WJ GROUNDWATER
Expert in Groundwater

Groundwater Assessment Report

Project Name: Buckingham Hotel

Buxton

Client: Mr A Barar

Project No.: P2175

t +44 (0)20 8950 7256 | info@wjgl.com | f +44 (0)20 8950 7959 | wjgl.com
Registered Office; Unit 5, Abbots Business Park, Primrose Hill, Kings Langley, Herts, WD4 8FR
Registered in England and Wales No: 6588827 VAT Number GB 916700564

WJ Document Control				
Document Reference & Revision	**Issued:**	**Prepared:**	**Checked:**	**Approved:**
464-2175 rev1	30/03/2016	U Markowicz	Dr T Roberts	Dr T Roberts

Amendment Record			
Date:	**Section No:**	**Change Description:**	**Changed By:**
23/03/2016	1.2	Structure details amended	UM

TABLE OF CONTENTS

1. OVERVIEW OF THE AVAILABLE INFORMATION

1.1. Introduction

The site is located at Buckingham Hotel, 1-2 Burlington Road, Buxton, Derbyshire SK17 9AS. The site is occupied by an existing Victorian structure with single basement which is to be demolished.

The proposed new development includes provision for a triple basement. The purpose of this study is to review the information available on the prevailing groundwater conditions and the need for additional information required to provide an assessment of the groundwater regime at the site and the impact this may have on the basement construction. This information is to be used by others to assess the impact the groundwater regime may have on the basement temporary works and structure.

1.2. Proposed Development

It is proposed to construct a new building with a triple basement of approximate plan size 39 m by 42 m to house a hotel and plant rooms. Existing ground level is at 297.5 to 299.7 mOD and the basement dig level is to approximately 292.3 to 290.5 mOD (up to about 9.2 m depth).

1.3. Geology and Ground Conditions

The following boreholes are located in the vicinity of the site, see Figure 1;

BH No	Ground Level mOD	Drilled Depth m	Bedrock	GWL mOD	Approx. distance from site
BH1	300	7.4	Bowland Shale	Not given	On site
BH2	300	7.0	Bowland Shale	Not given	On site
BH3	297.5	5.8	Bowland Shale	296.3	On site
R7	300	23.6	Bowland Shale	Not given	On site
SK07SE/1	Approx. 327	49.5	Millstone Grit (?)	321.5	400 m
SK07SE/3	Approx. 307	118	Monsal Dale Fm. over Bee Low Fm. (?)	Not given	435 m
SK07SW/10	Approx. 311	29.5	Kinderscout Grit over Millstone Grit	Not given	760 m
SK07SE/125	Approx. 298	7.5	Bowland Shale	292.7 (strike)	850 m
SK07SE/128	Approx. 297	8.0	Bowland Shale	292.1 (strike)	870 m

BH No	Ground Level mOD	Drilled Depth m	Bedrock	GWL mOD	Approx. distance from site
SK07SE/59	Approx. 309.5	20.3	Bee Low Limestone Fm. (?)	Not given	875 m
SK07SE/129	Approx. 297	9.1	Bowland Shale	291.5 (strike)	920 m

The site specific site investigation boreholes, BH1 to BH4 and R7, see Figure 2, indicate the following soil profile on site;

Stratum	Level mOD	Depth m
Made Ground	297.5 to 299.7	0
Alluvium comprising loose clayey Sand, soft sandy organic Clay and Peat	295 to 299	1 to 2.7
Weathered Mudstone/Shale	294 to 297	3.1 to 3.4
Shale/Mudstone	292 to 293 Proved to about 276 at borehole R7	3.6 to 7.2 Proved to 23.6

A cross section through the site and the proposed structure is shown on Figure 4.

Monitoring data [[9]] from a standpipe installed to 5.65 m depth indicated a standing ground water level in the range 295.0 to 296.3 mOD (1.3 to 2.5 m depth) in the superficial soils and weathered strata.

The remaining boreholes have been obtained from the British Geological Survey online data base [14] and [15]. These show that the site is underlain by the Bowland Shale Formation comprising dark mudstones with subordinate sequences of interbedded limestone and sandstone. The rocks of the Millstone Grit Group outcrop on the hillside to the north and west of the site. These series comprise sandstones interbedded with siltstones and mudstones. The geological maps of the area show that the limestone of the Peak Limestone Group are present to the South and Southeast of the site. These rocks comprise medium grey limestone of the dark facies of the Monsal Dale Limestone Formation and pale grey limestone of the Bee Low Limestone Formation. These units are older than the Bowland Shale and are expected to be present below the site at depth. The Monsal Dale Formation outcrops approximately 275 m to the southeast and 300 m to the south of the site (see Figure 1). The ground levels at the Buckingham Hotel site and at the outcrop are similar at approximately 300 mOD. The dip arrows within the Limestone [15] indicate dips of between 15° to 20° to the northwest. This implies that the top of the limestone at the Buckingham Hotel location should be

between approximately 74 m and 100 m below ground level. However the geological boundaries are not well defined and there is certainly some uncertainty with this assessment.

A schematic cross section through the area is shown on Figure 3.

The aquifer maps available online at the Environment Agency website [11] indicate that the Bowland Shale Formation is classified as a Secondary A Aquifer (minor aquifer) and the underlying Peak Limestone Group is classified as principal aquifer.

1.4. Groundwater Source Protection

Buxton has several large groundwater abstractions for drinking water which exploit the Principal Limestone Aquifer as described above. Much of the southern portion of Buxton is designated a Groundwater Source Protection Zone 1 which extends to within 25 m of the site [5] and [10]. Source Protection Zones (SPZ) form a key part of the Environment Agency's policy to control the risk to groundwater supplies from potentially polluting activities and accidental releases of pollutants. The Inner Protection Zone (SPZ1) is defined as "a 50-day travel time from any point below the water table to the source or a minimum 50 meter radius from the source, whichever is larger" [12]. The main purpose of the zone is to reduce the risk of the contamination as well as the protection of the yield. Protective measures include setting limits on maximum daily abstraction and controlling potentially harmful activities within 50 meters. The definition of the source protection within the karst aquifers, including Carboniferous limestone like the Peak Limestone Aquifer, is particularly problematic as the travel times through the aquifer may be very rapid. Therefore in order to protect the source, the SPZ incorporates the surface water catchment feeding the karst system. The Groundwater Protection Source maps available online [10] indicate that the SPZ1 in the vicinity of the site is aligned with the outcrop of the Peak Limestone Group aquifer to the southeast of the site. As stated above, the site under consideration is underlain by the Bowland Shale Formation which is of younger age than the limestone aquifer. It is expected that the top of the limestone underneath the site is between 74 and 100 m therefore neither the site investigation nor the construction activities on site should impact the aquifer.

1.5. Buxton Spring

Buxton is also the site of an historic thermal spring. Thermal springs occur where thermally heated groundwater emerges at the surface [13]. The average shallow groundwater temperature in the UK is between 10°c and 12°C, while the thermal spring is circulating at deeper depths and becomes heated by the heat stored in the Earth. The rate of temperature increase with depth is known as the geothermal gradient and as the temperature of Earth increases with depth, so does the temperature of water that comes in contact with it. Heated water can hold more dissolved minerals than colder water therefore hot springs often have a high mineral content. Because of this property thermal water is often used for therapeutic purposes.

The thermal spring emerges in the centre of Buxton at an elevation of approximately 291 mOD, under the Buxton Crescent building, approximately 500 m to the east of the site. The spring flows at approximately a million litres per day (just over 10 l/s) at a temperature of 27°C [13]. The precise origin of the spring water

is not known but it is thought that the principal flow path is at the contact between the Bowland Shale and Monsal Limestone with the groundwater circulating from a depth of at least 850 mbgl. Water from the spring is currently bottled by Nestle as Buxton Natural Mineral Water.

1.6. Groundwater regime on site

Monitoring data from a standpipe installed in BH3 [9] indicates a standing groundwater level at up to 296.3 mOD, see Figure 4. This is between 4.0 and 6.0 m above the formation level of the basement. There is no information on the permeability of the superficial deposits and the mudstone but our initial expectation, based on the descriptions alone is that the permeability is likely to be medium to low. This is consistent with the view that the Bowland Shale formation is a confining layer to the underlying limestone.

The groundwater level in the Monsal Dale Limestone below the site is not known. The ground level at the Buckingham Hotel is approximately 297 to 300 mOD, while the Buxton Spring emerges at a lower elevation of approximately 291 mOD suggesting that the groundwater level is probably not artesian relative to the site elevation. However, given the sensitive nature of the Limestone aquifer, possible inaccuracies of elevations used in this assessment and the unknown zone through which the thermal water flows, care must be taken while undertaking borehole investigations on site in order to avoid drilling to the top of the limestone or any risk of below ground contamination. The required arrangements are considered further below.

2. IMPLICATIONS FOR THE PROPOSED SCHEME

The proposed works require drawdown in the superficial soils and mudstone to facilitate construction of the basement. The inflows into the excavation will depend on the method of side support and in particular the extent to which this provides a barrier to groundwater flow and the permeability of these deposits, which as stated is expected to be to be medium to low. Providing provision is made to fully cut-off the superficial soils and weathered rock then inflows into the excavation should be modest with the dewatering requirements unlikely to extend beyond conventional sump and pump techniques which the main contractor would undertake.

When the water table is lowered the soil below the initial standing groundwater level experiences an increase in loading and will consolidate leading to surface settlements. The ultimate settlement is the settlement that may develop after a long period of time, which may be several years in the case of cohesive soils. In contrast the settlement of granular soils will occur virtually instantaneously with drawdown. Ground conditions above the standing groundwater level will not be affected by dewatering. Ground conditions below the standing groundwater level on site are indicated to be soft Alluvium comprising sand, clays and peat over weathered Mudstone and Mudstone.

In the absence of a perimeter cut-off, lowering of the groundwater could cause external drawdown, underdrainage of the superficial soils which in turn could lead to surface settlements which may impact adjacent structures with shallow foundations. Use of side support arrangements which provide a cut-off to

groundwater flow, such as secant piles, should greatly reduce groundwater inflows and the potential settlement risk posed by external drawdowns.

With respect to the permanent works, the groundwater monitoring on site [9] indicates a high standing groundwater level. At this stage we would recommend that the permanent works are designed to accept full hydrostatic uplift pressures up to ground level. Further monitoring should be undertaken but in practice, without very long term monitoring, it would be difficult to justify application of a lower groundwater level for the permanent works design. The depth of the basement means that there is the potential for significant uplift pressures which will need to be taken in to account in the design of the structure. If the dead weight of the completed structure is not sufficient to resist the potential uplift pressures then consideration would need to be given to the use of ground anchors or tension piles.

3. FURTHER INVESTIGATIONS

Further to the information obtained to date and in order to confirm the ground and groundwater regime on site we recommend that further site investigation is carried out as follows;

- Minimum 1 No borehole to be drilled to a depth of 25 m to the northeast of the proposed basement. This side of the building is further away from the Limestone outcrop therefore considered to be at lower risk of encountering the Limestone. Note that additional boreholes may be required if there is a requirement for the installation of tension piles or ground anchors.
- 3 No grouted vibrating wire transducers to be installed in the borehole at depths 3 m (Superficial Deposits), 10 m and 25 m (Mudstone). The data from the transducers would be used to confirm the groundwater regime on site.
- Temperature of the groundwater should be monitored regularly during drilling at least every 5m depth below the first 10 m. Should the temperature of the groundwater rise above the average (10°C to 12.5°C), drilling is to be suspended and the data reviewed before proceeding.
- Facilities should be available on site to immediately seal the borehole if the artesian or thermal water is encountered during drilling.
- Provision should be made for pollution control measures. A code for safe drilling practice is published by the British Drilling Association [16].

Urszula Markowicz

For and on behalf of

WJ GROUNDWATER LIMITED

Dr Toby Roberts

For and on behalf of

WJ GROUNDWATER LIMITED

REFERENCES

[1] Results of ground investigation. Strata Surveys report, January 2013, ref 2012/97-001-FAC-Rev0.

[2] Contamination appraisal. Strata Surveys report, 8 April 2013, ref 2012/97-002-CON-Rev0.

[3] Geotechnical desk study and flood risk screening report. Arup report, 2 August 2013 ref REP/GEO001 Issue 1.

[4] Buckingham Hotel, Buxton – Proposed ground investigation scope of works. Arup note, 14 August 2013 ref 231883-00.

[5] Request for information under the Freedom of Information Act. Environment Agency letter, undated, ER/E/EI/3860.

[6] Borehole log of R7. Strata Surveys log, 16 September 2013.

[7] An assessment of the risks of contaminating the principal limestone aquifer at Buckingham Hotel, Buxton as a result of rotary coring in bedrock. Strata Surveys letter report, 14 October 2013, ref JFRI/JM.

[8] Greig-Ling drawings; 676/20/A; 676/09/A; 676/21/A. Dated 3 December 2013.

[9] Groundwater level monitoring data for standpipe installed at Strata Surveys BH3, 23 July 2013 to 8 January 2016.

[10] Environment Agency. 2016. *Groundwater Source Protection Zones.* [ONLINE] Available at http://maps.environment-agency.gov.uk/wiyby/wiybyController?x=531500.0&y=181500.0&topic=groundwater&ep=map&scale=5&location=London,%20City%20of%20London&lang=_e&layerGroups=default&distance=&textonly=off#x=407133&y=374507&lg=1,10,&scale=6 [Accessed 08 March 2016].

[11] Environment Agency. 2016. *Aquifers.* [ONLINE] Available at http://maps.environment-agency.gov.uk/wiyby/wiybyController?topic=groundwater&layerGroups=default&lang=_e&ep=map&scale=5&x=531500&y=181500#x=410757&y=375698&lg=3,&scale=6 [Accessed 08 March 2016].

[12] Environment Agency. 2016. *Groundwater Source Protection Zones – Review of methods. Science report SC070004/SR1.* [ONLINE] Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/290724/scho0309bpsf-e-e.pdf [Accessed 08 March 2016].

[13] UK Groundwater Forum. 2016. *UK Thermal and Mineral Springs.* [ONLINE] Available at http://www.groundwateruk.org/UK_thermal_springs.aspx [Accessed 08 March 2016].

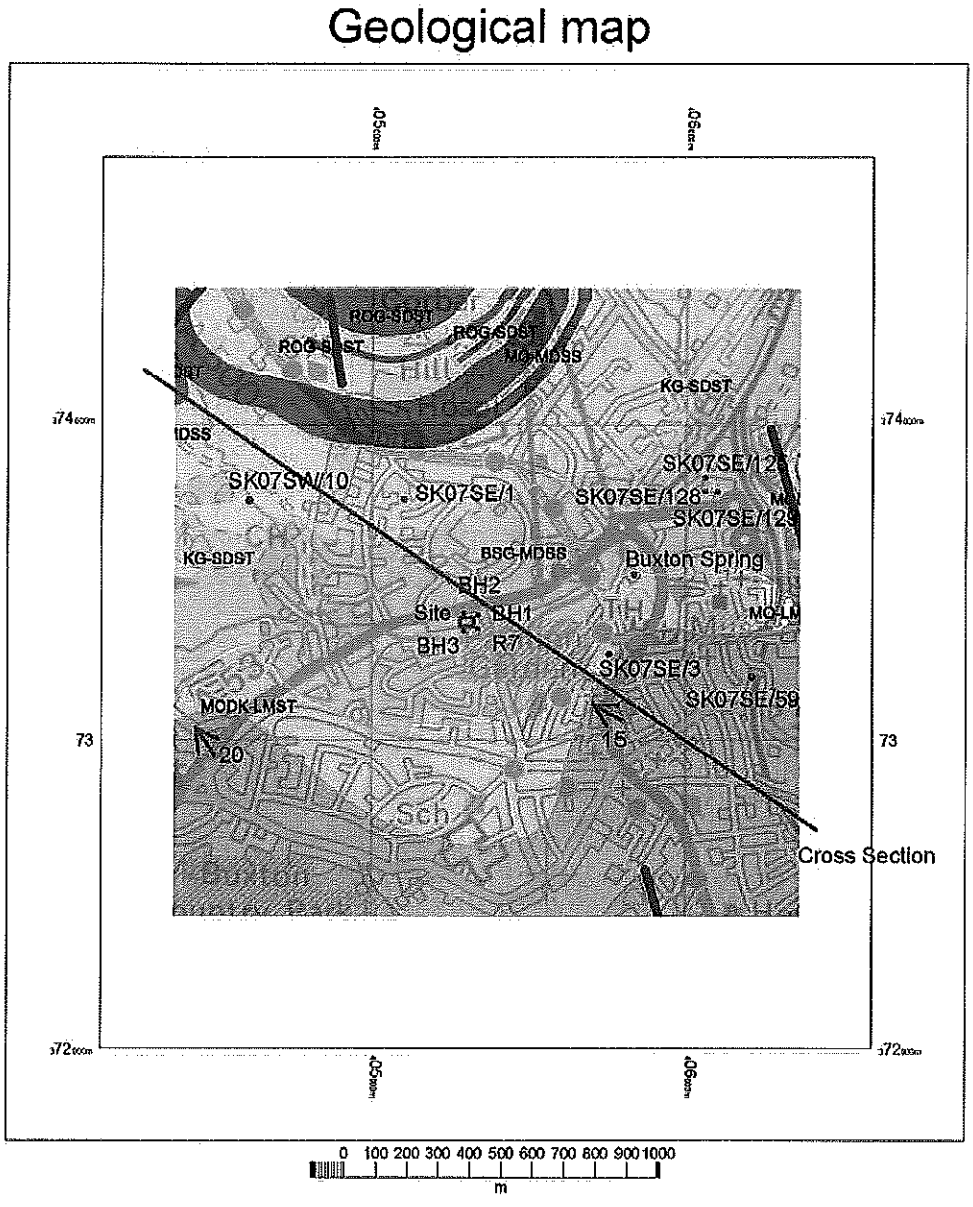
[14] British Geological Survey. 2016. *Geology of Britain viewer.* [ONLINE] Available at http://mapapps.bgs.ac.uk/geologyofbritain/home.html [Accessed 08 March 2016].

[15] British Geological Survey. 2016. *Map record details.* [ONLINER] Available at http://www.largeimages.bgs.ac.uk/iip/mapsportal.html?id=1001603 [Accessed 08 March 2016].

[16] British Drilling Association Health and Safety Manual for Land Drilling 2015: A code of safe drilling practice.

FIGURES

Figure 1: BGS 50k Geology



BGS 50k Geology - OS 50k Mapping
23 February 2016, ID: CM-00504898

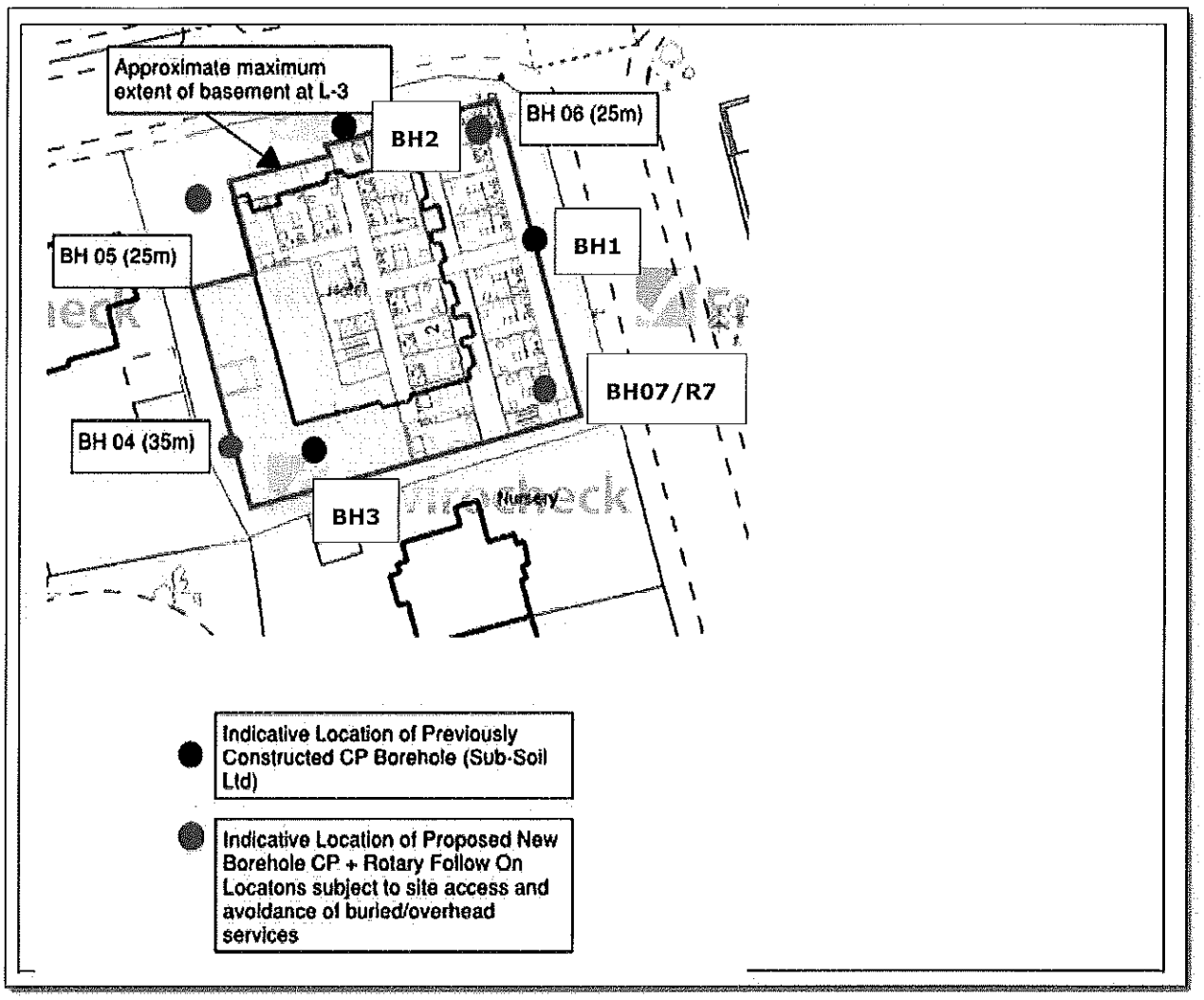
www.centremapslive.co.uk

1:25000 scale print at A5, Centre: 405366 E, 373434 N

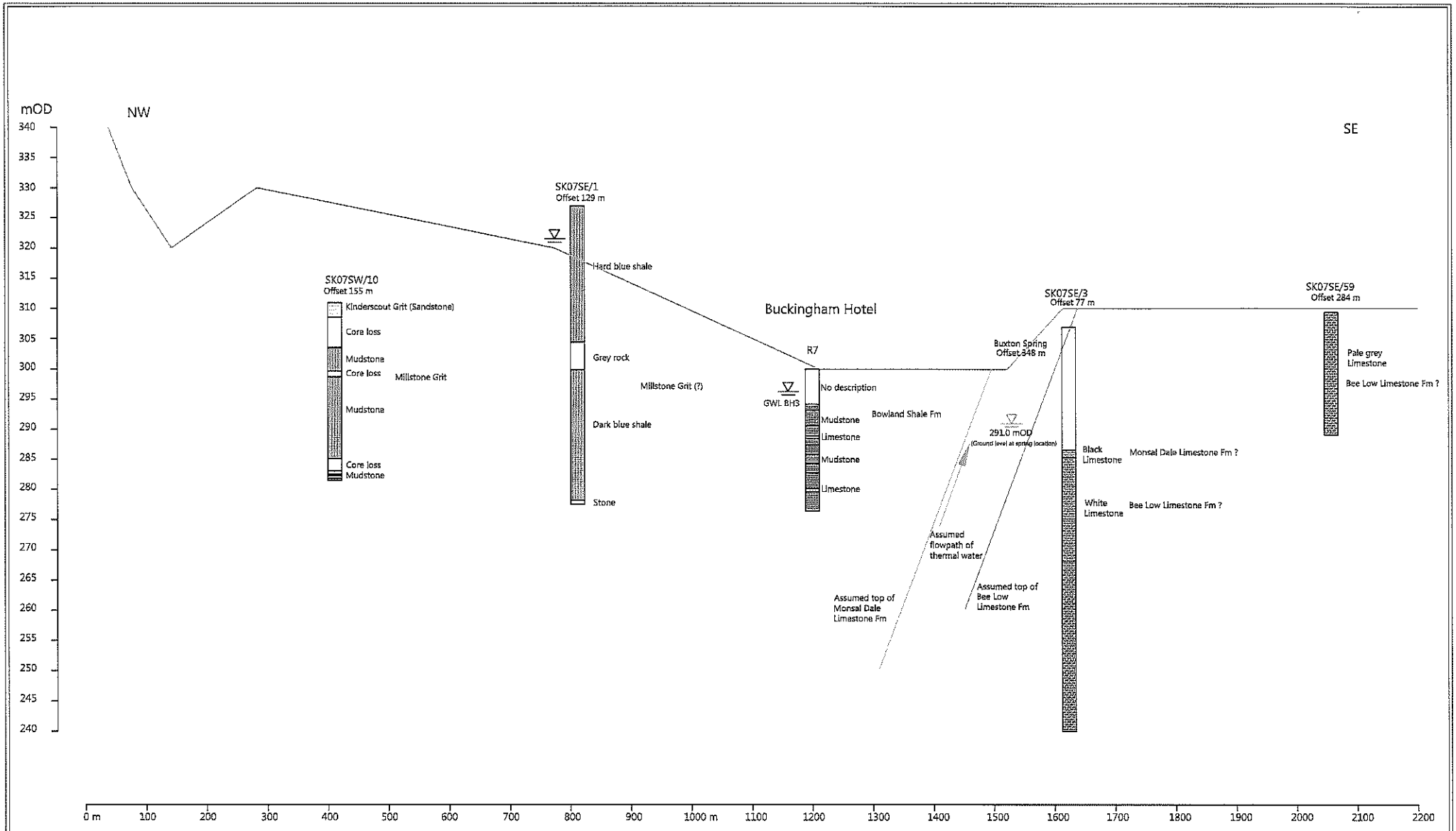
CENTRE MAPS LIVE.
FOR A BETTER POINT OF VIEW

KEY TO BEDROCK GEOLOGY				
Map Colour	**LEX Code**	**Rock Name**	**Rock Type**	**Max Age (Period)**
	COG-SDST	Corbar Grit http://www.bgs.ac.uk/Lexicon/lex_list.cfm?pub=COG	Sandstone	Carboniferous
	ROG-SDST	Roaches Grit http://www.bgs.ac.uk/Lexicon/lex_list.cfm?pub=ROG	Sandstone	Carboniferous
	KG-SDST	Kinderscout Grit http://www.bgs.ac.uk/Lexicon/lex_list.cfm?pub=KG	Sandstone	Carboniferous
	MG-MDSS	Millstone Grit Group [See Also Migr] http://www.bgs.ac.uk/Lexicon/lex_list.cfm?pub=MG	Mudstone, Siltstone And Sandstone	Carboniferous
	EYL-LMST	Eyam Limestone Formation http://www.bgs.ac.uk/Lexicon/lex_list.cfm?pub=EYL	Limestone	Carboniferous
	MO-LMST	Monsal Dale Limestone Formation http://www.bgs.ac.uk/Lexicon/lex_list.cfm?pub=MO	Limestone	Carboniferous
	MODK-LMST	Monsal Dale Limestone Formation (Dark Lithofacies) http://www.bgs.ac.uk/Lexicon/lex_list.cfm?pub=MODK	Limestone	Carboniferous
	LMB-LAVA	Lower Miller's Dale Lava Member http://www.bgs.ac.uk/Lexicon/lex_list.cfm?pub=LMB	Lava	Carboniferous
	BLL-LMST	Bee Low Limestone Formation http://www.bgs.ac.uk/Lexicon/lex_list.cfm?pub=BLL	Limestone	Carboniferous
	BSG-MDSS	Bowland Shale Formation http://www.bgs.ac.uk/Lexicon/lex_list.cfm?pub=BSG	Mudstone, Siltstone And Sandstone	Carboniferous

Figure 2: Additional Site Investigation Provisional Plan (Arup 2013)

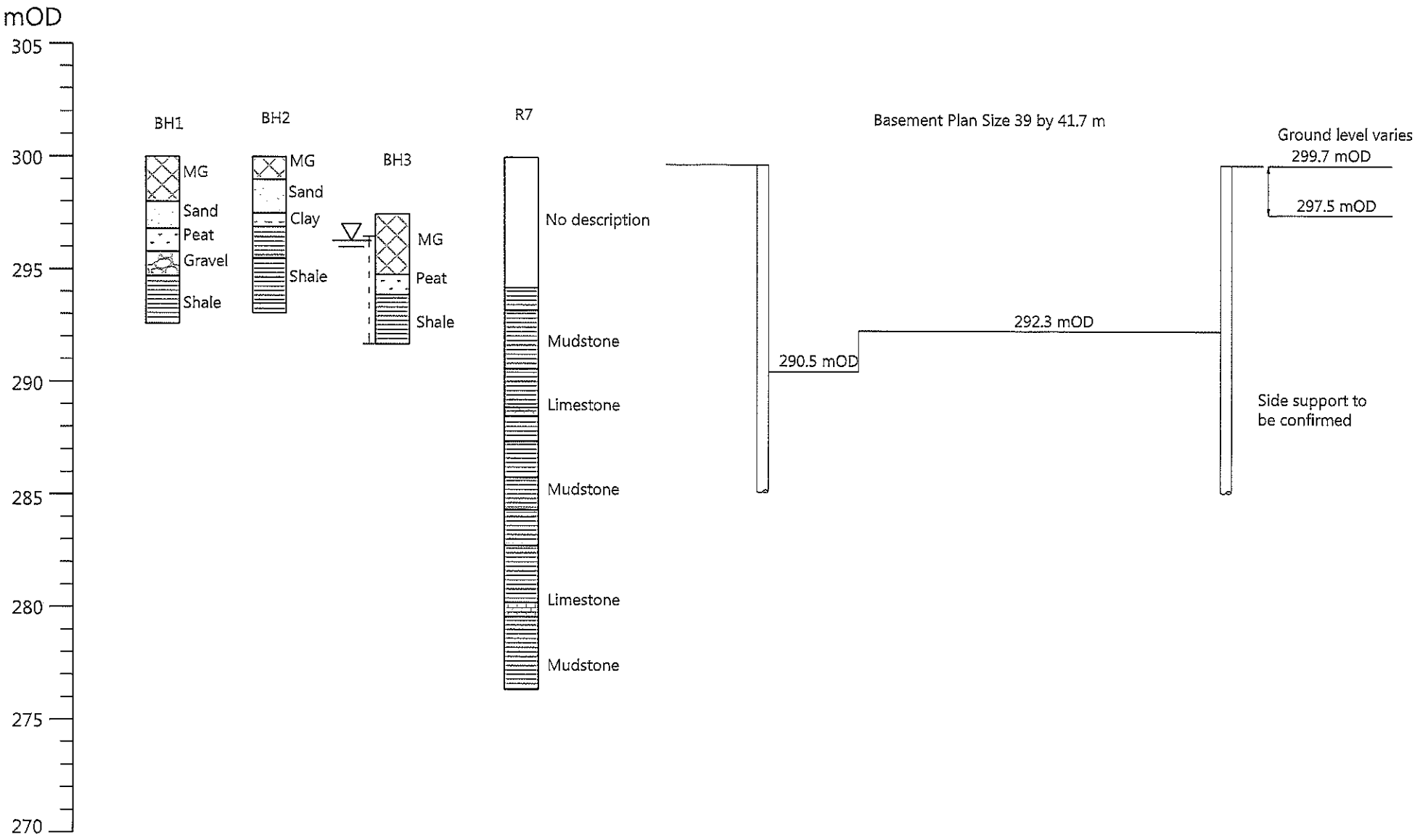


Note: The proposed new boreholes (BH04 to BH06) have not been drilled. The additional site investigation works was suspended following drilling of R7 (installed at the location of BH07).



WJ GROUNDWATER
Expert in Groundwater

Rev No	Drawn by	Check by	Date	Reason for revision	Project Name: Buckingham Hotel, Buxton
00	UM	TR	08/03/16	Issue for review	
					Drawing Title: Geological Long Section
					Drawing No: Figure 3 — Scale: As shown



WJ GROUNDWATER
Expert in Groundwater

Rev No:	Drawn by	Check by	Date	Reason for revision
01	UM	TR	29/03/16	Issue for review

Project Name:
Buckingham Hotel, Buxton

Drawing Title:
Site Cross Section

Drawing No: Figure 4

Scale: NTS