Colwall C.E Primary School

Groundwater Flooding - Desk Study & Site Investigation Report

Colwall Green, Malvern, Herefordshire, WR13 6DU

On Behalf of

Herefordshire County Council (HCC)

Quality Management

Prepared by:	Adam James – BSc FGS MIAH	
Reviewed by:	Michael Willis – BSc MSc FGS	
Authorised by:	Chris Betts – BSc MSc FGS CGeol	
Date:	December 2014	
Revision:	FINAL	
Project Number:	HYG124	
Document Reference:	HYG124 R 141014 AJ Colwall School Groundwater Flooding Investigation Report	
Document File Path:	P:\HYG124 Colwall School\Reports\Draft\HYG124 R 141014 AJ Colwall School Groundwater Flooding Investigation Report.docx	

COPYRIGHT © Hydrogeo

This report has been produced by Hydrogeo within the terms of the contract with the client and taking account of the resources devoted to it by agreement with the client.

We disclaim any responsibility to the client and others in respect of any matters outside the scope of the above.

This report is confidential to the client and we accept no responsibility of whatsoever nature to third parties to whom this report, or any part thereof, is made known. Any such party relies on the report at their own risk.

bsi. ISO 9001 Quality Management

Hydrogeo Ltd
36 Lion Street
Abergavenny
Monmouthshire
NP7 5NT
T: 01873 856813
E: info@hydrogeo.co.uk
W: hydrogeo.co.uk

Contents

Tables

Tables

Figures

Drawings

Appendices

1 Introduction

1.1 Background

Hydrogeo Limited (Hydrogeo) was commissioned by Herefordshire County Council (the client) to undertake Hydrogeological Desk Based Review, Site Walkover and Site Investigation with subsequent monitoring of the Colwall C.E Primary School, Colwall, Malvern, Herefordshire, (the site). The site is located off Walwyn Road in Colwall Green, west of Malvern, at National Grid Reference (NGR) 375055,241546 at an elevation of approximately 128 metres Above Ordnance Datum (mAOD).

An ongoing damp and excessive moisture issue has been encountered within the lower south-east section of the school building which comprises the staff room, children's toilets, circulation area and upper level class rooms. The damp issues in this section of the school were reported to Herefordshire County Council (HCC) in October 2013. The school building was vacated on the grounds of health and safety over the summer 2014. A temporary school has been formed upon the playing grounds, to the east of the old school building.

The damp and moisture continue to cause damage to the school building and has also been associated with high levels of staff and student sickness, which is part of an ongoing separate investigation.

The works commissioned by HCC include the following:

- A desk study review of the environmental setting to assess the local and surrounding, geology and hydrogeology;
- A site walkover survey of the school grounds and the wider surrounding area;
- An intrusive site investigation to characterise the shallow geology and groundwater conditions beneath the site;
- A Conceptual Site Model (CSM) based on the findings of the Desk Based Study and Site Investigation;
- Conclusions and recommendations based on findings of the site investigation works and the conceptual site model.

1.2 Principal Report Objectives

The objectives of this report are as follows:

- Determine current (baseline) environmental conditions at the site and the wider area, including the geological and hydrogeological status;
- Identify the cause(s) of the current groundwater flooding and damp issues within the school building.
- Review the hydrogeology / geology conditions beneath the site and in the wider area;
- Provide an explanation as to why the groundwater flooding issue has recently developed at the site;
- Identify potential further impacts on the current / future development presented by the current site conditions;
- Provide a range of recommendations to enable the issues to be remediated which will include the likelihood of success, lifespan and cost of the solution.

1.3 Report Structure

The remainder of this report is structured as follows:

- **Section 2**; Environmental Section: Describes the environmental setting and the sites context in the wider area based on available desk study data;
- **Section 3**; Site Walkover: Presents a summary of the site walkover. Key observations and anecdotal evidence are recorded along with photographs taken during the visit;
- **Section 4**; Site investigation: Details the site investigation works progressed at the site in October 2014;
- **Section 6**; Analysis of Results: Discussion of the findings from the desk based study, site walkover and site investigation;
- **Section 7**; Conceptual Site Model (CSM): This section sets out the site conceptual model of based on the desk based study and findings of the site investigation;
- **Section 8**; Summary & Recommendations: Sets out the conclusions of the report and presents recommendations.

1.4 Previous Site Reports

The following site reports that have previously been carried out at the Colwall C of E Primary School for Herefordshire Council are as follows:

- Soakaway Investigation at Colwall School, Colwall Green, Malvern, Worcestershire, September 2009. Ground Investigation and Piling Limited. AJM/17860;
- Investigation into Damp Complaints Colwall C. of E. Primary School, Colwall, WR13 6DU, April 2014. Environmental Health and Trading Standards, Herefordshire Council;
- Initial Investigation into Ground Water Issues, Colwall Church of England Primary School, Colwall Green, Malvern, Worcestershire, May 2014. HUB Professional Services Limited;
- Damp Survey, Monitoring and Damage Report at Colwall Primary School, June 2014. Richards Fire and Flood Limited. Ref 21952/B.

All of the above referenced reports should be read in conjunction with this report.

The HUB Professional Services Report in May 2014 was commissioned by HCC to undertake the initial damp survey investigation works at the site. This report provides details regarding the excavation of external trial holes around the perimeter of the site which were designed to monitor shallow groundwater levels, regular monitoring data, amendment works to the existing surface water drainage and pressure testing of all internal site drainage and water supply services.

The above reports have determined and indicated that the ongoing damp issues at the school is the result of shallow groundwater issues, although the exact cause of the issue or how it can be addressed has not yet been provided.

2 Environmental Setting

2.1 Introduction

This section of the report summaries the available information collected during the desk study review of the geological and hydrogeological setting of the site. Observations made by Hydrogeo during the site walkover undertaken on the 8th October 2014 are also included.

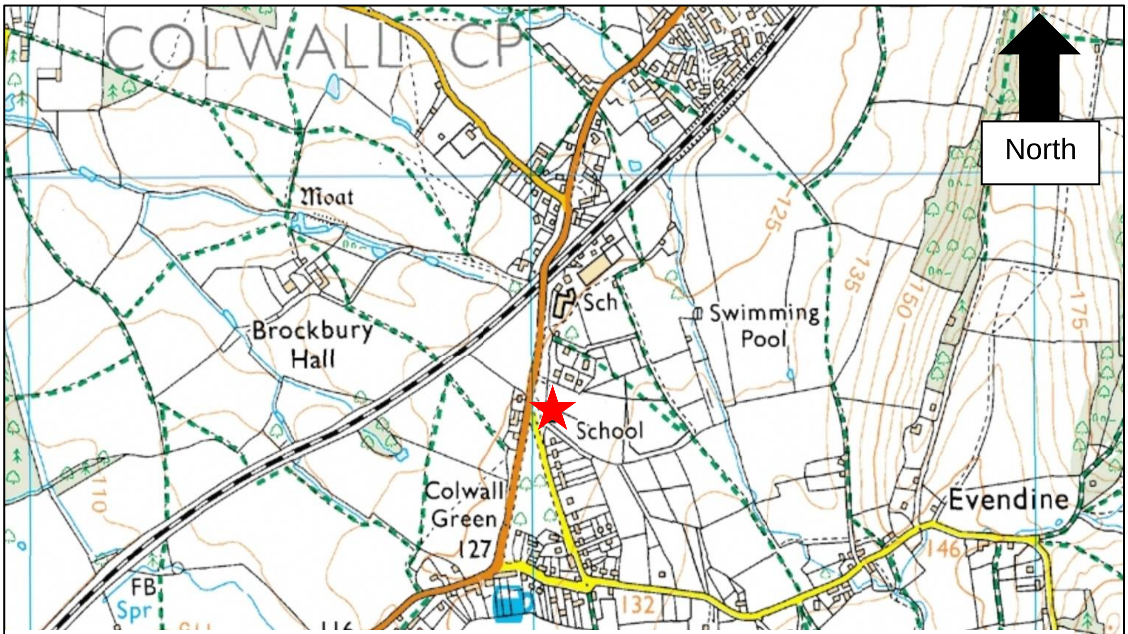
The school is located at National Grid Reference (NGR) at 375038,241548 at an elevation of approximately 130 to 126 metres Above Ordnance Datum (mAOD). The school is situated within Colwall Green, Colwall, off Walwyn Road to the west of the Malvern Hills on the Worcestershire and Herefordshire border.

This section of the report *"Contains Environment Agency information © Environment Agency and database right".* The information was obtained following a request by Hydrogeo to the Environment Agency to inform the report. The information provided by the Environment Agency can be viewed in Appendix A.

2.2 Site Description

The location of the school and wider area is shown below in Figure 1.

Figure 1 Colwall C. of E. Primary School Location

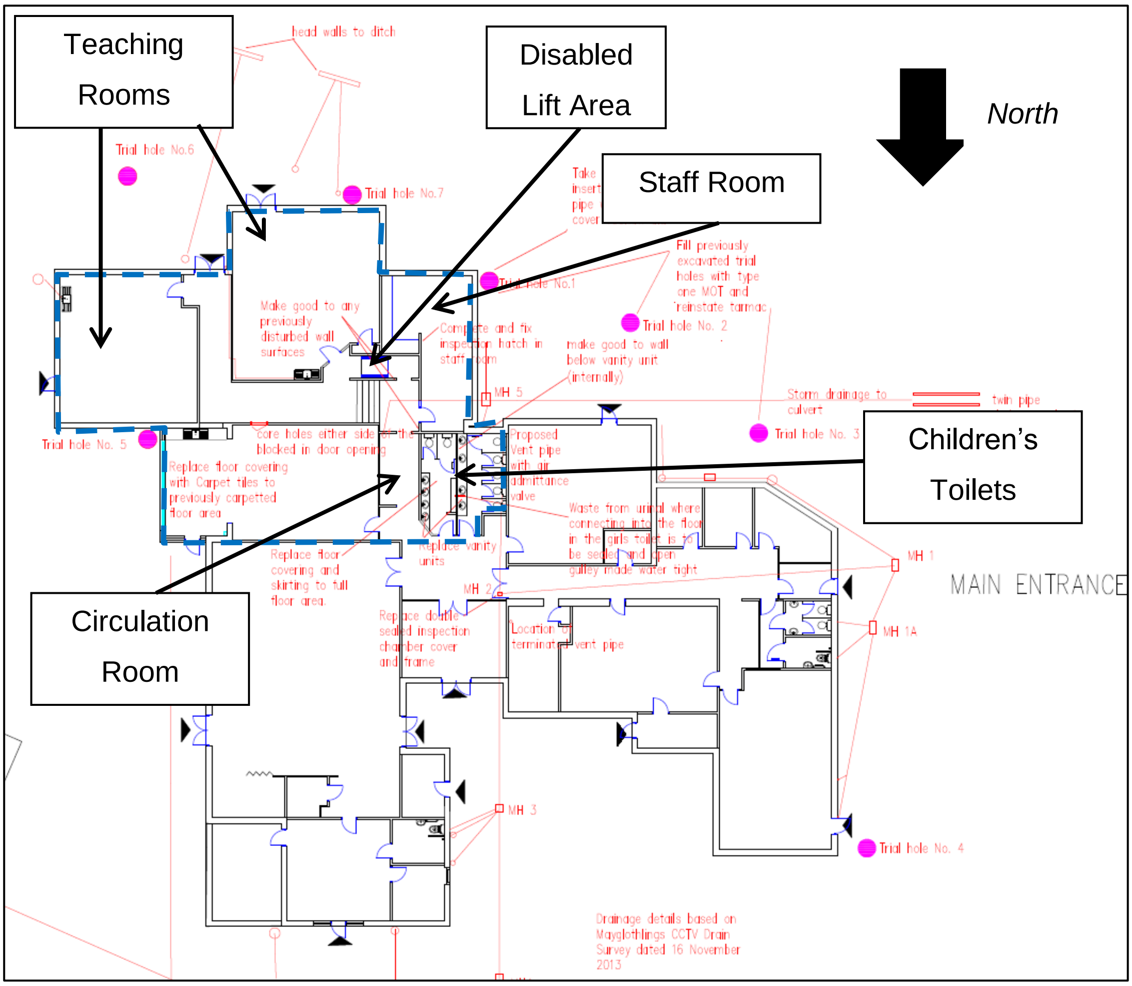


Ordnance Survey Map of Site Location. Crown copyright reserved, Licence No. 100047852

The site comprises the school building within the western area with the playground and current temporary school buildings located within the central and eastern area. The school building is located within the lowest lying part of the school grounds. The ground is tarmacked and concreted within the immediate surrounds of the school building.

The original primary school building was built in the Victorian Period in 1865 with extensions to the building occurring in 1981 and 1993 respectively. The existing building layout is depicted below in Figure 2 which has been provided by HCC. The indicative outline of the 1993 building extension, where the most noticeable issues have been observed is shown below by the dashed blue line.

Figure 2 Existing School Building Layout



The topography of the site generally slopes from the east, south-east towards the front of the school building to the west, north-west from a topographic high of 130mAOD to 126mAOD. A small open drain is situated adjacent to the school along the southern boundary running south-east to north-west which is then culverted as it runs beneath

Walwyn Road to the west of the site. The watercourse is not shown on the Ordnance Survey (OS) Map for the site.

The northern site boundary is adjacent to playing fields with residential properties beyond to the north-west and to the south of the site. Grassed fields, divided by fences and hedgerows are located to the east and north-east of the site. The school is accessed off Walwyn Road to the west of the school building.

The Malvern Hills are approximately 1.5km to the east of the site, with Malvern Wells situated on the eastern side of the Malvern Hills approximately 2.4km to the east of the school.

2.3 Information Sources

The following information has been provided to Hydrogeo upon request from the Environment Agency and has been reviewed in formulating this report. The information is appended in Appendix A, and is summarised below:

- Environment Agency Response Letter to Hydrogeo Enquiry (W-6105) 24th October 2014;
- Plan of 1.5km Water Pipeline;
- List of Discharge Consents within a 2km radius of the site;
- Plan which shows the 1.5km pipe line from the Malvern Water Spring source at Primeswell Spring (SO75995 40365) to the former spring water bottling works in Colwall.

Sources of information used to determine the environmental conditions and sensitivity both at the site and within the surrounding area are detailed below. Sources of guidance utilised are also referenced below:

- British Geological Survey (BGS) Geological Map, Worcester, Sheet 199, 1:50,000 Scale. Solid and Drift Geology. England and Wales.
- Environment Agency (EA) website for Aquifers, Licensed Abstractions and Floodplain data www.environment-agency.gov.uk;
- The Physical Properties of Minor Aquifers in England & Wales, Technical Report WD/00/04, BGS and Environment Agency;
- MET Office for Monthly Rainfall Data www.metoffice.gov.uk;
- Ordnance Survey Maps;

- BGS Borehole Records.

2.4 Geology

The geology of the site has been determined from the British Geological Survey (BGS) Geological Map, Worcester, England and Wales Sheet 199. Solid and Drift Geology, 1:50,000 Scale.

A full appraisal of the anticipated superficial deposits and geological strata is provided in the following sections;

Superficial Deposits

Superficial Deposits are depicted on the Geological Map for the site and are therefore anticipated to underlie the site. The Superficial Deposits underlying the site are known as the Colwall Gelifluctate Formation which formed up to 2 million years ago in the Quaternary Period. These deposits formed from material accumulating on subarial slopes by landslides, debris flows, solifluction, soil creep and hill wash.

The Colwall Gelifluctate Formation generally comprises stiff, mainly yellow-brown gravelly silty clay or clayey silt with angular clasts of local lithologies. The Colwall Gelifluctate Formation is shown to outcrop extensively in the Colwall area.

Solid Geology

The superficial deposits are underlain by the solid Raglan Mudstone Formation, an interbedded Mudstone and Siltstone which formed approximately 416 to 419 million years ago in the Silurian period. The Raglan Mudstone Formation generally comprises of red mudstones and silty mudstones with calcretes and sandstones.

Underlying the Raglan Mudstone Formation is the Downton Castle Sandstone Formation, a sandstone which formed approximately 416 to 419 million years ago in the Silurian Period. The Downton Castle Sandstone formation is shown to outcrop approximately 420 meters to the east of the site.

2.5 BGS Borehole Record

No British Geological Survey (BGS) borehole records are shown to exist within the site boundary area. A review of the BGS records indicates a small number of available borehole records within 2km of the site.

The closest BGS record to the site is borehole record S074SE2 at National Grid Reference (NGR) 375720,242650 with Colwall approximately 1.2km to the north of the site at Messrs. Schweppe's Mineral Water Factory. The borehole was drilled in 1890-1894 to a total depth of 379 metres on the outcropping Raglan Mudstone Formation. The Raglan Mudstone Formation has been interpreted to be 353 metres in thickness with the underlying Downton Castle Sand Formation found to be 4.9 metres thick. It was noted in the record that the great thickness of the Raglan Mudstone "greatly exceeded expectations".

The Raglan Mudstone Formation is expected to be of considerable thickness beneath the site. No borehole record exists within the local area of the site which has drilled through the Colwall Gelifluctate Formation and therefore the thickness of this unit is unproven to date in this area.

The anticipated geological sequence beneath the site is shown below in Table 2-1 and is based upon the available published information.

Table 2-1 Summary of Anticipated Site Geology

Period	Group	Formation	Description	Approximate Thickness (m)
Quaternary	Superficial Deposits	Colwall Gelifluctate Formation	Stiff, mainly yellow-brown gravelly silty clay or clayey silt with angular clasts of local lithologies.	Unknown
Silurian	Lower Old Red Sandstone Group	Raglan Mudstone	Red mudstones and silty mudstones with calcretes and sandstones.	100+

2.6 Hydrogeology

The Colwall Gelifluctate Formation Superficial Deposits are classified by the Environment Agency (EA) as a Secondary A Aquifer. The Colwall Gelifluctate Formation therefore included (granular) deposits which are capable of supporting water supplies at a local rather than strategic scale.

The underlying solid Raglan Mudstone Formation is also classified by the EA as a Secondary A Aquifer. The mudstone formation is therefore capable of supporting water supplies at a local rather than regional scale and are, in some cases, important sources of base flow to rivers and streams.

The Colwall Gelifluctate Formation is shown to outcrop over an extensive area, with recharge by rainfall to the superficial deposits likely to occur to the east of the site where the land is at a higher elevation. The Raglan Mudstone Formation will also be recharged where it outcrops to the east of the site and from the overlying Colwall Gelifluctate deposits.

A number of springs are shown on the Ordnance Survey (OS) Map for the site. The closest marked spring on the OS Map is situated approximately 972 metres to the west, south-west of the site at a lower level of 115mAOD to the school. The spring is shown to emerge within the outcropping Raglan Mudstone Formation, most likely at the junction between water bearing sandstone layers and the less permeable mudstone layers. This emergence is evidence that water is likely to be flowing through the Raglan Mudstone Formation in the local area.

Two further springs, situated within the outcropping Raglan Mudstone Formation, approximately 1.1km and 1.3km, respectively, are shown on the OS Map to the south-east of the site. The springs are situated at a higher level than the site at approximately 155mAOD and 185mAOD, respectively.

A possible spring fed wetland area is located approximately 315 metres to the west, south-west of the site at a slightly lower level to the site at 122mAOD. The wetland area is shown to be situated on the boundary between the Colwall Gelifluctate Formation and the Raglan Mudstone Formation, providing further evidence of groundwater existing within these deposits in the local area.

The letter response from the Environment Agency (Appendix A) generally comments that groundwater levels in the Colwall area have shown signs of recession over the summer months although they remain fairly high in the monitored aquifers from the previous winter period in 2013/2014. The EA also commented that the springs in the local Colwall area have likely reactivated due to these current groundwater conditions as Colwall is within a spring discharge zone within the Silurian rock aquifers. The large amount of geological folding and faulting in the area will likely provide pathways for groundwater flow off the higher level recharge zone of the Malvern Hills according to the EA.

The EA do not hold any groundwater level or water quality data for the Colwall area.

The site was checked against the EA Source Protection Zone (SPZ) maps (www.environment-agency.gov.uk) to confirm whether the site is within the SPZ or a nearby water supply. The school is not found to be within a groundwater SPZ although three SPZ's are shown to be present to the east of the site along the Malvern Hills, with the outer zone (Zone II) shown to extend across the crest of the Malvern Hill Complex (Granitic Rock) outcrop of the Malvern Hills.

One of the three SPZ's to the east and south-east of the site is for the Primeswell Spring abstraction License (see section 2.7 below). A spring is considered to be emerging at this point at the contact between the granitic Malvern Complex Aquifer and the underlying, less permeable, Coalbrookdale Formation (mudstone).

2.7 Groundwater / Surface Abstractions

Colwall falls within a groundwater license exemption zone, therefore the Environment Agency do not hold any information on groundwater licenses within the surrounding area of the site.

The only surface water abstraction license on record is the former Malvern Water Spring abstraction (18/54/09/0033) at the Primeswell Spring approximately 1.5km to the south-west of the site (SO75995 40365) at approximately 225mAOD. The license for the spring abstraction was transferred back to the landowner in May 2011 from Coca-Cola Enterprises following the closure of the bottling factory. The license is however still valid according to the EA. Water that was abstracted from the Primeswell Spring was transported via a 1.5km pipeline to the bottling works in Colwall, north of the school. A plan of the pipeline network can be viewed in Appendix A.

The abstraction license for the Primeswell Spring was for 109m^3/day (39823m^3/annum) and was licensed to abstract throughout the year. It is thought that the pipeline has been subsequently decommissioned and sealed (grouted) according to the EA and the following extract from Coca-Cola in October 2010:

"We will also be decommissioning the pipeline. The method for this will be to progressively backfill the pipe line with cement grout, injected at intervals along the length of the pipeline".

However, it not certain that the above proposed works has taken place to date. The EA response letter can be viewed in Appendix A.

2.8 Hydrology

The presence of surface water features, including streams, rivers, ditches, ponds and coastal waters has been determined from Ordnance Survey (OS) Maps for the site and wider area.

During the site walkover of the site, a small open watercourse was observed to flow directly adjacent to the southern boundary of the site with the flow from west to east past the school. This small water course (drain) is not shown on the OS Map for the site. The drain is likely collecting water as runoff from the fields to the east of the site. The drain is culverted at the south-western corner of the site and flows underneath Walwyn Road towards the playing fields to the north-west of the school. The water level in the drain was very low at the time of the site walkover with no observable flow at the surface of the open drain. Water was observed to be flowing in the open drain during a subsequent visit on the 18th November 2014.

The OS Map for the site shows a wetland area located approximately 315 metres to the west of the site which is likely to be spring fed. A stream is shown to be located approximately 340 metres to the east of the site with a flow direction to the north. This stream was observed to be flowing at the time of the site walkover and is likely collecting surface runoff from the Malvern Hills towards the east of this locality. It is considered likely that this stream is fed from water emerging from the Primeswell Spring to the south-east.

Two large moats are situated to the North of Brockbury House approximately 600 metres to the north-west of the site at 114mAOD. These moats are likely to be fed by the adjacent stream which flows from east to west past Brockbury House and from baseflow from underlying aquifers.

2.9 Discharge Consents

The Environment Agency has provided details of discharge consents within a 2km radius of the site. The discharge consents are summarised below in Table 2-2, with the full details provided within Appendix A.

The closest EA discharge consent to the site is located at Lower House Farm approximately 650 metres to the south-east of the site. The original license (DS/4635) was issued in 1963, with the new license (S/09/50179/S) issued by the EA 23rd November 1995 with discharge into the stream flowing approximately 340 metres to the east of the site.

Table 2-2 EA Licensed Discharge Consents within 2km

Operator	Permit No.	Receiving water	NGR
THE MALVERN HILLS HOTEL	S/09/20159/S	TRIB OF CRADLEY BROOK	SO7621040460
LOWER HOUSE FARM	S/09/50179/S	TRIB OF CRADLEY BROOK	SO7565041230
OLD CASTLE FARM	S/09/56052/S	TRIB OF CRADLEY BROOK	SO7520040690
COLWALL STORM OVERFLOW	S/09/20392/O	TRIB OF CRADLEY BROOK	SO7383042550
I2I LIMITED STP	S/09/55656/S	TRIB OF CRADLEY BROOK	SO7381042430
LITTLE ORCHARD	S/09/26855/S	TRIB OF CRADLEY BROOK	SO7579441344
1 HAMBLETON COTTAGE	EPRBP3629GD	TRIBUTARY OF CRADLEY BROOK	SO7656441082
2 HAMBLETON COTTAGES	EPRBP3629XZ	RIVER TEME	SO7655641067
AN STP SERVING 4 PROP BARTON FARM	S/09/55924/SG	SOAKAWAY	SO7420840097
EVENDINE COURT SCHOOL	S/09/14339/SG	UNDERGROUND STRATA	SO7590041100
BLACKHILL & BLACKHILL EAST	WQ/72/442	UNDERGROUND STRATA	SO7450040500
LOWER HOUSE FARM	DS/4635	NOT DEFINED	SO7500041000
STP SERVING BRAND LODGE	EPRMP3223KE	TRIB OF CRADLEY BROOK	SO7656541267
WESTERIA COTTAGE STP	EPRQP3520XK	TRIB OF CRADLEY BROOK	SO7649541161
COLWALL STW	S/09/55757/R	CRADLEY BROOK	SO7368042960

3 Site Walkover

3.1 Introduction

A site walkover was undertaken by Hydrogeo on the 8th October 2014 which included a detailed inspection of the site, immediate surrounding area and water features in the wider surrounding area. The purpose of the site walkover was to inform the desk based study, to formulate the site investigation works and siteundertake a water features survey of the surrounding site area.

During the site walkover, consultants from Hydrogeo met with Alun Humphries from Herefordshire County Council (HCC) and the acting Head at the school to view the site and to discuss the historical ongoing damp issues.

During the walkover, photographs of the site and features in the local area were captured. A detailed description of each photograph along with a plan indicating the position of the photo is presented below in Figure 3 for the site and in

Figure ***4*** for the wider area of the school. Selected photographs are presented below in

Figure 3 Site Walkover Photograph Location and Direction – School Site

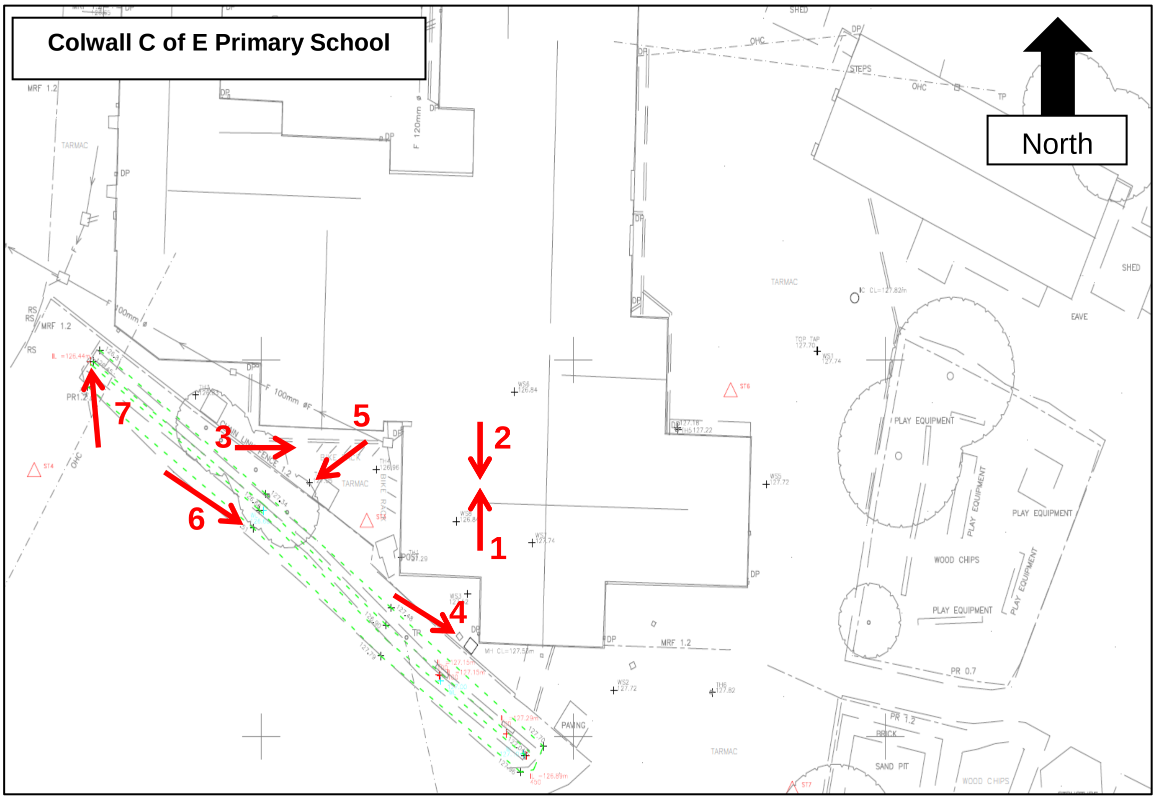


Figure 4 Site Walkover Photograph Location and Direction – Wider Area

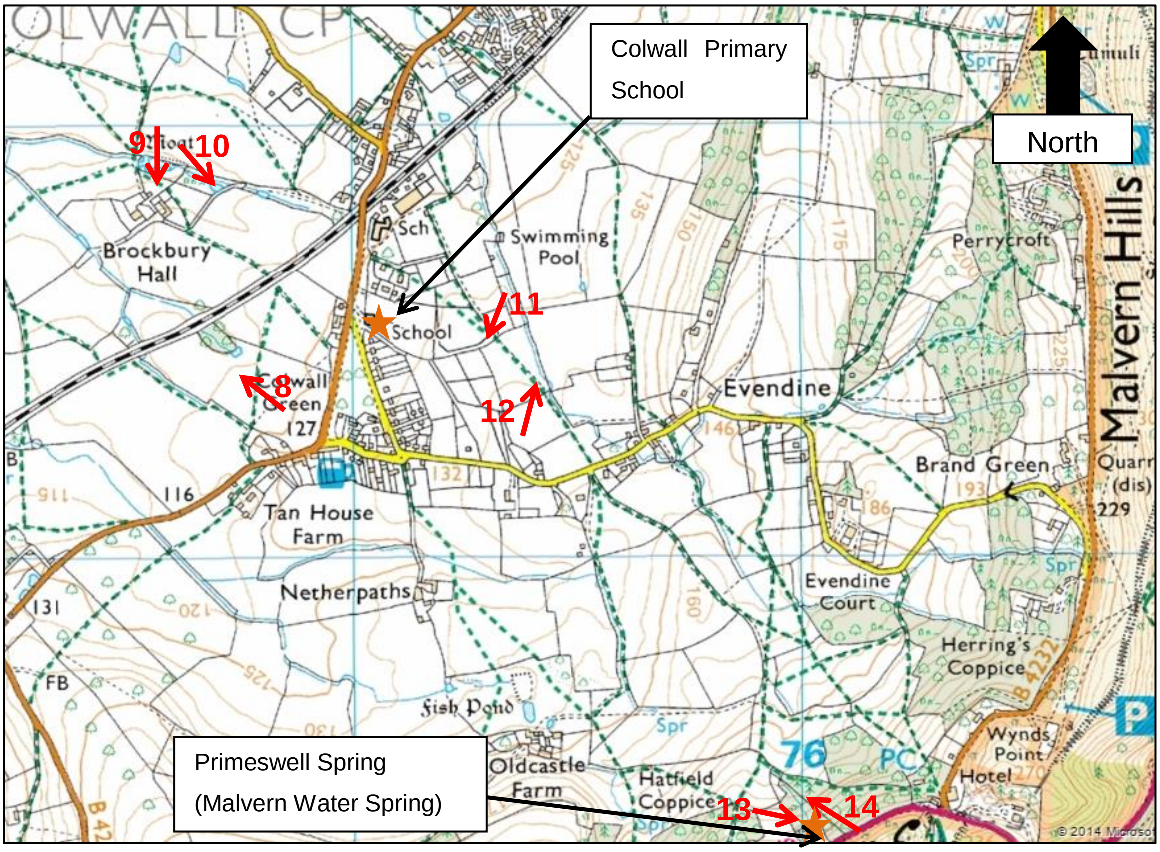
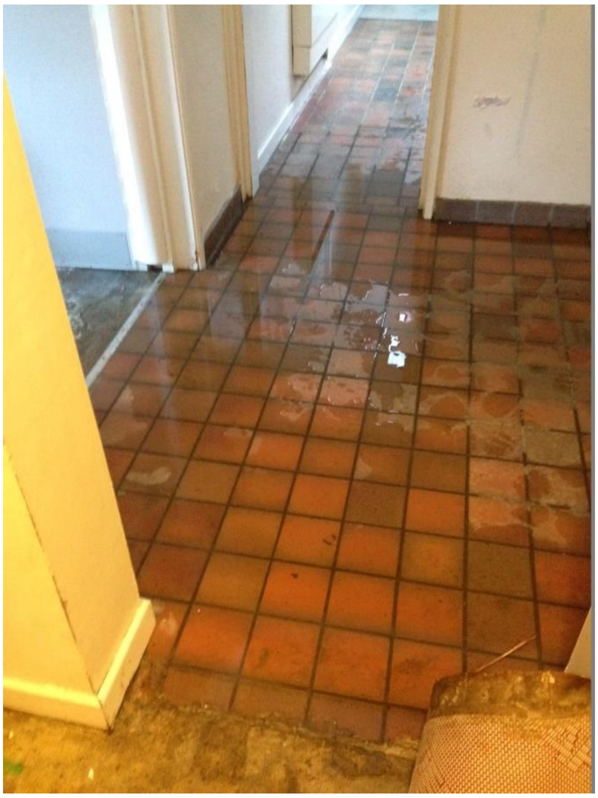


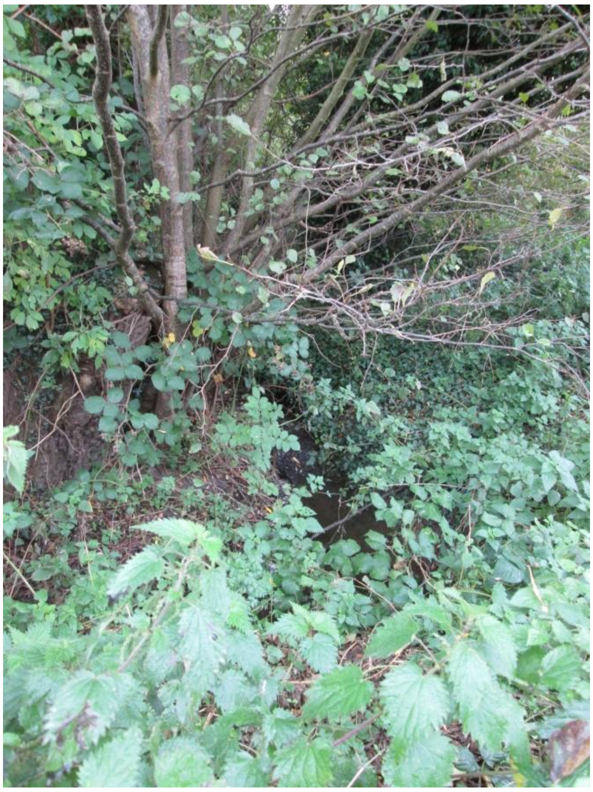
Table 3-1 Site Walkover Photographic Record and Description

Ref.	Photograph	Description
1		Photograph taken from the disabled lift access area viewing the corridor and along the circulation area towards the north of the site. The photograph shows the extent of groundwater flooding in this lower area of the 1993 building extension.

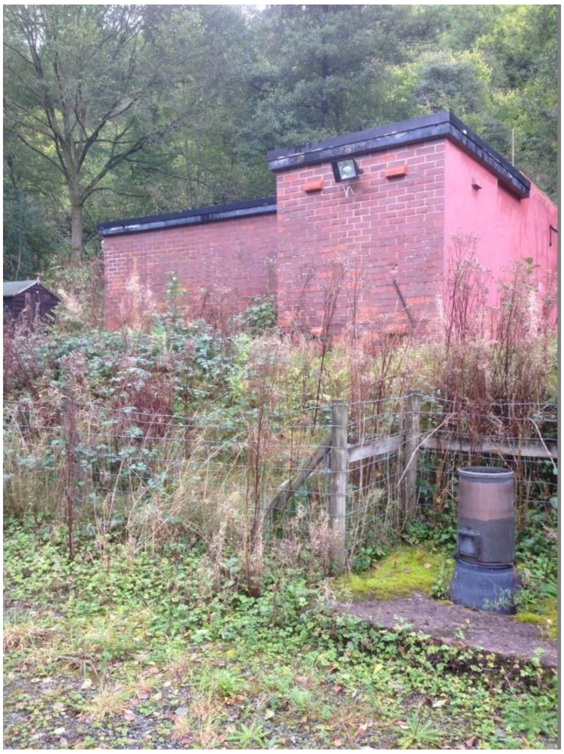
Ref.	Photograph	Description
2		View towards the disabled access area of the 1993 building extension. The exact point of groundwater seepage inflow was not clear.
3		Photograph viewing the staff room looking towards the east of the site. The photograph shows the outside ground level sloping from the southern boundary towards the north. The difference between the outside ground level in the floor level within the staff room is approximately 0.70m in the southern part of the room.

Ref.	Photograph	Description
4		Photograph shows the newly installed drainage system which runs along the southern boundary of the old school building. The drainage system carries the water that is collected as runoff from the temporary school building with discharge off site to the west of the old school building. It was observed that there are two outlets into the open watercourse just off the site to the south. Water will likely be discharged into the water course from the drainage system following periods of high rainfall. The water in the drain was measured to be approximately 0.30m below ground level in the grate shown in the photograph.
5		Photograph showing Trial Hole TH2 along the southern boundary of the site. The water level in the trial hole was observed to be very close to the ground level (0.13mbgl).

Ref.	Photograph	Description
6		Photograph taken viewing the southern adjacent drain (water course) towards the east, along the southern school boundary. The drain was observed to be very overgrown with little water visible within the watercourse during the site walkover.
7		View of the drain before it becomes culverted in the south western corner of the site. It was not clear as to where the culvert reappears, but it is thought the culvert flows to the north-west away from the school towards the playing fields.

Ref.	Photograph	Description
8		Photograph shows a wetland area situated to the west of the site. The wetland area is thought to be fed by a discharging spring although no spring discharge into the wetland could be observed at the time of the walkover.
9		Photograph is taken viewing farm buildings at Brockbury House to the south-west. Brockbury House is situated approximately 550 metres to the north-west of the site. The photograph shows one of the three moats in the local area.
10		Photograph shown in Ref 10 is the stream which was flowing at the time of the site walkover and feeds the moats in this area of Brockbury House.

Ref.	Photograph	Description
11		Photograph showing a blue pole maker which marks the position of the underground spring water pipe network approximately 225 metres to the east of the old school building.
12		Photograph of a stream which is situated approximately 340 metres to the east of the site. The stream was observed to be flowing at the time of the site visit.

Ref.	Photograph	Description
13		Photograph viewing the Primeswell Spring abstraction site and associated buildings approximately 1.5km to the south, south-west of the site (SO7599540365).
14		Photograph viewing the spring outlet which shows the overflow pipe discharging water out of the brick chamber. The rate of flow was estimated to be approximately 1.5l/s.

4 Site Investigation

4.1 Introduction

Following the completion of the desk based study review and site walkover, a scope for site investigation works was formulated for the site. The site investigation comprised the advancement of 8 no. narrow diameter windowless sample holes around the perimeter of the school and within the school building itself to inform on the ongoing damp and flooding issues. The investigation was concentrated around the southern and south-eastern area of the school as this is where flooding is occurring and is therefore considered the 'problem area'. The approach of the site investigation works was discussed and agreed with the client prior to the commencement of site based works.

The investigation works were undertaken over 2 no. days on the 16th and 17th October 2014. Works were supervised by an experienced Geo-Environmental Consultant in accordance with current guidance advocated by the regulatory authorities, including:

- BS 5930: 1999+A2:2010 Code of practice for site investigations;
- BS ISO 5667-11: 2009 Water quality. Sampling. Guidance on sampling of groundwaters.

4.2 Windowless Sampling

Five of the eight windowless sample boreholes designated WS1-WS5 were advanced around the perimeter of the school building with the remaining 3 no. holes (WS6-WS8) drilled within the school building. The windowless sample boreholes were drilled across the site area to confirm the nature of the shallow soils and in order to facilitate the installation of shallow groundwater monitoring standpipes.

Site constraints and service plans were provided in advance of works by HCC. A Cable Avoidance Tool (CAT) was utilised prior to the advancement of the exploratory boreholes in order to avoid the potential for inadvertently damaging any site services.

The soil profiles encountered were logged in detail and photographs of each windowless sample holes were recorded. The windowless sample logs note the depth at which soil samples were obtained, change in strata and note the depth at which water was encountered / present within the hole following the completion of drilling. The windowless sample logs are presented within Appendix B.

Shallow soil samples were obtained from 4 no. boreholes across the site area at various depths for natural moisture content and dry bulk density analysis to calculate the porosity of the underlying soils. The results of the soil analysis are provided within Appendix C.

The exploratory Windowless Sample locations and locations of the trial holes TH1-TH7 are shown in Figure 5 and in Drawing 001. The boreholes were installed with 50mm diameter monitoring standpipes, with the upper 1m plain with a bentonite seal surround (with the exception of WS8), with the lower part of the boreholes slotted with a filter sock and gravel filter. Stopcock covers were concreted in at each point flush to ground surface.

Representative photographs taken of the drilling works during the site investigation phase can be seen within the photo board attached in Appendix H.

4.3 Laboratory Testing

Representative soil and groundwater samples were collected and sent to Alcontrol Geochem Analytical Limited (UKAS and MCERTS accredited laboratory) for chemical testing. The analysis for soil moisture content and dry bulk density of the 4 no. soil samples is provided within Appendix C, with the chemical analysis undertaken on the 8 no. groundwater samples provided within Appendix D.

The analysis for the groundwater samples includes the following determinants:

- Major Ions to include: Ionic Balance, Calcium, Iron, Magnesium, Nitrite, Sodium, Ammoniacal Nitrogen, Nitrate, Potassium, Alkalinity, Chloride and Sulphate;
- Electrical Conductivity;
- pH and;
- Low levels of Volatile Organic Compounds (VOCs) to include trihalomethanes (sum of), which are an indicator of mains water.

4.4 Groundwater Monitoring

Subsequent groundwater level monitoring has been undertaken at the site on the 22nd October, 29th October and 18th November 2014. The newly installed monitoring boreholes and the already present shallow trial hole installations were dipped to determine the groundwater surface and also to record the depth to groundwater and base of the borehole location.

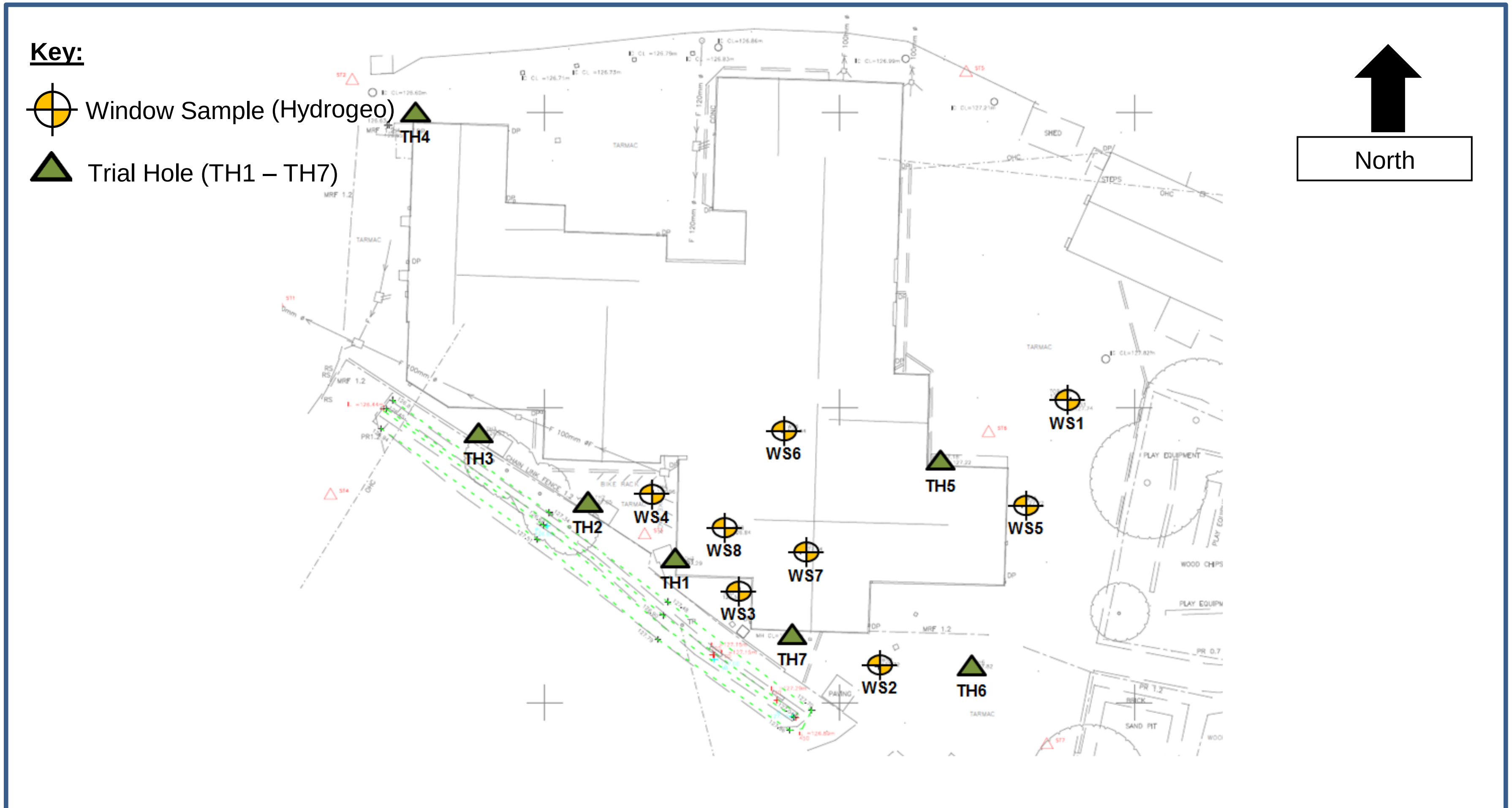
Representative groundwater samples were obtained from all 8 no. monitoring wells during the first monitoring round, following purging of three well volumes of groundwater. Groundwater samples were obtained using a fresh bailer and sampling line for each borehole.

Groundwater samples were placed into laboratory supplied bottles, labelled and stored within a cool box. Fresh freezer packs were placed within the cool boxes during the day and prior to forwarding the samples to the laboratory for analysis.

In addition to the 3 no. groundwater monitoring rounds, a level logger (pressure transducer) and barometric pressure logger were suspended within borehole WS3 on the 29th October until the 18th November 2014. The data loggers were set to record the water level within the borehole at an hourly interval. The fluctuations in the water level within WS3 were compared to the recorded daily rainfall results are presented in section 4.9.

The groundwater dip levels in both the trial hole installations and monitoring boreholes are provided in Appendix E.

Figure 5 Windowless Sample Hole Location Plan Colwall Primary School



HYDROGEO Groundwater and Environment

Site Investigation: Windowless Sample Holes and Previous Trial Hole Location, Colwall C of E Primary School, Colwall.

4.5 Ground Conditions

The exploratory holes at the site allowed for the made ground, Colwall Gelifluctate Formation and the Raglan Mudstone Formation to be visually inspected, logged and sampled to a maximum depth of 4 metres. The locations of the exploratory borehole locations are presented within Figure 5 and within the logs presented within Appendix B.

Made Ground

Made ground was encountered within all 8 no. windowless sample holes drilled at the site. The windowless sample holes, designated WS1-WS5, were drilled around the southern and eastern perimeter of the school building and were all found to comprise a black tarmac (Asphalt) layer overlying a grey-black silty sub base gravel with varying compositions of sands & gravels underlying the gravel sub base. Beneath the sub-base was a grey very silty slightly, clayey, fine to medium gravel comprising angular to sub-rounded gravels of dark grey limestone. This made ground gravel layer varied in colour and thickness with a red to light grey colour observed within WS4, with an orange, very sandy gravel layer found to overly the grey gravel layer in WS3 at a shallow depth.

Within the school building, boreholes WS6-WS8 encountered a strong grey concrete layer with a maximum thickness of 0.32m in WS7. The made ground encountered within WS6-WS8 underlying the concrete was found to vary in thickness and content. WS7 was observed to comprise the largest thickness of made ground material with a thickness of 0.75 metres compared to a much smaller thickness of 0.45 metres within WS6 and 0.50 metres in WS8. The made ground comprised layers of very silty sandy gravels to very silty sand layers. The gravel layer underlying the concrete in WS8 was observed to be very wet upon retrieval from the hole.

Orange angular brick fragments were observed within the silty gravel sub base underlying the tarmac in WS1, WS2 and WS3. The made ground was also observed to have a black smearing on the soils which is charcoal and/or ash particulates. A dark brown mottled green very silty gravelly soft to firm clay (sub-soil) was observed to be underlying the light grey silty gravel layer between 0.25-0.35mbgl within WS5.

Colwall Gelifluctate Formation

The Colwall Gelifluctate Formation was encountered underlying the made ground within all 8 no. windowless sample holes. The Colwall Gelifuctate Formation beneath the site was found to comprise a light brown, orange, mottled grey sandy very gravelly soft to firm clay. Sand was observed to be fine to medium grained with the gravels varying from angular to sub-rounded fine to occasional coarse size melange of sandstones and limestone's. Gravel content varied within the Gelifluctate Formation with depth and locality across the site area. A typical sample of the Colwall Geliflluctate Formation can be viewed below within Figure 6.

Figure 6 Sample of Colwall Gelifluctate Formation

A loose dark to light grey slightly clayey fine to medium gravel layer was observed within the Colwall Gelifluctate Formation in windowless sample holes WS3 and WS5, with a very gravelly clay layer observed within WS8. The gravels encountered within WS3 are shown below in Figure 7.

The gravel layers within the Gelifluctate Formation were observed between 2mbgl to 2.45mbgl and again at 3mbgl to 3.90mbgl within WS3, with a very thin layer of gravels observed in WS5 at 1.95mbgl to 2mbgl and a very gravelly clay layer in WS8 at 1mbgl to 1.35mbgl.

The gravel bands within WS3 were observed to be very wet upon retrieval during drilling. The gravels were found to comprise a mixture of varying fine to medium, sub-angular to sub-rounded sandstones and limestones as shown in Figure 6. No other borehole around the site encountered gravel bands like the bands observed in WS3.

Figure 7 Gravel Band within the Colwall Gelifluctate

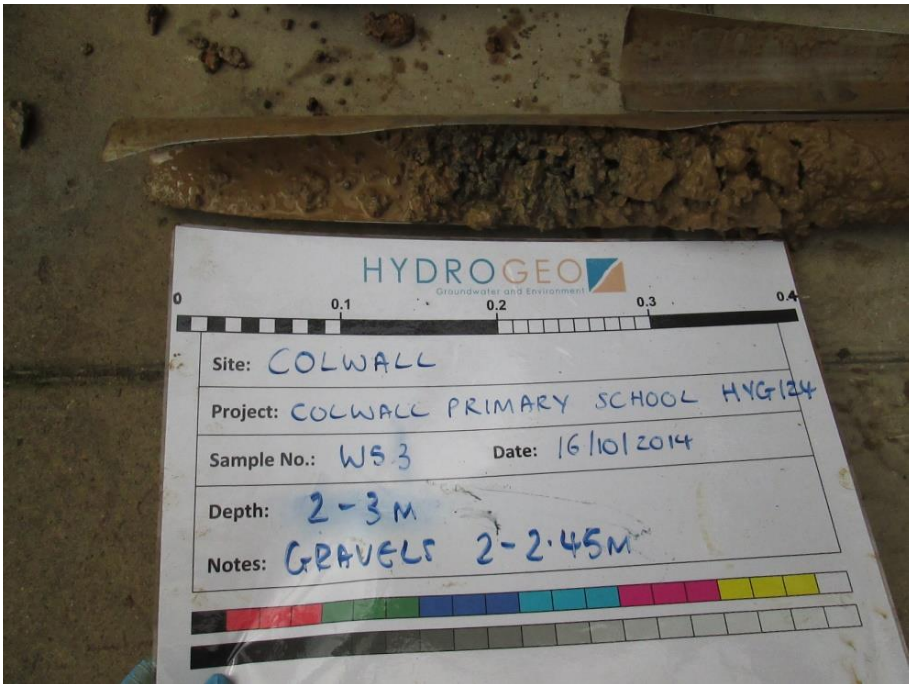


Figure 8 Colwall Gelifluctate Formation Gravels

The transition from the Colwall Gelifluctate Formation to the underlying weathered Raglan Mudstone Formation was quite distinctive in colour and is easily observed as shown in Figure 9.

Figure 9 Transition from Colwall Gelifluctate Formation to the Raglan Mudstone

Figure 9 shows the transition from the light brown Colwall Gelifluctate Formation to the dark red Raglan Mudstone Formation encountered within WS1 at 2.95mbgl. The transition was encountered at its shallowest in WS8 within the staff room area at 2.50mbgl and at its deepest within WS2 at 3.20mbgl.

Raglan Mudstone Formation

The Raglan Mudstone Formation was generally found to comprise a dark red to dark brown mottled grey with silt and varying amounts of sand and gravel, soft to firm clay. All windowless sample holes, except WS3, encountered the Raglan Mudstone Formation underlying the Colwall Gelifluctate Formation. Gravel and sand content varied within locality and depth within the holes and generally comprised a fine to medium sand with angular to sub-rounded sandstone gravels. A typical sample recovery and cross section of the Raglan Mudstone Formation encountered at the site can be seen in Figure 10 and Figure 11, respectively.

Figure 10 Raglan Mudstone Formation

Figure 11 Sample of the Raglan Mudstone Formation

A gravel layer was observed within the Raglan Mudstone Formation in WS1 which was comprised a loose, very clayey, grey to red sub-angular to sub-rounded fine to medium of dark grey to yellow sandstones. This is considered likely to be a highly weathered zone of the Raglan Mudstone Formation and was found to contain the most gravel within the mudstone formation at the site.

Figure 12 Raglan Mudstone Formation Gravels

The gravels in the Raglan Mudstone Formation in WS1 were found to be very wet upon retrieval from the hole between 3mbgl to 3.30mbgl. Occasional dark grey pockets of sand and fine gravels were observed as shown in Figure 13.

Figure 13 Pockets of Sand and Gravels in the Raglan Mudstone Formation

A dark brown to red slightly clayey silty fine to medium sand of the Raglan Mudstone Formation was observed within WS4 at 3.30mbgl to the base of the hole. The sand was distinctively different to the overlying firm clay and was not encountered within any of the other windowless sample holes across the site. The sand was observed to be dry upon recovery from the hole and was very crumbly easily broken apart as shown below in Figure 14.

Figure 14 Sand Layer In The Raglan Mudstone Formation

4.6 Key Points / Observations

The site investigation works allowed for the shallow geology beneath the site to be visually inspected, logged and sampled. The windowless sample borehole locations are depicted within Figure 5 and Drawing 001, with the logs presented in Appendix B.

Table 4-1 summarises the made ground and the shallow geology encountered to a maximum depth of 4mbgl during the site investigation works.

Table 4-1 Summary Description of Geology Encountered

Description	Thickness / Location	
	Min (m)	Max (m)
MADE GROUND: Comprising black asphalt tarmac, strong grey concrete and varying sand and gravel sub-bases across the whole site area.	0.20 WS4	0.75 WS7
COLWALL GELIFLUCTATE FORMATION: Light brown orange mottled grey with pockets of dark brown to black sandy very gravelly soft to firm CLAY.	1.15 WS8	2.75 WS2
COLWALL GELIFLUCTATE FORMATION: Loose very wet grey to black slightly clayey fine to medium GRAVEL.	0.05 WS5	0.90 WS3
RAGLAN MUDSTONE FORMATION: Red to dark brown mottled grey patches slightly sandy very gravelly CLAY.	0.45 WS4	1.50 WS8
RAGLAN MUDSTONE FORMATION: Loose very wet grey to black very clayey fine to medium GRAVEL.	0.30 WS1	0.30 WS1
RAGLAN MUDSTONE FORMATION: Dark brown to red slightly clayey silty fine to medium SAND.	0.70 WS4	0.70 WS4

The key points and observations from the site investigation works are detailed below:

- The majority of the material encountered underlying the made ground across the site area comprised the natural Colwall Gelifluctate Formation gravelly clays and Raglan Mudstone Formation.
- The made ground was found to comprise a black asphalt tarmac layer overlying a granular sub-base in WS1-WS5 and a strong grey concrete in WS6-WS8 within the school building. The made ground was found to be thicker within the holes drilled inside the school building with a maximum thickness of 0.70 metres observed within WS7.
- The made ground gravel layer underlying the concrete layer in WS8 between 0.20mbgl and 0.50mbgl was observed to be very wet upon retrieval from the borehole. Made ground layers encountered in the other boreholes across the site were found to be dry.
- Boreholes WS1 to WS3 were found to comprise occasional angular orange brick fragments within the granular made ground sub-base beneath the tarmac layer.
- The full extent of the Colwall Gelifluctate Formation gravelly clays were observed in all of the windowless sample boreholes except within WS3. Thicknesses ranged from 1.15 metres in WS8 to 2.75 metres within WS2.
- The clays of the Colwall Gelifuctate Formation were observed to comprise of angular to sub-rounded gravels of fine to medium sandstones and limestones with occasional cobbles and rounded sandstone pebbles.

- Two bands of gravels were encountered within WS3 with thicknesses of 0.45 and 0.90 metres respectively. Gravel within the Colwall Gelifluctate Formation was also observed within WS5 with a thin 0.05m band. These gravel bands were not observed within the other boreholes across the site. The gravels were observed to be very wet and comprised a mixture of limestone and sandstones in WS3.
- The full extent of the Raglan Mudstone Formation was not observed at the site. A very silty slightly clayey sand was encountered at 3.30mbgl to the base of the hole in WS4. This sand was not observed in any of the other holes within the Raglan Mudstone Formation and was found to be dry during the drilling of the hole.
- A loose, very wet and clayey gravel band was observed within the Raglan Mudstone Formation in WS1 between 3-3.30mbgl. Some gravel was left remaining in the sample liner following retrieval from WS8 within the staff room between 3mbgl to 4mbgl due to a 80% loss in sample. This loss of sample is likely due to the large amount of water encountered and possibly high quantity of gravels within the Raglan Mudstone Formation at this depth.

The logs for the Windowless Sampling Holes are presented within Appendix B. of this report.

4.7 Groundwater Observations

Groundwater was encountered in all exploratory holes except WS4 and WS5 which were both found to be dry upon completion of the holes.

The shallowest water strike was observed within WS3 at 0.70mbgl with the deepest strike at 3.65m within WS7 inside the school building which is situated at a higher level to WS8 and WS6 within the school building.

The largest rise in the water level following the completion of drilling was observed within WS1 with a rise of 1.45 metres in the water level from 2.65mbgl to 1.2mbgl. Groundwater that was encountered within the exploratory holes were all found to rise following the completion of drilling which would indicate that groundwater is confined and under pressure beneath the site.

Groundwater was subsequently detected within WS5 upon later groundwater monitoring rounds (section 4.9 Groundwater Level Monitoring) however, no groundwater has been detected within WS4 to date (discussed further in section 4.9).

The groundwater water strikes / levels recorded within the holes during the site investigation works are summarised below in Table 4-2.

Table 4-2 Groundwater Observations

Borehole ID	Drill Depth/Installation Depth (m)	Water Strike / Water Level (m)	Water Level Upon Completion of Drilling (m)
WS1	4.0/4.0	2.65	1.2
WS2	4.0/3.85	3.7	3
WS3	4.0/4.0	0.70	0.40
WS4	4.0/4.0	DRY	DRY
WS5	4.0/4.0	DRY	DRY
WS6	4.0/4.0	3.8	2.5
WS7	4.0/4.0	3.65	3
WS8	4.0/3.0	1.9	1.3

4.8 Rainfall Data

Daily rainfall was recorded by staff from the primary school from the 17th October until the 18th November. Rainfall measurements were not taken during the half term period (25/10/2014 – 02/11/2014) and over the weekends during this monitoring period.

The recorded rainfall data from the rain gauge at the site has also been plotted on Figure 16 and is presented in Table 4-3.

Table 4-3 Recorded Rainfall (mm)

Date	Recorded Rainfall (mm)
25-29/10/2014	5.5
03/11/2014	0
04/11/2014	10
05/11/2014	0
06/11/2014	0
07/11/2014	8
08-09/11/2014	8
10/11/2014	1
11/11/2014	8
12/11/2014	0.5
13/11/2014	0
14/11/2014	1
15-17/11/2014	2
18/11/2014	0

A measurement of 5.5mm was recorded on the 29th October as a total reading during a groundwater monitoring round at the school over the half term period.

Total rainfall was recorded at 44mm with the majority (35mm) falling on the 4th November until the 11th November 2014. During this period, the groundwater level is shown to increase from a low point (126.97mAOD) on the 1st November, to a high of 127.06mAOD on the 7th November 2014. The total fluctuation of the water level in WS3 is 0.085 metres.

4.9 Groundwater Levels

Three groundwater level monitoring rounds were undertaken on the 22nd October, 30th October and 18th November 2014 using a groundwater dip meter. Groundwater was encountered in seven of the monitoring wells, with WS4 found to be dry on all 3 no. monitoring rounds. Trial hole TH4, situated near to the entrance of the school in the north-western area of the site was found to be dry on the 22nd October and was not accessible on the 30th due to ongoing groundwork's at the site.

The groundwater levels recorded during the 3 no. monitoring rounds are summarised below in Table 4-4, and an inferred groundwater level contour plot for groundwater levels on the 22/10/2014 is presented in Drawing 001. A Hydrograph is also presented in Figure 13 which depicts the groundwater levels over the 3 no. monitoring periods.

Groundwater was observed to recharge very quickly to its original level within WS3 following purging, in comparison to the other sampled monitoring boreholes installed across the site area. WS3 is situated within the southern area of the site, between the staff room and the adjacent drain which runs along the southern boundary of the site. The gravel bands encountered within WS3 are providing the quick recharge of groundwater in this area due to the high permeability of the deposits and recharge from the southern adjacent drain (discussed further in Section 5).

Table 4-4 outlines the recorded groundwater dips recorded across the site area and the converted level into metres Above Ordnance Datum (mAOD) following the surveying of all monitoring wells.

Table 4-4 Recorded Groundwater Levels

Borehole ID	Ground Level (mAOD)	Hole Depth (mbgl)	Hole Depth (mAOD)	Minimum		Maximum		Range
				GW Level (mbgl)	GW Level (mAOD)	GW Level (mbgl)	GW Level (mAOD)	(m)
Trial Hole 1	127.29	0.64	126.65	0.43	126.69	0.60	126.86	0.17
Trial Hole 2	127.05	0.64	126.41	0.12	126.60	0.45	126.93	0.33
Trial Hole 3	126.83	0.79	126.04	0.26	126.49	0.34	126.57	0.08
Trial Hole 4	126.65	0.87	125.78	0.72	125.83	0.82	125.93	0.10
Trial Hole 5	127.22	0.66	126.56	0.42	126.71	0.51	126.80	0.09
Trial Hole 6	127.82	0.72	127.1	0.33	127.13	0.69	127.49	0.36
Trial Hole 7	127.53	0.69	126.84	0.46	126.86	0.67	127.07	0.21
WS1	127.74	4	123.74	0.84	126.66	1.08	126.90	0.24
WS2	127.72	4	123.72	0.50	127.05	0.67	127.22	0.17
WS3	127.52	4	123.52	0.46	127.00	0.52	127.06	0.06
WS4	126.96	4	122.96	DRY	DRY	DRY	DRY	DRY
WS5	127.72	4	123.72	0.72	126.77	0.95	127.00	0.23
WS6	126.84	4	122.84	1.29	125.40	1.44	125.55	0.15
WS7	127.74	4	123.74	0.94	126.64	1.10	126.80	0.16
WS8	126.84	3	123.84	0.48	125.95	0.89	126.36	0.41

Table 4-4 shows that during the monitoring period the greatest fluctuation in groundwater levels occurred beneath the staff room within WS8 whereas the least variation was recorded within WS3. WS4 was found to be dry on each of the three monitoring rounds.

The groundwater levels for the 8 no. monitoring boreholes (WS1-WS8) are presented in Figure 15. The trial holes have not been included within the hydrograph as they are very shallow in comparison to the monitoring boreholes and therefore, combined with their construction may not fully represent the groundwater levels beneath the site.

The groundwater levels recorded within both the trial hole installations and monitoring boreholes are provided within Appendix E.

Figure 15 Groundwater Level Hydrograph (22/10/2014 – 18/11/2014)

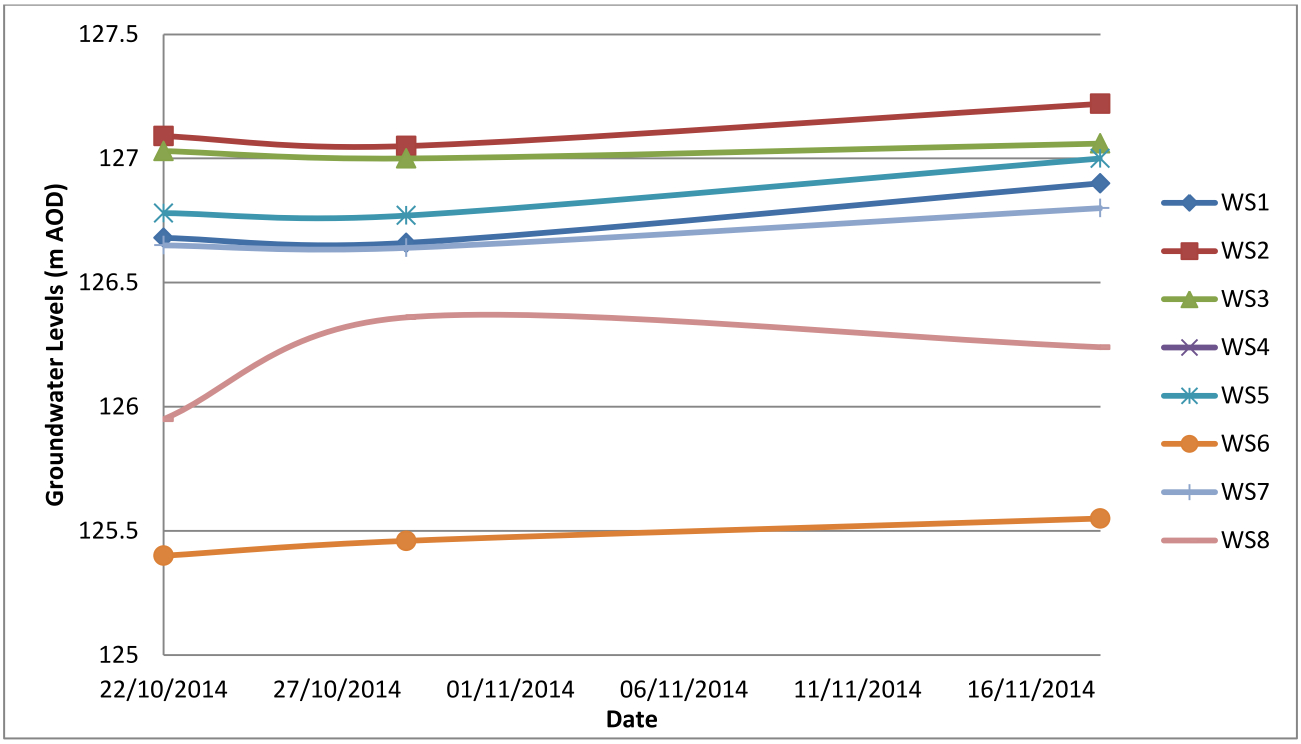


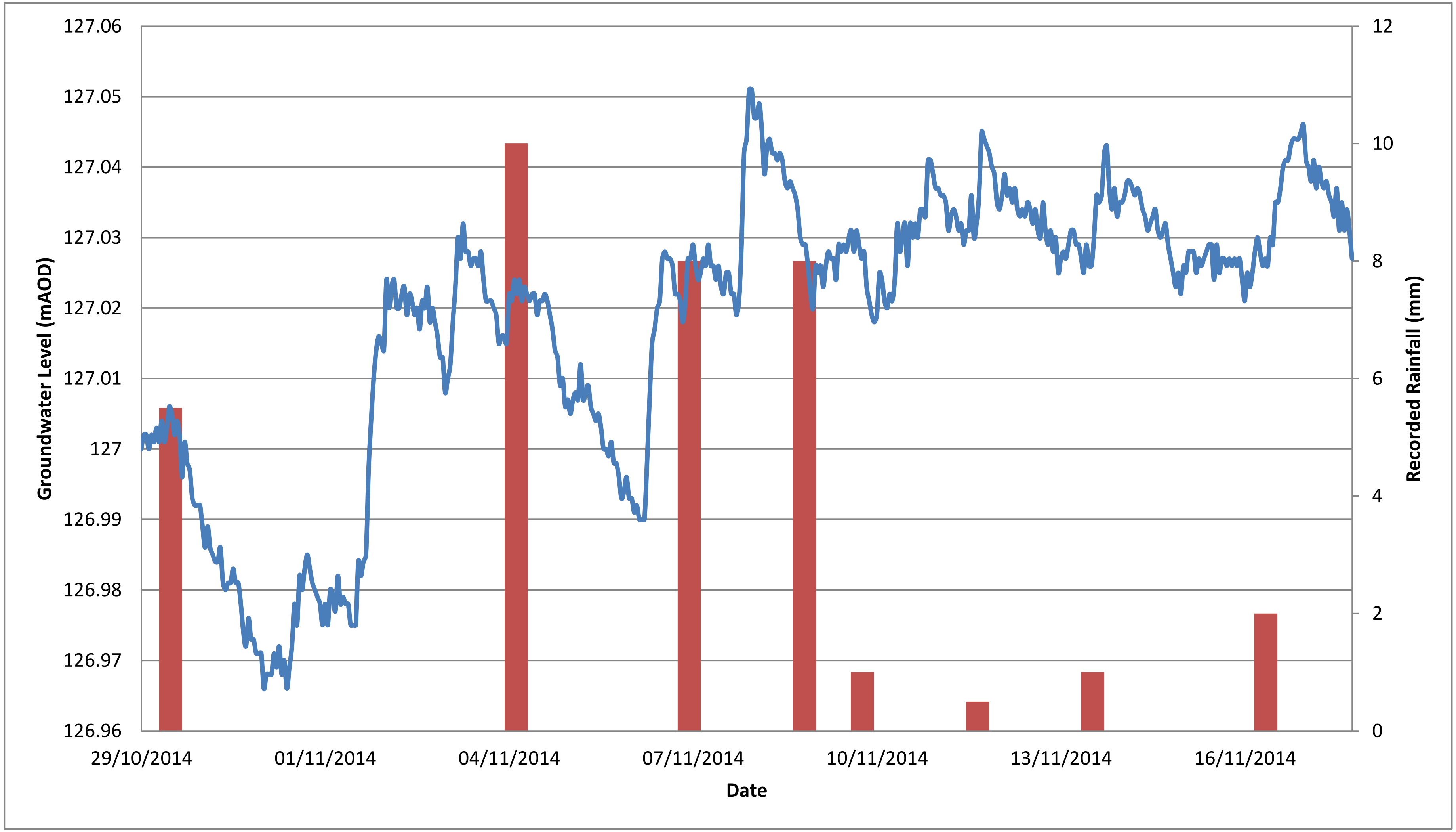
Figure 15 and the groundwater contour plot in Drawing 1 shows that the groundwater level is highest in the south-eastern area of the site in WS2 (127.05 to 127.22mAOD). The lowest recorded groundwater level is in WS6, situated towards the centre of the school building (125.40 to 125.55mAOD).

Groundwater levels generally increase during the monitoring period in all of the boreholes with the exception of WS8, which recorded the largest fluctuation in groundwater during this period. The groundwater level in WS8 was a maximum of 126.36mAOD on the 29th Ocotber 2014 with the groundwater level subsequently falling to 126.24mAOD on the 18th November 2014. .

Drawing 001 shows that the piezometric head of the groundwater level surface beneath the site falls to the north-west of the site towards WS6 from WS2. The main groundwater flow direction is therefore inferred to be towards the north-west beneath the site. The hydraulic gradient (slope of the groundwater level surface) is generally flat outside of the school building in the south-eastern area (close to WS2) with the gradient becoming steeper between WS3 to WS6. This hydraulic gradient is 0.52 between WS3 to WS8 compared to a much shallower gradient of 0.092 between WS2 and WS7 (discussed further in Section 5).

In addition to the groundwater monitoring rounds, a level logger (pressure transducer) and barometric pressure logger were installed within WS3 on the 29th October until the 18th November 2014 to record the groundwater level within the borehole at hourly intervals. The variation in groundwater level in WS3 during the monitoring period is presented in Figure 16.

Figure 16 WS3 Groundwater Level Hydrograph (29/10/2014 – 18/11/2014)



4.10 Permeability Testing

14 no. in situ rising / falling head permeability tests were carried out in WS3, WS5, WS7 and WS8 which are advanced to 4 metres depth around the site. A solid 'slug' was dropped into the boreholes to cause a sudden rise / drop in the water level which was monitored by a pressure transducer (logger) installed towards the base of the hole. The data was analysed using AquiferWin32 to calculate the permeability of the underlying soils.

The calculated permeability values for the falling / rising head tests ranged between 3.08 m/d in WS3 and 0.0097 m/d in WS7. The outputs and graphs of the rising head permeability tests are included within Appendix G and are summarised below in Table 4-5 . The large range in calculated permeability values (two orders of magnitude) across the site is representative of the varying geology encountered beneath the site.

The higher calculated permeability values are shown to be within WS3 where two thick gravel bands were encountered within the Colwall Gelifluctate Formation. The gravel bands encountered within the southern area of the site in WS3 will provide a preferential flow pathway for groundwater due to the high permeability of gravels. The calculated permeability values for WS5, WS7 and WS8 in comparison are the result of higher clay content and less gravels encountered within these areas of the site.

WS4 borehole was dry, therefore falling head permeability tests only were carried out in this borehole. The window sample hole was filled to the top with clean water and the subsequent fall in the water level was routinely measured during the 2 no. tests carried out. The first test was manually monitored using a dip meter, whereas the pressure transducer was utilised to record the drop in the water level during the second test. The data was analysed using AquiferWin32 to calculate the permeability of the soils. The results of the falling head permeability tests for WS4 are also displayed in Table 4-5 .

Table 4-5 Permeability Test Results

Borehole ID	Test 1 (m/d)	Test 2 (m/d)	Test 3 (m/d)	Test 4 (m/d)	Test 5 (m/d)	Test 6 (m/d)
WS3	2.40	1.82	2.44	3.08	2.41	2.57
WS5	0.0063	-	-	-	-	-
WS7	0.016	0.020	0.0097	0.0097	0.022	-
WS8	0.0019	0.018	-	-	-	-
WS4	0.0034	0.0025	-	-	-	-

The water level during both falling head tests in WS4 was monitored over a period of 2.5 hours in which the water level had dropped to 2.70 and 2.10 metres respectively. The borehole was observed to be dry on subsequent groundwater monitoring visits to the site.

4.11 Soil Sample Analysis and Results

Representative soil samples were obtained from the windowless sample holes WS2, WS3, WS5 and WS6 during the site investigation works which were then forwarded to Alcontrol Geochem to be analysed for Moisture Content and Dry Bulk Density.

Soil samples WS2 and WS6 were representative of the red, Raglan Mudstone Formation and WS3 and WS5 were representative of the shallower, light brown to grey gravelly clay Colwall Gelifluctate Formation.

The effective porosity of the sampled, representative material underlying the site has been calculated using the ‘porosity calculator’ from the Environment Agency Remedial Target Spreadsheets. An extract of the porosity calculator is presented within Appendix F. The results of the analysis are summarised in Table 4-6 with the full laboratory analysis results presented in Appendix C.

Table 4-6 Soil Sample Analysis Results

Borehole ID	Depth (m)	Moisture Content	Bulk Density	Dry Bulk Density	Porosity (%)
WS2	3.5-3.8	17	2.19	1.86	**0.33**
WS3	1.7-2.0	16	2.21	1.91	**0.31**
WS5	0.6-1.0	14	2.20	1.93	**0.31**
WS6	3.1-3.4	17	2.21	1.89	**0.32**

The calculated porosity values are very similar for both the Colwall Gelifluctate Formation and the underlying Raglan Mudstone Formation, ranging between 0.31% - 0.33% which is a typical porosity range gravelly clays.

4.12 Groundwater Sample Analysis and Results

The full laboratory analysis from the groundwater results are provided within Appendix D.

WS3 was analysed for the presence of low levels VOC’s which include the sum of trihalomethanes, an indicator of mains water. None of the low level VOC’s analysed for in WS3 were found to record above the laboratory limit of detection (LOD) with the exception of Bromoform which recorded slightly above the LOD at 0.00011mg/l. This non detection of trihalomethanes indicates that mains water is not the source of the flooding within the southern area of the site.

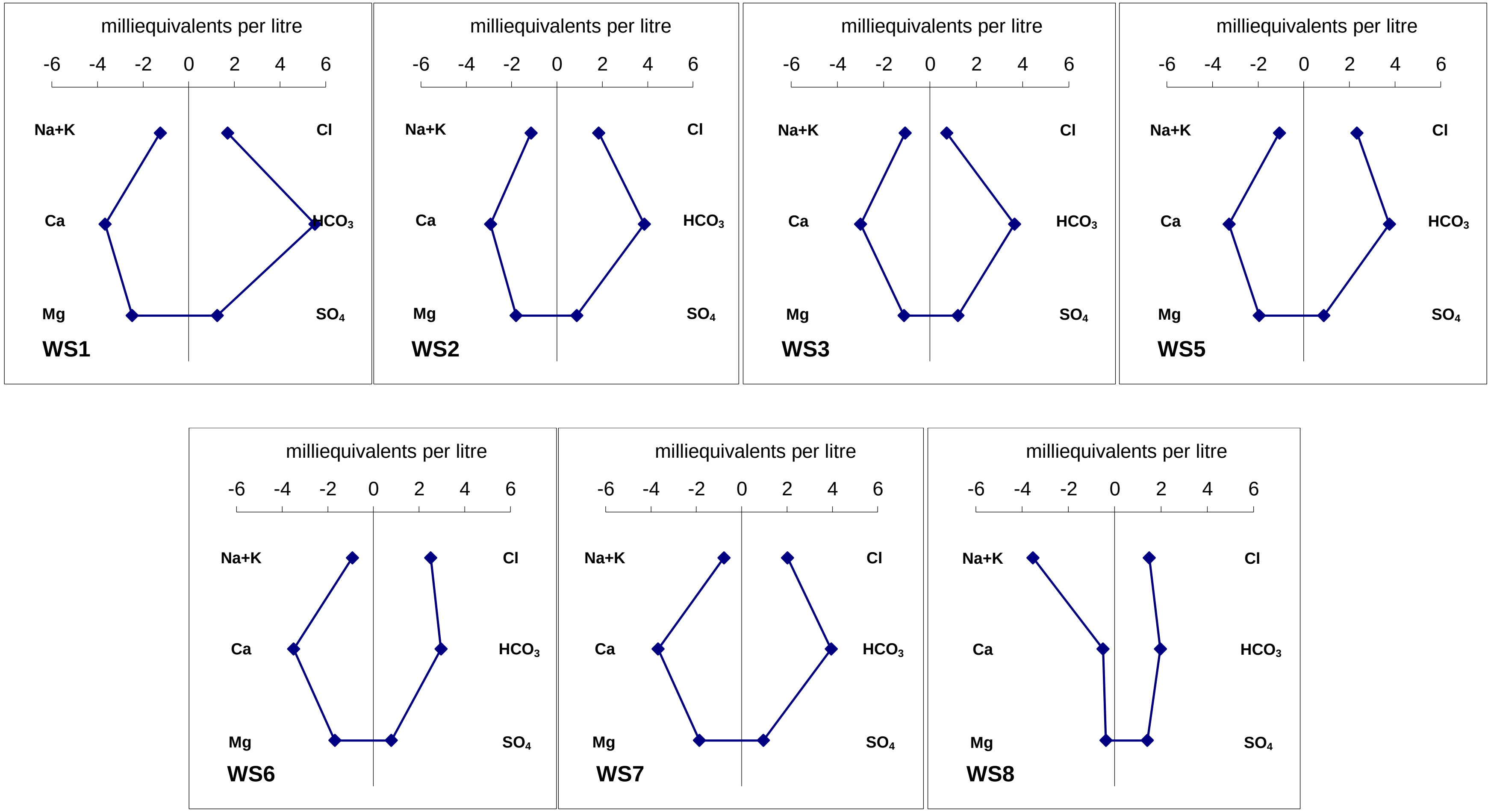
The major ions (cations and anions) were analysed for in the 7 no. groundwater samples. The results of the analysis are summarised in Table 4-7 with the full set of results provided in Appendix D.

Table 4-7 Groundwater Quality Data

Determinant	Limit of Detection (mg/l)	Concentration Minimum (mg/l)	Location of Minimum	Concentration Maximum (mg/l)	Location of Maximum
Alkalinity Total ($CaCO_3$)	<2	100	WS8	280	WS1
Bicarbonate (HCO_3-)	<2	40	WS8	280	WS1
Ammoniacal Nitrogen	<0.2	<0.2	WS1, WS2, WS3, WS6	0.745	WS8
Conductivity (mS/cm)	<0.005	0.480	WS8	0.668	WS1
Nitrite	<0.05	<0.05	WS1, WS2, WS7	2.38	WS6
Sulphate	<2	37.7	WS6	67.8	WS8
Chloride	<2	25.4	WS3	88.9	WS1
Nitrate	<0.3	<0.3	WS1, WS7, WS8	9.02	WS3
Calcium	<0.012	10.1	WS8	73.8	WS7
Sodium	<0.076	17.3	WS7	64.8	WS8
Magnesium	<0.036	4.62	WS8	30.1	WS1
Potassium	<1	<1	WS1	27.9	WS8
Iron	<0.019	<0.019	WS1, WS3, WS5, WS6, WS7, WS8	0.0571	WS2
pH	<1	6.89	WS5	9.55	WS8
Ionic Balance (%)	-	-4.48%	WS6	-7.44%	WS1

Stiff diagrams have been plotted for the groundwater samples to graphically compare the concentrations of major anions (Bicarbonate, Sulphate & Chloride) and cations (Calcium, Magnesium, Sodium & Potassium) to investigate the providence of the water samples, shown in Figure 17.

Figure 17 Stiff Diagrams



Stiff Diagrams

HYDROGEO Groundwater and Environment

The largest anion-cation charge balance error (CBE) was calculated in WS1 (-7.11%) compared to the smallest CBE in WS6 (-4.48%). The larger charge balance error calculated in WS1 is likely to be due to the larger amounts of dissolved species present within the sample or some other dissolved species which have not been analysed for are largely present within the sample.

The highest concentrations of dissolved ions in groundwater at the site were in sample WS1. This would suggest that groundwater at this part of the site is derived from recharge over a greater distance in comparison to groundwater in the southern area of the site, which is derived from local recharge (as discussed in section 5).

The stiff diagram plots for the groundwater samples have similar shapes and therefore similar proportions of major ions. This would suggest that groundwater is flowing through the natural deposits of the Colwall Gelifluctate Formation and Raglan Mudstone Formation, and is being recharged in the local area.

The exception is sample WS8 which has markedly different water chemistry. The difference in the stiff diagram for WS8 is due to the low cation concentrations of bicarbonate, magnesium and calcium, and very high concentrations in potassium. This difference in water chemistry beneath the staff room is possibly the result of groundwater flowing through the sub-base layer beneath the concrete floor. Groundwater flow and interaction with this made ground layer has altered the chemistry of the groundwater beneath WS8. Groundwater at all other areas of the site which have been sampled are likely therefore to be flowing through the natural underlying deposits.

The pH of the groundwater was found to range between 6.89 to 7.39 pH Units in WS1 to WS7 although was found to be much higher in WS8 with a value of 9.55 (Alkaline). This is further evidence that the groundwater in this part of the site is being altered through interaction with the sub-base made ground as groundwater is flowing beneath this lower level area of the school building.

5 Analysis of Results

This section of the report discusses the findings of the desk based study, site walkover and site investigation/monitoring.

The staff room, the children's toilets, circulation area and the upper level classroom were constructed in 1993 and are situated within the southern area of the site.

Drawing 002 shows a conceptual cross section through the site. The floor level of the staff room is below the external ground level, with the ground falling from south to north. The staff room, circulation room and disabled lift area are all below the floor level in the classroom where WS7 is installed. Figure 18 shows building floor levels and external ground levels.

Figure 18 School Building Ground Levels (mAOD)

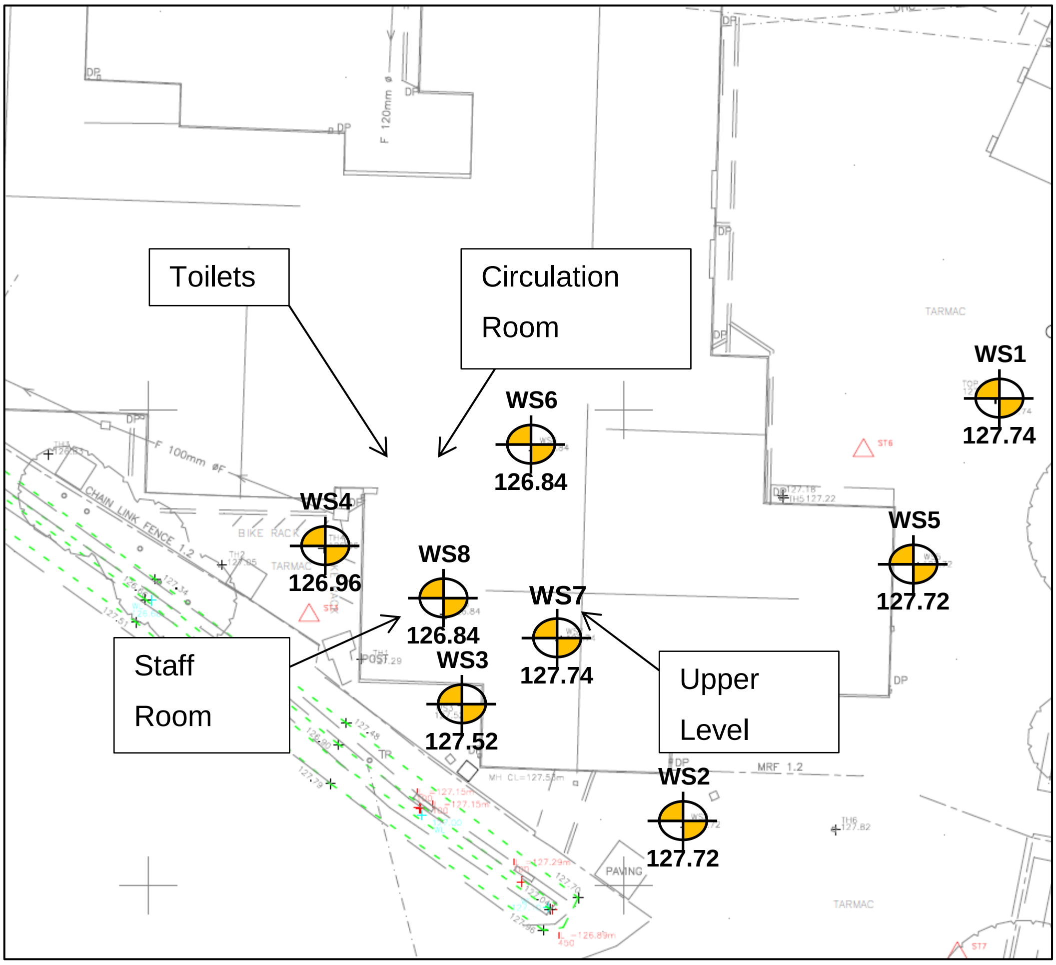


Figure 18 shows a 0.90m difference in floor level between WS7 and WS8 and a 0.68m difference between WS3 and WS8. Boreholes WS8 and WS6 represent the lowest areas of the site under investigation. The staff room, circulation area and the lift section of the lower level 1993 extension is where groundwater flooding has occurred although the exact points of entry are not clear.

Groundwater present in the superficial deposits is recharged where the Colwall Gelifluctate Formation outcrops to the east of the site, where building/hardstanding are absent. Superficial deposits within the southern and south-eastern area of the site are being recharged by water flowing in the unlined drain which runs along the southern boundary of the site as shown in Drawing 001. The water level in the drain was between 127 to 127.1mAOD on the 22nd October 2014 which is similar to the recorded groundwater level in WS3 on the same day. Drawing 001 and Drawing 002 show groundwater flowing from the open drain to the north-west, beneath the school building. The water levels in the drain and WS3 are both above the staff room floor level (126.84mAOD).

Water levels were surveyed in the drain during a comparatively dry period on the 22nd October 2014; there was standing water but little visible flow in the drain on this day. On the 18th November (third monitoring round) approximately 0.05 to 0.15m depth of water was present flowing within the drain. It was also observed that the drainage outlet, closest to WS3, was discharging run-off water into the stream (Figure 19).

Figure 19 Discharge of Runoff Water into Adjacent Watercourse

Water leaking from the unlined open drain will recharge shallow groundwater to the south of the school building. This raises the shallow groundwater level locally, and induces groundwater flow towards the school building. Drawing 001 depicts an increase in the groundwater hydraulic gradient from WS3 to WS8.

The increased steepness in the hydraulic gradient between WS3 and WS8, is likely the result of groundwater being forced downwards beneath the foundations of the 1993 building extension. Groundwater will be forced to flow towards the school building and will flow under pressure behind and beneath the building foundations and floor slab membrane where the building has been excavated below the natural ground level.

The water level in the drain will increase following periods of rainfall, which will increase recharge and shallow groundwater levels adjacent to the school. This rise in levels will increase the pressure beneath the floor slab damp proof membrane.

Gravel bands present within the deposits extending from the open drain to beneath the school, as identified in WS3, will act as a preferential pathway for groundwater flow. Groundwater will flow preferentially and in greater volumes in these bands.

The made ground sub base beneath the concrete floor slab and membrane will provide a high permeability pathway for groundwater flow. The water in WS8 has a markedly different water chemistry signature to the other monitoring points which indicates that groundwater chemistry is changed as it flows through the sub-base material beneath the staff room.

Groundwater encountered within the exploratory holes across the site area all rose following the completion of the drilling works. This suggests that groundwater within the underlying deposits is confined and under pressure beneath the site. It is likely that where this pressure is greatest beneath the floor slab membrane, such as in the lowest part of the building, this weakened the damp proof membrane over a period of time ultimately resulting in the failure of the membrane. Groundwater is then free to flow through these failure points in the damp proof membrane due to the external groundwater pressure, which is elevated by recharge from the adjacent open drain.

The extent of the gravels encountered within WS3 is unknown beneath the school building. Groundwater will likely seep through the sub-base and foundations as it flows beneath the school building, resulting in the damp issues elsewhere in the school.

Monitoring borehole WS4 was observed to be dry on all 3 monitoring rounds. It is thought that groundwater is absent in WS4 as a result of groundwater being diverted through the gravel bands identified within WS3. These gravel bands may therefore be draining the deposits locally within this area of the site as the groundwater flows towards and beneath the school building. Limited gravels were encountered within WS4 therefore there may be limited hydraulic connection with the open drain in this part of the site.

6 Conceptual Site Model

This section sets out the Conceptual Site Model (CSM) which qualitatively describes the sources of groundwater recharge, the groundwater flow pathways and discharge zones at the site.

The CSM is illustrated in Drawing 002, with the key points of the school conceptual model summarised below (numbers cross reference to Drawing 002):

1) Surface runoff from rainfall flows in from the fields to the east of the site into the open drain adjacent to the schools southern boundary.
2) Water that is collected as runoff from the new school building to the east of the old school building is being discharged into the adjacent open drain following periods of high rainfall. Water flowing to the open drain adjacent to the school provides recharge to groundwater in the granular deposits beneath the watercourse.
3) Groundwater recharged from the drain flows towards the school building. Recharge will increase with higher water levels in the drain (following rainfall), increasing groundwater flow volumes.
4) Groundwater is forced downwards beneath the lower level footings of the 1993 building extension in the south-eastern area of the site (between WS3 and WS8).
5) Groundwater is forced to flow towards the school building and flows under pressure behind and beneath the building foundations where the building has been excavated below the natural ground level. It is assumed that this pressure has weakened the damp proof membrane over time, ultimately resulting in the failure of the membrane.
6) Groundwater now seeps through failure points in the floor slab membrane due to external groundwater pressure from the ‘head’ of water in the open, adjacent drain.
7) Groundwater now also seeps through the buildings foundations and structures as it flows beneath the school, causing damp issues elsewhere in the school.

7 Summary and Recommendations

7.1 Summary

Hydrogeo Limited (Hydrogeo) was commissioned by Herefordshire County Council (the client) to undertake a Hydrogeological Desk Based Review, Site Walkover and Site Investigation with subsequent monitoring of the Colwall C.E Primary School, Colwall, Malvern, Herefordshire. The school has encountered an ongoing damp and excessive moisture issue within the lower south-east section of the school building over recent years. This has been linked with staff and student sickness and health issues.

Eight windowless sample boreholes were advanced across the site area to confirm the nature of the shallow soils and for the installation of shallow groundwater monitoring standpipes. Groundwater level monitoring and site investigation works were concentrated within the southern and south-eastern area of the school building.

The study has concluded that the source of the water entering the school is from the open drain which runs along the southern boundary of the site. This unlined drain is collecting surface runoff from the site and surrounding land and provides recharge to groundwater present in the granular deposits beneath the watercourse.

The school has been excavated below the water level in the drain, and the shallow groundwater level. The groundwater beneath the site flows from the open drain towards and beneath the school building to the north, north-west. The water is under pressure beneath the building floor slab and wall damp proof membrane in part of the school. This pressure has weakened the membrane over time, ultimately resulting in the failure of the membrane and ingress of shallow groundwater.

Once the damp proof membrane has been breached, groundwater will seep through the buildings foundations and structure beneath the building causing damp issues in the rest of the school.

7.2 Recommendations

A number of possible solutions are outlined below which are based on the conceptual model for the site. Each option has considered the operation and maintenance issues, regulatory issues, the likelihood of success, the lifespan of the solution and risk factors where possible. The final solution is expected to comprise a combination of options, as opposed to a single solution.

Option 1: Re-lining and Cleaning out of the Open Drain

The open drain is considered the main source of the shallow groundwater flooding and moisture ingress. It is recommended therefore that leakage/recharge from the base and sides of the watercourse to the underlying gravel deposits is reduced by one of the following:

- Lining the open drain with clay;
- Lining the open drain with concrete;
- Constructing a culvert.

It is recommended that the silt and debris in the open drain be cleared out prior to any remedial works taking place. The clay lining option, although the lowest cost option, would require regular maintenance over time to ensure the drain does not repeatedly silt up again and the water does not leak through the base. Vegetation growth in the open drain could also result in increased leakage through the clay liner over time.

Concrete lining would provide a longer term reduction in leakage from the drain and would also minimise plant growth within the watercourse.

Culverting the stream would also provide a long term solution to reducing leakage, but is the highest cost option and may also require regulatory approval. The culvert would also require regular maintenance. The condition of the existing culvert which the open drain currently flows into should be surveyed and remedial works undertaken if required.

Option 2: Cut-off Wall

This solution would require a barrier of clay/concrete or a driven sheet pile wall to be installed between the school building and the adjacent water course to divert groundwater flow around the school building. This option would therefore break the pathway between the source (open drain) and groundwater flow towards and beneath the school building. This option is considered an alternative to option one although it is more costly and it has a higher chance of failure as the wall would need to be ‘keyed’ into a continuous layer of low permeability strata. Access for plant and machinery to this part of the site with the current buidling still present is very limited.

Option 3: Groundwater Collection Drain

A groundwater collection drain would need to be excavated between the school building and the adjacent open drain. This would need to be designed to lower groundwater levels below the base of the school floor slab sub base, and would comprise a linear deep gravel filled drain with collector pipework. It would not be feasible for the water in the groundwater collection drain to be gravity fed to discharge to the open drain due to the water level in the open drain. Therefore, the water would need to be actively pumped/dewatered from the groundwater collection drain on a regular (or continuous) basis. This solution would therefore require a deep drainage channel to depths greater than 4 metres. The system would require routine maintenance and abstraction/discharge permits from the Environment Agency.

Option 4: Sump Pumping within the School Building

This solution would involve the installation of sump structures beneath ground level within the school building and installation of pumps to lower the level of the groundwater beneath the school building. Several of these sumps would need to be installed in order to adequately drawdown the shallow groundwater beneath the building and therefore prevent further groundwater ingress. The pumping from these sumps may need to be continuous and would also need to be discharged off site or into the adjacent open drain. This option would require regular maintenance and may need licensing approval from the Environment Agency prior to works commencing. Should option 1 be undertaken, the sump pumps could be used as a backup measure, with pumps installed with an alarm which would remove shallow groundwater should it be detected before flooding occurs.

Option 5: Waterproofing and Relining of the Membrane

The integrity of the damp proof membrane beneath the existing school building floor slab is considered compromised and therefore needs to be replaced. It is therefore recommended that the current membrane is removed and replaced with an adequate waterproof membrane. Waterproofing, which is known as tanking, should be undertaken on all floors (and below ground level walls) throughout the entire building. Tanking of the school fabric can be achieved via two options, external waterproofing / cementitious waterproofing or through the use of cavity drainage systems.

Cementitious waterproofing is a traditional waterproofing method in which a dense sand/cement slurry mix is applied to the walls and floors several times by spray. The slurry will then cure to form a water impermeable barrier which then should be covered with a render to protect it.

The second option, a cavity drain membrane, provides an alternative to the conventional tanking option. The cavity drain system controls the flow of water using cavity forming membranes, drainage channels and pump water evacuation systems. The cavity membranes can also be fixed to the walls which can then be dry lined or plastered. This option should be combined with option 4 which will evacuate the water from beneath the building.

There is no need for drainage or pumping systems to be installed with the cementitious waterproofing option. The cavity drainage system will require regular pumping to remove the water within the drainage system and maintenance. Again, this option could be considered as a backup measure should the unlined drain be lined. It is strongly recommended a specialist contractor is contacted to provide further information and costs.

Option 6: New School Building

All of the above possible solutions are based on retaining the old school building in its current location at the site. The option of building a new school building is the most costly of all the recommended options but would offer the best solution in terms of success and lifespan.

The school could either be built in its current location or to the east of the site where the temporary school exists. If the school is re-built in its current location, it is advised that the new building and floor level be built above the existing outside ground level and the level of water in the adjacent stream. Therefore, option 1 would only need to be undertaken to ensure the protection of the new building in this part of the site.

The new building would still need to have measures in place to prevent any moisture ingress from any shallow sources of both shallow groundwater and surface water flooding. This would likely require a waterproof membrane below the concrete slab and adequate surface drainage to prevent ingress from surface runoff.

Recommended Option

It is recommended that Herefordshire County Council clean out the adjacent open drain and survey the existing culvert to check the size, clean out and reline if necessary. The open drain should then be re-profiled and lined with concrete to prevent any recharge to shallow groundwater beneath the school building. This will ultimately lower the level of the groundwater beneath the school building prevent ingress of groundwater and moisture.

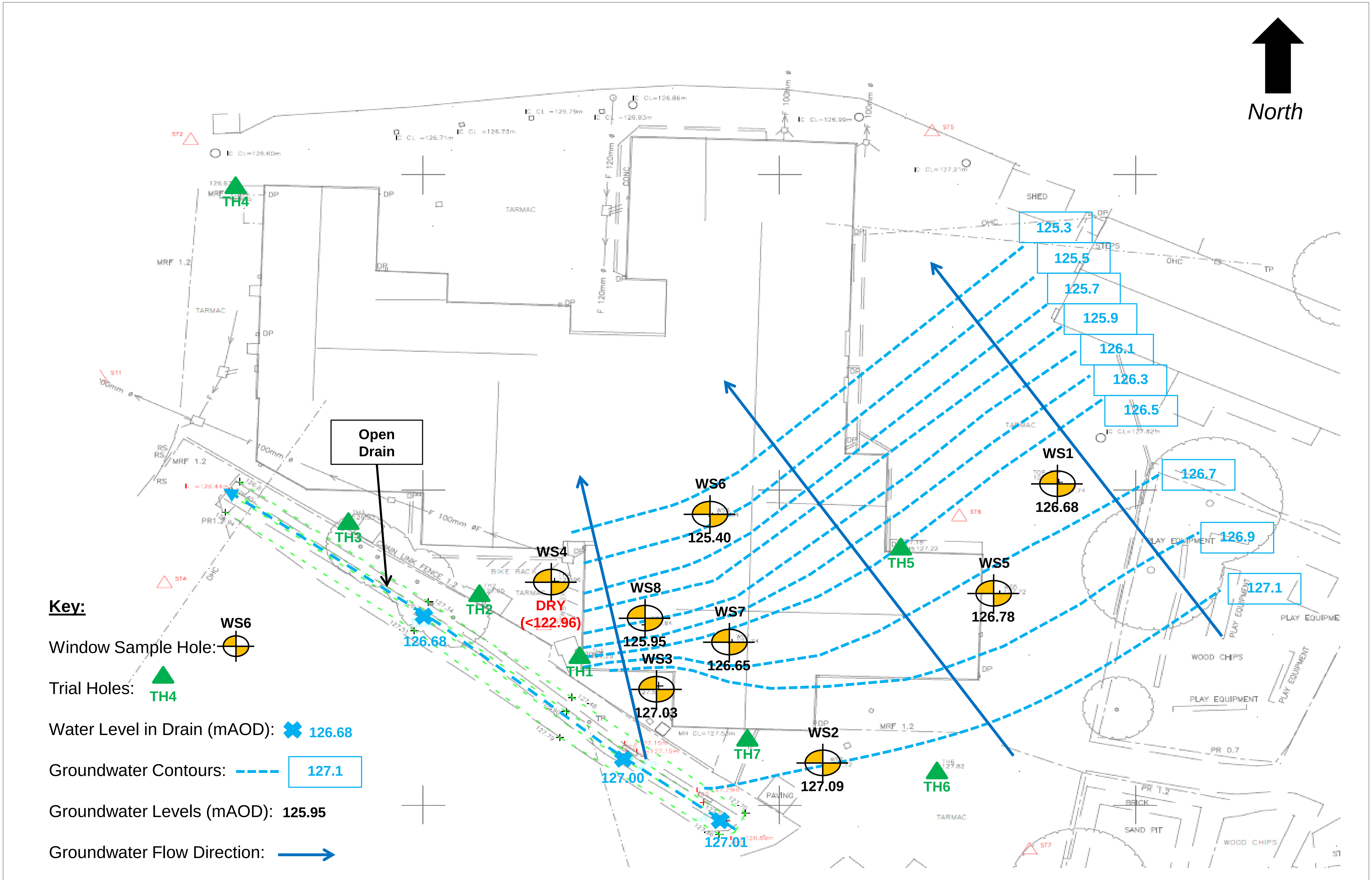
Waterproof tanking or the installation of a cavity drain membrane should be installed across the whole of the school building or any new building that is built. It is also recommended that a sump pumping system be installed beneath the school as a back-up measure.

Recommended Further Works

It is recommended that the following further works be carried out at the site to inform on the above options:

- Discuss the options with specialist contractors;
- Continue to monitor water levels within the installed trial holes and monitoring boreholes be over the winter period.
- Monitor the water level in the stream to inform on the design of the above options.
- Survey the culvert to confirm the size and integrity and clean out and reline if deemed to be necessary.

Drawings



Groundwater Contour Levels Colwall C of E Primary School – 22/10/14

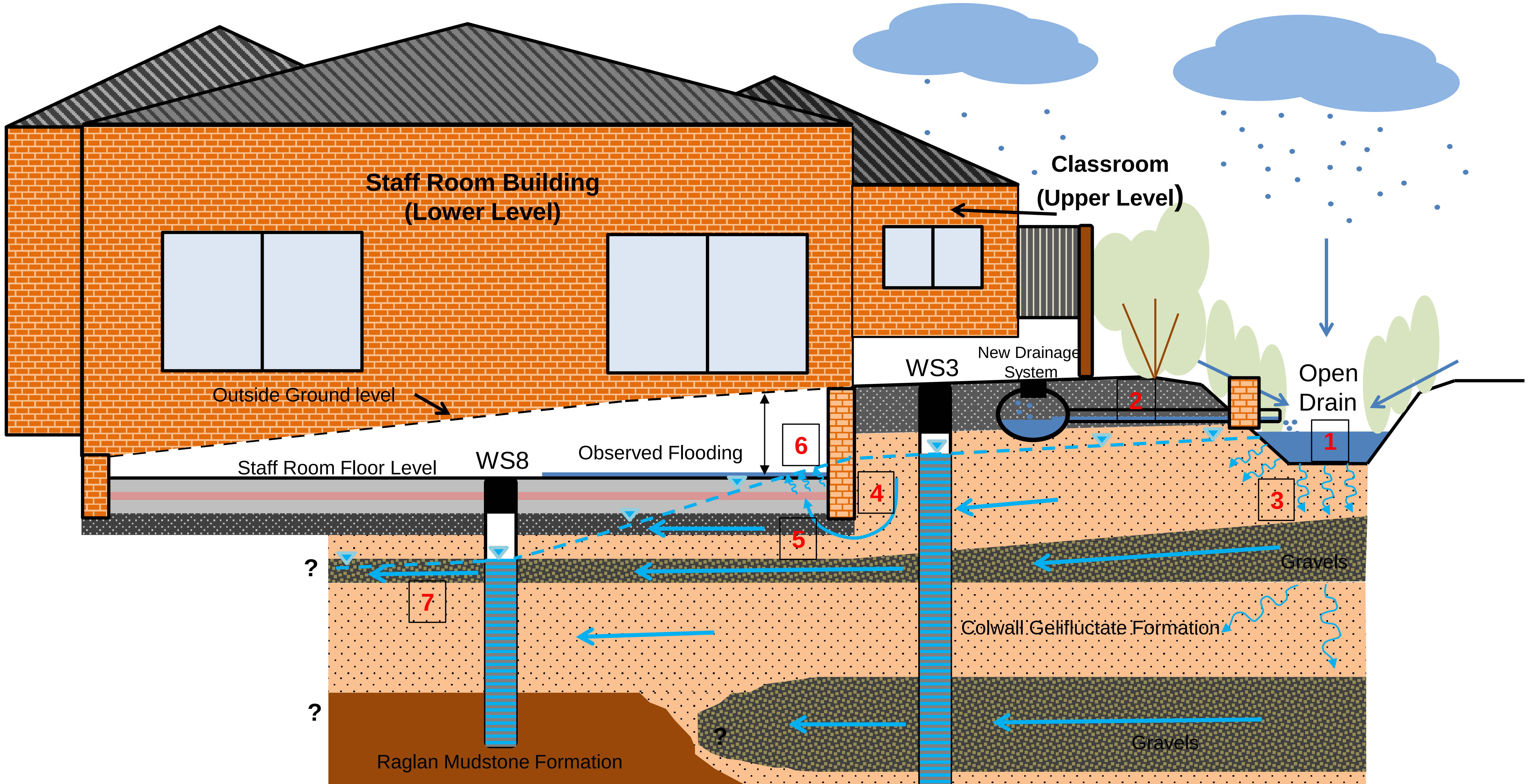
Client: Herefordshire County Council

Project: HYG124 Colwall C of E Primary School

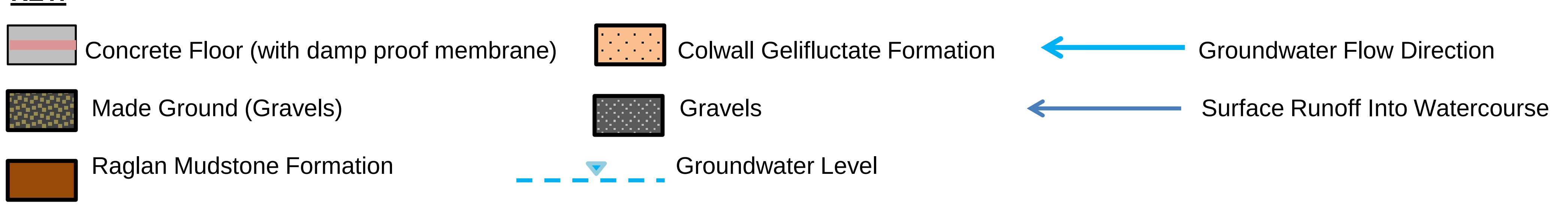
Date: 28/11/2014 Checked: CB Ref: Drawing - 001

HYDROGEO Groundwater and Environment

Tel. 01873 856813 Email chris@hydrogeo.co.uk W www.hydrogeo.co.uk



KEY:



Colwall Primary School – Conceptual Site Model

Client: Herefordshire County Council

Project: HYG124 Colwall C of E Primary School

Date: 21/11/2014 Checked: CB Ref: Drawing - 002

HYDROGEO Groundwater and Environment

Tel. 01873 856813 Email chris@hydrogeo.co.uk W www.hydrogeo.co.uk

Appendices

Appendix A

Environment Agency Response Letter and Data

Adam James
Hydrogeo Ltd
36c Lion Street
Abergavenny
Monmouthshire
NP7 5NY
E-mail: adam@hydrogeo.co.uk

Our Ref: W-6105

Your Ref:

Date: 24 October 2014

Dear Adam James

Enquiry regarding: Groundwater flooding: at Colwall C of E Primary School, Herefordshire

Thank you for your enquiry which was received on 15 October 2014.

We respond to requests under the Freedom of Information Act 2000 and Environmental Information Regulations 2004.

Details of any licensed surface or groundwater abstractions or discharge consents on or surrounding the site (within a 2km radius);
Colwall falls within a groundwater licence exemption zone and therefore the Agency holds on information on any groundwater licences within 2km. The only surface water licence of note is the one referred to already below 18/54/09/0033 which is a spring surface water licence – see below for more information.

Discharge consents.
Please find attached a spreadsheet with a list of Discharge Consents in a 2km radius of the school as well as groundwater quality data for 2 springs that are in or near the search area.

In particular, any information regarding changes in the groundwater or surface water abstraction regime over the past 5 years within a 2km radius;
This is a very open ended question. We have no information other than that provided below concerning licence 18/54/09/0033. As a very general comment, groundwater levels remain high across aquifers due to the excessive recharge over the previous winter period 2013/2014. There has been some recession of groundwater levels of recent months, but they remain high in those aquifers we do monitor such as the Permo-Triassic Sandstone principal aquifer to the south of this area around Bromsberrow. It is possible that springs in the Colwall area have reactivated due to these higher groundwater conditions, especially as Colwall is within a spring discharge zone within the Silurian rock aquifers.

Also there are weathered superficial drift deposits sat on top of the bedrock which are a known pathway for shallow groundwater. Tectonically, the area has been crumpled by folding and much faulted providing pathways for groundwater flow off the higher recharge zone of the Malvern Hills. The high groundwater table maybe a contributing factor along with a steep hydraulic gradient off the surrounding hills. Numerous springs issue on the flanks of the Malvern Hills, especially where there is geological change be it a change in strata type or a structural fault. Valleys also tend to concentrate flows as well.

The only man-made feature in the area is the old Malvern Water pipeline and this is referred to below.

Details regarding the former Malvern spring abstraction: License 18/54/09/0033; When did the license end and has abstraction ceased? Has there been any transfer of the license? Has any pipeline been decommissioned?
18/54/09/0033 was transferred back to the landowner at Barton Court in May 2011 from Coca-Cola Enterprises. The licence is still valid. A 1.5km long pipeline (see attached plan) ran from the Malvern Water spring source at Primeswell Spring (approx grid ref: SO7599540365) to the bottling works in Colwall. We understand this pipeline was decommissioned and grouted up as per the extract from a letter reproduced below provided by Coca-Cola in October 2010:

> We will also be decommissioning the pipeline. The method for this will be to progressively backfill the pipeline with cement grout, injected at intervals along the length of the pipeline.

Any Groundwater Level and Quality Data within the surrounding area.
The Environment Agency holds no groundwater level or groundwater quality data in this area.

Monthly Rainfall data over the last 10 years for the Colwall area?
The Environment Agency do not hold any groundwater data for any borehole within 8km of the specified location.

Regarding rainfall data, the nearest gauge for which we have data is Upper Colwall storage gauge. The record finishes in 2012, however, so I have also attached monthly data from Ledbury TBR in case this is of any use. The NGRs are given in the data files.

Any know records or reports of similar groundwater flooding issues reported within the Colwall area?
The Agency holds no data on groundwater flooding in the Colwall area. The Lead Local Flood Authority at Herefordshire Council may hold more information and should be contacted.

If you wish to discuss this in further detail please contact Steve Brown on 01684 864433 or e-mail: steve.brown@environment-agency.gov.uk.

Environment Agency, Riversmeet House, Newtown Industrial Estate, Northway Lane, Tewkesbury, Gloucestershire, GL20 8JG.
Customer services line: 08708 506 506
E-mail: enquiries@environment-agency.gov.uk
www.gov.uk/environment-agency

I have attached our Standard Notice which explains the permitted use of this information.

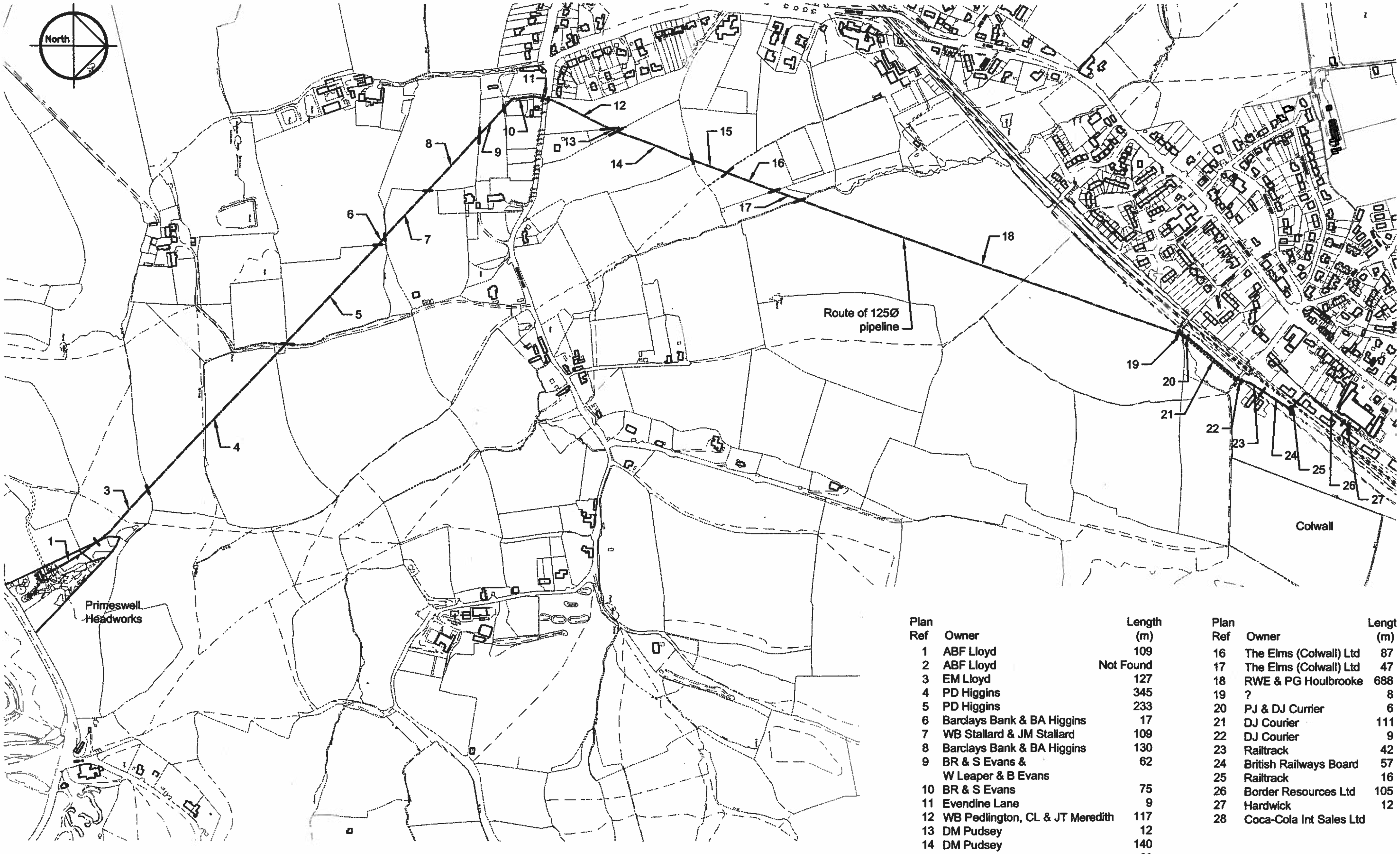
Please get in touch if you have any further queries or contact us within two months if you'd like us to review the information we have sent.

Yours sincerely

Rachel Hamer
External Relations Officer

For further information please contact the Customer Service team:
Tel: 01743 283410/3412
Direct e-mail:- MIDLANDSCUSTOMERSERV@environment-agency.gov.uk

Enc.
Standard Notice.



Plan Ref	Owner	Length (m)
1	ABF Lloyd	109
2	ABF Lloyd	Not Found
3	EM Lloyd	127
4	PD Higgins	345
5	PD Higgins	233
6	Barclays Bank & BA Higgins	17
7	WB Stallard & JM Stallard	109
8	Barclays Bank & BA Higgins	130
9	BR & S Evans & W Leaper & B Evans	62
10	BR & S Evans	75
11	Evendine Lane	9
12	WB Pedlington, CL & JT Meredith	117
13	DM Pudsey	12
14	DM Pudsey	140
15	?	63

Plan Ref	Owner	Lengt (m)
16	The Elms (Colwall) Ltd	87
17	The Elms (Colwall) Ltd	47
18	RWE & PG Houlbrooke	688
19	?	8
20	PJ & DJ Currier	6
21	DJ Courier	111
22	DJ Courier	9
23	Railtrack	42
24	British Railways Board	57
25	Railtrack	16
26	Border Resources Ltd	105
27	Hardwick	12
28	Coca-Cola Int Sales Ltd	

Preliminary		Approval		Information		Construction	

Rev.	Date	Description

Drawn: DR
Checked:
Approved:
Date: MAY 02
Scales: NTS

COCA-COLA ENTERPRISES LTD – COLWALL

LOCATION OF SPRING WATER PIPELINE
LAND OWNERSHIP – OVERALL PIPELINE

Job No. 1178
Sheet No. 300
Rev.

Morrish & Partners
Consulting Enginee
Phone 01707 3360
E-mail eng@morrish.co.

F:\autocad\Work-dwg\1178 CCE Colwall Pipeline Survey\1178301.dwg, 02/07/2002 14:15:45

Appendix B

Window Sample Logs

Hydrogeo
36 Lion Street
Abergavenny, Monmouthshire, NP7 5NT
Telephone: 01873 856 813

Project				BOREHOLE No
Colwall Primary School				**WS1**
Job No: HYG124	Date: 17-10-14 17-10-14	Ground Level (mAOD): 127.74	Co-Ordinates ()	
Contractor: Jackson Drilling Limited				Sheet: 1 of 1

SAMPLES & TESTS / STRATA

Depth	Test Type	Test Result	Water	Reduced Level	Legend	Depth (Thickness)	DESCRIPTION
						0.12	Black ASPHALT overlying a light grey to black silty GRAVEL (SUB BASE).
						(0.28) 0.40	Loose light grey to brown silty clayey fine to medium GRAVEL. Gravel sub-angular to angular of limestone and sandstone with occasional orange brick fragments (MADE GROUND).
			1 (strike) / 1 (rest)			(2.50) 2.90	Light brown orange mottled grey with pockets of dark brown to black sandy very gravelly soft to firm CLAY. Sand is fine to medium. Gravels are fine to medium angular to sub-rounded of sandstone and limestone with occasional coarse sized sub-rounded gravels of sandstone and limestone (Colwall Gelifluctate Formation) Wet from 2.60 metres. Cobble sized sub-rounded sandstone encountered at 0.60 metres depth within the clay. Very gravelly band observed between 2.60 to 2.65 metres within the clay.
						3.00	Red to brown sandy very gravelly soft CLAY. Gravel sub-angular to sub-rounded fine to medium of dark grey to light grey sandstone (RAGLAN MUDSTONE FORMATION).
						(0.30) 3.30	Loose very wet grey red black clayey fine to medium GRAVEL. Gravel sub-angular to sub-rounded of sandstone and limestone (RAGLAN MUDSTONE FORMATION). 30% loss of sample from the 3-4m run between 3 to 3.30 metres with only gravels remaining in the liner.
						(0.70) 4.00	Red to brown sandy very gravelly soft CLAY. Gravel sub-angular to sub-rounded fine to medium of dark grey to light grey sandstone (RAGLAN MUDSTONE FORMATION).

Instrument/ Backfill

Boring Progress and Water Observations

Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Depth

Chiselling / Water Added

Chiselling From	To	Hours	Water Added From	To

GENERAL REMARKS

1) - Position CAT scanned prior to drilling;
2) - Water strike at 2.65m, rose to 1.20m after 20 minutes;
3) - 1m plain pipe with bentonite seal, 3m slotted pipe with gravel filter.

All dimensions in metres Scale 1:25	Client: Herefordshire County Council	Method/ Plant Used: Windowless Sampling Rig	Logged By: Adam James

AGS3 UK BH HYG124 T 141020 AJ COLWALL PRIMARY SCHOOL DRILLING LOGS.GPJ GINT STD AGS 3_1.GDT 10/12/14

HYDROGEO
Groundwater and Environment

Hydrogeo
36 Lion Street
Abergavenny, Monmouthshire, NP7 5NT
Telephone: 01873 856 813

Project				BOREHOLE No
Colwall Primary School				WS2
Job No: HYG124	Date: 17-10-14 / 17-10-14	Ground Level (mAOD): 127.72	Co-Ordinates ()	
Contractor: Jackson Drilling Limited				Sheet: 1 of 1

SAMPLES & TESTS / STRATA

Depth	Test Type	Test Result	Water	Reduced Level	Legend	Depth (Thickness)	DESCRIPTION
						0.10	Black ASPHALT overlying a light grey to black silty GRAVEL (SUB BASE).
						(0.35) 0.45	Loose light grey to brown silty clayey fine to medium GRAVEL sub-angular to angular of limestone and sandstone with occasional orange brick fragments (MADE GROUND).
						(2.75) 3.20	Light brown orange mottled grey with pockets of dark brown to black sandy very gravelly soft to firm CLAY. Sand is fine to medium. Gravels are fine to medium angular to sub-rounded of sandstone and limestone with occasional coarse sized sub-rounded gravels of sandstone and limestone (Colwall Gelifluctate Formation). Wet from 2.55 metres. Grey sub-angular cobble of metamorphosed rock observed within the clay at 0.55 metres depth.
3.50	DS	3.5-3.85m				(0.80) 4.00	Red to brown very sandy gravelly soft CLAY. Gravel sub-angular to sub-rounded fine to medium of dark grey to light grey sandstone with occasional coarse sandstone sub-angular to sub-rounded sandstone gravel (RAGLAN MUDSTONE FORMATION).

Instrument/ Backfill

Boring Progress and Water Observations

Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Depth

Chiselling / Water Added

Chiselling From	Chiselling To	Hours	Water Added From	Water Added To

GENERAL REMARKS

1) - Position CAT scanned prior to drilling;
2) - Water at 3.7m after drilling, rose to 3m after 20 minutes;
3) - Hole collapsed at 3.85m;
4) - 1m plain pipe with bentonite seal, 2.85m slotted pipe with gravel filter.

All dimensions in metres Scale 1:25	Client: Herefordshire County Council	Method/ Plant Used: Windowless Sampling Rig	Logged By: Adam James

HYDROGEO
Groundwater and Environment

Hydrogeo
36 Lion Street
Abergavenny, Monmouthshire, NP7 5NT
Telephone: 01873 856 813

Project				BOREHOLE No
Colwall Primary School				**WS3**
Job No: HYG124	Date: 17-10-14 / 17-10-14	Ground Level (mAOD): 127.52	Co-Ordinates ()	
Contractor: Jackson Drilling Limited				Sheet: 1 of 2

SAMPLES & TESTS / STRATA

Depth	Test Type	Test Result	Water	Reduced Level	Legend	Depth (Thickness)	DESCRIPTION	Instrument/ Backfill
						0.10	Black ASPHALT overlying a light grey to black silty GRAVEL (SUB BASE).	
						0.25	Loose light grey to brown silty clayey fine to medium GRAVEL sub-angular to angular of limestone and sandstone with occasional orange brick fragments (MADE GROUND).	
			1			(0.25) 0.50	Loose orange to light grey silty very sandy GRAVEL. Gravel sub-angular to sub-rounded fine to medium of limestone with occasional coarse gravel (MADE GROUND).	
1.70	DS	1.7 - 2m	1			(1.50) 2.00	Light brown orange mottled grey with pockets of dark brown to black sandy very gravelly soft to firm CLAY. Sand is fine and gravels are fine to medium sub-angular to sub-rounded of sandstone and limestone with occasional coarse sized sub-rounded gravels of sandstone and limestone and rare rounded sandstone gravels (Colwall Gelifluctate Formation). Soils moist to wet from 0.80 metres depth to base of the hole. 15% loss of sample between 1-2 metres depth.	
						(0.45) 2.45	Loose very wet grey to black slightly clayey fine to medium GRAVEL. Gravel sub-angular to sub-rounded of sandstone and limestone with occasional coarse gravels (Colwall Gelifluctate Formation). 20% loss of sample betwee 2 - 3 metres.	
						(0.55) 3.00	Light brown orange mottled grey with pockets of dark brown to black sandy very gravelly soft to firm CLAY. Sand is fine and gravels are fine to medium sub-angular to sub-rounded of sandstone and limestone with occasional coarse sized sub-rounded gravels of sandstone and limestone and rare rounded sandstone gravels (Colwall Gelifluctate Formation).	
						(0.90) 3.90	Loose very wet grey to black slightly clayey fine to medium GRAVEL. Gravel sub-angular to sub-rounded of a melange of sandstone and limestones with occasional coarse gravels (Colwall Gelifluctate Formation). 80% loss of the sample between 3 - 4 metres.	
						4.00	Light brown to dark brown with pockets of dark brown to black	

Boring Progress and Water Observations

Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Depth

Chiselling

From	To	Hours

Water Added

From	To

GENERAL REMARKS

1) - Position CAT scanned prior to drilling;
2) - Water at 0.40m following completion of drilling;
3) - 1m plain pipe with bentonite seal, 3m slotted pipe with gravel filter.

All dimensions in metres Scale 1:25	Client: Herefordshire County Council	Method/ Plant Used: Windowless Sampling Rig	Logged By: Adam James

AGS3 UK BH HYG124 T 141020 AJ COLWALL PRIMARY SCHOOL DRILLING LOGS.GPJ GINT STD AGS 3_1.GDT 10/12/14

Hydrogeo
36 Lion Street
Abergavenny, Monmouthshire, NP7 5NT
Telephone: 01873 856 813

Project: Colwall Primary School				BOREHOLE No: **WS3**
Job No: HYG124	Date: 17-10-14 / 17-10-14	Ground Level (mAOD): 127.52	Co-Ordinates ()	
Contractor: Jackson Drilling Limited				Sheet: 2 of 2

SAMPLES & TESTS			STRATA					
Depth	Test Type	Test Result	Water	Reduced Level	Legend	Depth (Thickness)	DESCRIPTION	Instrument/ Backfill
							sandy slightly gravelly soft to firm CLAY (Colwall Gelifluctate Formation).	

Boring Progress and Water Observations

Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Depth

Chiselling

From	To	Hours

Water Added

From	To

GENERAL REMARKS

1) - Position CAT scanned prior to drilling;
2) - Water at 0.40m following completion of drilling;
3) - 1m plain pipe with bentonite seal, 3m slotted pipe with gravel filter.

All dimensions in metres Scale 1:25	Client: Herefordshire County Council	Method/ Plant Used: Windowless Sampling Rig	Logged By: Adam James

Hydrogeo
36 Lion Street
Abergavenny, Monmouthshire, NP7 5NT
Telephone: 01873 856 813

HYDROGEO Groundwater and Environment

Project				BOREHOLE No
Colwall Primary School				**WS4**
Job No: HYG124	Date: 17-10-14 / 17-10-14	Ground Level (mAOD): 126.96	Co-Ordinates ()	
Contractor: Jackson Drilling Limited				Sheet: 1 of 1

SAMPLES & TESTS / STRATA

Depth	Test Type	Test Result	Water	Reduced Level	Legend	Depth (Thickness)	DESCRIPTION	Instrument/ Backfill
						0.10	Black ASPHALT overlying a light grey to black silty GRAVEL (SUB BASE).	
						0.20	Loose red to slightly grey silty fine GRAVELS (MADE GROUND).	
						(2.65) 2.85	Light brown orange mottled grey with pockets of dark brown to black sandy very gravelly soft to firm CLAY. Sand is fine and gravels are fine to medium sub-angular to sub-rounded of sandstone and limestone with occasional coarse sized sub-rounded gravels of sandstone and limestone (Colwall Gelifluctate Formation).	
						(0.45) 3.30	Red to dark brown mottled grey to green in patches slightly sandy gravelly soft CLAY. Gravel sub-angular to sub-rounded fine to medium of dark grey to light grey sandstone (RAGLAN MUDSTONE FORMATION).	
						(0.70) 4.00	Dark brown to red slighty clayey silty fine to medium SAND (RAGLAN MUDSTONE FORMATION).	

Boring Progress and Water Observations

Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Depth

Chiselling / Water Added

Chiselling From	Chiselling To	Hours	Water Added From	Water Added To

GENERAL REMARKS

1) - Position CAT scanned prior to drilling;
2) - Hole was dry following completion of drilling;
3) - 1m plain pipe with bentonite seal, 3m slotted pipe with gravel filter.

All dimensions in metres Scale 1:26.25	Client: Herefordshire County Council	Method/ Plant Used: Windowless Sampling Rig	Logged By: Adam James

Hydrogeo
36 Lion Street
Abergavenny, Monmouthshire, NP7 5NT
Telephone: 01873 856 813

Project				BOREHOLE No
Colwall Primary School				**WS5**
Job No: HYG124	Date: 17-10-14 / 17-10-14	Ground Level (mAOD): 127.72	Co-Ordinates ()	
Contractor: Jackson Drilling Limited				Sheet: 1 of 1

SAMPLES & TESTS / STRATA

Depth	Test Type	Test Result	Water	Reduced Level	Depth (Thickness)	DESCRIPTION
					0.10	Black ASPHALT overlying a light grey to black silty GRAVEL (SUB BASE).
					0.25	Loose light grey to brown silty clayey fine to medium GRAVEL sub-angular to angular of limestone (MADE GROUND).
					0.35	Dark brown very silty slightly gravelly firm CLAY. Gravel sub-angular to sub-rounded of fine to medium sandstone (SUB SOIL).
0.60	DS	0.60-1m			(0.50) 0.85	Light brown orange mottled grey to green sandy very gravelly soft to firm CLAY. Sand is fine and gravels are fine to medium sub-angular to sub-rounded of sandstone and limestone with occasional coarse sized sub-rounded gravels of sandstone and limestone (Colwall Gelifluctate Formation). Very gravelly between 0.60 - 0.80 metres.
					(1.10) 1.95	Light brown orange mottled grey with pockets of dark brown to black sandy very gravelly soft to firm CLAY. Sand is fine and gravels are fine to medium sub-angular to sub-rounded of sandstone and limestone with occasional coarse sized sub-rounded gravels of sandstone and limestone and rare rounded sandstone gravels (Colwall Gelifluctate Formation).
					2.00	Loose grey to black clayey fine to medium GRAVEL. Gravel sub-angular to sub-rounded of sandstone and limestone with occasional coarse gravels (Colwall Gelifluctate Formation).
					(0.80) 2.80	Light brown orange mottled grey with pockets of dark brown to black sandy very gravelly soft to firm CLAY. Sand is fine and gravels are fine to medium sub-angular to sub-rounded of sandstone and limestone with occasional coarse sized sub-rounded gravels of sandstone (Colwall Gelifluctate Formation).
					(1.20) 4.00	Red to brown very sandy gravelly soft CLAY. Gravel sub-angular to sub-rounded fine to medium of dark grey to light grey sandstone with occasional pockets of fine to medium grey sand within the clay (RAGLAN MUDSTONE FORMATION).

Boring Progress and Water Observations

Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Depth

Chiselling / Water Added

Chiselling From	To	Hours	Water Added From	To

GENERAL REMARKS

1) - Position CAT scanned prior to drilling;
2) - Hole was dry following completion of drilling;
3) - 1m plain pipe with bentonite seal, 3m slotted pipe with gravel filter.

All dimensions in metres Scale 1:25	Client: Herefordshire County Council	Method/Plant Used: Windowless Sampling Rig	Logged By: Adam James

HYDROGEO
Groundwater and Environment

Hydrogeo
36 Lion Street
Abergavenny, Monmouthshire, NP7 5NT
Telephone: 01873 856 813

Project				BOREHOLE No
Colwall Primary School				**WS6**
Job No: HYG124	Date: 18-10-14 / 18-10-14	Ground Level (mAOD): 126.84	Co-Ordinates ()	
Contractor: Jackson Drilling Limited				Sheet: 1 of 1

SAMPLES & TESTS / STRATA

Depth	Test Type	Test Result	Water	Reduced Level	Legend	Depth (Thickness)	DESCRIPTION	Instrument/ Backfill
						0.18	Strong light grey CONCRETE (MADE GROUND).	
						0.25	Red to orange very clayey silty fine SAND (MADE GROUND).	
						(0.20) 0.45	Dark grey slightly clayey very silty fine to medium GRAVEL. Gravel sub-angular to sub-rounded of limestone (MADE GROUND).	
			1			(2.20) 2.65	Light brown orange mottled grey with pockets of dark brown to black sandy very gravelly soft to firm CLAY. Sand is fine and gravels are fine to medium sub-angular to sub-rounded of sandstone and limestone with occasional coarse sized sub-rounded gravels of sandstone and limestone and rare rounded sandstone gravels (Colwall Gelifluctate Formation).	
3.10	DS	3.1-3.4m	1			(1.35) 4.00	Red to brown sandy very gravelly soft CLAY. Gravel sub-angular to sub-rounded fine to medium of dark grey to light grey sandstone (RAGLAN MUDSTONE FORMATION). Soils moist to wet from 2.65 metres to the base of the hole.	

Boring Progress and Water Observations

Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Depth

Chiselling / Water Added

Chiselling From	Chiselling To	Hours	Water Added From	Water Added To
			0	0.18

GENERAL REMARKS

1) - Position CAT scanned prior to drilling;
2) - Water at 3.80m following completion of drilling, rose to 2.5m after 20 minutes.
3) - 1m plain pipe with bentonite seal, 3m slotted pipe with gravel filter.

All dimensions in metres Scale 1:25	Client: Herefordshire County Council	Method/ Plant Used: Windowless Sampling Rig	Logged By: Adam James

HYDROGEO
Groundwater and Environment

Hydrogeo
36 Lion Street
Abergavenny, Monmouthshire, NP7 5NT
Telephone: 01873 856 813

Project				BOREHOLE No
Colwall Primary School				**WS7**
Job No: HYG124	Date: 18-10-14 / 18-10-14	Ground Level (mAOD): 127.74	Co-Ordinates ()	
Contractor: Jackson Drilling Limited				Sheet: 1 of 1

SAMPLES & TESTS / STRATA

Depth	Test Type	Test Result	Water	Reduced Level	Legend	Depth (Thickness)	DESCRIPTION	Instrument/ Backfill
						(0.32) 0.32	Strong light grey CONCRETE (MADE GROUND).	
						0.45	Dark grey very silty fine to medium GRAVEL. Gravel sub-angular to sub-rounded of dark grey limestone (SUB BASE). Gravels are very wet.	
						0.50	Dark red to orange very silty fine to medium SAND (MADE GROUND).	
						0.60	Dark grey very silty fine to medium GRAVEL. Gravel sub-angular to sub-rounded of dark grey limestone with occasional coarse size light grey to dark limestone gravels (MADE GROUND).	
						0.75	Red very sandy silty fine to medium GRAVEL. Sand is fine to medium, gravel sub-angular to sub-rounded of grey to yellow sandstones (MADE GROUND).	
						(1.95) 2.70	Light brown orange mottled grey with pockets of dark brown to black sandy very gravelly soft to firm CLAY. Sand is fine and gravels are fine to medium sub-angular to sub-rounded of sandstone and limestone with occasional coarse sized sub-rounded gravels of sandstone and limestone and rare rounded sandstone gravels (Colwall Gelifluctate Formation).	
			1			(1.30) 4.00	Red to brown sandy very gravelly soft CLAY. Gravel sub-angular to sub-rounded fine to occasional medium of dark grey to light grey sandstone (RAGLAN MUDSTONE FORMATION). 20% loss of sample between 3 - 4 metres.	

Boring Progress and Water Observations

Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Depth

Chiselling / Water Added

Chiselling From	Chiselling To	Hours	Water Added From	Water Added To
			0	0.32

GENERAL REMARKS

1) - Position CAT scanned prior to drilling;
2) - Water at 3.65m following completion of drilling, rose to 3m after 20 minutes.
3) - 1m plain pipe with bentonite seal, 3m slotted pipe with gravel filter.

All dimensions in metres Scale 1:25	Client: Herefordshire County Council	Method/ Plant Used: Windowless Sampling Rig	Logged By: Adam James

AGS3 UK BH HYG124 T 141020 AJ COLWALL PRIMARY SCHOOL DRILLING LOGS.GPJ GINT STD AGS 3_1.GDT 10/12/14

HYDROGEO
Groundwater and Environment

Hydrogeo
36 Lion Street
Abergavenny, Monmouthshire, NP7 5NT
Telephone: 01873 856 813

Project				BOREHOLE No
Colwall Primary School				**WS8**
Job No: HYG124	Date: 18-10-14 / 18-10-14	Ground Level (mAOD): 126.84	Co-Ordinates ()	
Contractor: Jackson Drilling Limited				Sheet: 1 of 1

SAMPLES & TESTS / STRATA

Depth	Test Type	Test Result	Water	Reduced Level	Legend	Depth (Thickness)	DESCRIPTION	Instrument/ Backfill
						0.30 (0.30)	Strong light grey CONCRETE (MADE GROUND).	
						0.50 (0.20)	Loose light grey to brown silty very clayey fine to medium GRAVEL sub-angular to angular of limestone and sandstone with occasional coarse gravels (SUB BASE). Gravels very wet underlying the concrete slab layer. 20% loss of sample between base of concrete to 1m depth.	
						1.00 (0.50)	Light brown orange mottled grey with pockets of dark brown to black sandy very gravelly soft to firm CLAY. Sand is fine to medium. Gravels are fine to medium angular to sub-rounded of sandstone and limestone with occasional coarse sized sub-rounded gravels of sandstone and limestone (Colwall Gelifluctate Formation).	
			1			1.35 (0.35)	Loose light grey to brown very clayey fine to medium GRAVEL sub-angular to angular of limestone and sandstone with occasional coarse gravels (Colwall Gelifluctate Formation).	
			1			2.50 (1.15)	Light brown orange mottled sandy gravelly soft to firm CLAY. Sand is fine to medium. Gravels are fine to medium angular to rounded of sandstone with occasional coarse sized sub-rounded gravels of sandstone and limestone (Colwall Gelifluctate Formation). Observed to be less gravelly in comparison to the overlying clay between 0.5 - 1m.	
						4.00 (1.50)	Red to brown sandy very gravelly soft CLAY. Gravel sub-angular to sub-rounded fine to occasional medium of dark grey to light grey sandstone (RAGLAN MUDSTONE FORMATION). 80% loss on recovery of sample between 3 - 4 metres. Gravels remaining within the liner on recovery, very wet.	

Boring Progress and Water Observations

Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Depth

Chiselling / Water Added

Chiselling From	Chiselling To	Hours	Water Added From	Water Added To
			0	0.30

GENERAL REMARKS

1) - Position CAT scanned prior to drilling;
2) - Water at 1.9m following completion of drilling, rose to 1.3m after 20 minutes;
3) - 0.30m plain pipe with bentonite seal, 2.70m slotted pipe with gravel filter.

All dimensions in metres Scale 1:25	Client: Herefordshire County Council	Method/ Plant Used: Windowless Sampling Rig	Logged By: Adam James

Appendix C

Soil Laboratory Results

ALcontrol Laboratories

Unit 7-8 Hawarden Business Park
Manor Road (off Manor Lane)
Hawarden
Deeside
CH5 3US
Tel: (01244) 528700
Fax: (01244) 528701
email: mkt@alcontrol.com
Website: www.alcontrol.com

Hydrogeo Ltd
36c Lion Street,
Abergavenny
Monmouthshire
NP7 5NT

Attention: Adam James

CERTIFICATE OF ANALYSIS

Date:	29 October 2014
Customer:	H_HYDROGEO_MON
Sample Delivery Group (SDG):	141020-18
Your Reference:	HVG124
Location:	Colwall Primary School
Report No:	289795

We received 4 samples on Saturday October 18, 2014 and 4 of these samples were scheduled for analysis which was completed on Wednesday October 29, 2014. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

All chemical testing (unless subcontracted) is performed at ALcontrol Hawarden Laboratories.

Approved By:

Sonia McWhan
Operations Manager

mCERTS THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

ilac-MRA UKAS TESTING 1291

Alcontrol Laboratories is a trading division of ALcontrol UK Limited
Registered Office: Units 7 & 8 Hawarden Business Park, Manor Road, Hawarden, Deeside, CH5 3US. Registered in England and Wales No.

SDG:	141020-18	**Location:**	Colwall Primary School	**Order Number:**	
Job:	H_HYDROGEO_MON-27	**Customer:**	Hydrogeo Ltd	**Report Number:**	289795
Client Reference:	HVG124	**Attention:**	Adam James	**Superseded Report:**	

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
10216829	WS2		3.50 - 3.80	16/10/2014
10216830	WS3		1.70 - 2.00	16/10/2014
10216833	WS5		0.60 - 1.00	16/10/2014
10216836	WS6		3.10 - 3.40	17/10/2014

Only received samples which have had analysis scheduled will be shown on the following pages.

CERTIFICATE OF ANALYSIS

SDG:	141020-18	**Location:**	Colwall Primary School	**Order Number:**	
Job:	H_HYDROGEO_MON-27	**Customer:**	Hydrogeo Ltd	**Report Number:**	289795
Client Reference:	HVG124	**Attention:**	Adam James	**Superseded Report:**	

SOLID

Results Legend

- **X** Test
- **N** No Determination Possible

Lab Sample No(s)			10216829		10216830		10216833		10216836	
Customer Sample Reference			WS2		WS3		WS5		WS6	
AGS Reference										
Depth (m)			3.50 - 3.80		1.70 - 2.00		0.60 - 1.00		3.10 - 3.40	
Container			1kg TUB	400g Tub (ALE214)	1kg TUB	400g Tub (ALE214)	1kg TUB	400g Tub (ALE214)	1kg TUB	400g Tub (ALE214)
Bulk density*	All	NDPs: 0 Tests: 4	X		X		X		X	
Sample description	All	NDPs: 0 Tests: 4		X		X		X		X

SDG:	141020-18	**Location:**	Colwall Primary School	**Order Number:**	
Job:	H_HYDROGEO_MON-27	**Customer:**	Hydrogeo Ltd	**Report Number:**	289795
Client Reference:	HVG124	**Attention:**	Adam James	**Superseded Report:**	

Sample Descriptions

Grain Sizes

very fine	fine	medium	coarse	very coarse
<0.063mm	0.063mm - 0.1mm	0.1mm - 2mm	2mm - 10mm	>10mm

Lab Sample No(s)	Customer Sample Ref.	Depth (m)	Colour	Description	Grain size	Inclusions	Inclusions 2
10216829	WS2	3.50 - 3.80	Red	Clay	0.063 - 0.1 mm	Stones	None
10216830	WS3	1.70 - 2.00	Light Brown	Silt Loam	0.063 - 0.1 mm	Stones	None
10216833	WS5	0.60 - 1.00	Light Brown	Silt Loam	0.063 - 0.1 mm	Stones	None
10216836	WS6	3.10 - 3.40	Red	Clay	0.063 - 0.1 mm	Stones	None

These descriptions are only intended to act as a cross check if sample identities are questioned, and to provide a log of sample matrices with respect to MCERTS validation. They are not intended as full geological descriptions.

We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally ocurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample.

Other coarse granular materials such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

ALcontrol Laboratories

Validated

CERTIFICATE OF ANALYSIS

SDG:	141020-18	**Location:**	Colwall Primary School	**Order Number:**	
Job:	H_HYDROGEO_MON-27	**Customer:**	Hydrogeo Ltd	**Report Number:**	289795
Client Reference:	HVG124	**Attention:**	Adam James	**Superseded Report:**	

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&♦§@	Sample deviation (see appendix)

		Customer Sample R	WS2	WS3	WS5	WS6		
		Depth (m)	3.50 - 3.80	1.70 - 2.00	0.60 - 1.00	3.10 - 3.40		
		Sample Type	Soil/Solid	Soil/Solid	Soil/Solid	Soil/Solid		
		Date Sampled	16/10/2014	16/10/2014	16/10/2014	17/10/2014		
		Sample Time	.	.	.	.		
		Date Received	18/10/2014	18/10/2014	18/10/2014	18/10/2014		
		SDG Ref	141020-18	141020-18	141020-18	141020-18		
		Lab Sample No.(s)	10216829	10216830	10216833	10216836		
		AGS Reference						
Component	**LOD/Units**	**Method**						
Moisture Content Ratio (% of as received sample)	%	PM024	12	12	13	12		
Bulk density report*	-	SUB	See Attached	See Attached	See Attached	See Attached		

10:13:28 29/10/2014

SDG:	141020-18	**Location:**	Colwall Primary School	**Order Number:**	
Job:	H_HYDROGEO_MON-27	**Customer:**	Hydrogeo Ltd	**Report Number:**	289795
Client Reference:	HVG124	**Attention:**	Adam James	**Superseded Report:**	

Table of Results - Appendix

Method No	Reference	Description	Wet/Dry Sample [1]	Surrogate Corrected
PM024	Modified BS 1377	Soil preparation including homogenisation, moisture screens of soils for Asbestos Containing Material		
SUB		Subcontracted Test		
TM133	BS 1377: Part 3 1990;BS 6068-2.5	Determination of pH in Soil and Water using the GLpH pH Meter		

[1] Applies to Solid samples only. DRY indicates samples have been dried at 35°C. NA = not applicable.

SDG:	141020-18	**Location:**	Colwall Primary School	**Order Number:**	
Job:	H_HYDROGEO_MON-27	**Customer:**	Hydrogeo Ltd	**Report Number:**	289795
Client Reference:	HVG124	**Attention:**	Adam James	**Superseded Report:**	

Test Completion Dates

Lab Sample No(s)	10216829	10216830	10216833	10216836
Customer Sample Ref.	WS2	WS3	WS5	WS6
AGS Ref.				
Depth	3.50 - 3.80	1.70 - 2.00	0.60 - 1.00	3.10 - 3.40
Type	SOLID	SOLID	SOLID	SOLID
Bulk density*	29-Oct-2014	29-Oct-2014	29-Oct-2014	29-Oct-2014
Sample description	21-Oct-2014	21-Oct-2014	21-Oct-2014	21-Oct-2014

harrisontesting
SERVICES

Harrison Testing Services
Units 1 & 2 Alston Road
Hellesdon Park Industrial Estate
Norwich NR6 5DS
Tel: +44 (0) 1603 416333
Fax +44 (0) 1603 416443

Client: Alcontrol Laboratories
Unit 7-8 Harwarden Business Park
Harwarden
Deeside
CH5 3US

For the attention of: Kelly Rathbone

Date of Issue: 28/10/2014
Page Number 1 of 2

TEST REPORT TRANSMITTAL

Report Form FMR3000 Rev.C Revision Date 26/11/08

Project	**141020-18**	**Samples received**	**22/10/2014**
Report No	**L18770**	**Instruction received**	**22/10/2014**
Your Ref	**270786**	**Testing commenced**	**24/10/2014**

SUMMARY OF RESULTS ATTACHED

Test Method and Description	Quantity	UKAS Accredited
BS1377: Part 2: 1990:7.3 Bulk Density - Immersion Method	4	No

All of the above tests were performed by Harrison Testing Services at our permanent laboratory premises. No tests were subcontracted to other laboratory facilities

Remarks:

Issued by: M Willson

Approved Signatories:

M Willson (Laboratory Manager), G Bream (Senior Laboratory Technician)

Unless we are notified to the contrary, samples will be disposed after a period of one month from this date
This report should not be reproduced except in full without the written approval of the laboratory
Only those results indicated in this report are UKAS accredited and any opinion or interpretations expressed are outside the scope of UKAS accreditation

A division of Harrison Group Environmental Ltd.
Registered in England No. 1306165 Registered Office: Old Rectory, Flordon, Norfolk NR15 1RL

harrisontesting SERVICES

PROJECT NAME: 141020-18
PROJECT NUMBER: L18770
CLIENT: Alcontrol Laboratories
DATE OF ISSUE: 28/10/2014

DETERMINATION OF BULK & DRY DENSITY (IMMERSION METHOD) TO BS1377 : PART 2 : 1990 : CLAUSE 7.3

BH/TP No.	Sample Depth (m)	Sample No.	Moisture Content (%)	Bulk Density (Mg/m^3)	Dry Density (Mg/m^3)	Sample Description
WS2	3.50-3.80	10226799	17	2.19	1.86	Reddish brown slightly gravelly CLAY
WS3	1.70-2.00	10226806	16	2.21	1.91	Brown slightly gravelly CLAY
WS5	0.60-1.00	10226798	14	2.20	1.93	Brown mottled light grey and grey brown slightly gravelly slightly sandy CLAY
WS6	3.10-3.40	10226791	17	2.21	1.89	Reddish brown silty CLAY

REMARKS (Including any abnormalities or departures from procedure)

Harrison Geotechnical Engineering
Units 1 & 2
Norwich
Norfolk
NR6 5DS
Tel: +44 (0)1603 416333
Fax: +44 (0)1603 416443
email: laboratory@harrisongroupuk.com

Appendix

General

1. Results are expressed on a dry weight basis (dried at 35ºC) for all soil analyses except for the following: NRA and CEN Leach tests, flash point LOI, pH, ammonium as NH4 by the BRE method, VOC TICS and SVOC TICS.

2. Samples will be run in duplicate upon request, but an additional charge may be incurred.

3. If sufficient sample is received a sub sample will be retained free of charge for 30 days after analysis is completed (e-mailed) for all sample types unless the sample is destroyed on testing. The prepared soil sub sample that is analysed for asbestos will be retained for a period of 6 months after the analysis date. All bulk samples will be retained for a period of 6 months after the analysis date. All samples received and not scheduled will be disposed of one month after the date of receipt unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage. ALcontrol Laboratories reserve the right to charge for samples received and stored but not analysed.

4. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.

5. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited by ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.

6. When requested, the individual sub sample scheduled will be analysed in house for the presence of asbestos fibres and asbestos containing material by our documented in house method TM048 based on HSG 248 (2005), which is accredited to ISO17025. If a specific asbestos fibre type is not found this will be reported as "Not detected". If no asbestos fibre types are found all will be reported as "Not detected" and the sub sample analysed deemed to be clear of asbestos. If an asbestos fibre type is found it will be reported as detected (for each fibre type found). Testing can be carried out on asbestos positive samples, but, due to Health and Safety considerations, may be replaced by alternative tests or reported as No Determination Possible. The quantity of asbestos present is not determined unless specifically requested.

7. If no separate volatile sample is supplied by the client, or if a headspace or sediment is present in the volatile sample, the integrity of the data may be compromised. This will be flagged up as an invalid VOC on the test schedule and the result marked as deviating on the test certificate.

8. If appropriate preserved bottles are not received preservation will take place on receipt. However, the integrity of the data may be compromised.

9. NDP -No determination possible due to insufficient/unsuitable sample.

10. Metals in water are performed on a filtered sample, and therefore represent dissolved metals -total metals must be requested separately.

11. Results relate only to the items tested.

12. LODs for wet tests reported on a dry weight basis are not corrected for moisture content.

13. **Surrogate recoveries** -Most of our organic methods include surrogates, the recovery of which is monitored and reported. For EPH, MO, PAH, GRO and VOCs on soils the result is not surrogate corrected, but a percentage recovery is quoted. Acceptable limits for most organic methods are 70 -130 %.

14. **Product analyses** -Organic analyses on products can only be semi-quantitative due to the matrix effects and high dilution factors employed.

15. Phenols monohydric by HPLC include phenol, cresols (2-Methylphenol, 3-Methylphenol and 4-Methylphenol) and Xylenols (2,3 Dimethylphenol, 2,4 Dimethylphenol, 2,5 Dimethylphenol, 2,6 Dimethylphenol, 3,4 Dimethyphenol, 3,5 Dimethylphenol).

16. Total of 5 speciated phenols by HPLC includes Phenol, 2,3,5-Trimethyl Phenol, 2-Isopropylphenol, Cresols and Xylenols (as detailed in 15).

17. Stones/debris are not routinely removed. We always endeavour to take a representative sub sample from the received sample.

18. In certain circumstances the method detection limit may be elevated due to the sample being outside the calibration range. Other factors that may contribute to this include possible interferences. In both cases the sample would be diluted which would cause the method detection limit to be raised.

19. Mercury results quoted on soils will not include volatile mercury as the analysis is performed on a dried and crushed sample.

20. For the BSEN 12457-3 two batch process to allow the cumulative release to be calculated, the volume of the leachate produced is measured and filtered for all tests. We therefore cannot carry out any unfiltered analysis. The tests affected include volatiles GCFID/GCMS and all subcontracted analysis.

21. For all leachate preparations (NRA, DIN, TCLP, BSEN 12457-1, 2, 3) volatile loss may occur, as we do not employ zero headspace extraction.

22. We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample. Other coarse granular material such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

23. Analysis and identification of specific compounds using GCFID is by retention time only, and we routinely calibrate and quantify for benzene, toluene, ethylbenzenes and xylenes (BTEX). For total volatiles in the C5-C12 range, the total area of the chromatogram is integrated and expressed as ug/kg or ug/l. Although this analysis is commonly used for the quantification of gasoline range organics (GRO), the system will also detect other compounds such as chlorinated solvents, and this may lead to a falsely high result with respect to hydrocarbons only. It is not possible to specifically identify these non-hydrocarbons, as standards are not routinely run for any other compounds, and for more definitive identification, volatiles by GCMS should be utilised.

Sample Deviations

1	Container with Headspace provided for volatiles analysis
2	Incorrect container received
3	Deviation from method
4	Holding time exceeded before sample received
5	Samples exceeded holding time before presevation was performed
§	Sampled on date not provided
•	Sample holding time exceeded in laboratory
@	Sample holding time exceeded due to sampled on date
&	Sample Holding Time exceeded - Late arrival of instructions.

Asbestos

Identification of Asbestos in Bulk Materials & Soils

The results for identification of asbestos in bulk materials are obtained from supplied bulk materials which have been examined to determine the presence of asbestos fibres using Alcontrol Laboratories (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

The results for identification of asbestos in soils are obtained from a homogenised sub sample which has been examined to determine the presence of asbestos fibres using Alcontrol Laboratories (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

Asbestos Type	Common Name
Chrysotile	White Asbestos
Amosite	Brown Asbestos
Crocidolite	Blue Asbestos
Fibrous Actinolite	-
Fibrous Anthophyllite	-
Fibrous Tremolite	-

Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than:
- Trace - Where only one or two asbestos fibres were identified.

Further guidance on typical asbestos fibre content of manufactured products can be found in HSG 264.

The identification of asbestos containing materials and soils falls within our schedule of tests for which we hold UKAS accreditation, however opinions, interpretations and all other information contained in the report are outside the scope of UKAS accreditation.

Appendix D

Water Laboratory Results

Unit 7-8 Hawarden Business Park
Manor Road (off Manor Lane)
Hawarden
Deeside
CH5 3US
Tel: (01244) 528700
Fax: (01244) 528701
email: mkt@alcontrol.com
Website: www.alcontrol.com

Hydrogeo Ltd
36c Lion Street,
Abergavenny
Monmouthshire
NP7 5NT

Attention: Adam James

CERTIFICATE OF ANALYSIS

Date:	03 November 2014
Customer:	H_HYDROGEO_MON
Sample Delivery Group (SDG):	141024-39
Your Reference:	HVG124
Location:	Colwall Primary School
Report No:	290362

We received 7 samples on Friday October 24, 2014 and 7 of these samples were scheduled for analysis which was completed on Monday November 03, 2014. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

All chemical testing (unless subcontracted) is performed at ALcontrol Hawarden Laboratories.

Approved By:

Sonia McWhan
Operations Manager

1291

Alcontrol Laboratories is a trading division of ALcontrol UK Limited
Registered Office: Units 7 & 8 Hawarden Business Park, Manor Road, Hawarden, Deeside, CH5 3US. Registered in England and Wales No.

SDG:	141024-39	**Location:**	Colwall Primary School	**Order Number:**	PO-14-0081
Job:	H_HYDROGEO_MON-27	**Customer:**	Hydrogeo Ltd	**Report Number:**	290362
Client Reference:	HVG124	**Attention:**	Adam James	**Superseded Report:**	

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
10250033	WS1		0.00 - 0.00	22/10/2014
10250017	WS2		0.00 - 0.00	22/10/2014
10250010	WS3		0.00 - 0.00	22/10/2014
10250024	WS5		0.00 - 0.00	22/10/2014
10249986	WS6		0.00 - 0.00	22/10/2014
10250003	WS7		0.00 - 0.00	22/10/2014
10249994	WS8		0.00 - 0.00	22/10/2014

Only received samples which have had analysis scheduled will be shown on the following pages.

CERTIFICATE OF ANALYSIS

SDG:	141024-39	**Location:**	Colwall Primary School	**Order Number:**	PO-14-0081
Job:	H_HYDROGEO_MON-27	**Customer:**	Hydrogeo Ltd	**Report Number:**	290362
Client Reference:	HVG124	**Attention:**	Adam James	**Superseded Report:**	

LIQUID

Results Legend

X Test

N No Determination Possible

Lab Sample No(s)			10250033			10250017			10250010				10250024			10249986			10250003			10249994		
Customer Sample Reference			WS1			WS2			WS3				WS5			WS6			WS7			WS8		
AGS Reference																								
Depth (m)			0.00 - 0.00			0.00 - 0.00			0.00 - 0.00				0.00 - 0.00			0.00 - 0.00			0.00 - 0.00			0.00 - 0.00		
Container			1plastic (ALE221)	H2SO4 (ALE244)	NaOH (ALE245)	1plastic (ALE221)	H2SO4 (ALE244)	NaOH (ALE245)	1plastic (ALE221)	H2SO4 (ALE244)	NaOH (ALE245)	Vial (ALE297)	1plastic (ALE221)	H2SO4 (ALE244)	NaOH (ALE245)	1plastic (ALE221)	H2SO4 (ALE244)	NaOH (ALE245)	1plastic (ALE221)	H2SO4 (ALE244)	NaOH (ALE245)	1plastic (ALE221)	H2SO4 (ALE244)	NaOH (ALE245)
Alkalinity Filtered as CaCO3	All	NDPs: 0 Tests: 7	X			X			X				X			X			X			X		
Ammoniacal Nitrogen	All	NDPs: 0 Tests: 7		X			X			X				X			X			X			X	
Anions by Kone (w)	All	NDPs: 0 Tests: 7	X			X			X				X			X			X			X		
Conductivity (at 20 deg.C)	All	NDPs: 0 Tests: 7	X			X			X				X			X			X			X		
Ionic Balance	All	NDPs: 0 Tests: 7	X			X			X				X			X			X			X		
Low Level VOCs in Water	All	NDPs: 0 Tests: 1										X												
Metals by iCap-OES Dissolved (W)	All	NDPs: 0 Tests: 7	X			X			X				X			X			X			X		
Nitrite by Kone (w)	All	NDPs: 0 Tests: 7			X			X			X				X			X			X			X
pH Value	All	NDPs: 0 Tests: 7	X			X			X				X			X			X			X		

ALcontrol Laboratories

Validated

CERTIFICATE OF ANALYSIS

SDG:	141024-39	**Location:**	Colwall Primary School	**Order Number:**	PO-14-0081
Job:	H_HYDROGEO_MON-27	**Customer:**	Hydrogeo Ltd	**Report Number:**	290362
Client Reference:	HVG124	**Attention:**	Adam James	**Superseded Report:**	

Results Legend

#	ISO17025 accredited.
M	mCERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Customer Sample R	WS1	WS2	WS3	WS5	WS6	WS7
Depth (m)	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00
Sample Type	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)
Date Sampled	22/10/2014	22/10/2014	22/10/2014	22/10/2014	22/10/2014	22/10/2014
Sample Time	.	.	.	.	.	.
Date Received	24/10/2014	24/10/2014	24/10/2014	24/10/2014	24/10/2014	24/10/2014
SDG Ref	141024-39	141024-39	141024-39	141024-39	141024-39	141024-39
Lab Sample No.(s)	10250033	10250017	10250010	10250024	10249986	10250003
AGS Reference						

Component	LOD/Units	Method	WS1	WS2	WS3	WS5	WS6	WS7
Ionic balance	% Diff	Calulation	-7.44	-6.24	-5.25	-5.63	-4.48	-5
Alkalinity,Total as CaCO3 (diss.filt)	<2 mg/l	TM043	280	195	185	190	150	200
Alkalinity, Bicarbonate as CaCO3 (diss.filt)	<2 mg/l	TM043	280	195	185	190	150	200
Ammoniacal Nitrogen as N	<0.2 mg/l	TM099	<0.2 #	<0.2 #	<0.2 #	0.256 #	<0.2 #	0.291 #
Conductivity @ 20 deg.C	<0.005 mS/cm	TM120	0.668 #	0.565 #	0.484 #	0.599 #	0.594 #	0.603 #
Nitrite as NO2	<0.05 mg/l	TM184	<0.05 #	<0.05 #	0.65 #	1.62 #	2.38 #	<0.05 #
Sulphate	<2 mg/l	TM184	59.8 #	41.8 #	58 #	42.3 #	37.7 #	45.9 #
Chloride	<2 mg/l	TM184	60.2 #	65.4 #	25.4 #	82.8 #	88.9 #	71.7 #
Nitrate as NO3	<0.3 mg/l	TM184	<0.3 #	0.443 #	9.02 #	0.414 #	7.14 #	<0.3 #
Calcium (diss.filt)	<0.012 mg/l	TM228	73.4 #	58.7 #	60.1 #	65.6 #	70.1 #	73.8 #
Sodium (diss.filt)	<0.076 mg/l	TM228	28.1 #	25.6 #	22.5 #	23.7 #	20.6 #	17.3 #
Magnesium (diss.filt)	<0.036 mg/l	TM228	30.1 #	21.9 #	13.7 #	23.7 #	17.8 #	22.6 #
Potassium (diss.filt)	<1 mg/l	TM228	<1 #	1.1 #	3.65 #	1.49 #	1.12 #	1.23 #
Iron (diss.filt)	<0.019 mg/l	TM228	<0.019 #	0.0571 #	<0.019 #	<0.019 #	<0.019 #	<0.019 #
pH	<1 pH Units	TM256	7.02 #	7.11 #	7.63 #	6.89 #	7.21 #	7.39 #
Vinyl chloride	<0.0001 mg/l	TM265			<0.0001 #			
Chloroethane	<0.0002 mg/l	TM265			<0.0002 #			
Trichlorofluoromethane	<0.0001 mg/l	TM265			<0.0001 #			
1,1-Dichloroethene	<0.0001 mg/l	TM265			<0.0001 #			
Trans-1,2-Dichloroethene	<0.0001 mg/l	TM265			<0.0001 #			
1,1-Dichloroethane	<0.0001 mg/l	TM265			<0.0001 #			
Cis-1,2-Dichloroethene	<0.0001 mg/l	TM265			<0.0001 #			
Bromochloromethane	<0.0002 mg/l	TM265			<0.0002 #			
Chloroform	<0.0002 mg/l	TM265			<0.0002 #			
1,1,1-Trichloroethane	<0.0001 mg/l	TM265			<0.0001 #			
1,1-Dichloropropene	<0.0001 mg/l	TM265			<0.0001 #			
Carbontetrachloride	<0.0001 mg/l	TM265			<0.0001 #			
1,2-Dichloroethane	<0.0002 mg/l	TM265			<0.0002 #			
Benzene	<0.0002 mg/l	TM265			<0.0002 #			
Trichloroethene	<0.0001 mg/l	TM265			<0.0001 #			
1,2-Dichloropropane	<0.0002 mg/l	TM265			<0.0002 #			
Dibromomethane	<0.0001 mg/l	TM265			<0.0001 #			

Results Legend

#	ISO17025 accredited.
M	mCERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&•§@	Sample deviation (see appendix)

Customer Sample R			WS1	WS2	WS3	WS5	WS6	WS7
Depth (m)			0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00
Sample Type			Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)
Date Sampled			22/10/2014	22/10/2014	22/10/2014	22/10/2014	22/10/2014	22/10/2014
Sample Time			.	.	.	.	.	.
Date Received			24/10/2014	24/10/2014	24/10/2014	24/10/2014	24/10/2014	24/10/2014
SDG Ref			141024-39	141024-39	141024-39	141024-39	141024-39	141024-39
Lab Sample No.(s)			10250033	10250017	10250010	10250024	10249986	10250003
AGS Reference								
Component	**LOD/Units**	**Method**						
Bromodichloromethane	<0.0001 mg/l	TM265			<0.0001 #			
cis-1,3-Dichloropropene	<0.0001 mg/l	TM265			<0.0001 #			
Toluene	<0.0002 mg/l	TM265			<0.0002 #			
trans-1,3-Dichloropropene	<0.0002 mg/l	TM265			<0.0002 #			
1,1,2-Trichloroethane	<0.0001 mg/l	TM265			<0.0001 #			
1,3-Dichloropropane	<0.0001 mg/l	TM265			<0.0001 #			
Tetrachloroethene	<0.0001 mg/l	TM265			<0.0001 #			
Dibromochloromethane	<0.0001 mg/l	TM265			<0.0001 #			
1,2-Dibromoethane	<0.0001 mg/l	TM265			<0.0001 #			
Chlorobenzene	<0.0006 mg/l	TM265			<0.0006 #			
1,1,1,2-Tetrachloroethane	<0.0001 mg/l	TM265			<0.0001 #			
Ethylbenzene	<0.0001 mg/l	TM265			<0.0001 #			
m,p-Xylene	<0.0002 mg/l	TM265			<0.0002 #			
o-Xylene	<0.0002 mg/l	TM265			<0.0002 #			
Styrene	<0.0001 mg/l	TM265			<0.0001 #			
Bromoform	<0.0001 mg/l	TM265			0.00011 #			
Isopropylbenzene	<0.0001 mg/l	TM265			<0.0001 #			
1,1,2,2-Tetrachloroethane	<0.0001 mg/l	TM265			<0.0001 #			
1,2,3-Trichloropropane	<0.0003 mg/l	TM265			<0.0003 #			
Bromobenzene	<0.0001 mg/l	TM265			<0.0001 #			
Propylbenzene	<0.0001 mg/l	TM265			<0.0001 #			
2-Chlorotoluene	<0.0001 mg/l	TM265			<0.0001 #			
1,3,5-Trimethylbenzene	<0.0001 mg/l	TM265			<0.0001 #			
4-Chlorotoluene	<0.0001 mg/l	TM265			<0.0001 #			
tert-Butylbenzene	<0.0001 mg/l	TM265			<0.0001 #			
1,2,4-Trimethylbenzene	<0.0001 mg/l	TM265			<0.0001 #			
sec-Butylbenzene	<0.0001 mg/l	TM265			<0.0001 #			
4-iso-Propyltoluene	<0.0001 mg/l	TM265			<0.0001 #			
1,3-Dichlorobenzene	<0.0001 mg/l	TM265			<0.0001 #			
1,4-Dichlorobenzene	<0.0001 mg/l	TM265			<0.0001 #			
n-Butylbenzene	<0.0001 mg/l	TM265			<0.0001 #			
1,2-Dichlorobenzene	<0.0001 mg/l	TM265			<0.0001 #			

Results Legend

#	ISO17025 accredited.
M	mCERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&•§@	Sample deviation (see appendix)

Customer Sample R			WS1	WS2	WS3	WS5	WS6	WS7
Depth (m)			0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00
Sample Type			Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)
Date Sampled			22/10/2014	22/10/2014	22/10/2014	22/10/2014	22/10/2014	22/10/2014
Sample Time			.	.	.	.	.	.
Date Received			24/10/2014	24/10/2014	24/10/2014	24/10/2014	24/10/2014	24/10/2014
SDG Ref			141024-39	141024-39	141024-39	141024-39	141024-39	141024-39
Lab Sample No.(s)			10250033	10250017	10250010	10250024	10249986	10250003
AGS Reference								
Component	**LOD/Units**	**Method**						
1,2-Dibromo-3-chloropropane	<0.0002 mg/l	TM265			<0.0002 #			
1,2,4-Trichlorobenzene	<0.0001 mg/l	TM265			<0.0001 #			
Hexachlorobutadiene	<0.0001 mg/l	TM265			<0.0001 #			
Naphthalene	<0.0001 mg/l	TM265			<0.0001 #			
1,2,3-Trichlorobenzene	<0.0001 mg/l	TM265			<0.0001 #			

ALcontrol Laboratories

CERTIFICATE OF ANALYSIS

Validated

SDG:	141024-39	**Location:**	Colwall Primary School	**Order Number:**	PO-14-0081
Job:	H_HYDROGEO_MON-27	**Customer:**	Hydrogeo Ltd	**Report Number:**	290362
Client Reference:	HVG124	**Attention:**	Adam James	**Superseded Report:**	

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&♦§@	Sample deviation (see appendix)

		Customer Sample R	WS8						
		Depth (m)	0.00 - 0.00						
		Sample Type	Water(GW/SW)						
		Date Sampled	22/10/2014						
		Sample Time	.						
		Date Received	24/10/2014						
		SDG Ref	141024-39						
		Lab Sample No.(s)	10249994						
		AGS Reference							
Component	**LOD/Units**	**Method**							
Ionic balance	% Diff	Calulation	-4.64						
Alkalinity,Total as CaCO3 (diss.filt)	<2 mg/l	TM043	100						
Alkalinity, Bicarbonate as CaCO3 (diss.filt)	<2 mg/l	TM043	40						
Ammoniacal Nitrogen as N	<0.2 mg/l	TM099	0.745 #						
Conductivity @ 20 deg.C	<0.005 mS/cm	TM120	0.48 #						
Nitrite as NO2	<0.05 mg/l	TM184	1.8 #						
Sulphate	<2 mg/l	TM184	67.8 #						
Chloride	<2 mg/l	TM184	52.9 #						
Nitrate as NO3	<0.3 mg/l	TM184	<0.3 #						
Calcium (diss.filt)	<0.012 mg/l	TM228	10.1 #						
Sodium (diss.filt)	<0.076 mg/l	TM228	64.8 #						
Magnesium (diss.filt)	<0.036 mg/l	TM228	4.61 #						
Potassium (diss.filt)	<1 mg/l	TM228	27.9 #						
Iron (diss.filt)	<0.019 mg/l	TM228	<0.019 #						
pH	<1 pH Units	TM256	9.55 #						

SDG:	141024-39	**Location:**	Colwall Primary School	**Order Number:**	PO-14-0081
Job:	H_HYDROGEO_MON-27	**Customer:**	Hydrogeo Ltd	**Report Number:**	290362
Client Reference:	HVG124	**Attention:**	Adam James	**Superseded Report:**	

Table of Results - Appendix

Method No	Reference	Description	Wet/Dry Sample [1]	Surrogate Corrected
Calulation				
TM043	Method 2320B, AWWA/APHA, 20th Ed., 1999 / BS 2690: Part109 1984	Determination of alkalinity in aqueous samples		
TM099	BS 2690: Part 7:1968 / BS 6068: Part2.11:1984	Determination of Ammonium in Water Samples using the Kone Analyser		
TM120	Method 2510B, AWWA/APHA, 20th Ed., 1999 / BS 2690: Part 9:1970	Determination of Electrical Conductivity using a Conductivity Meter		
TM184	EPA Methods 325.1 & 325.2,	The Determination of Anions in Aqueous Matrices using the Kone Spectrophotometric Analysers		
TM208	Modified: US EPA Method 8260b & 624	Determination of Volatile Organic Compounds by Headspace / GC-MS in Waters		
TM228	US EPA Method 6010B	Determination of Major Cations in Water by iCap 6500 Duo ICP-OES		
TM256	The measurement of Electrical Conductivity and the Laboratory determination of pH Value of Natural, Treated and Wastewaters. HMSO, 1978. ISBN 011 751428 4.	Determination of pH in Water and Leachate using the GLpH pH Meter		
TM265				

[1] Applies to Solid samples only. DRY indicates samples have been dried at 35°C. NA = not applicable.

SDG:	141024-39	**Location:**	Colwall Primary School	**Order Number:**	PO-14-0081
Job:	H_HYDROGEO_MON-27	**Customer:**	Hydrogeo Ltd	**Report Number:**	290362
Client Reference:	HVG124	**Attention:**	Adam James	**Superseded Report:**	

Test Completion Dates

Lab Sample No(s)	10250033	10250017	10250010	10250024	10249986	10250003	10249994
Customer Sample Ref.	WS1	WS2	WS3	WS5	WS6	WS7	WS8
AGS Ref.							
Depth	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00
Type	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID	LIQUID
Alkalinity Filtered as CaCO3	31-Oct-2014	31-Oct-2014	31-Oct-2014	31-Oct-2014	31-Oct-2014	31-Oct-2014	31-Oct-2014
Ammoniacal Nitrogen	29-Oct-2014	29-Oct-2014	29-Oct-2014	29-Oct-2014	29-Oct-2014	29-Oct-2014	29-Oct-2014
Anions by Kone (w)	31-Oct-2014	31-Oct-2014	31-Oct-2014	31-Oct-2014	31-Oct-2014	31-Oct-2014	31-Oct-2014
Conductivity (at 20 deg.C)	28-Oct-2014	28-Oct-2014	03-Nov-2014	28-Oct-2014	31-Oct-2014	31-Oct-2014	31-Oct-2014
Ionic Balance	31-Oct-2014	31-Oct-2014	31-Oct-2014	31-Oct-2014	31-Oct-2014	31-Oct-2014	31-Oct-2014
Low Level VOCs in Water			29-Oct-2014				
Metals by iCap-OES Dissolved (W)	29-Oct-2014	29-Oct-2014	29-Oct-2014	29-Oct-2014	29-Oct-2014	29-Oct-2014	29-Oct-2014
Nitrite by Kone (w)	30-Oct-2014	30-Oct-2014	30-Oct-2014	30-Oct-2014	30-Oct-2014	30-Oct-2014	30-Oct-2014
pH Value	27-Oct-2014	27-Oct-2014	28-Oct-2014	27-Oct-2014	28-Oct-2014	28-Oct-2014	29-Oct-2014

Appendix

General

1. Results are expressed on a dry weight basis (dried at 35ºC) for all soil analyses except for the following: NRA and CEN Leach tests, flash point LOI, pH, ammonium as NH4 by the BRE method, VOC TICS and SVOC TICS.

2. Samples will be run in duplicate upon request, but an additional charge may be incurred.

3. If sufficient sample is received a sub sample will be retained free of charge for 30 days after analysis is completed (e-mailed) for all sample types unless the sample is destroyed on testing. The prepared soil sub sample that is analysed for asbestos will be retained for a period of 6 months after the analysis date. All bulk samples will be retained for a period of 6 months after the analysis date. All samples received and not scheduled will be disposed of one month after the date of receipt unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage. ALcontrol Laboratories reserve the right to charge for samples received and stored but not analysed.

4. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.

5. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited by ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.

6. When requested, the individual sub sample scheduled will be analysed in house for the presence of asbestos fibres and asbestos containing material by our documented in house method TM048 based on HSG 248 (2005), which is accredited to ISO17025. If a specific asbestos fibre type is not found this will be reported as “Not detected”. If no asbestos fibre types are found all will be reported as “Not detected” and the sub sample analysed deemed to be clear of asbestos. If an asbestos fibre type is found it will be reported as detected (for each fibre type found). Testing can be carried out on asbestos positive samples, but, due to Health and Safety considerations, may be replaced by alternative tests or reported as No Determination Possible. The quantity of asbestos present is not determined unless specifically requested.

7. If no separate volatile sample is supplied by the client, or if a headspace or sediment is present in the volatile sample, the integrity of the data may be compromised. This will be flagged up as an invalid VOC on the test schedule and the result marked as deviating on the test certificate.

8. If appropriate preserved bottles are not received preservation will take place on receipt. However, the integrity of the data may be compromised.

9. NDP -No determination possible due to insufficient/unsuitable sample.

10. Metals in water are performed on a filtered sample, and therefore represent dissolved metals -total metals must be requested separately.

11. Results relate only to the items tested.

12. LODs for wet tests reported on a dry weight basis are not corrected for moisture content.

13. **Surrogate recoveries** -Most of our organic methods include surrogates, the recovery of which is monitored and reported. For EPH, MO, PAH, GRO and VOCs on soils the result is not surrogate corrected, but a percentage recovery is quoted. Acceptable limits for most organic methods are 70 -130 %.

14. **Product analyses** -Organic analyses on products can only be semi-quantitative due to the matrix effects and high dilution factors
employed.

15. Phenols monohydric by HPLC include phenol, cresols (2-Methylphenol, 3-Methylphenol and 4-Methylphenol) and Xylenols (2,3 Dimethylphenol, 2,4 Dimethylphenol, 2,5 Dimethylphenol, 2,6 Dimethylphenol, 3,4 Dimethyphenol, 3,5 Dimethylphenol).

16. Total of 5 speciated phenols by HPLC includes Phenol, 2,3,5-Trimethyl Phenol, 2-Isopropylphenol, Cresols and Xylenols (as detailed in 15).

17. Stones/debris are not routinely removed. We always endeavour to take a representative sub sample from the received sample.

18. In certain circumstances the method detection limit may be elevated due to the sample being outside the calibration range. Other factors that may contribute to this include possible interferences. In both cases the sample would be diluted which would cause the method detection limit to be raised.

19. Mercury results quoted on soils will not include volatile mercury as the analysis is performed on a dried and crushed sample.

20. For the BSEN 12457-3 two batch process to allow the cumulative release to be calculated, the volume of the leachate produced is measured and filtered for all tests. We therefore cannot carry out any unfiltered analysis. The tests affected include volatiles GCFID/GCMS and all subcontracted analysis.

21. For all leachate preparations (NRA, DIN, TCLP, BSEN 12457-1, 2, 3) volatile loss may occur, as we do not employ zero headspace extraction.

22. We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample. Other coarse granular material such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

23. Analysis and identification of specific compounds using GCFID is by retention time only, and we routinely calibrate and quantify for benzene, toluene, ethylbenzenes and xylenes (BTEX). For total volatiles in the C5-C12 range, the total area of the chromatogram is integrated and expressed as ug/kg or ug/l. Although this analysis is commonly used for the quantification of gasoline range organics (GRO), the system will also detect other compounds such as chlorinated solvents, and this may lead to a falsely high result with respect to hydrocarbons only. It is not possible to specifically identify these non-hydrocarbons, as standards are not routinely run for any other compounds, and for more definitive identification, volatiles by GCMS should be utilised.

Sample Deviations

1	Container with Headspace provided for volatiles analysis
2	Incorrect container received
3	Deviation from method
4	Holding time exceeded before sample received
5	Samples exceeded holding time before presevation was performed
§	Sampled on date not provided
•	Sample holding time exceeded in laboratory
@	Sample holding time exceeded due to sampled on date
&	Sample Holding Time exceeded - Late arrival of instructions.

Asbestos

Identification of Asbestos in Bulk Materials & Soils

The results for identification of asbestos in bulk materials are obtained from supplied bulk materials which have been examined to determine the presence of asbestos fibres using Alcontrol Laboratories (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

The results for identification of asbestos in soils are obtained from a homogenised sub sample which has been examined to determine the presence of asbestos fibres using Alcontrol Laboratories (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

Asbestos Type	Common Name
Chrysotile	White Asbestos
Amosite	Brown Asbestos
Crocidolite	Blue Asbestos
Fibrous Actinolite	-
Fibrous Anthophyllite	-
Fibrous Tremolite	-

Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than:
- Trace - Where only one or two asbestos fibres were identified.

Further guidance on typical asbestos fibre content of manufactured products can be found in HSG 264.

The identification of asbestos containing materials and soils falls within our schedule of tests for which we hold UKAS accreditation, however opinions, interpretations and all other information contained in the report are outside the scope of UKAS accreditation.

Appendix E

Groundwater Level Dips

Groundwater Level (mbgl)

Trial Hole ID	27/05/2014	08/10/2014	17/10/2014	22/10/2014	29/10/2014	18/11/2014	Min	Max	Average	Range
Trial Hole 1	0.60	0.43	0.44	0.45	0.46	0.44	0.43	0.60	0.47	0.17
Trial Hole 2	0.17	0.45	0.13	0.12	0.12	0.12	0.12	0.45	0.19	0.33
Trial Hole 3	0.31	0.33	0.27	0.33	0.34	0.26	0.26	0.34	0.31	0.08
Trial Hole 4	0.79	0.82	0.75	DRY	-	0.72	0.72	0.82	0.77	0.10
Trial Hole 5	0.47	0.43	0.43	0.49	0.51	0.42	0.42	0.51	0.46	0.09
Trial Hole 6	0.43	0.69	0.48	0.54	0.62	0.33	0.33	0.69	0.52	0.36
Trial Hole 7	0.67	0.50	0.51	0.52	0.57	0.46	0.46	0.67	0.54	0.21
WS1	-	-	0.96	1.06	1.08	0.84	0.84	1.08	0.99	0.24
WS2	-	-	0.56	0.63	0.67	0.5	0.50	0.67	0.59	0.17
WS3	-	-	0.47	0.49	0.52	0.46	0.46	0.52	0.49	0.06
WS4	-	-	DRY	DRY	DRY	DRY				
WS5	-	-	0.90	0.94	0.95	0.72	0.72	0.95	0.88	0.23
WS6	-	-	-	1.44	1.38	1.29	1.29	1.44	1.37	0.15
WS7	-	-	-	1.09	1.10	0.94	0.94	1.10	1.04	0.16
WS8	-	-	-	0.89	0.48	0.6	0.48	0.89	0.66	0.41

Groundwater Level (mAOD)

Trial Hole ID	Ground Level	27/05/2014	08/10/2014	17/10/2014	22/10/2014	29/10/2014	18/11/2014	Min	Max	Average
Trial Hole 1	127.29	126.69	126.86	126.85	126.84	126.83	126.85	126.69	126.86	126.82
Trial Hole 2	127.05	126.88	126.6	126.92	126.93	126.93	126.93	126.6	126.93	126.87
Trial Hole 3	126.83	126.52	126.5	126.56	126.5	126.49	126.57	126.49	126.57	126.52
Trial Hole 4	126.65	125.86	125.83	125.9			125.93	125.83	125.93	125.88
Trial Hole 5	127.22	126.75	126.79	126.79	126.73	126.71	126.8	126.71	126.8	126.76
Trial Hole 6	127.82	127.39	127.13	127.34	127.28	127.2	127.49	127.13	127.49	127.31
Trial Hole 7	127.53	126.86	127.03	127.02	127.01	126.96	127.07	126.86	127.07	126.99
WS1	127.74			126.78	126.68	126.66	126.9	126.66	126.9	126.76
WS2	127.72			127.16	127.09	127.05	127.22	127.05	127.22	127.13
WS3	127.52			127.05	127.03	127	127.06	127	127.06	127.04
WS4	126.96									
WS5	127.72			126.82	126.78	126.77	127	126.77	127	126.84
WS6	126.84				125.4	125.46	125.55	125.4	125.55	125.47
WS7	127.74				126.65	126.64	126.8	126.64	126.8	126.70
WS8	126.84				125.95	126.36	126.24	125.95	126.36	126.18

Dip to Base (mbgl)

Trial Hole ID	22/10/2014	18/11/2014
Trial Hole 1	0.64	0.64
Trial Hole 2	0.64	0.64
Trial Hole 3	0.79	0.79
Trial Hole 4	0.87	0.87
Trial Hole 5	0.66	0.66
Trial Hole 6	0.72	0.72
Trial Hole 7	0.69	0.69
WS1	3.82	3.64
WS2	3.86	3.72
WS3	3.15	2.92
WS4	4	4
WS5	3.94	3.91
WS6	3.95	3.92
WS7	3.95	3.91
WS8	2.94	2.9

Dip to Base (mAOD)

Trial Hole ID	22/10/2014	18/11/2014
Trial Hole 1	126.65	126.65
Trial Hole 2	126.41	126.41
Trial Hole 3	126.04	126.04
Trial Hole 4	125.78	125.78
Trial Hole 5	126.56	126.56
Trial Hole 6	127.1	127.1
Trial Hole 7	126.84	126.84
WS1	123.92	124.1
WS2	123.86	124
WS3	124.37	124.6
WS4	122.96	122.96
WS5	123.78	123.81
WS6	122.89	122.92
WS7	123.79	123.83
WS8	123.9	123.94

Appendix F

EA Remedial Target Spreadsheet – Porosity Calculator

Porosity Calculator

These results are not carried through to any of the other worksheets

DRY BULK DENSITY DATA

Variable	Value	Unit	justification
Natural Moisture Content	17.00	% wt	
Particle Density	2.78	tonnes/m^3	(Change this number only if you have specific information)
Dry Bulk Density	1.86	tonnes/m^3	
Calculated Parameters			
Voids Ratio	0.49	fraction	
Initial Saturation	95.55	*%*	
Total porosity	**0.331**	**fraction**	
Air Filled Porosity	**0.015**	**fraction**	
Water Filled Porosity	**0.316**	**fraction**	

WET BULK DENSITY DATA

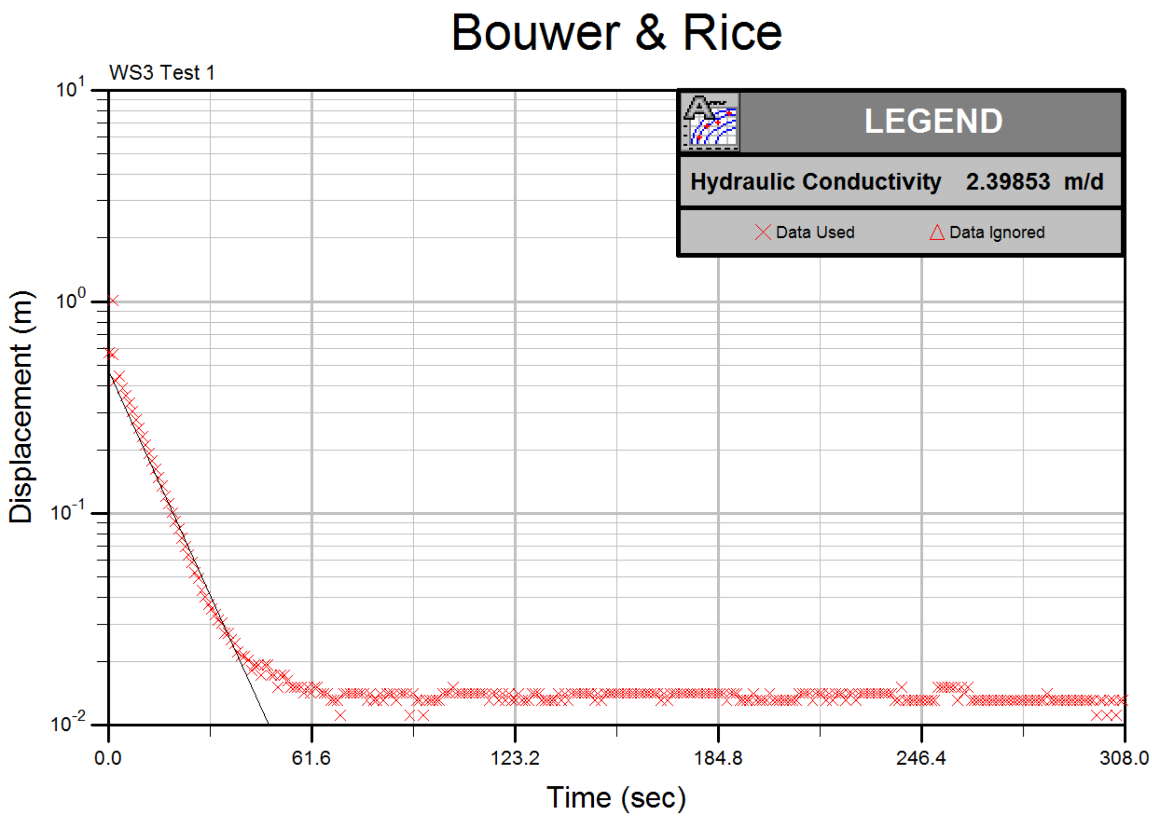
Variable	Value	Unit	
Moisture Content	0.00	% wt	
Particle Density	2.78	tonnes/m^3	(Change this number only if you have specific information)
Actual (wet) Bulk Density (i.e. at natural MC)	0.00	tonnes/m^3	
Calculated Parameters			
Voids Ratio	#DIV/0!	fraction	
dry bulk density	0.00	tonnes/m^3	
Initial Saturation	#DIV/0!	*%*	
Total porosity	**1.000**	**fraction**	**#DIV/0!**
Air Filled Porosity	**#DIV/0!**	**fraction**	
Water Filled Porosity	**#DIV/0!**	**fraction**	

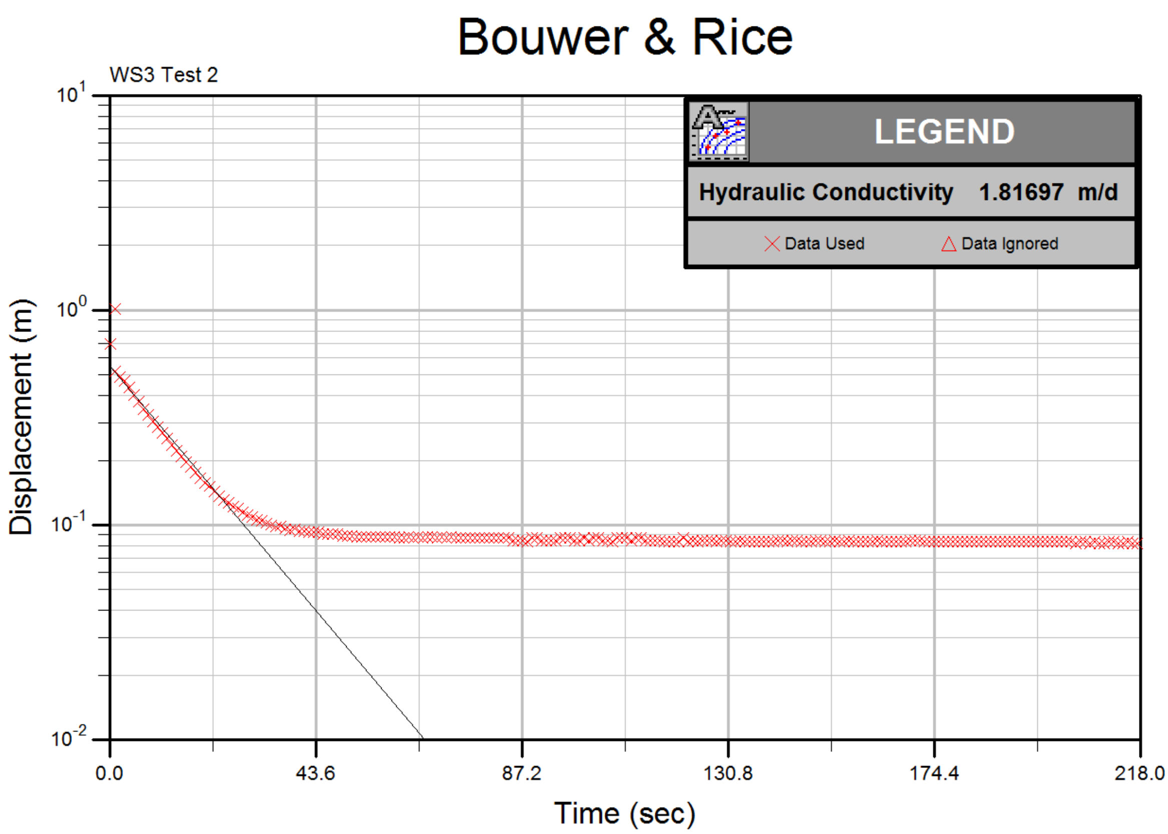
Analytical solutions provided by David Hall, Golder Associates (UK) Ltd

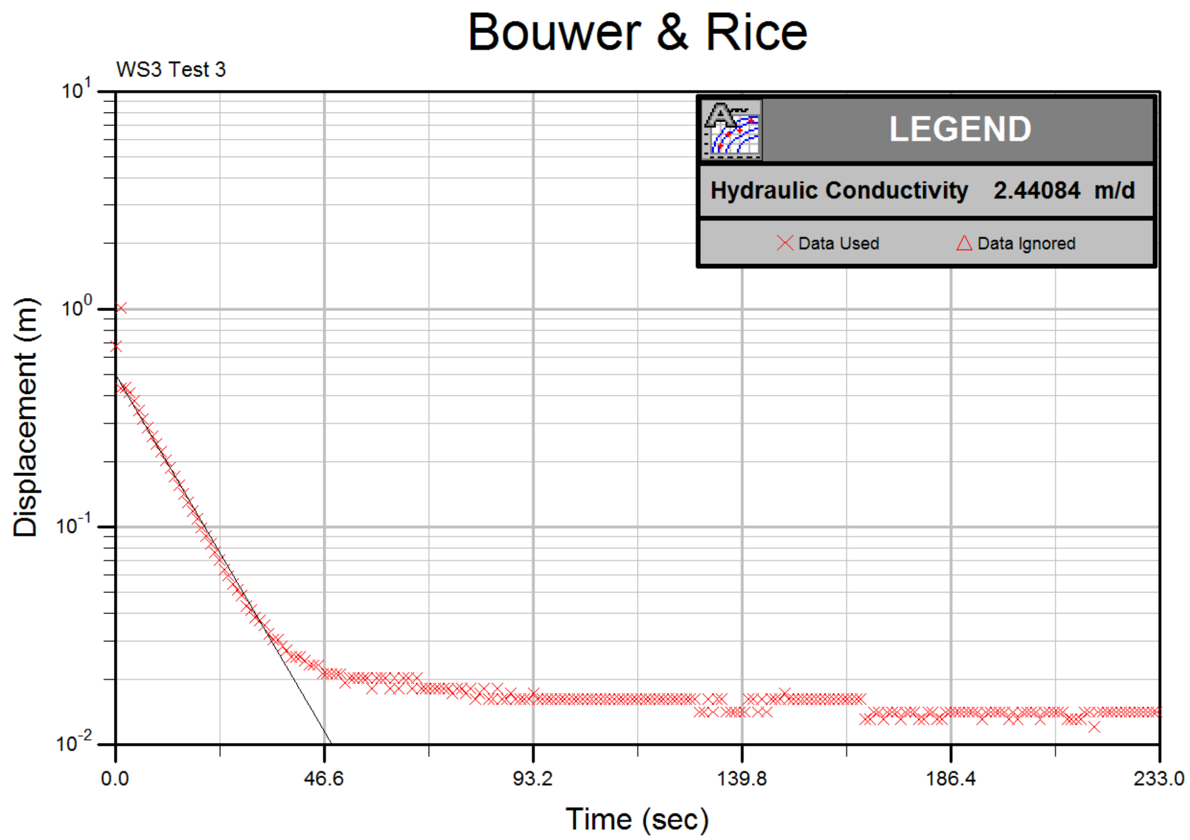
Appendix G

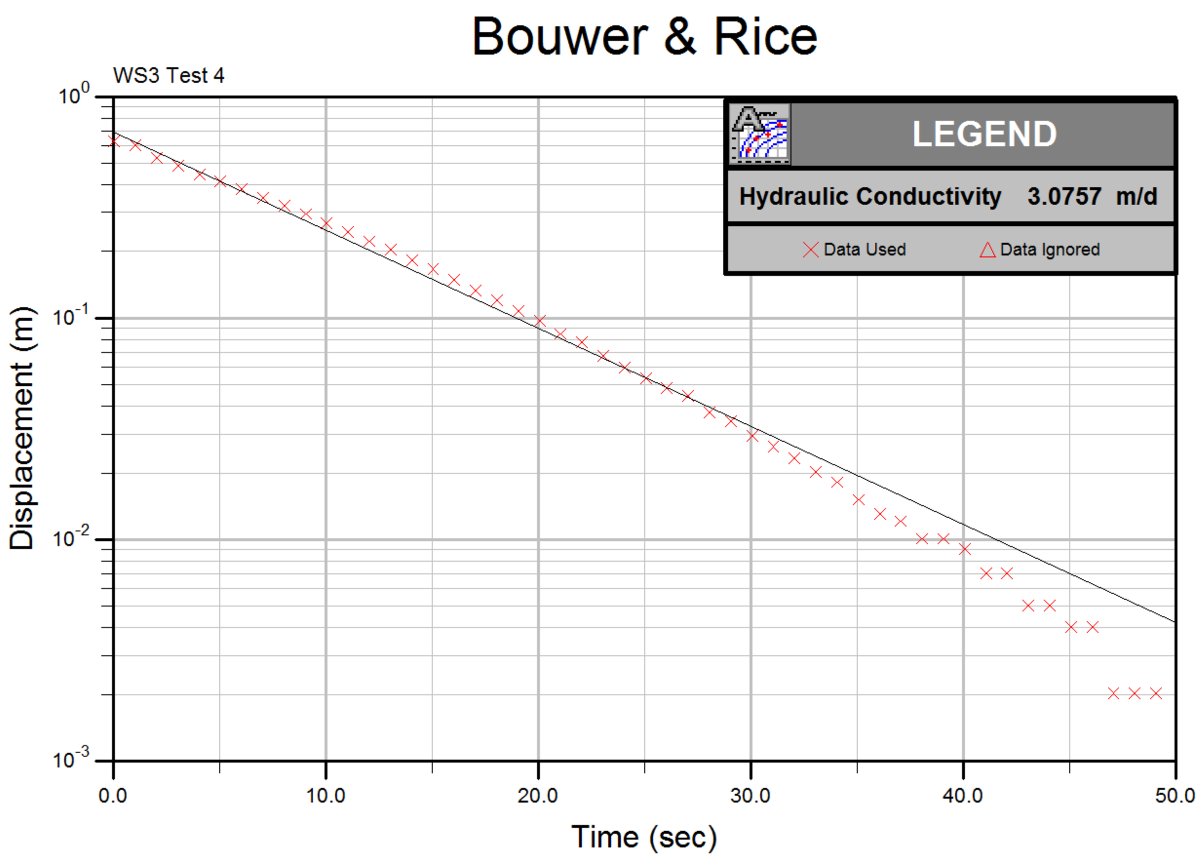
Permeability Test Outputs

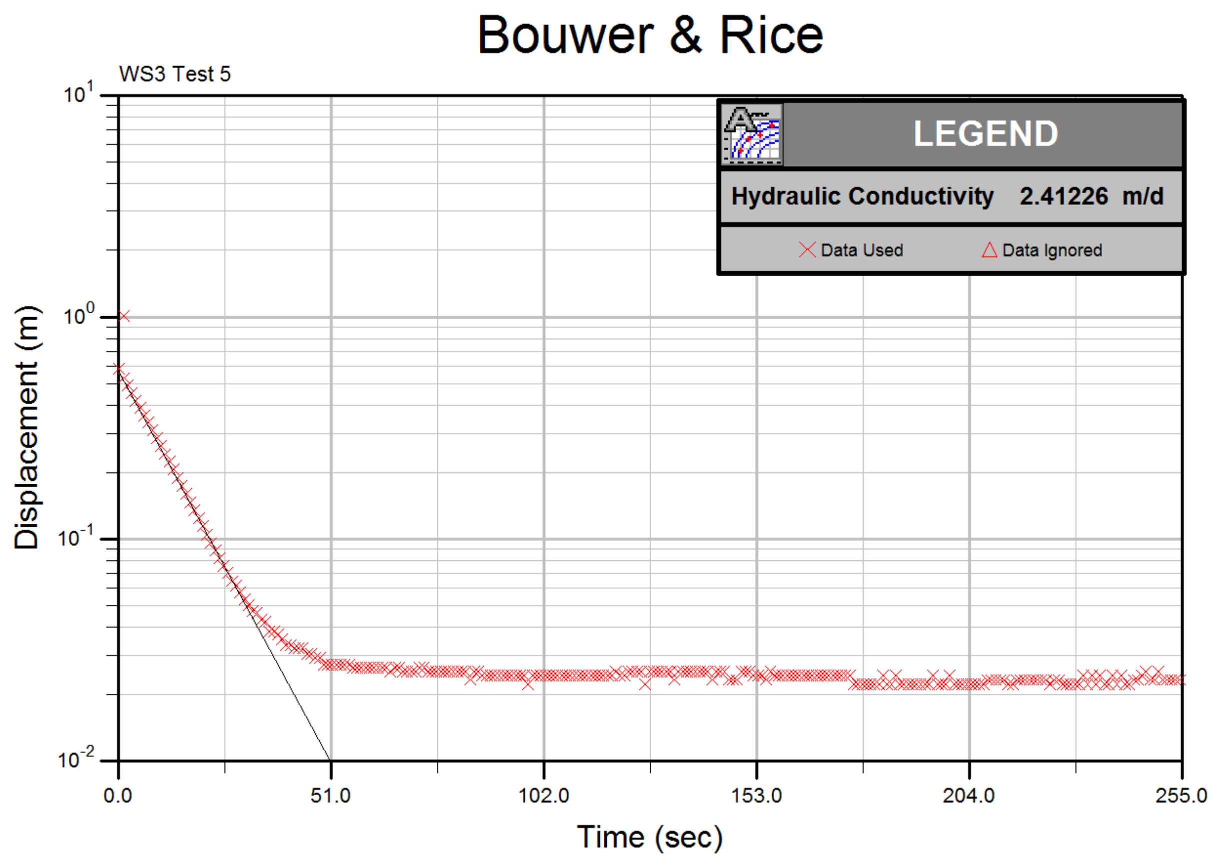
Permeability Test Data Outputs

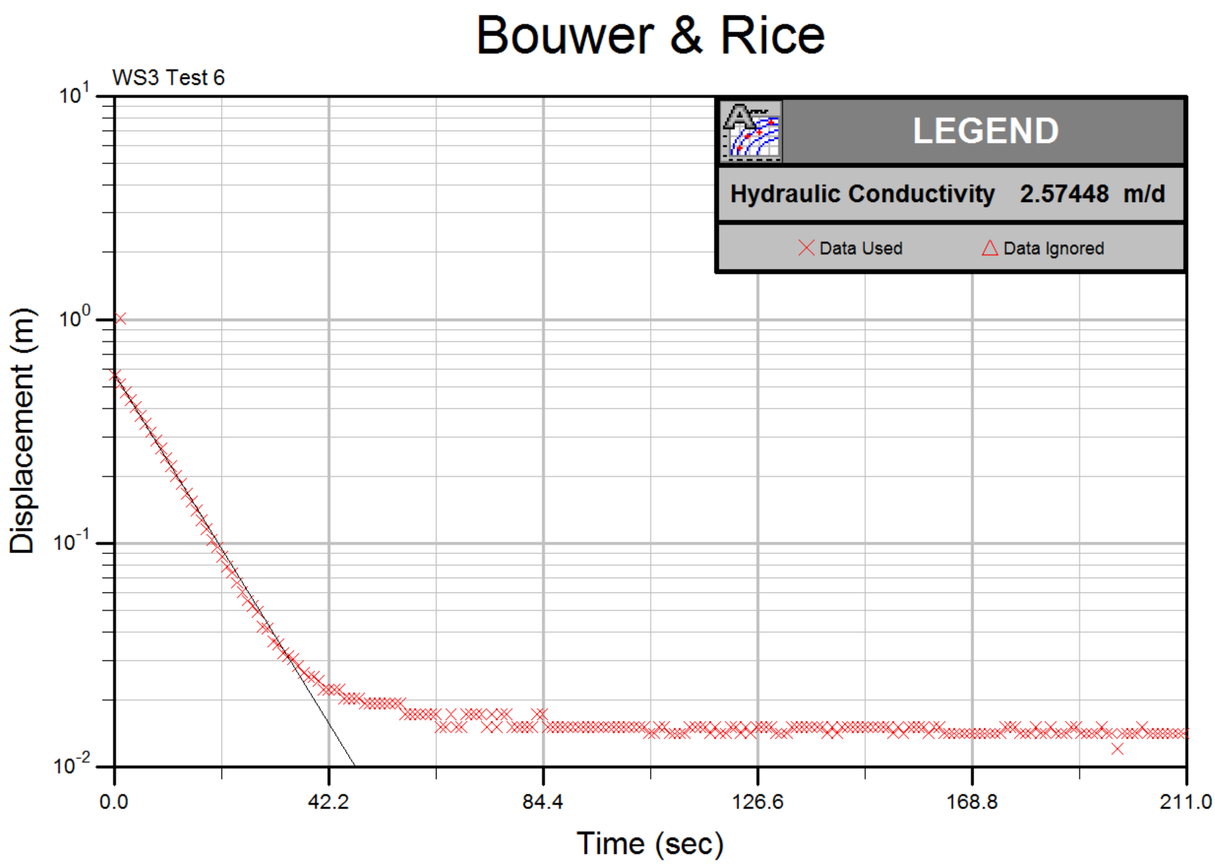


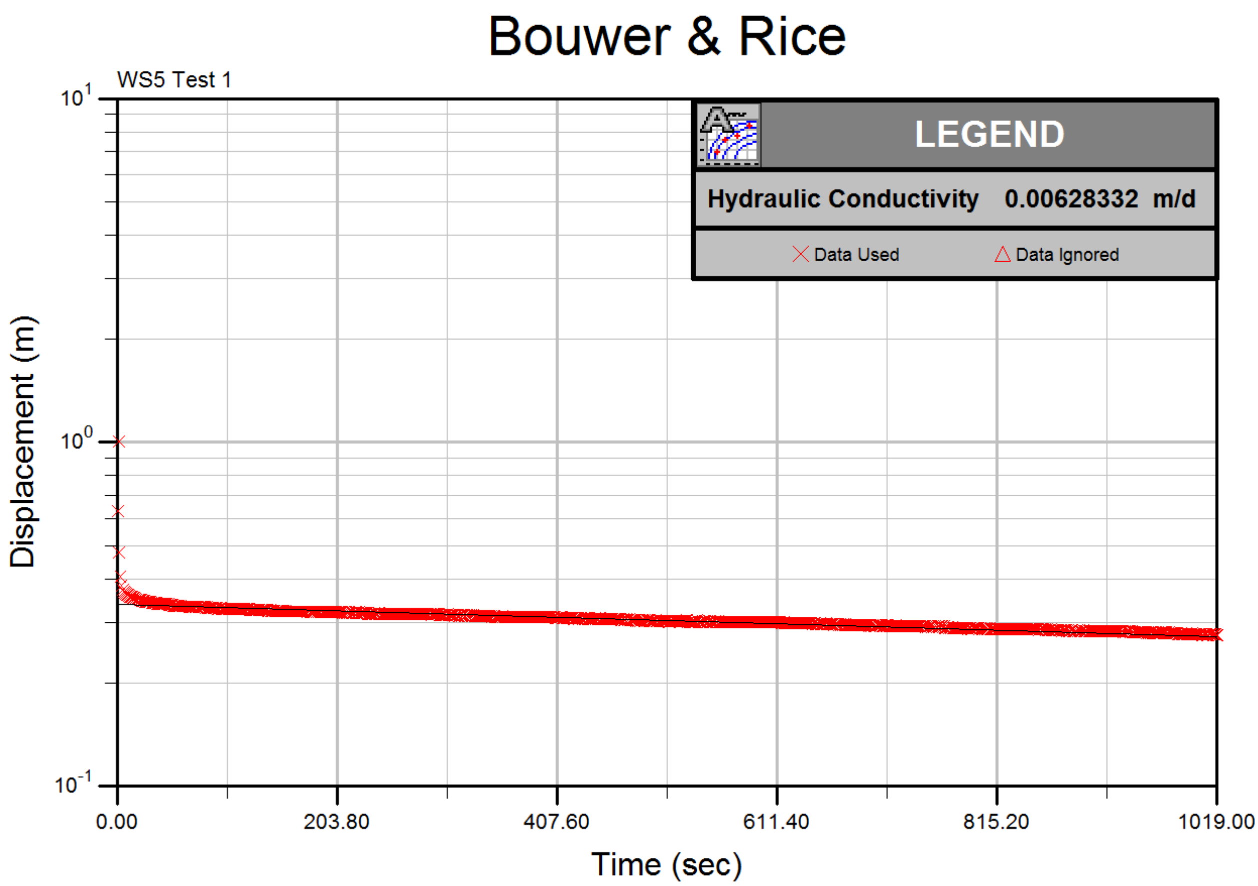


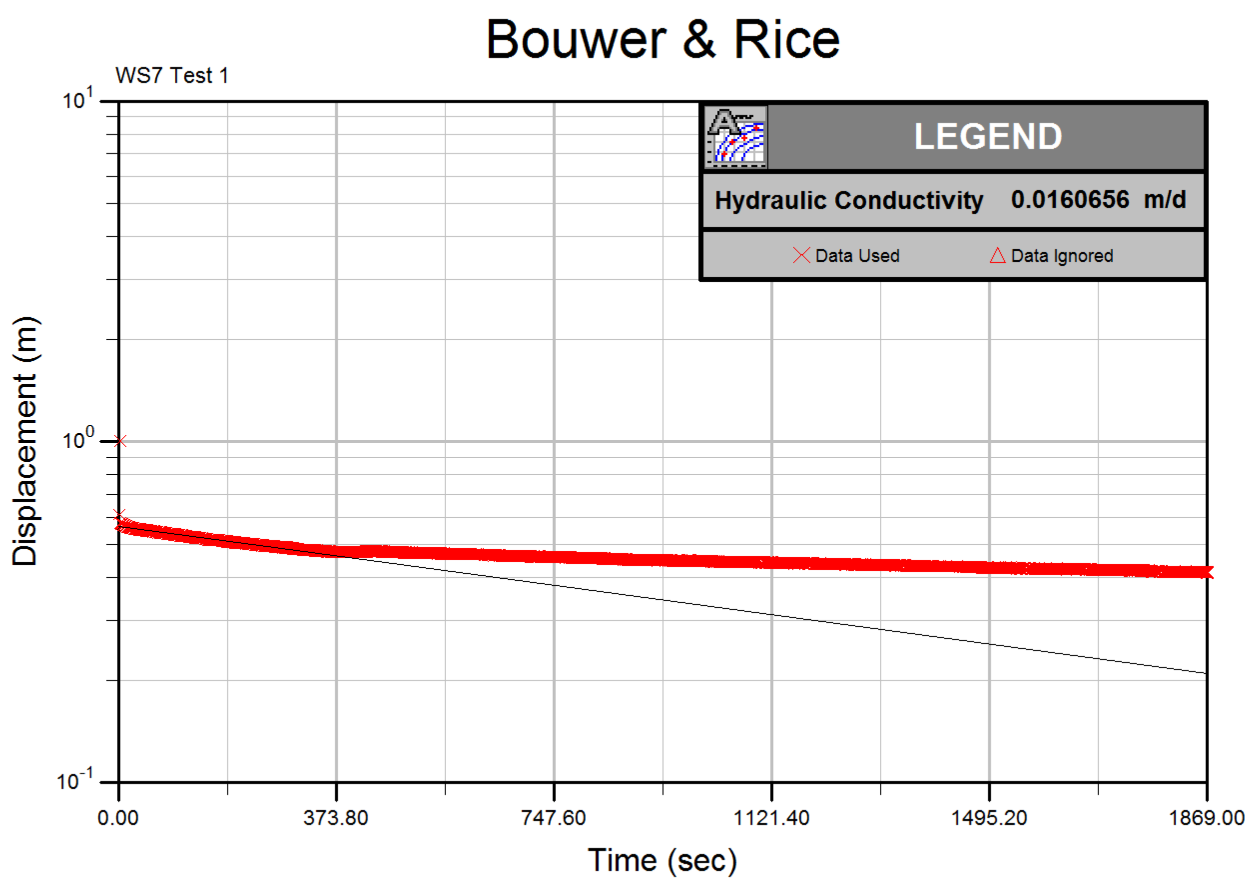

Bouwer & Rice
WS3 Test 3
LEGEND
Hydraulic Conductivity 2.44084 m/d
Data Used
Data Ignored
Displacement (m)
Time (sec)
10^1
10^0
10^-1
10^-2
0.0
46.6
93.2
139.8
186.4
233.0

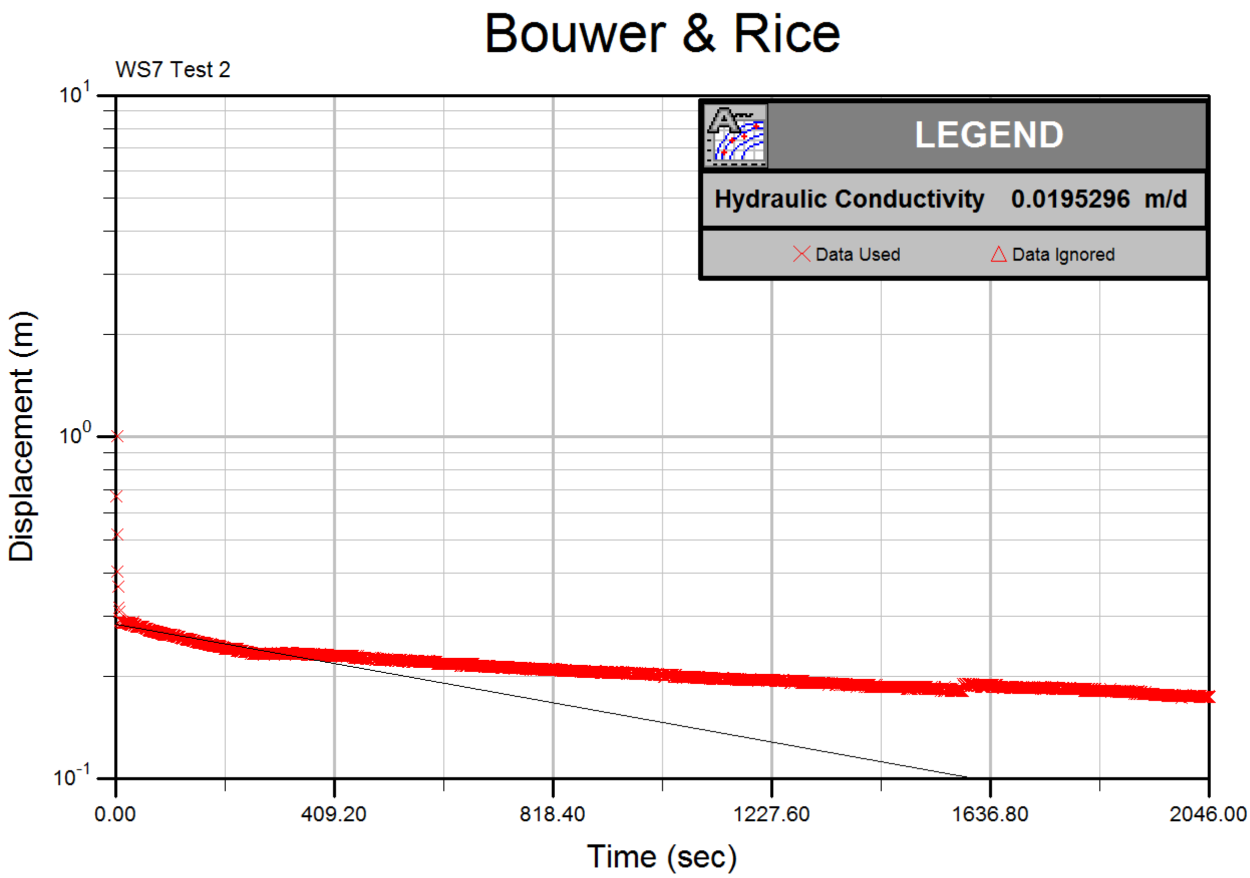

Bouwer & Rice
WS3 Test 4
LEGEND
Hydraulic Conductivity 3.0757 m/d
Data Used
Data Ignored
Displacement (m)
Time (sec)
10^0
10^-1
10^-2
10^-3
0.0
10.0
20.0
30.0
40.0
50.0

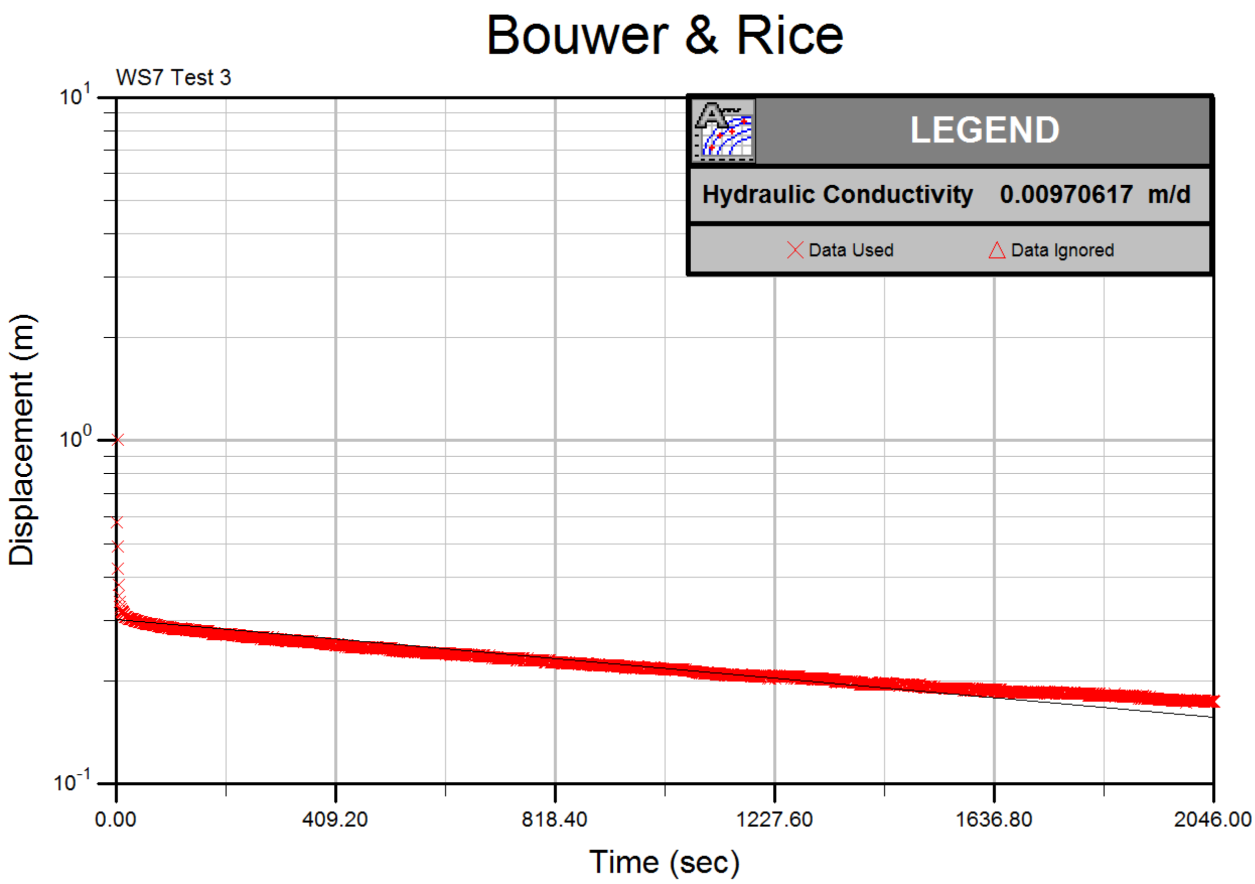

Bouwer & Rice
WS3 Test 5
LEGEND
Hydraulic Conductivity 2.41226 m/d
Data Used
Data Ignored
Displacement (m)
Time (sec)
0.0
51.0
102.0
153.0
204.0
255.0

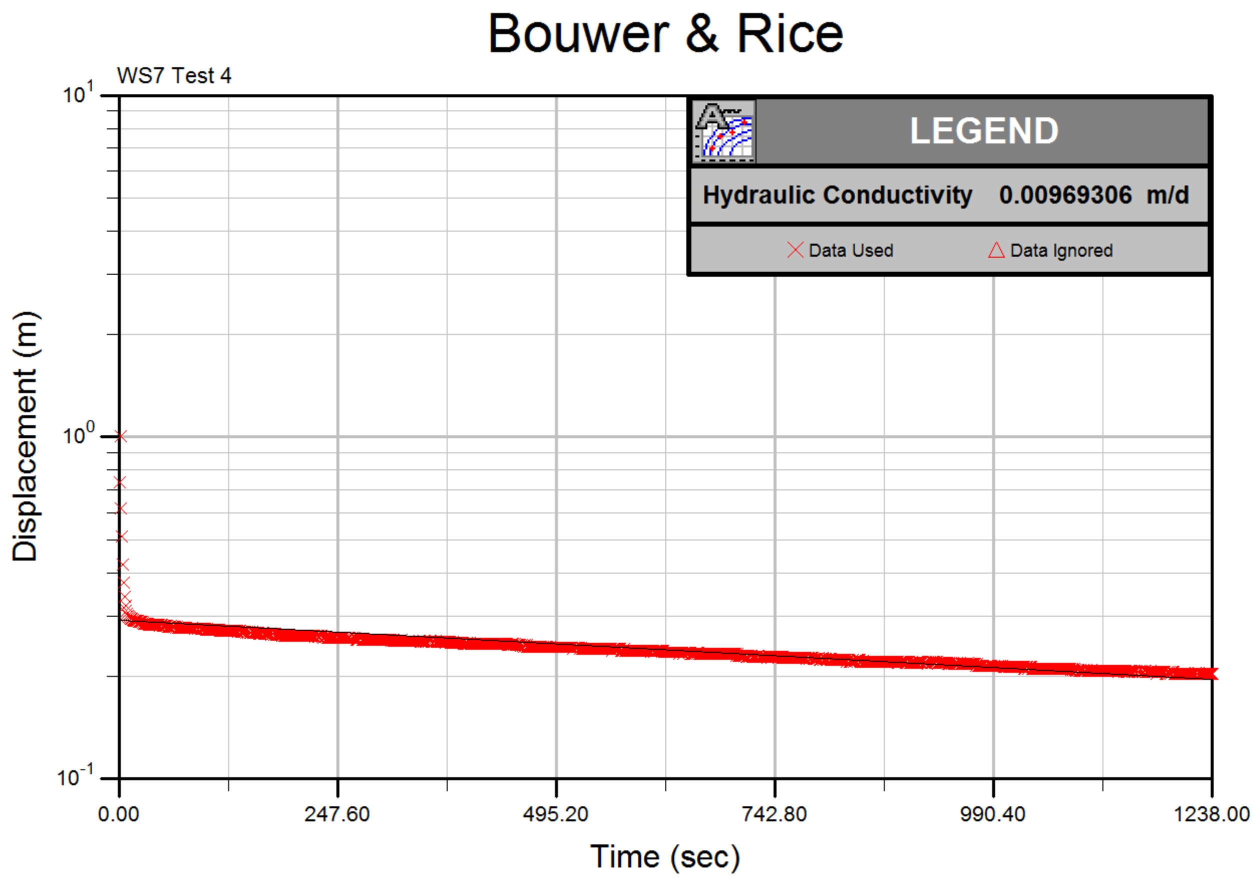

Bouwer & Rice
WS3 Test 6
LEGEND
Hydraulic Conductivity 2.57448 m/d
Data Used
Data Ignored
Displacement (m)
Time (sec)
0.0
42.2
84.4
126.6
168.8
211.0


Bouwer & Rice
WS5 Test 1
LEGEND
Hydraulic Conductivity 0.00628332 m/d
Data Used
Data Ignored
Displacement (m)
Time (sec)
0.00
203.80
407.60
611.40
815.20
1019.00

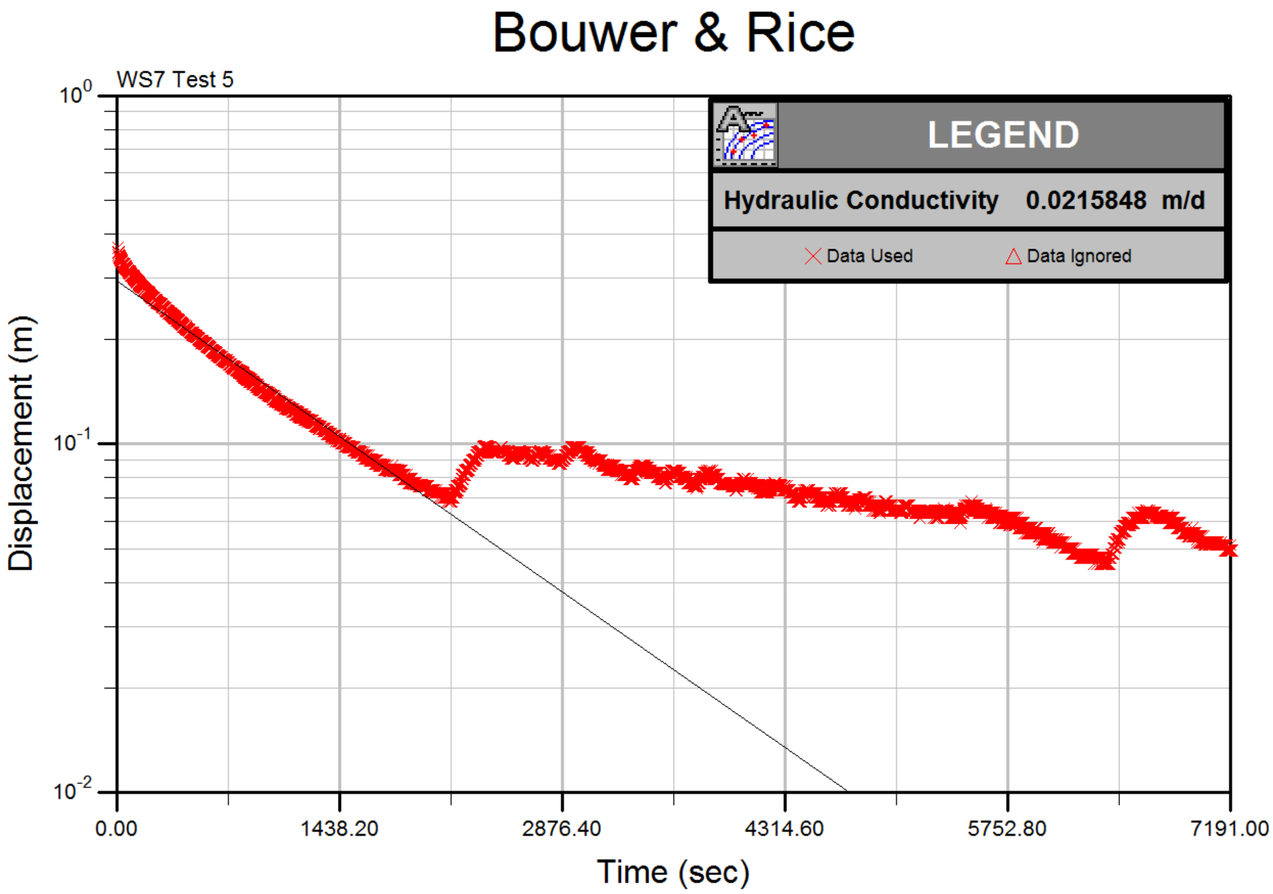

Bouwer & Rice
WS7 Test 1
LEGEND
Hydraulic Conductivity 0.0160656 m/d
Data Used
Data Ignored
Displacement (m)
Time (sec)
0.00
373.80
747.60
1121.40
1495.20
1869.00


Bouwer & Rice
WS7 Test 2
LEGEND
Hydraulic Conductivity 0.0195296 m/d
Data Used
Data Ignored
Displacement (m)
10^1
10^0
10^{-1}
0.00
409.20
818.40
1227.60
1636.80
2046.00
Time (sec)

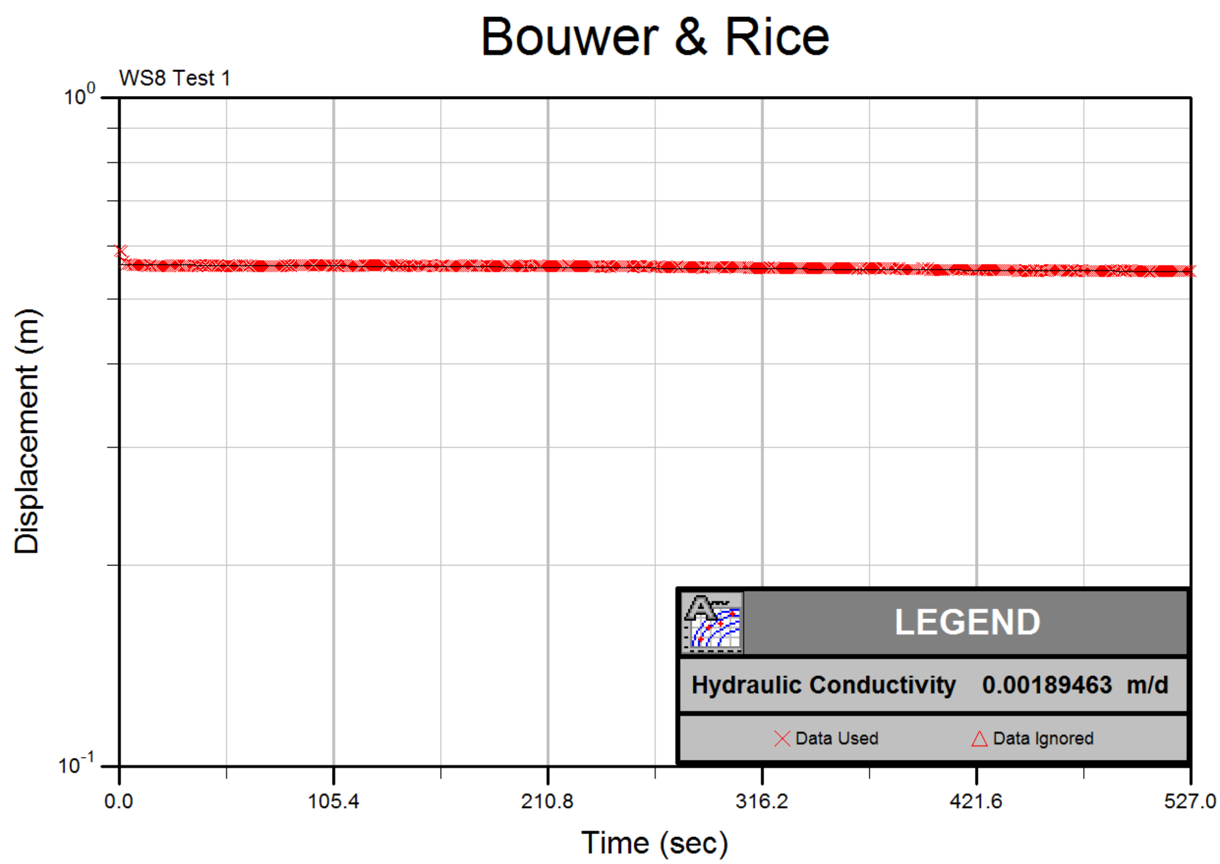

Bouwer & Rice
WS7 Test 3
LEGEND
Hydraulic Conductivity 0.00970617 m/d
Data Used
Data Ignored
Displacement (m)
10^1
10^0
10^{-1}
0.00
409.20
818.40
1227.60
1636.80
2046.00
Time (sec)



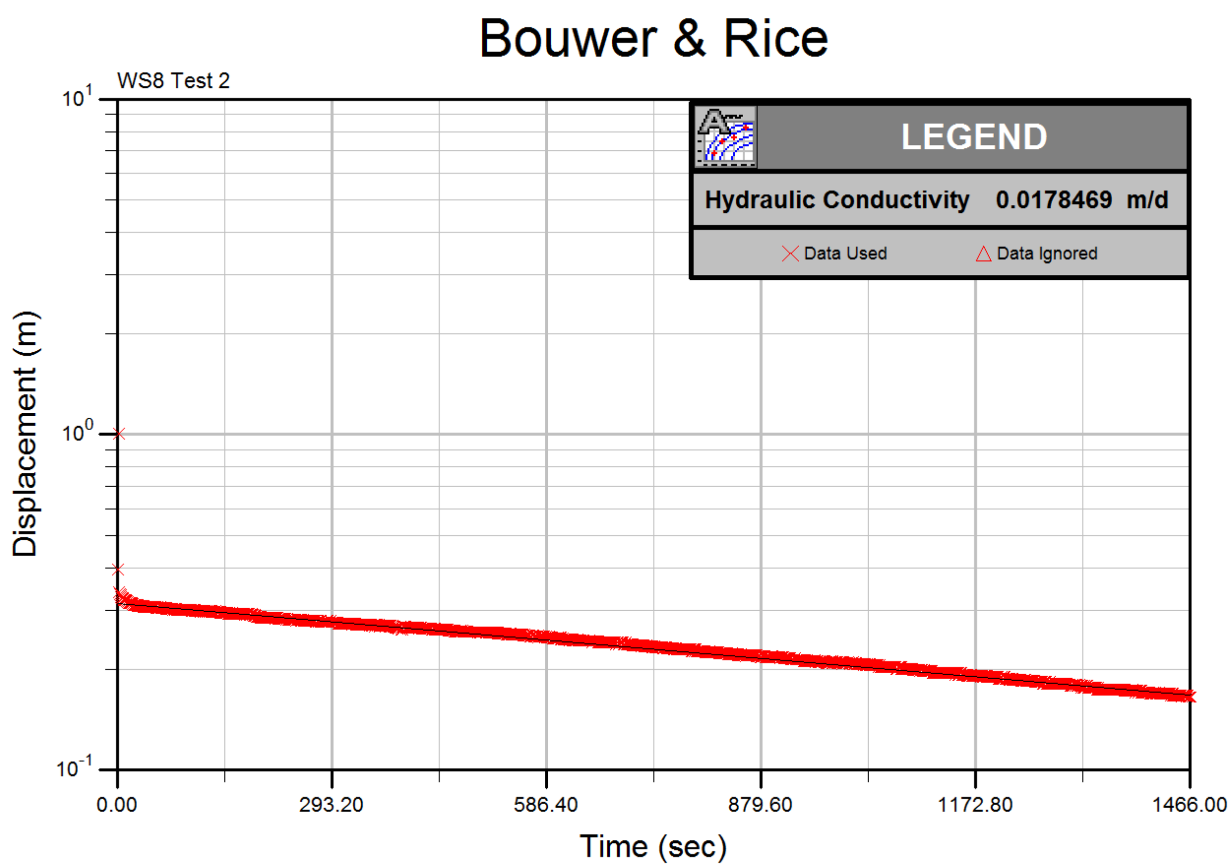
Bouwer & Rice
WS7 Test 4
LEGEND
Hydraulic Conductivity 0.00969306 m/d
Data Used
Data Ignored
Displacement (m)
Time (sec)
10^1
10^0
10^-1
0.00
247.60
495.20
742.80
990.40
1238.00



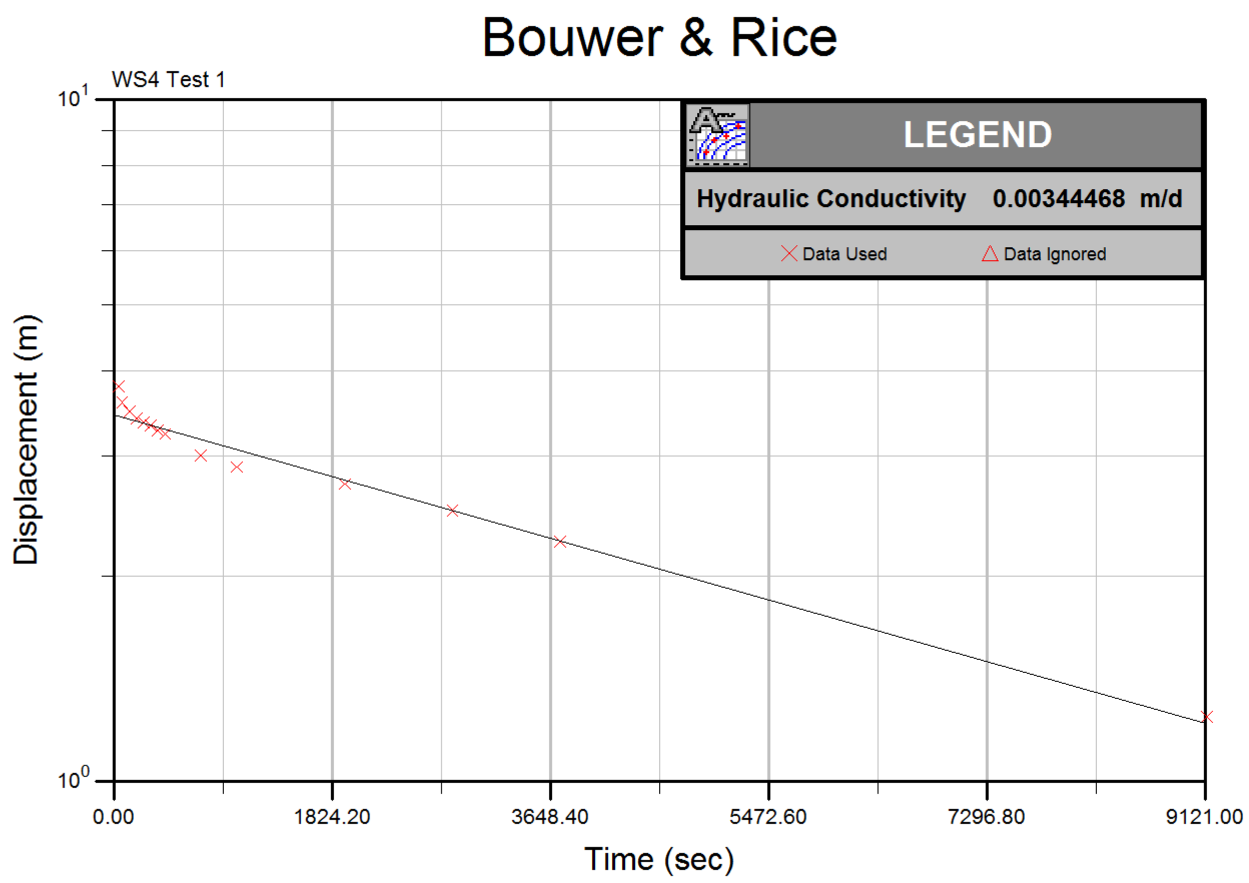
Bouwer & Rice
WS7 Test 5
LEGEND
Hydraulic Conductivity 0.0215848 m/d
Data Used
Data Ignored
Displacement (m)
Time (sec)
10^0
10^-1
10^-2
0.00
1438.20
2876.40
4314.60
5752.80
7191.00

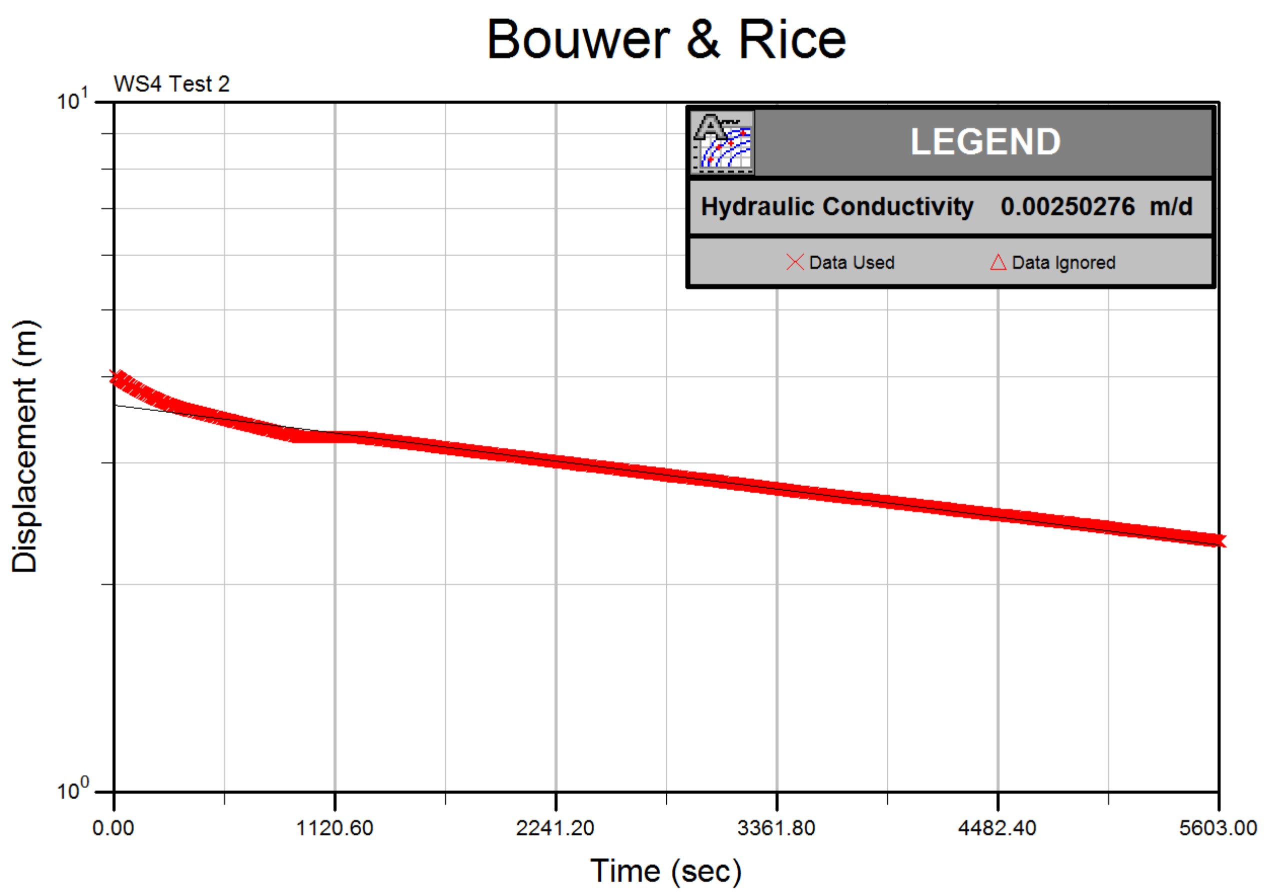


Bouwer & Rice
WS8 Test 1
Displacement (m)
Time (sec)
0.0
105.4
210.8
316.2
421.6
527.0
LEGEND
Hydraulic Conductivity 0.00189463 m/d
Data Used
Data Ignored



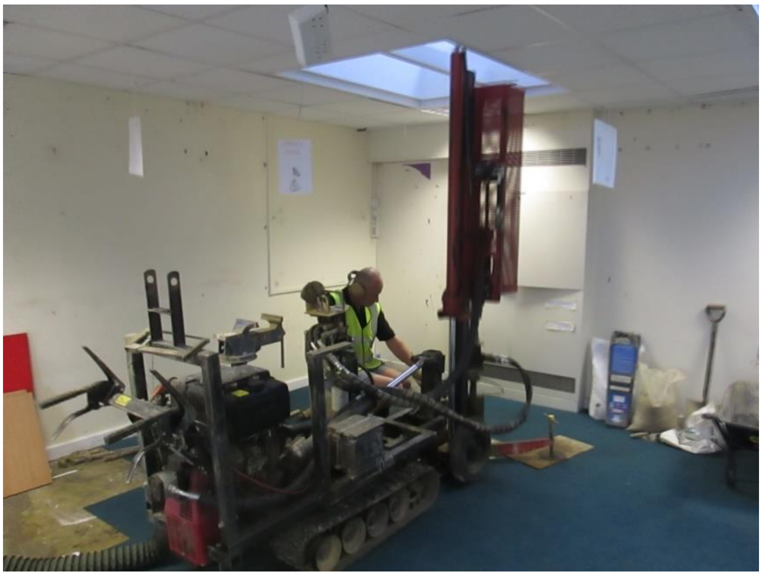
Bouwer & Rice
WS8 Test 2
Displacement (m)
Time (sec)
0.00
293.20
586.40
879.60
1172.80
1466.00
LEGEND
Hydraulic Conductivity 0.0178469 m/d
Data Used
Data Ignored


Bouwer & Rice
WS4 Test 1
LEGEND
Hydraulic Conductivity 0.00344468 m/d
Data Used
Data Ignored
Displacement (m)
Time (sec)
0.00
1824.20
3648.40
5472.60
7296.80
9121.00


Bouwer & Rice
WS4 Test 2
LEGEND
Hydraulic Conductivity 0.00250276 m/d
Data Used
Data Ignored
Displacement (m)
Time (sec)
0.00
1120.60
2241.20
3361.80
4482.40
5603.00

Appendix H

Photo Board – Site Investigation Works

	Photo depicting the 'Competitor' Windowless Sampling Rig drilling WS5 within the current car-parking compound, around the perimeter of the school building.
	Photo showing the drilling of WS6 within one of the classrooms in the school building. The concrete floor was cored out prior to the commencement of the drilling using a concrete corer attachment.
	Representative photograph depicting a concrete core from the coring of WS7 within the school building. The concrete was found to be 0.18 metres thick within WS6, 0.32 metres in WS7 and 0.30 metres thick in WS8.

	The photo shows the drilling rig set up in one of the classrooms to the east of the school building. The ceiling panels within the classroom and also within the staff room (WS8) had to be removed to allow for the clearance of the rig mast (3 metres) to drill the holes.
	Photo depicts a representative retrieved sample run of the made ground and shallow geology encountered during drilling down to 4mbgl in WS7.
	Photograph depicts a very wet, clayey, gravel band encountered within the Colwall Gelifluctate Formation within WS3 between 3mbgl to 3.90mbgl. WS3 had the shallowest water strike at 0.70mbgl of all the holes and the highest rise of the water level to 0.40mbgl following the completion of drilling.