484500	495600
Northing	104000	104500	104320
Depth (m)	156.00	6.00	132.58
GL (mAOD)	30.00		
Depth to base of:			
Drift (undifferentiated)	3.00	4.70	
London Clay	102.00	6.00 - End of BH	
Lambeth - Reading Beds	136.00		
Chalk	156 - End of BH		132.82 End of BH
Groundwater	Drilled by rotary mud flush, therefore groundwater depth not apparent.	2.00	5.49

Section A-A
1:10



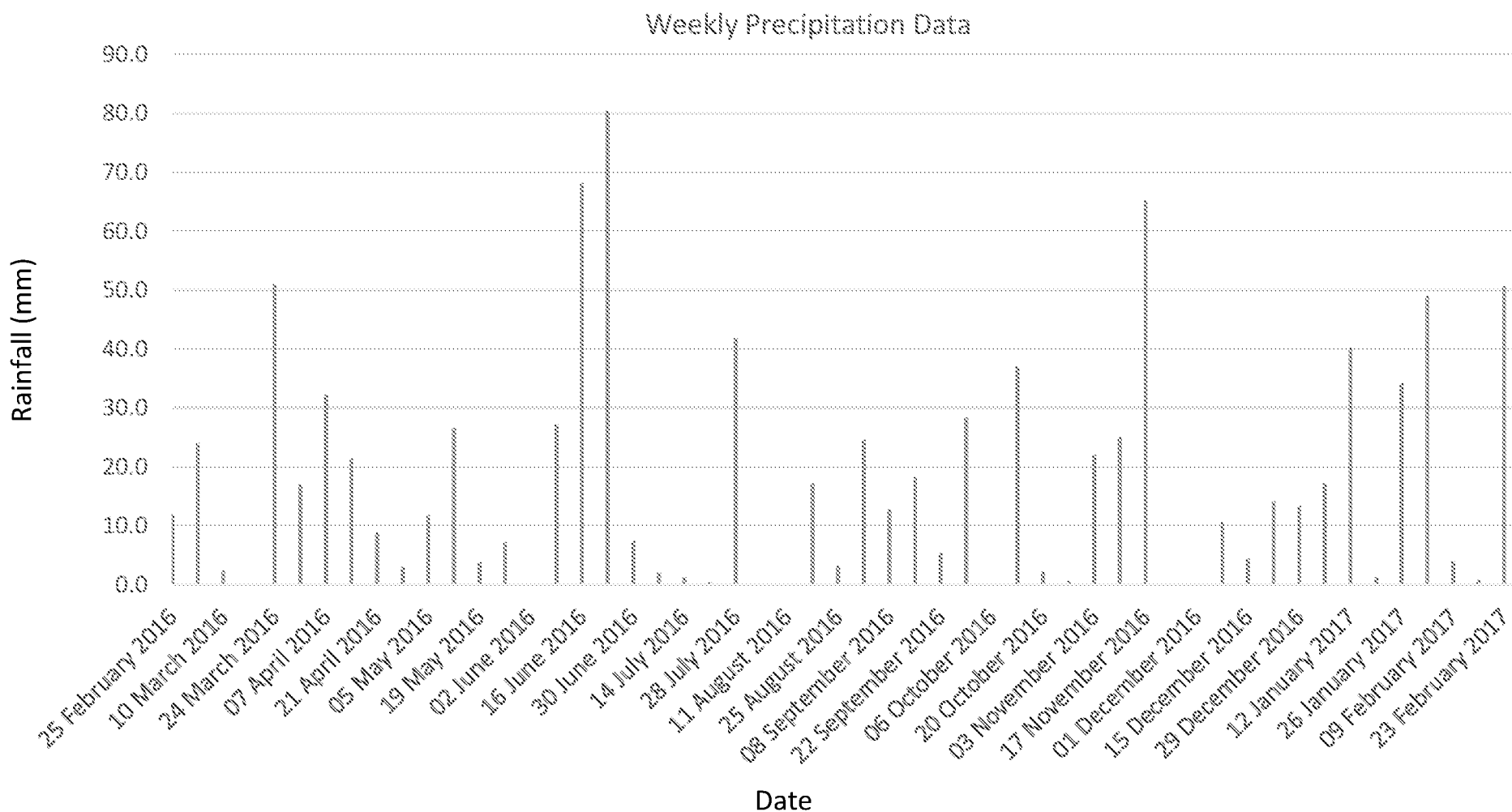
Plan
1:20



Section B-B

Section B-B
1:10

Appendix F: Precipitation Data



Source: http://rp5.co.uk/Weather_archive_on_Thorney_Island

Location: Thorney Island

			Bingham : Hall Associates Oakleigh Connaught Rd Attleborough Norfolk NR17 2BW
Drwan By:	Chcked By:	Apprvd By:	
RB	AB	AB	
			Rainfall Profile