Pendle Borough Council

Desk Study Report

For

Earby, Pendle

REPORT NO: 21PBC010/DS

- *Desk Studies and Site Walkovers*
- *Intrusive Contaminated Land Investigations*
- *Geotechnical Appraisals and Ground Investigations*
- *Landfill Gas Assessments and Remedial Design*
- *Remediation Design and Implementation*
- *Remediation Project Management and Supervision*
- *Site Abnormal Assessments (Foundations and Contaminated Land)*

GEOTECHNICAL - CONTAMINATED LAND - FLOOD RISK

DOCUMENT ISSUE RECORD

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REVISION RECORD

Revision	Date	Description	Prepared by
0	Feb 22	Draft for comment	RMC/BL

BETTS GEO
CONSULTING ENGINEERS

CONTENTS

1 SITE DESCRIPTION

1.1 Introduction

This investigation was carried out on the instruction of Pendleton Borough Council. The purpose of the work was to carry out a Desk Study to provide geo-environmental and hydrogeological risk assessment information to inform the due diligence processes for the site, in particular the risk and cause of increased groundwater flooding to the properties. The site boundary can be seen below;

1.2 Site Location

The site is in the town of Earby, Pendle, Lancashire, BB186PF (coordinates for centre of site 390931 446360). The site area is 3.2 hectares. See Site Location Plan in Appendix A.

1.3 Site Description

1.3.1 On-Site

Pre-Site Walkover – The site is roughly rectangular in shape. The current site use for the site is primarily residential housing, with >60 semi-detatched residential properties on site. There is a road running directly through the middle of the site from North to South called Wentcliffe Drive, with two crescents coming off the road in the Northwest and Southeast area of site. The Northern boundary of the site runs parallel to a road called chapel street. The Eastern boundary of the site is made up of a Mill and carpark at the Northeast boundary, and a field and some residential properties on the Southeast boundary. The Southern boundary is running parralel to a road called Bawhead Road. The Western Boundary is made up of residential properties in the Northwest, and the Southwest boundary is made up of a playground and open field resembling a park, as well as some residential plots in the Southwest corner.

A site walkover post collation of maps etc was undertaken on the 16th of February 2022 to assess off site ground / surface water infleunces to the east of site. This is summarised in Section 4.6

1.3.2 Surrounding Area

Surrounding land uses for the site are as follows:

- North – 0m – 250m Residential Properties, 250m– 500m open fields, 500m Earby Beck River
- Northeast – 0m – 500m Residential properties, 200m – 500m Wentcliff Brook running Southwest to Northeast.
- East – 0m – 200m Residential Properties, 200m School, 0m – 500m Stoney Bank Road running West to East, 300m – 500m open fields, <50m Mill works/carpark
- South – 0m – 100m Residential Properties, 100m – 500m open fields with multiple water bodies present
- West – 0m – 400m Residential properties, 200m New Cut River running North to South through the town of Earby

2 SITE HISTORY

2.1 Site History from Ordnance Survey Maps

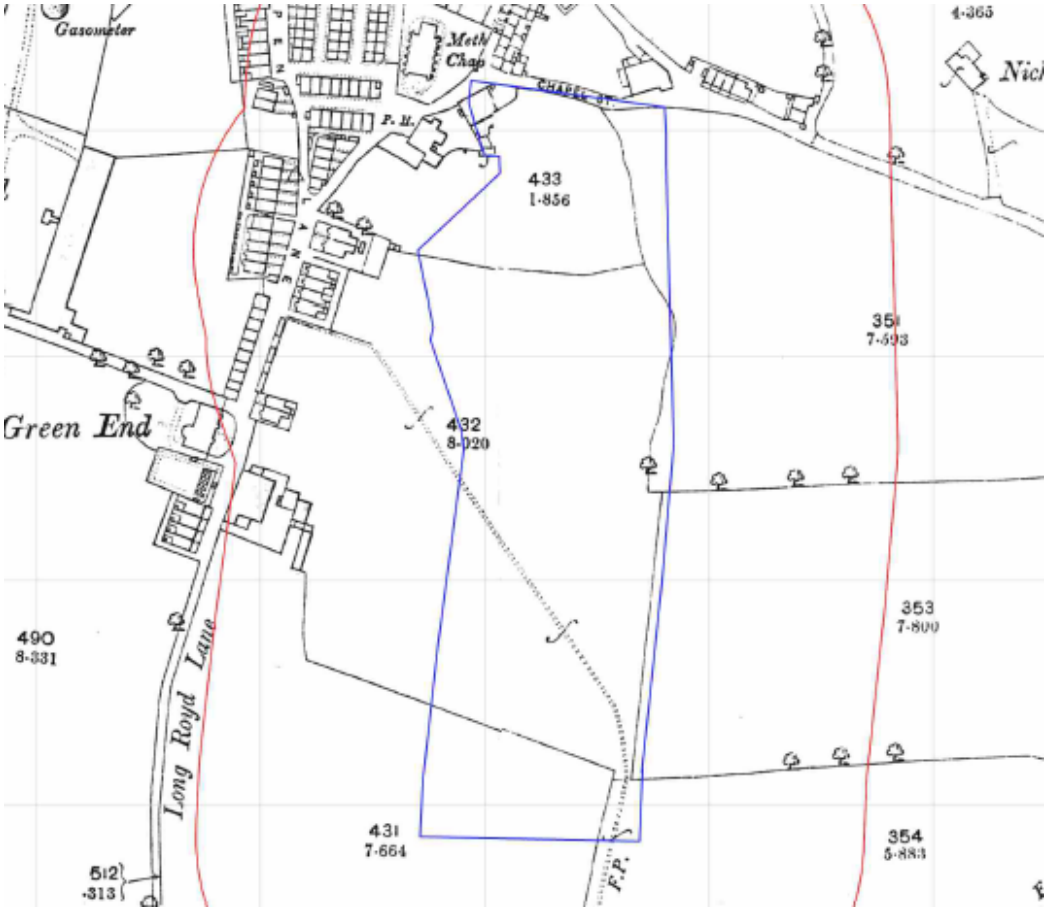
A search of available historic maps was undertaken to establish the land-use history of the site. Extracts of the maps are discussed below and can be found in full in Appendix B of this report. All maps are Ordnance Survey unless otherwise stated. All distances quoted on OS maps are taken from the site boundary, which is marked on the map. It should be noted there is only partial coverage for some of the available maps and there is an alignment issue with the 1991-1993 maps.

2.2 Summary of Site History

2.2.1 On-Site

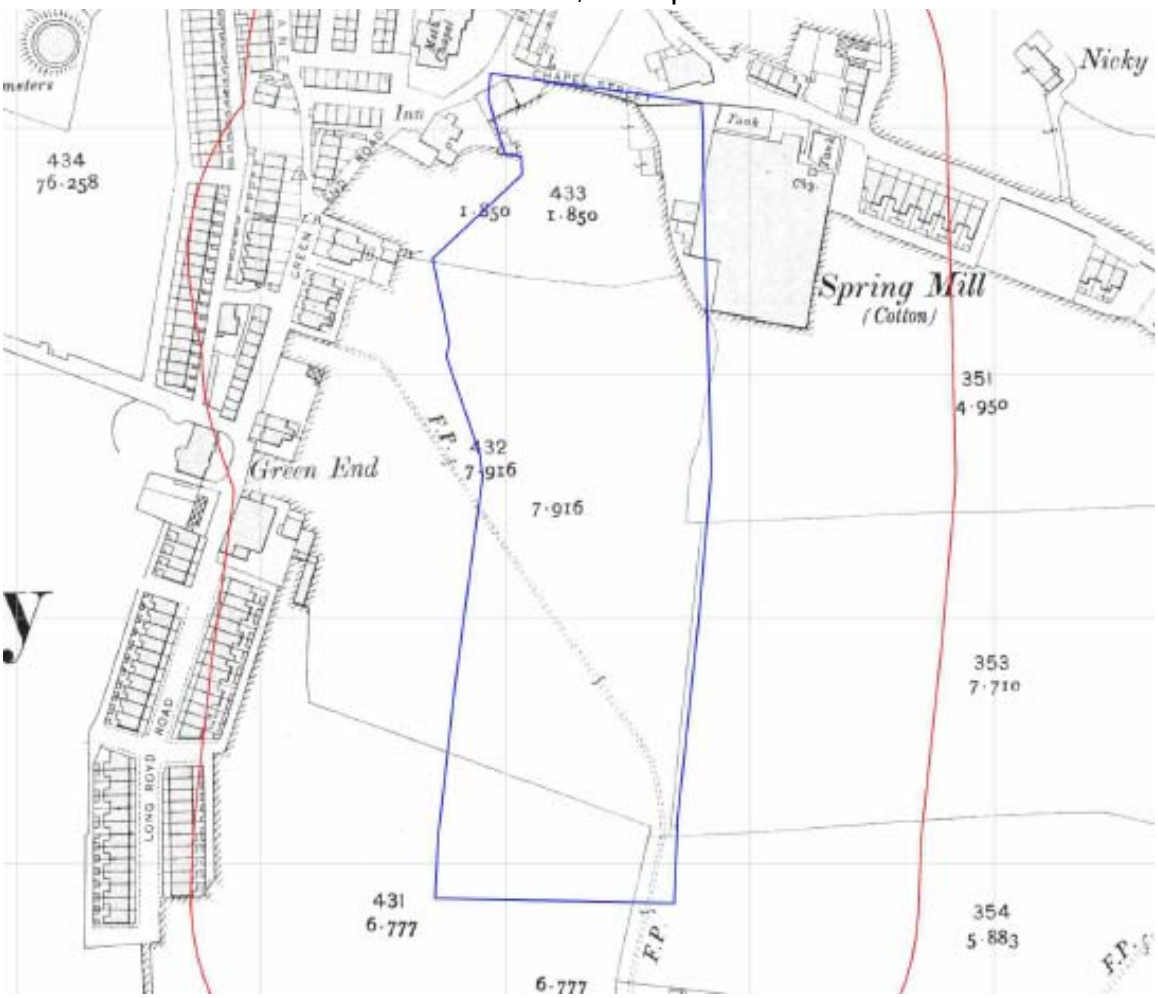
The first available OS map dated 1892, shows the site is a vacant open field. There is a road running parallel to the Northern boundary. There are two structures located in the Northwest Corner of the site. The site also has been divided up multiple fields with boundary lines now appearing with some trees present at the centre of the Eastern Boundary.

1892 1:2,500 Map



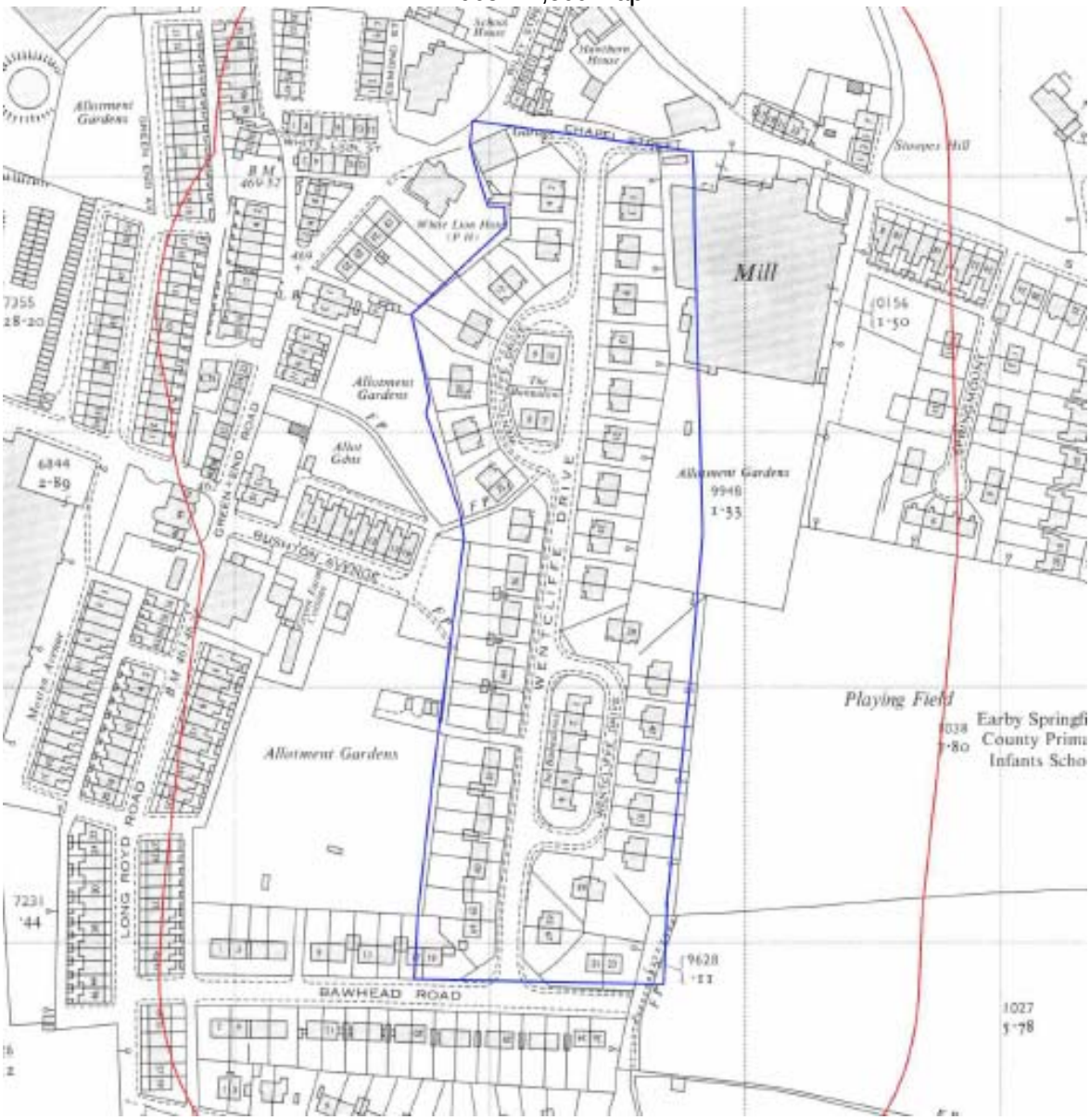
The next available map was from 1909, and shows a Mill has been developed to the Northeast of the site which cross cuts the boundary, as can be seen from the map below:

1909 1:2,500 Map



The next available OS map is from 1963 shows the site to have been developed into a residential estate with >60 semi-detached properties on site. There has also been a road constructed running straight through the centre of the site in a North to South direction. The road has two crescents running off the main road in the Northwest and Southeast areas of the site. There has also been an allotment area developed on the eastern boundary of the site, just south of the Mill.

1963 1:2,500 Map



There was no change to the site until 1992-1993, when the allotment area on the Eastern boundary, just South of Spring Mill was redeveloped into a structure resembling a carpark for the mill. The residential estate has stayed the same with no obvious changes.

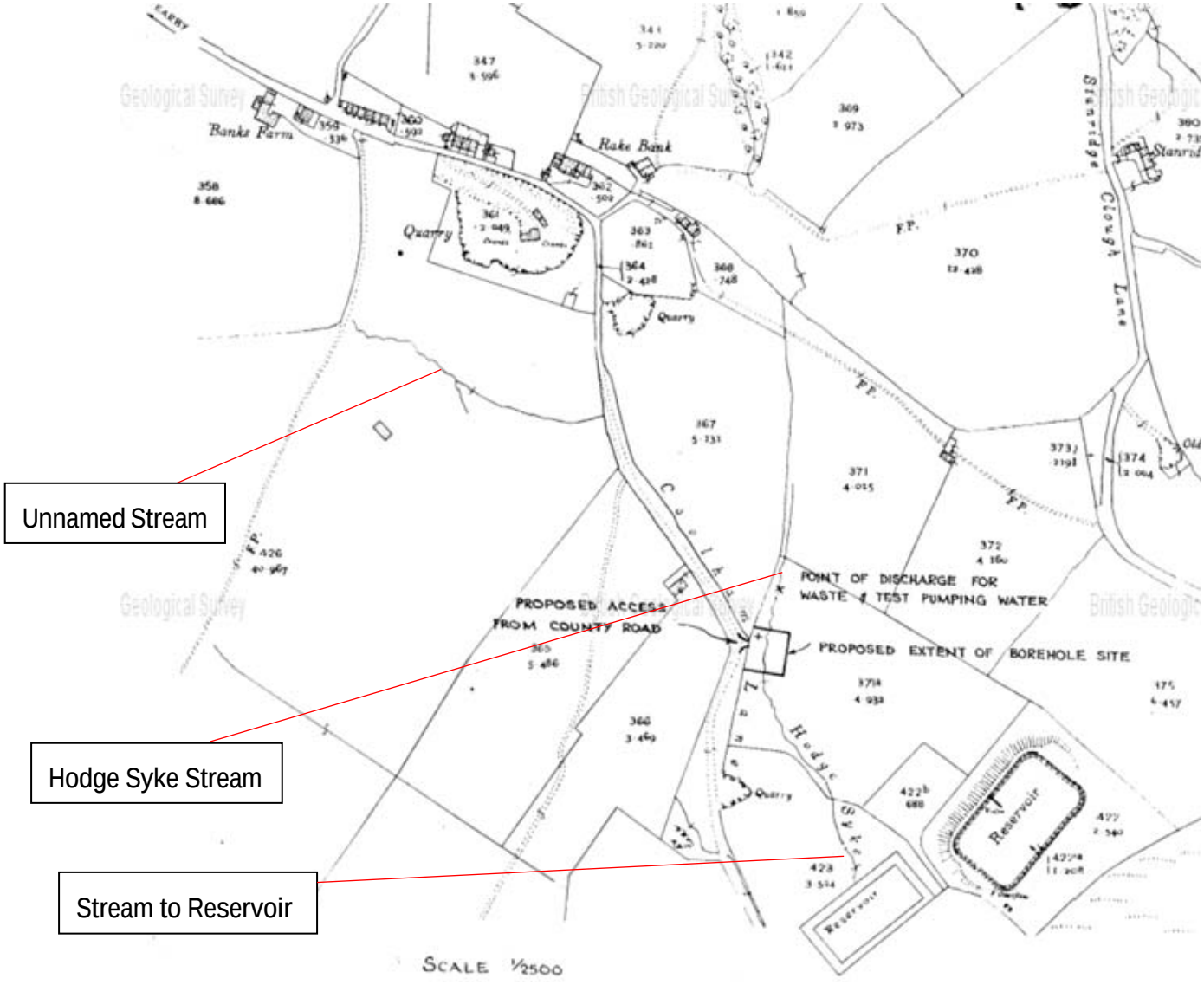
1992-1993 1:2,500

There have been no changes to the site from 1992-1993 to present day.

2.2.2 Surrounding Area

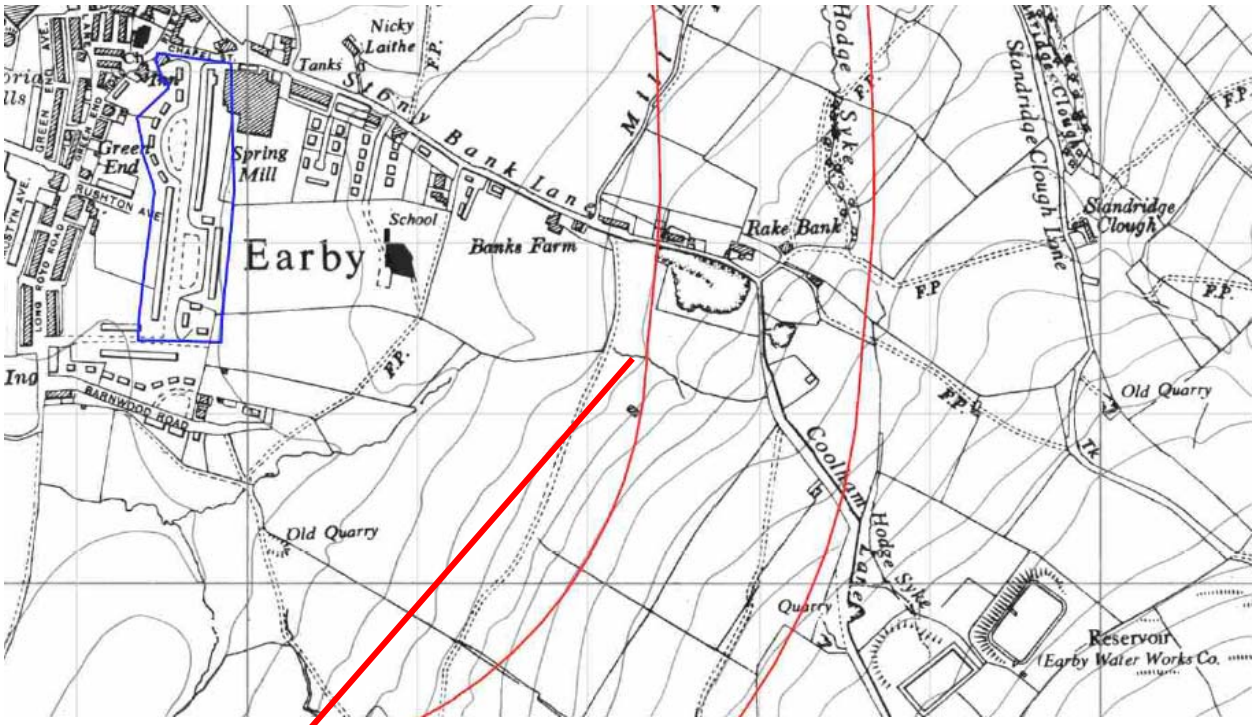
This is a Map dated back to 1909 showing the area to the Southeast of the site. The map shows the reservoirs to be present to 1000m southeast of the site, with a stream called Hodge Syke running from the reservoir in a Northwest direction. On the streams course there is labelled a point of discharge for waste and test pumping water approximately 800m Southeast of the site. There is also an Unnamed stream 600m Southeast of the site which begins 100m West of the Hodge Syke stream. This unnamed stream is running directly towards the site. This could possibly be the Hodge Syke stream running down gradient and picking up again.

1909 1:2500



The next map from 1950 shows the unnamed stream from the previous map extending further, and directly reaching the site. From the contour lines the gradient of the hill where the reservoir is located is clearly shown to be running directly towards the site, and the town of Earby. Hodge Syke stream also still present.

1950 1:10,560



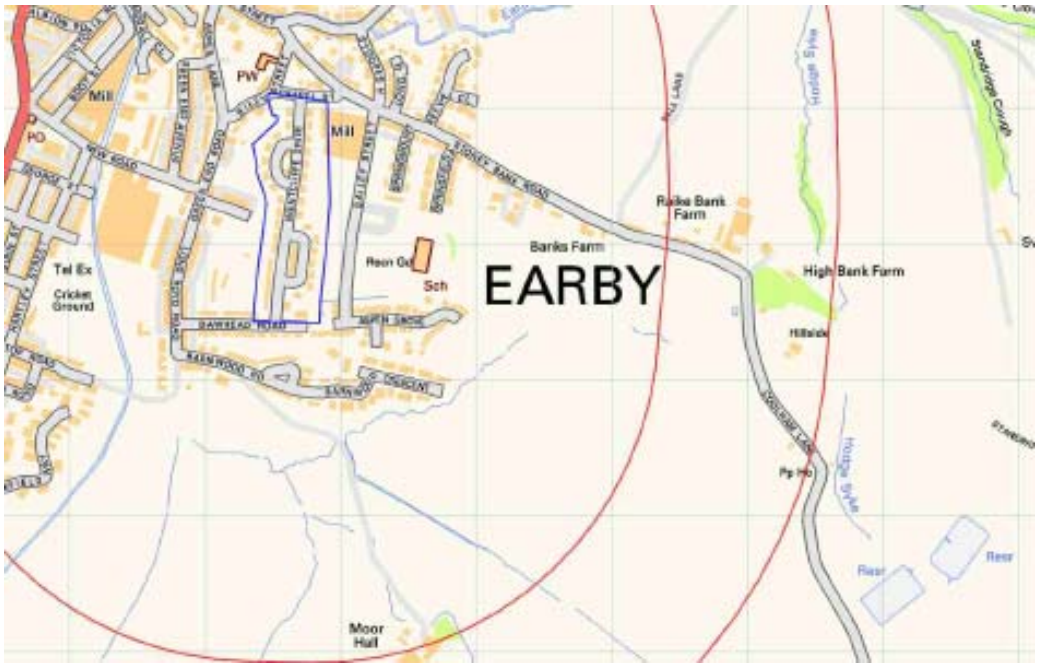
Unnamed stream approximately 100m West of Hodge Syke stream. The stream has now extended and is running towards the site, but appears to fall away to the south

The next map is dated from 1971 and shows there to potentially be a pipe labelled 'Iron Main' running directly from the Reservoir, along the Hodge Syke stream, bending west towards and across the unnamed stream/field drainage which is connected to the site. There is also a tank located along the Hodge Syke stream.

1971 BGS iGeology App

Historical maps show the Reservoir to still be present in 2010, however the unnamed stream has become less apparent and is no longer stretching clearly all the way to the site.

2010 1:10,000



However, from looking at Google Earth maps the Reservoirs have become disused and are no longer visible by 2011. As can be seen from the map below:

Google Earth 2011

The following table summarises the significant changes in historical use surrounding the site:

Date First Shown	Land Uses
1853 (Map is fairly faded and unclear)	Majority of surrounding area is dominated by agricultural land, with developments found in parts as can be seen below: 0m-250m North – Small village with structures present 300m Northwest – Earby School 100m Northeast – Methodist chapel 250m Northeast – pit head, potential mining activity? 500m Northeast – Cowgate 500m Northeast – Trough 500m East – Bank 500m Southeast – Spring 100m West – Trough 100m West - Cotton Mills 200m West – Gasometer 300m West – New Cut / River / Stream? 400m West – Railway line present
1892	125m North – Blacksmith 50m Northwest – Estate has been developed further 250m Northwest – Mill has been developed and is now a large building 350m Northwest – New Mill has been developed 400m Northwest – School has been developed and is now a large structure present 100m North – Watercourse running through the village from West to East 500m Northeast – Large Farmhouse called Cowgarth House 500m East – Quarry present 300m East – Large farm area called Banks Farm South to Southwest dominated by agricultural land and open fields 250m West – Earby Beck River running directly parallel to site from North to South 450m West – Gasometer x2 and Cotton Mill
1907	0m Northwest – Further development to residential estate 200m Northwest – Victoria Cotton Mill 350m Northwest – Albion Mill 400m Northwest – Grove Shed Cotton Mill 400m North – Cemetery has appeared 250m Northeast – Residential development <50m East – Spring Mill and 2 x Tanks 250m Southeast – Old Quarry present 100m West – Residential development, looks like rows of terraced houses? 400m West – Residential development, again potentially looks like rows of terraced houses 400m West – Large A-Road has appeared running parallel to the site from North to South
1950	250m North – New school has been developed 100m East – New Residential development next to Spring Cotton Mill 250m East – New School has been developed 200m West – New Mill has appeared just south of Victoria Mills
1963	100m North – Works 100m Northeast - Garage
1971 - 1973	500m Northwest – Allotment Gardens and Industrial works constructed 450m Northwest – New Industrial works developed 250m Southeast – Old Quarry no longer present 300m West – Open field has been developed into a cricket ground East – Industrial and Residential development
1975 - 1977	20m Northwest – Garage 250m Northwest – Carpark 200m West - Garage
2001	200m Northwest – Mill label has disappeared; however, structure is still in place. Mill disused. 100m West – Mill has been removed 400m West – Railway track is no longer present <50m East – Allotment area removed
2022	200m West – Mill has been removed

3 ENVIRONMENTAL DATA

3.1 Published Geology

The documented geology of the site is summarised on the British Geological Survey map principally, with further site-specific details detailed below.

Geology	Artificial Ground & Land Slip	Superficial	Bedrock
1:50,000	No record	Till, Devensian – Diamicton	Bowland Shale Formation – Mudstone – Visean Pendle Grit Member – Sandstone - Namurian

Superficial Geology

ID	Location	LEX Code	Description	Rock description
1	On site	TILLD-DMTN	TILL, DEVENSIAN	DIAMICTON

Bedrock Geology

ID	Location	LEX Code	Description	Rock age
1	On site	BSG-MDST	BOWLAND SHALE FORMATION - MUDSTONE	VISEAN
3	On site	PG-SDST	PENDLE GRIT MEMBER - SANDSTONE	NAMURIAN

3.1.1 Linear Features

One 1No.) linear features are mapped as detailed below; with there being a fault line bisecting through the site from Northwest to Southeast:

ID	Location	Category	Description
2	On site	FAULT	Fault, inferred

3.1.2 Bedrock Permeability

Two types of Bedrock permeability have been recorded on site, as can be seen from the table below:

Location	Flow type	Maximum permeability	Minimum permeability
On site	Fracture	High	Moderate
On site	Fracture	Low	Low

3.1.3 Historic Borehole Records

There has been no record of Historic Boreholes within 250m of the site (however records do exist further afield to the east for ground water extraction (see Section 5)

3.2 Geological Features

The table below summarises the presence/absence of recorded mining, extraction and natural cavities records within 500m of site. If entries are present within 250m, further details are provided in the relevant section below.

Data Type	On Site	0m – 50m	50m – 250m	250 – 500m
Geological				
Natural Cavities	-	-	-	-
BritPits	-	-	1	1
Surface Ground Workings	-	-	6	-
Underground Workings	-	-	-	-
Historical Mineral Planning Areas	-	-	-	-
Non-Coal Mining	2	-	-	-
Mining Cavities	-	-	-	-
JPB Mining Areas	-	-	-	-
Coal Mining	-	-	-	-
Brine Areas	-	-	-	-
Gypsum Areas	-	-	-	-
Tin Mining	-	-	-	-
Clay Mining	-	-	-	-

3.2.1 BritPits

There is has been One BritPit recorded within 250m of the site, as can be seen on the table below:

ID	Location	Details	Description
A	247m S	Name: Barnwood Field Address: EARBY, Lancashire Commodity: Sandstone Status: Ceased	Type: A surface mineral working. It may be termed Quarry, Sand Pit, Clay Pit or Opencast Coal Site Status description: Site which, at date of entry, has ceased to extract minerals. May be considered as Closed by operator. May be considered to have Active, Dormant or Expired planning permissions by Mineral Planning Authority

3.2.2 Surface Ground Workings

Six surface ground workings are recorded within 250m of the site. Further details on the feature are presented below;

ID	Location	Land Use	Year of mapping	Mapping scale
A	230m S	Unspecified Old Quarry	1950	1:10560
A	231m S	Unspecified Pit	1892	1:10560
A	235m S	Unspecified Old Quarry	1907	1:10560
A	238m S	Unspecified Old Quarry	1914	1:10560
A	239m S	Unspecified Pit	1892	1:10560
A	239m S	Unspecified Old Quarry	1914	1:10560

3.2.3 Radon

In the North of the site the estimated percentage of dwellings exceeding the Radon Action Level lies between 1% and 3%. In the South of the site the estimated percentage of dwellings exceeding the Radon Action Level are less than 1%. Please see the table below:

Location	Estimated properties affected	Radon Protection Measures required
On site	Less than 1%	None**
On site	Between 1% and 3%	None

3.3 Hydrogeological and Hydrological Features

The table below summarises the presence/absence of any hydrological licences and incidents within 500m of the proposed site. If entries are present within 250m, further details are provided in the relevant subsection below;

Data Type	On-Site	0m – 50m	50m – 250m	250 – 500m
Hydrogeology & Hydrology				
Licenced Discharge Consents	-	-	-	24
Red List Discharge Consents	-	-	-	-
Ground Water Abstraction Licences	-	-	-	-
Surface Water Abstraction Licences	-	-	2	5
Potable Water Abstraction Licences	-	-	-	-
Source Protection Zones	-	-	-	-
Water Network	-	3	24	-

3.3.1 Surface Water Abstractions

There has been two recording of surface water abstractions within 250m of the site, as can be seen in the table below:

ID	Location	Details	
A	178m W	Status: Historical Licence No: 2/27/15/153 Details: General Cooling (Existing Licences Only) (Low Loss) Direct Source: SURFACE WATER Point: NEWCUT EARBY Data Type: Point Name: COACH HOUSE ANTIQUES Easting: 390700 Northing: 446600	Annual Volume (m^3): - Max Daily Volume (m^3): - Original Application No: - Original Start Date: 27/01/1966 Expiry Date: - Issue No: 101 Version Start Date: 28/03/2002 Version End Date: -
A	178m W	Status: Historical Licence No: 2/27/15/153 Details: General use relating to Secondary Category (Medium Loss) Direct Source: SURFACE WATER Point: NEWCUT EARBY Data Type: Point Name: COACH HOUSE ANTIQUES Easting: 390700 Northing: 446600	Annual Volume (m^3): - Max Daily Volume (m^3): - Original Application No: - Original Start Date: 27/01/1966 Expiry Date: - Issue No: 101 Version Start Date: 28/03/2002 Version End Date: -

Note:

Whilst not recorded in the dataset historic BGS borehole datasets have highighted abstarction points up on the hilside to the east – see Section 5 for more details.

3.3.2 Water Network

There are records of twenty-seven water network features on site and a further three within 250 m of site. Details of which are given below;

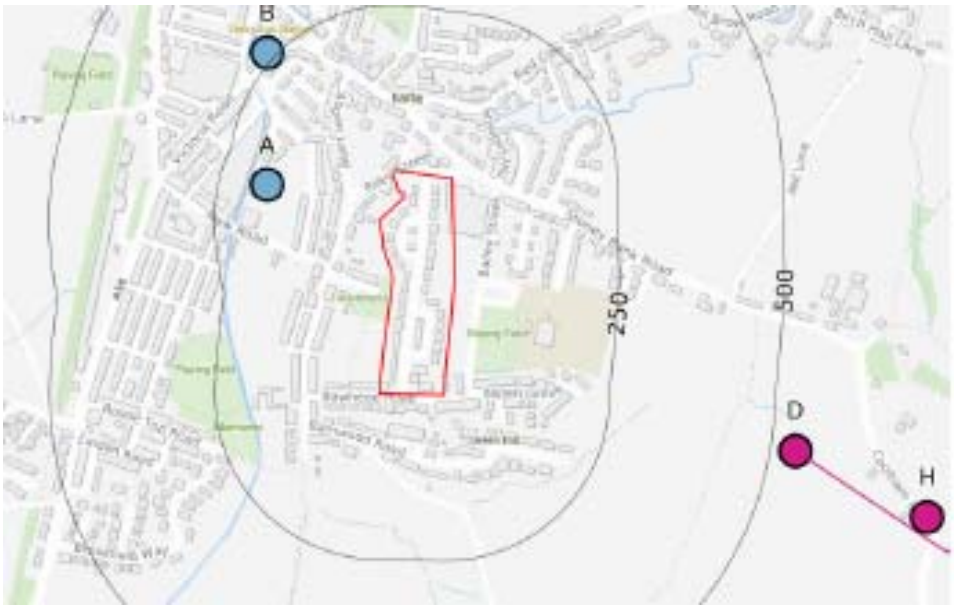
ID	Location	Type of water feature	Ground level	Permanence	Name
B	3m E	Inland river not influenced by normal tidal action.	On ground surface	Watercourse contains water year round (in normal circumstances)	-
B	28m E	Inland river not influenced by normal tidal action.	Underground	Watercourse contains water year round (in normal circumstances)	-
B	44m E	Inland river not influenced by normal tidal action.	On ground surface	Watercourse contains water year round (in normal circumstances)	-
C	110m N	Inland river not influenced by normal tidal action.	On ground surface	Watercourse contains water year round (in normal circumstances)	Earby Beck
C	110m N	Inland river not influenced by normal tidal action.	On ground surface	Watercourse contains water year round (in normal circumstances)	Earby Beck
C	110m N	Inland river not influenced by normal tidal action.	On ground surface	Watercourse contains water year round (in normal circumstances)	Earby Beck
C	112m N	Inland river not influenced by normal tidal action.	On ground surface	Watercourse contains water year round (in normal circumstances)	Earby Beck
C	113m N	Inland river not influenced by normal tidal action.	On ground surface	Watercourse contains water year round (in normal circumstances)	Earby Beck
C	114m N	Inland river not influenced by normal tidal action.	On ground surface	Watercourse contains water year round (in normal circumstances)	Earby Beck
C	115m N	Inland river not influenced by normal tidal action.	On ground surface	Watercourse contains water year round (in normal circumstances)	Earby Beck
C	117m N	Inland river not influenced by normal tidal action.	Underground	Watercourse contains water year round (in normal circumstances)	Earby Beck
C	121m NE	Inland river not influenced by normal tidal action.	On ground surface	Watercourse contains water year round (in normal circumstances)	Earby Beck
C	126m NE	Inland river not influenced by normal tidal action.	On ground surface	Watercourse contains water year round (in normal circumstances)	Earby Beck
C	137m N	Inland river not influenced by normal tidal action.	On ground surface	Watercourse contains water year round (in normal circumstances)	Earby Beck

3.3.3 Hydrogeology

- The superficial deposit of till which cover the whole of the site are designated as a Secondary Undifferentiated Aquifer.
- There are two types of bedrock. The Sandstone has been designated as a Principle Aquifer, Mudstone has been designated as a Secondary A Aquifer.
- There are four records of Groundwater vulnerability within 50m of the site, with two of them are located on the site.
- There are twelve licenced groundwater abstractions or surface water abstractions within 2000m of the site.
- The site does not lie within a Source Protection Zone.

3.4 Historical Water Abstractions

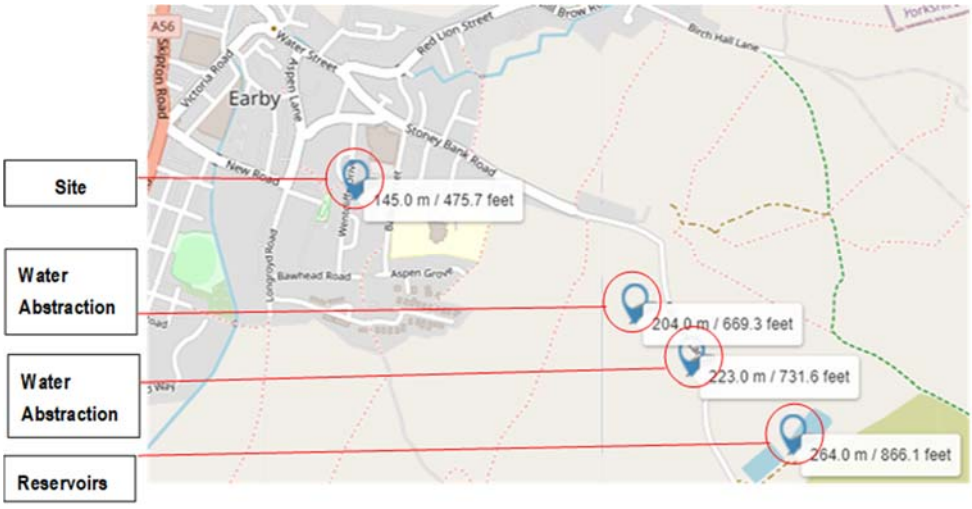
To the East of the site approximately 500m & 750m, there are two Groundwater Abstraction Licence points recorded (springs and boreholes). As can be seen from the map & table below:



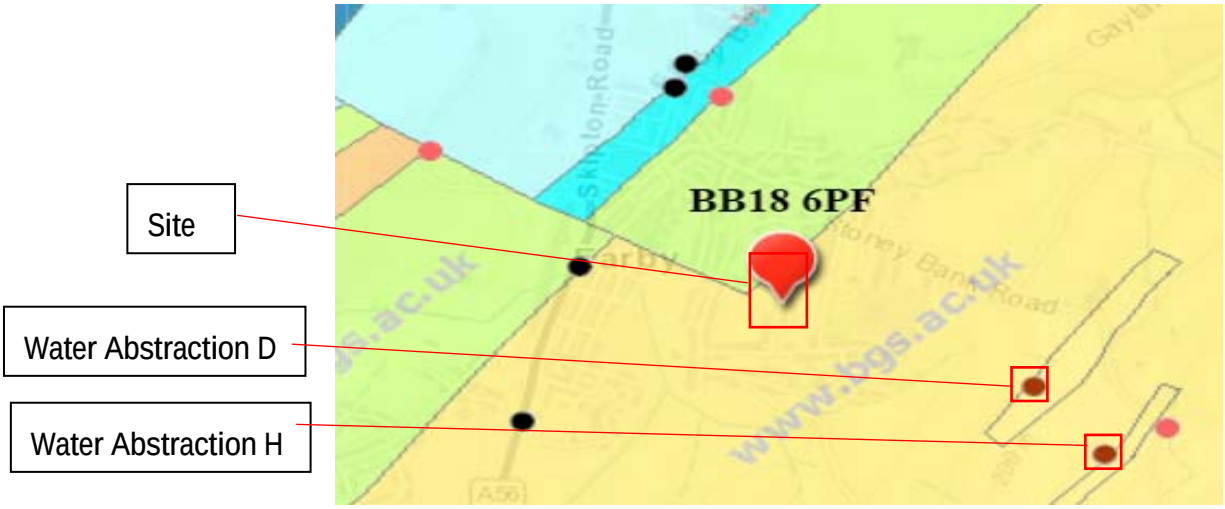
ID	Location	Details	
D	537m E	Status: Historical Licence No: 2/27/15/114 Details: General Farming & Domestic Direct Source: GROUNDWATERS Point: SPRING Data Type: Point Name: BOWKER Easting: 391500 Northing: 446200	Annual Volume (m^3): - Max Daily Volume (m^3): - Original Application No: - Original Start Date: 17/03/1966 Expiry Date: - Issue No: 100 Version Start Date: 17/03/1966 Version End Date: -
D	537m E	Status: Historical Licence No: 2/27/15/114 Details: General Farming & Domestic Direct Source: GROUNDWATERS Point: SPRING - EARBY Data Type: Point Name: BOWKER Easting: 391500 Northing: 446200	Annual Volume (m^3): - Max Daily Volume (m^3): - Original Application No: - Original Start Date: 17/03/1966 Expiry Date: - Issue No: 100 Version Start Date: 17/03/1966 Version End Date: -
H	753m E	Status: Historical Licence No: 2/27/15/235 Details: Potable Water Supply - Direct Direct Source: GROUNDWATERS Point: BOREHOLE - PENDLE GRIT - HODGE CLOUGH Data Type: Point Name: YORKSHIRE WATER SERVICES LTD Easting: 391700 Northing: 446100	Annual Volume (m^3): 618269 Max Daily Volume (m^3): 2727.66 Original Application No: - Original Start Date: 25/06/1969 Expiry Date: - Issue No: 100 Version Start Date: 22/10/1969 Version End Date: -

Elevation recordings from the site and the surrounding area shows the site to be located at the bottom of a steeply graded slope, running roughly 1000m East of the site.

The site has been located at an Elevation of 475.7ft, Water Abstraction 1 is recorded at approximately 669.3ft, Water Abstraction 2 is recorded at 731.6ft, and the reservoirs at the top of the slope are located at 866.1ft.



Recordings from the British Geological Survey show the site to be consisting of two different types of Bedrock. To the South of the site the bedrock is a Pendle Grit Sandstone, a permeable sedimentary rock. To the North of the site the bedrock is Bowland Shale Mudstone, a very fine-grained sedimentary rock with low permeability.

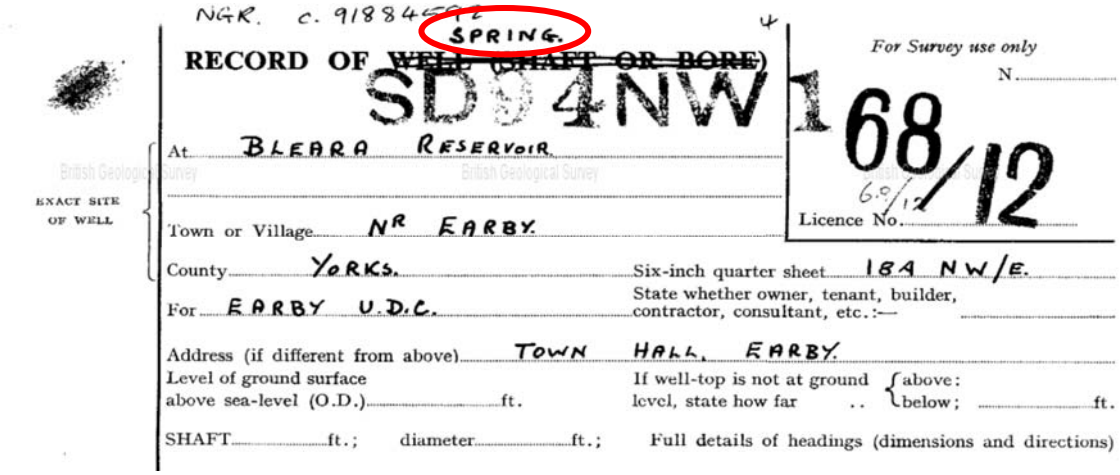


3.5 Historic Boreholes

Historical borehole samples were recorded approximately 1000m Southeast of the site, within close proximity to the Reservoir.

One of the borehole records (ref. SD94NW6) was recorded to a depth of 200m. There was superficial made ground recorded down to 5ft. Beneath this mainly consisted of a varying grain size of sandstone from fine to course. There was also sections of deposited fine clay and shales. This again further shows the Geology to the east of the site to consist of permeable Geology.

Another Borehole recorded approximately 1000m Southeast of the site showed that the abstraction point was in fact a Spring. This record showed that this spring produced a maximum of 634,000 gallons per day of water. As can be seen from the record below:



NGR. c. 91884[illegible]

SPRING.

RECORD OF ~~WELL (SHAFT OR BORE)~~

SD 94NW 4

For Survey use only

N.

168/12

6.9.12

Licence No.

At BLEARA RESERVOIR

British Geological Survey

ENACT SITE OF WELL

Town or Village NR EARBY.

County YORKS.

Six-inch quarter sheet 18A NW/E.

For EARBY U.D.C.

State whether owner, tenant, builder, contractor, consultant, etc.:—

Address (if different from above) TOWN HALL, EARBY.

Level of ground surface above sea-level (O.D.) ..... ft.

If well-top is not at ground level, state how far { above: / below; ..... ft.

SHAFT ..... ft.; diameter ..... ft.;

Full details of headings (dimensions and directions)

ANALYSIS (please attach copy if available)

Extract from letter dated 21.8.52 filed with W6. correspondence.

		Maximum	Minimum
Gauge	A.	500,000 g.h.d.	16,000 g.h.d.
Gauge	B.	134,000 g.h.d.	18,000 g.h.d.

"The supplies are measured over right angle V-notches & the flows recorded as above."

All available details of the installation are shown on the 6" map.

3.6 Additional Site Walkover

A further site visit was undertaken post heavy rain on the 15th of February 2022. Following the initial desk based assessment. The following salient features were noted (not previously evident using desk based info)

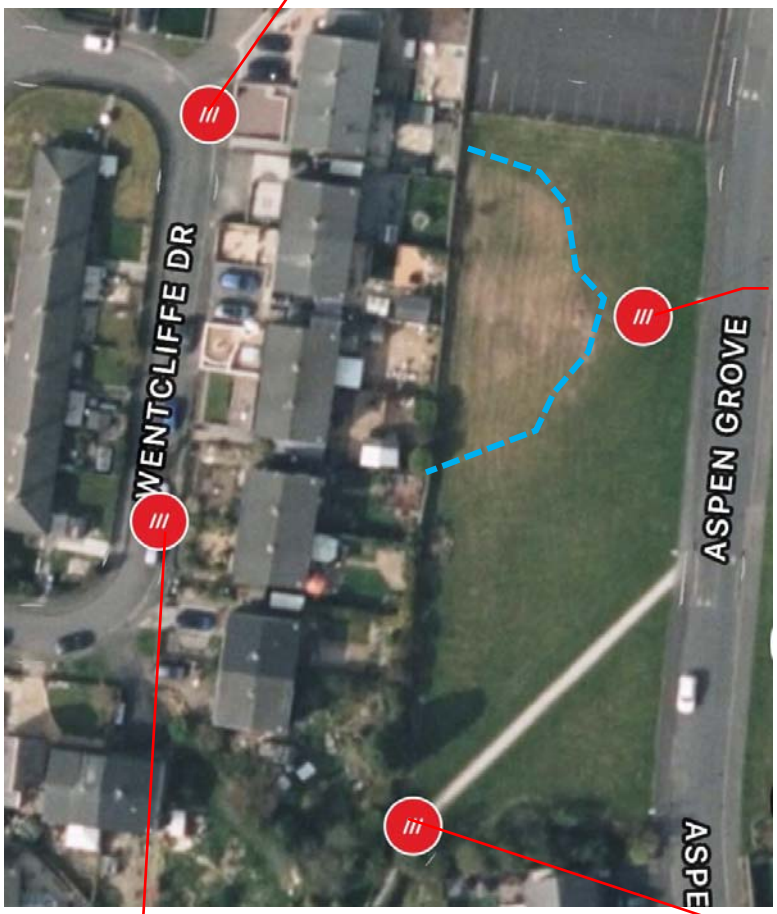
1) Water filled ditch along the footpath which runs north south along the field boundary to the east (accessed from Pleasant View). Water flow appeared to be to the South towards existing ditch / drain

2) Area of potential spring or broken drain welling out of the grassed area west of Aspen Grove – water flow was significant and direction of water flow to the west.

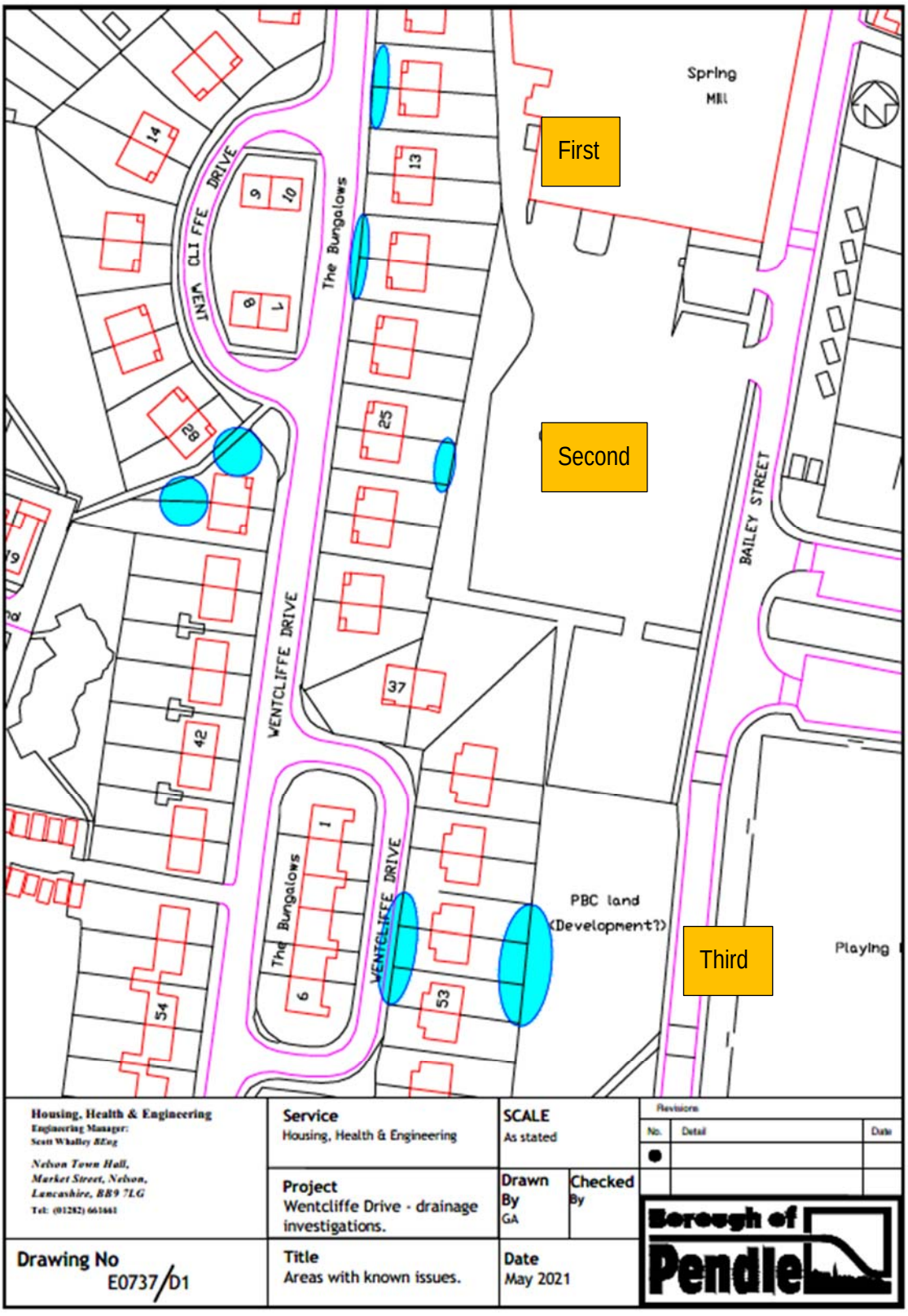
Looking north

Looking west

The houses directly west of the suspected spring (2) had water running along their frontage.



There are three areas of groundwater flooding as identified on the Pendle drawing below and confirmed during the walkover.

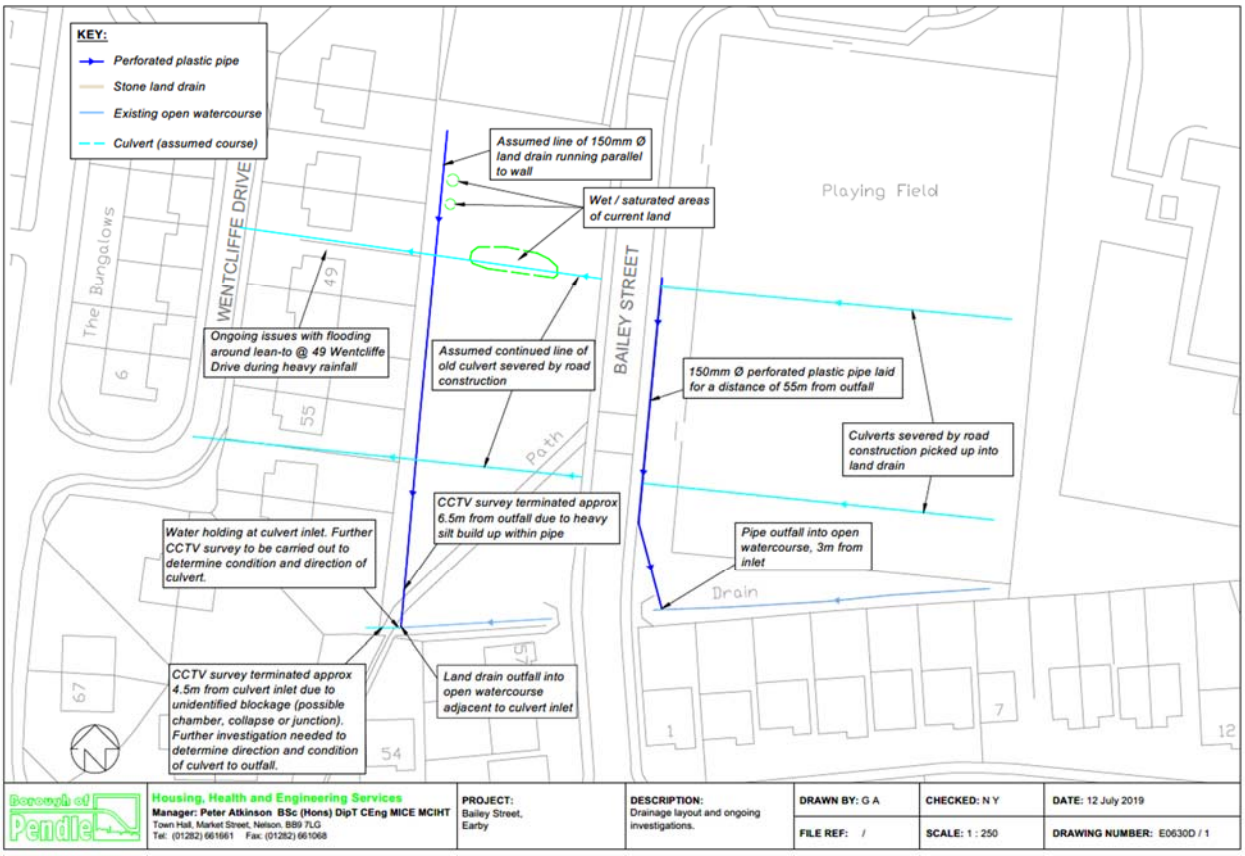


The first area is believed to be associated with the spring / drain feature – from the walkover the area appears to have grown larger to the north.

Second – probably the same body of water / spring line but emanating from the car park area.

Third – around the houses at 30 Wentcliffe Drive which is potentially influenced by GSHP installed to the Bungalows no 7 -10, but it is also noted to be poorly drained soil in these gardens and in a low area – may just be holding surface water. Poorly drained soils were also noted at the Bungalows.

It is noted that a drainage investigation was undertaken by Pendle BC to establish if the old field drainage has been picked up along developed boundary and sports playing pitch and existing car park – shown below.



4 CONCLUSIONS

4.1 Summary of Historic Data and Potential Hydrogeological Influence

It is reported that over the last few years groundwater flooding has increased within the area with various spring lines developing.

Within the area there are many streams, watercourses and springs that have been active since our earliest maps, dating back to the 19th century. There is potentially a large amount of water present within the ground in the surrounding the site. As the site is located at the bottom of a steeply graded hill to the East, naturally the ground and surface water is likely to migrate in the direction of the slope and toward the site. Also, as can be seen from the historical mapping section there are streams leading directly to the site, potentially providing pathways for ground and surface water to migrate.

However, the ground water levels and flows over the last century have likely been limited and maintained by the abstraction and retention of the water in the area. Somewhere between 1892 and 1907 large reservoirs were constructed approximately 1250m Southeast of the site, providing a location for water storage. Also, water abstraction points were placed locally to the reservoir, where abstracted water from natural springs would have been extracted in order to store the water in the reservoir, or pump it elsewhere. It is important to note that this was pre development.

Between 2010-2011 the Earby Reservoir became disused and was infilled. Also, abstraction points became disused at an unknown date. This could have possibly caused ground and surface water levels to increase, and so with an increased amount of water contained within the permeable sandstone bedrock, water could have begun to migrate down the slope towards the site, increasing levels from 2011.

Increased amounts of ground and surface water levels due to decreased water abstraction in the area has migrated down the slope towards the site. Water has likely reached the site through the highly permeable sandstone to the east, or through the streams and pathways present or over land without being captured in the previous abstraction systems. As the water has moved through the sandstone, it has eventually reached the mudstone formation, which is impermeable. When unable to move horizontally, it has followed the path of least resistance and migrated vertically through the superficial deposits to ground level, resulting in increased groundwater being present at surface. The overlying confining geology (unknown thickness) is likely to act as an aquitard and in turn has a high risk of an underlying potentially artesian water table.

Groundwater abstraction has decreased (stopped) from the sandstone aquifer to the east / up gradient since building the properties which may have increase water table and or risk of artesian water. The Yorkshire Water plant has been recently demolished and details unknown capping / decommissioning of the abstraction points

4.2 Summary of Other Potential Water Sources

It is suggested that the ground water is geology related and potentially also influenced by human activity.

It is noted that ground source heat pumps have been installed within several properties in the area recently – however little detail on the type of due diligence undertaken to determine risk of artesian water is known. It is also understood that these are to the west, down gradient of the main area of surface flooding.

In addition, it is noted that drainage from the hillside historically led to the site – the condition of which is unclear.

Whilst the installation of a ground source heat pump or a water source heat pump on domestic premises is usually considered to be permitted development, not needing an application for planning permission best practice documents should be followed.

The Environment Agency: Environmental good practice guide for ground source heating and cooling V3 states the following:

'Both open loop systems and closed systems installed at depth can result in the interconnection of different aquifers units during drilling - affecting water quality or flow.'

'Before you start drilling a borehole (for both closed and open loop schemes) you should seek the advice of a qualified hydrogeologist to understand the geology and hydrogeology you will be drilling into in order to anticipate and mitigate any problems. When drilling a closed loop borehole there is no obligation to consult us, but it is good practice to identify the risks in advance. For open loop schemes, you require a groundwater investigation consent from us to drill and test the borehole.

It is worth noting that for water wells drilled deeper than 15m you are legally required to notify the British Geological Survey, however it is good practice to notify them for any borehole. On completion of drilling, a brief report and drilling log should be submitted to the British Geological Survey, using the form found on their website'.

The use and interpretation of geological data is likely to require the involvement of a specialist consultant or advisor. There are a number of documents detailing best practice for borehole construction including our Water Supply Borehole Construction and Headworks: Guide to Good Practice (EA2000).

'Note 4: You also need to understand the aquifer conditions prior to excavation. If there is a risk of artesian groundwater conditions being encountered during drilling, we recommend you find an alternative location for closed loop schemes due to the risk of causing uncontrolled artesian overflow. Be aware that it can be very difficult (and costly) to control artesian groundwater pressures if appropriate precautions are not taken at the design and construction stages. Where this is not possible you will need to:

- *identify the risks of artesian overflow*
- *seek advice from competent professionals such as hydrogeologists and drilling experts*

• contact us to discuss a drilling and grouting plan to control the artesian pressure during construction and on completion.

If you have assessed the risks prior to drilling this should minimise the chance to encountering unexpected artesian flows. However if small artesian flows are inadvertently encountered, the completed borehole must be securely sealed, typically by backfilling with a non-shrinking grout mixture of low enough hydraulic conductivity (10-9 m/s or less) that any future leakage of artesian groundwater is prevented. If you allow uncontrolled artesian overflow you will be in contravention of water resources legislation, which could lead to regulatory action by us. For open loop schemes, the method of drilling and a contingency plan should be agreed with us to ensure that artesian heads can be safely controlled during and after drilling. Where the artesian pressures are too great for the abstracted water to be returned to the aquifer when also taking into account the additional pressure of reinjection, such schemes would likely be classed as consumptive. It is possible that we would not be able to issue an abstraction licence in these circumstances because of the potential impact on other users and the water resource.'

Whilst this may be a contributing factor it is unlikely to be a source of surface flooding to the east of the site.

Global warming – increased rainfall may be a contributing factor however given the visual increase it is unlikely to be a significant factor / magnitude

It is advised that the assistance of the Environment Agency and British Geological Survey may be sought to establish their opinion on the above conclusion.

4.3 Further Work Required

It is suggested that to try to aid conclusion and remedial works the following should be undertaken:

- Undertake hand pitting to establish the presence of the possible spring / broken drain features and the culvert features mentioned by PBC. Look at potential for further interception and routing to the known watercourse to the south. Care required so not to penetrate any clay cover and allow artesian water to emanate.

- Request geothermal boring risk assessment from third parties and Environment Agency request for comment on their Guidance Document and potential breach of water resource legislation.

- Request information from the BGS to establish if records were provided by the ground source heat pump drilling company (assess if greater than 15m to see if any breaches of legal requirements to consult the BGS)

- Request decommissioning details from Yorkshire Water and Environment Agency for the water abstraction wells upon the hillside.

5 REFERENCES

5.1 BS 5930:2015 Code of Practice for Ground Investigation.

5.2 Investigation of Potentially contaminated sites BS10175:2011 +A1:2013.

5.3 Environment Agency: Environmental good practice guide for ground source heating and cooling V3 https://www.gshp.org.uk/pdf/EA_GSHC_Good_Practice_Guide.pdf

5.4 BS8576:2013 Guidance on investigations for ground gas.

5.5 R & D Publication CLR 8 (March 2002) Assessment of Risks to Human Health from Land Contamination: An Overview of the Development of Soil Guideline Values and Related Research. Environment Agency.

5.6 R & D Publication CLR 10 (March 2002) The Contaminated Land Exposure Assessment Model (CLEA): Technical basis and algorithms. Environment Agency.

5.7 Contaminated Land Risk Assessment; a Guide to Good Practice; CIRIA C552: 2001.

5.8 BRE 211 Radon: guidance on protective measures for new buildings (including supplementary advice for extensions, conversions and refurbishment) (2007 edition).

5.9 Assessment of risks to human health from land contamination: an overview of the development of guideline values and related research. EA, 2002.

5.10 Health and Safety in Construction, HSG150, HSE, 1996.

5.11 Baker W (1987), Investigation Strategy - lecture at City of Birmingham Development Department Symposium on Methane Generating Sites, 9 December 1987, Industrial Research Laboratories, Birmingham.

5.12 NHBC Standards, Chapter 4.2, 2020 Building Near Trees.

5.13 'Guidance on Evaluation of Development Proposals on Sites Where Methane and Carbon Dioxide are Present', Report Edition No.04 March 2007 NHBC – designed for use with low rise residential properties.

5.14 CIRIA C665 'Assessing risks posed by hazardous ground gases for buildings' 2007 - for high rise residential / flats.

5.15 BS8485:2015+A1:2019 'Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings'.

5.16 BRE 414 'Protective measures for housing on gas-contaminated land' Roger Johnson, Parkman Environment 2001.

5.17 BS 8500-2:2015+A1:2016 'Concrete British Standard to BS EN 206. Specification for constituent materials and concrete'.

5.18 CLR11 'Model Procedures for the Management of Land Contamination' DEFRA 2004.