

**PHASE 1 & 2 GEOTECHNICAL AND
GEO-ENVIRONMENTAL SITE INVESTIGATION**

**THE OLD QUARRY, COMMON ROAD
BRIERLEY**

FOR

MR C. GROOM



39496-001

10 March 2016

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Appendix 3 Trial Pit Logs TP1 – TP5

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1.0 EXECUTIVE SUMMARY

1. The site is located to the north of Common Road in Brierley, around 8 km north east of Barnsley Town Centre. The site has an area of around 0.3 hectares and is centred around grid reference SE 413 110 (441305, 411008). The site is rectangular in shape on plan and slopes down towards the north north-west away from Common Road. The proposed development is to comprise one residential property of conventional construction with a private garden and driveway.
2. Currently, the site is unoccupied and comprises an old quarry which is overgrown with scrub trees and shrubs. Areas of tipped material were present, especially at the south-west corner and the eastern side of the site. Historically, no previous uses are indicated on the site, although it has been used as a sandstone quarry at some point in the past, with a high wall running along the northern side of the site. The surrounding land is predominantly residential in nature.
3. The geology beneath the site is indicated to comprise the Brierley Rock sandstone of the Middle Coal Measures.
4. Precautions against the effects of shallow coal mining are not considered to be required.
5. The Environment Agency flood maps indicate the site does not lie within a flood zone.
6. Topsoil/ made ground was encountered across the majority of the site overlying possible made ground (which was probably locally reworked natural ground) of sandy gravelly clay and clayey sandy gravel and cobbles of sandstone. Below these deposits, hard strata was encountered in two of the trial pits at depths of approximately 3 m bgl, which is considered to be bedrock in the base of the quarry.
7. Groundwater was encountered in TP2 in the north of the site at 0.6 m with a fast ingress into the pit. This pit was within the lowest area of the site, and the water is likely to be the result of perched surface water collecting at the base of the current slope above the hard bedrock.
8. The site currently drains by infiltration into the natural ground, and it is proposed to maintain this arrangement within the proposed development. Ponding of surface water on the site is not apparent, although some perched water is currently present within the ground. However, this is likely to soakaway through the underlying bedrock. A soakaway test was undertaken within the sandy deposits in the south of the site which worked satisfactorily, although this may have been within fill materials. Further testing may be necessary to prove the available

infiltrations rates within the bedrock, but is currently considered that infiltration drainage will be suitable for the development.

9. It is proposed to keep the finished floor level of the house below the level of Common Road, with a limited amount of cut and fill required to create a level development plateau. It is expected that there will be approximately 3 m of made ground below the house, with hard bedrock below. Therefore, trench fill footings can be used. Alternatively simple concrete pads, or short piles could be considered with ground beams spanning between.
10. Precast concrete ground floors are recommended with a 250 mm high ventilated void below.
11. No radon precautions are required.
12. A negligible risk of gas generation may be presented by the made ground on the site, However, the plot is to use a suspended ground floor, with a ventilated void below. This is considered adequate to mitigate the risk of gas entering the dwelling and no other protective measures are proposed.
13. The current topsoil/made ground on the site contains elevated concentrations of PAH compounds, including benzo(a)pyrene. It is recommended that a 600 mm capping layer of topsoil is placed above the existing material where it remains on site. Alternatively, the existing site won material can be excavated and removed.
14. The topsoil/ made ground would be assigned a Design Sulphate Class of DS-2 and an ACEC class of AC-3z. The made ground would be assigned a Design Sulphate Class of DS-1 and an ACEC class of AC-3z, due to the low pH levels recorded.
15. Should any unusual, brightly coloured, ashy or odorous material be encountered during construction this should be brought to the attention of the site staff and investigated.
16. The conclusions made in this report in relation to contamination are subject to agreement by the approving bodies such as the Local Authority and any warranty provider.

2.0 INTRODUCTION

2.1 Terms of Reference

This report presents the findings of a geotechnical and geo-environmental site investigation carried out by Eastwood and Partners (Consulting Engineers) Ltd for, and on the behalf of, Mr C Groom, under the instruction of M. Booth Design Limited. Any other parties using the information in this report do so at their own risk and any duty of care is excluded.

2.2 Context

Eastwood & Partners are not aware of any previous investigations having been undertaken on the site.

2.3 Aims and Objectives

The aims and objectives of this investigation were as follows.

- Assimilate Phase 1 data to derive an outline conceptual model identifying potential contaminants, pathways and receptors, as well as possible linkages between these;
- Obtain additional information and incorporate with previous data enabling refinement and subsequent further testing of the conceptual model;
- Detail the ground conditions and their geotechnical properties enabling outline foundation proposals to be made for the proposed residential development;
- Carry out tiered risk assessment to establish the likely risks to future receptors, involving the use of generic assessment criteria and where unacceptable risks are identified, site specific assessment criteria within a detailed quantitative risk assessment;
- Identify feasible remediation options if unacceptable risks are highlighted;
- Develop an appropriate remediation strategy where remediation is required.

2.4 Scope of Investigation

This document is split into two sections. These constitute the findings of the Phase 1 and Phase 2 investigations, consecutively.

2.4.1 Phase 1

The Phase 1 investigation involved a review of information extracted from published documentation as well as that obtained from a site reconnaissance. Information regarding the current and former land uses both on and surrounding the site, as well as the environmental sensitivity of the site location as determined by factors including geology, hydrogeology and hydrology have been examined.

Information analysed in this section of the report has been obtained from a variety of sources and included the following:

- A Landmark Envirocheck report. This includes historical Ordnance Survey maps, as well as information regarding environmental issues such as abstraction licenses, pollution incidences and waste facilities. It compiles information obtained from amongst others, the Environment Agency and the Local Authority;
- Coal Authority Mining Report;
- Geological Maps and associated Geological Memoirs;
- The British Geological Survey website.
- A site walkover.

2.4.2 Phase 2

This part of the investigation consisted of intrusive works and laboratory analysis. The findings were used to test the conceptual model and produce a final risk assessment.

The intrusive works comprised the excavation of trial pits and infiltration testing to enable:

- Examination of the upper few metres of ground;
- In situ description of soils, enabling any localised lateral and vertical changes in soil conditions to be logged;
- Assessment of any contamination identified using visual and olfactory methods;
- Collection of soil samples for chemical testing; and
- To establish if soakaways are a suitable form of surface water drainage.

2.5 Limitations of Investigation

This report is based on the assumption that the site will be developed with a single residential property which will be of conventional construction, with a private garden and driveway.

Where assessments of site areas affected in particular ways are given, these are approximate. All information, comments and opinions given in this report are based on the ground conditions encountered during the site work, on the results of laboratory testing carried out as part of the investigation and information gained from a geological and historical desk study. However, there may be conditions at the site that have not been taken into account, such as unpredictable soil strata and water conditions between or below investigation points. It should be noted that groundwater and gas levels vary due to seasonal or other effects, and may at times differ from those measured during the investigation.

This report considers the ground and groundwater and does not cover any buildings or their fabric. Generally, testing has only been carried out for contaminants identified as potentially present with no assessment made of biological contamination. Risks to ecological receptors, such as bats, have not been considered.

3.0 THE SITE

3.1 Description

The site is located to the north of Common Road in Brierley, around 8 km north east of Barnsley Town Centre. The site has an area of around 0.3 hectares and is centred around Ordnance Survey national grid reference SE 413 110 (441310, 411000). The site is approximately rectangular in shape on plan, the long axis being orientated from east to west. The site slopes north north-west from Common Road at a level of around 94 m AOD down to around 89 m AOD in the north western corner.

Currently, the site is currently undeveloped, and is roughly surfaced with assorted soils. Self-seeded grass, trees and shrubs are present at the north-east corner and the south-west corner of the site. Areas of fly tipped material were present, especially at the south-west corner and the eastern side of the site.

The site is bordered to the north by a steep sandstone rock face with trees growing above it. This is considered to be an old quarry highwall. The highwall extends around part of the western boundary also, with a stone retaining wall and trees forming the remainder of this boundary. A brick wall is present along the eastern side of the site with fencing and trees. The southern boundary is formed by a stone wall adjacent to Common Road.

The 'Exploratory Hole Location Plan', drawing reference 39496/001, and photographs of the site are included in Appendix 1.

3.2 History

A review of historical maps has been carried out for the purposes of assessing former land usage at and within the vicinity of the site. Copies of historical maps for the site, from the Envirocheck report, are in Appendix 2.

3.2.1 The Site

The earliest map reviewed, dated 1854, shows the site to be occupied by non-coniferous trees. The earliest 1:2500 map sheet shows the west of the site to have a change in level. By 1906 a rock face is shown along the northern edge of the site. Although the maps do not label it, the site is likely to have been a quarry at this time. Workings may already have ceased by this time, given the trees indicated across the site.

By 1976, the trees are no longer shown, and by 1993 a wall is shown to the south-west of the site. The 2015 map sheet shows trees across the site again.

No other changes are indicated by the maps.

3.2.2 The Surrounding Area

The earliest map, from 1884, shows the area immediately surrounding the site to be mainly open fields and woodland. Road configurations such as Common Road had been developed and a public house was located around 150 m south-west. By 1893 this was no longer shown.

Much of the woodland surrounding the site had been cleared by 1894 and residential development had begun to the west of Church Street. A railway line had also been developed around 800 m to the north of the site.

By 1907 an old quarry is shown around 260 m to the east of the site. This is no longer labelled by 1933. Brierley Colliery had been developed 250 m south-west of the site by 1933 and an area labelled as 'Miners Welfare Recreation Ground' was shown 180 m north-east. Windmill Hill Quarry was also shown 800 m south of the site and a sewage works had been developed 500 m south adjacent to some allotment gardens. Further residential development had also taken place west and east.

By 1967 the sewage works and Brierley quarry were no longer shown and Windmill Hill quarry is labelled as disused. Residential development had begun to the south.

No further significant changes are shown to have occurred on the historical maps.

3.3 Geology

The British Geological Survey map sheets 87 (1:50,000 scale) and 263 SW (1:10,560 scale) show the site to overlie the Brierley Rock of the Middle Coal Measures, described on the maps as being a "rather hard reddish yellow sandstone, strongly false bedded with thin lenticular flaggy layers and soft ochreous patches". No superficial deposits are indicated to be present.

No faults or other lines of weakness are shown to cross the site and the strata are indicated to dip generally towards the east. Using local colliery shaft data, the strata are expected to dip at an angle of around 9°.

The British Geological Survey website shows a number of historical boreholes within 200 m of the site. The nearest, (referenced SE41SW193) is approximately 150m north of the site, and extends to

around 2.95 m bgl. It records predominantly topsoil over weathered silty sandstone with clayey sand to 1.4 m depth over laminated sandstone.

Another borehole record, around 150 m north, records 0.4 m of topsoil, over silty sand to 1.5 m depth, over laminated silty sandstone to 3.15 m below ground level.

Hodroyd Colliery is shown by the maps to have been located around 250 m south-west of the site (in the same position as Brierley Colliery as shown by the historical maps), which recorded sandstone to a depth of around 11 m bgl, with mudstones with thin coal bands below this.

3.4 Hydrogeology

According to the Environment Agency, the solid geology below the site is classified as a Secondary A Aquifer. This is defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.

Information within the Envirocheck Report also states that the site does not lie within or close to a Groundwater Source Protection Zone.

The Envirocheck report records no licensed water abstractions within 1 km of the site.

3.5 Hydrology

The nearest surface water feature is a tertiary river located 87 m south east from the site. This is unlikely to be affected by activities on the site.

3.6 Extractive Industries

3.6.1 Coal Mining

The geological maps indicate the shallowest named coal seam to be the Brierley Coal, which is shown to outcrop around 300 m south of the site. Reference to the geological memoir indicates the Brierley Coal in the north of Brierley near Frickley Bridge to be around 28 inches thick (0.7 m) overlain by dark shales with ironstones and underlain by a thick bed of yellow fireclay. To the west at Brierley/Hodroyd Colliery, the seam is recorded to be 39 inches thick (1.0 m). thick, although the lower 600 mm of the seam includes dirt band. The memoir refers to the seam as being an inferior coal. It is therefore unlikely that the Brierley Coal has been worked. The shafts at the nearby colliery extended below this to work deeper coal seams.

The Brierley Coal is expected to be encountered at a depth of around 45 m below ground level, and therefore is unlikely to affect developments at surface in the unlikely event that workings have been attempted.

The second shallowest named seam of coal expected beneath the site is the Shafton Coal which is recorded in the Geological Memoir as being 530 foot (162 m) below the Brierley Coal. The Shafton Coal was encountered at 196 m bgl within the Hodroyd Shafts. The seam will be slightly deeper beneath the site, and therefore not at a level where workings are expected to impact the site. The seam is likely to have been worked in the past.

A number of thin, unnamed seams are likely to be present at shallow depth beneath the site. However, these are no more than a few hundred millimetres thick, and therefore will not have been of economic interest in the past.

A Coal Authority Report has been obtained for the site. It states that the site is in the likely zone of influence from workings in four seams of coal at approximately 190 m to 660 m bgl, and last worked in 1986. The shallowest workings are therefore likely to be within the Shafton Coal. Any ground movement from these coal workings should have stopped by now. According to the report, there are no known coal mine entries within, or within 20 m of the boundary of the boundary of the site.

The site is not in the likely zone of influence of any present underground coal workings. There are no current applications for a licence to remove coal using underground methods in the local area, however reserves of coal do exist in the area and could be worked at some point in the future, although this is considered to be unlikely given the demise of the coal mining industry in this area. The site is not within the boundary of any historical opencast coal mining sites.

The Coal Authority has not received a damage notice or claim for the subject property, or any property within 50 metres, since 31 October 1994. There is no record of a mine gas emission requiring action by the Coal Authority within the boundary of the property.

The site is in an area for which a notice of entitlement to withdraw support was published in 1953. This has not yet been revoked.

Based on the information from the geological maps and the Coal Authority report, the site is not expected to be at risk from historical coal mining at shallow depth. No further investigation is considered necessary, and no remedial works such as drilling and grouting should be required.

3.6.2 Quarrying

The Brierley Rock has been worked locally via surface extraction in quarries. The geological memoirs record workings near Holgate Hospital, 1.5 km north of the site and also at Pudding Hill 640 m east of Brierley Church.

The site also appears to have been quarried in the past, possibly during the late 1800s or early 1900s, with sandstone exposed in the face of a highwall which forms the northern and western site boundary. This is around 10 m in height, which is approximately the thickness which the Brierley Rock sandstone was found to be in the nearby colliery.

It is therefore possible that the sandstone has been completely removed from within the site, leaving the underlying shale/mudstone. Some reworked material may also have been replaced into the excavation after completion of the workings.

3.7 Ground Gas

3.7.1 Landfill Gas

Information obtained from the Envirocheck report and from the Environment Agency's website, indicates that there are no historical or active landfills within 500 m of the site. Landfill gas migration onto the site from the surrounding area is therefore not considered to be a potential risk to the development.

Deep made ground may be expected on the site if the former quarry has been partially backfilled. The fill materials would generally be expected to comprise the natural overburden and general quarry waste, which would likely include sand, clay and sandstone fragments. This will have been in place for many years, and is unlikely to be a significant source of gas generation unless a significant proportion of degradable materials are present within the fill. However, it is possible that additional materials have been deposited over the years, in which the potential for gas generation could be higher. An intrusive investigation will be required to confirm the nature of any fill materials which are present.

Gas monitoring may be required if significant depths of made ground are present or if a significant amount of organic/degradable matter is present. Alternatively, gas resisting measures could be incorporated into the buildings substructure.

3.7.2 Radon

The Envirocheck report states that the property is in a lower probability radon area, as less than 1% of homes are above the action level. No radon protective measures are therefore required in new dwellings.

3.7.3 Mine Gas

Shallow mine workings are not expected below the site, and therefore mine gas is not considered to present a potential risk to the site.

3.8 Pollution Incidents to Controlled Waters

The Envirocheck report does not record any pollution incidents to controlled waters within 500 m of the site.

3.9 Discharge Consents

The Envirocheck Report does not record any active discharge consents within 500 m of the site.

3.10 Flooding

According to the Environment Agency flood maps, the site does not lie within a flood zone.

4.0 OUTLINE CONCEPTUAL MODEL

The site is being considered for a residential development, comprising a single dwelling with a private garden and driveway.

4.1 Potential Sources of Contamination

Historically, the site has generally been undeveloped previously, but quarry workings have been undertaken. The quarry may have been partially infilled, although the workings could possibly have progressed horizontally from the roadside into the natural slope.

If fill materials are present, these may comprise reworked natural soil and fragments of sandstone rock remaining from the quarry workings. However, there may potentially also be imported materials included in any backfill.

The depth of fill is difficult to judge at this stage, as the base of the quarry could extend below the current surfacing. Fill in excess of 2 m deep could be present. The made ground may contain some elevated concentrations of heavy metals such as arsenic, nickel, copper or zinc, as well as elevated levels of PAHs, particularly if ashy materials are present. There is also the potential for asbestos containing material to have been fly tipped on the site.

4.2 Ground Gas

Ground gas may be a potential issue at this site if made ground is encountered at a thickness of more than around 2 m, or if significant biodegradable material is found within the made ground. No risk of landfill gas migration from the surrounding area is considered to be present.

Radon precautions are not required.

4.3 Potential Pollutant Linkages

The following table details the possible sources and associated contaminants of concern, pathways and receptors, highlighted by the Phase 1 investigation as potentially present.

Source	Pathway	Receptor
- Heavy metals and PAHs in any made ground present. - Naturally elevated levels of heavy metals in the natural ground.	Ingestion, inhalation, direct contact	- Site construction workers - Future residents and visitors to the site.
	Root uptake	Plants
	Migration through ground	Secondary A aquifer
Sulphates in made ground.	Direct contact	Below ground concrete
PAHs and heavy metals in made ground.	Direct contact	Water supply pipes
Ground gas from deep made ground	- Migration into buildings. - Inhalation	- Future residents and visitors to the site. - Buildings

5.0 GROUND INVESTIGATION

5.1 Site Works

We visited site on 8 February 2015 and excavated five trial pits, TP1 to TP5, in order to determine the underlying ground conditions. These reached depths of between 0.6 m and 4.2 m below ground level (bgl).

TP2 was terminated upon encountering groundwater with a fast ingress into the pit. TP3 was terminated due to the limit of the machine being reached and TP4 and TP5 were terminated in hard ground, where further progression was difficult. The trial pit positions were selected to give good site coverage.

Copies of the trial pit logs are presented in Appendix 3, and the pit locations are indicated on the Exploratory Hole Location Plan, Drawing number 39496/001 revision A in Appendix 1.

An infiltration test was undertaken in TP1. The test results are included in Appendix 4.

5.2 Laboratory Testing

One sample of topsoil, four samples of topsoil/organic made ground and five samples of made ground/possible made ground were despatched for chemical testing. Soil samples were taken in 1 kg plastic tubs and 250 ml amber glass jars and analysed at Chemtest Laboratories, Newmarket using MCERTs accredited methodologies where available.

Laboratory testing results are presented in Appendix 4 and discussed further in Sections 7.0 and 8.0.

6.0 GROUND CONDITIONS

6.1 Surface Covering

Topsoil/organic made ground was encountered across the site from surface, which comprised slightly sandy slightly gravelly clay. TP2 to the south-west corner of the site encountered gravel of sandstone and mudstone, whereas the material across the rest of the site had inclusions of brick, plastic, glass, ceramics, rubber, sandstone and wood. The topsoil/made ground generally extended to depths of between 0.3 m and 0.4 m bgl, but extended to 2 m bgl in TP5.

6.2 Made Ground

Definite made ground was encountered in three of the trial pits, TP1, TP3 and TP4, to depths of between 0.6 m and 1.1 m bgl. The materials comprised loose orange brown sand and clay with gravel and cobbles of sandstone, and are probably reworked natural ground.

Material which was considered to possibly be made ground was encountered in all five trial pits. This also comprised loose gravelly cobbly sand, locally becoming clay, where the gravel and cobbles were of sandstone. The material was very soft, and easy to excavate through, which suggested that it may have been reworked. However some layering of the strata was evident, which could represent natural bedding, but could also be due to the way the materials were deposited. With reference back to Section 3.3, the Brierley Rock Sandstone formation is noted to include bands of softer sand, and local borehole encountered bands of silty material. It is therefore possible that this soft material is one of these layers within the sandstone.

This 'possible made ground' extended to depths of between 3.1 m and 3.3 m in TP4 and TP5, but in TP1 and TP3 was extended to depths in excess of 2.3 m and 4.2 m respectively. However, TP1 and TP3 were excavated in areas where slopes/ramps have obviously been created for access onto the site where reworked soil may have been placed. In TP2, the trial pit was terminated at 0.6 m bgl due to an ingress of groundwater.

6.3 Natural Ground

Natural ground was not recovered from any of the trial pits, although as discussed above, the 'possible made ground' may potentially represent the natural strata in some locations. In two of the trial pits, TP4 and TP5, hard strata was encountered in the base of the trial pit at depths 3.1 m and 3.3 m bgl, which is likely to be bedrock, either of the Brierley Rock formation or the underlying Coal Measures strata. Both of these trial pits were excavated in the lower part of the site, which probably formed the base of the former quarry.

6.4 Obstructions

No significant obstructions were encountered. No boulders of sandstone were encountered within the made ground or reworked materials.

The ground in the north of the site was found to be saturated and very soft, and the excavator had difficulty in accessing this part of the site.

6.5 Groundwater

Groundwater was encountered in TP2 at 0.6 m depth with a fast ingress, increasing to 0.4 m after 10 minutes. This trial pit was excavated in the lowest part of the site, and this inflow may be the result of perched water which has migrated to the base of the made ground/sand strata.

6.6 Evidence of Contamination

Visual or olfactory evidence of possible significant contamination was not identified in any of the exploratory holes. No materials which would be suspected of containing asbestos were encountered.

7.0 GEOTECHNICAL APPRAISAL

7.1 General

The proposed development is to comprise a single, large residential property, which is to be of conventional construction.

Made ground, or possible made ground/loose natural ground was encountered to an unproven thickness of 4.2 m in TP3. Hard ground was encountered within TP4 and TP5 at 3.1 m and 3.3 m depth, which is expected to comprise bedrock.

The ground on the site is predominantly granular in nature, and is therefore not expected to be shrinkable. The reworked soil/made ground/possible made ground is not considered to be a suitable strata for supporting foundations due to its looseness. The natural bedrock will be suitable for supporting foundations, and is expected to provide an allowable bearing capacity of at least 200 kN/m².

7.2 Foundations

Currently, deep made ground is present in the southern part of the site, which reduces in thickness as the ground level drops towards the north. Based on the initial design drawings, the proposed finished floor level of the dwelling is at 92.3 m AOD. This will require a cut and fill exercise across the plot footprint to level the ground, and will thus reduce the thickness of fill along the front elevation of the plot, but will increase the depth of fill to the rear.

Based on the trial pit information, bedrock is expected at a level of around 88.5 to 89 m AOD under the house. This will therefore result in foundation depths of around 3 m across much of the plot. It is considered that a trench fill footing could be used at this depth perhaps cast prior to filling the ground. Alternatively, simple concrete pads could be used, or short piles driven into the bedrock, with reinforced ground beams spanning between.

7.3 Ground Floors

Due to the depth of made ground beneath the plot, precast concrete floors with a ventilated void of at least 250 mm height will be required.

7.4 Superstructure Precautions

No additional superstructure precautions will be required based on the ground conditions encountered.

7.5 Excavation Problems

The stability of any trenches is likely to be variable due to the presence of made ground, although the sides of all trial pits were stable in the short term.

Support will be required in accordance with current Health & Safety Regulations wherever access is required to trenches deeper than 1.2 m or less where there is risk of collapse.

Groundwater inflow was encountered in the lower, northern area, and this may cause local inundation of excavations. It may be necessary to excavate a sump and to pump the water out of foundation excavations prior to pouring the concrete.

7.6 Surface Water Drainage

Infiltration tests were undertaken in TP1, in the south east of the site, at a depth of 2.3 m bgl. The base of the pit was within the loose sand (possible made ground). Two tests were undertaken, with the water draining away in both within 30 minutes.

The soakaway pit logs, test results and infiltration calculations are provided in Appendix 4, and the results are summarised in the table below.

Infiltration Rates			
Soakaway Test		BR365 Infiltration Rate ($\times 10^{-6}$) m/s	Average Infiltration Rate ($\times 10^{-6}$) m/s
TP1	Test 1	190	130
	Test 2	82	82

The rates indicated by the testing are good, and on that basis soakaway drainage would be considered viable at the site. Currently, the site drains via percolation to the lowest point, in the north. It is assumed that from this point, the groundwater infiltrates through the bedrock, and that the infiltration rate is fast enough to prevent the water backing up and causing ponding at surface within the site. At the time of the investigation, the ground in the north of the site was saturated, but groundwater was only encountered at around 600mm below surface which is expected to be just above the bedrock level. Additionally, the winter of 2015/16 was extremely wet, this probably creating 'worst case' conditions. Although the shallow soils were saturated, no ponding was noted. However, the softness of the soil prevented full access by the excavator, and thus a soakaway test could not be undertaken or the bedrock level confirmed in this part of the site.

It is therefore considered that surface water from the proposed development could be undertaken using a combination of soakaways and permeable surfacing/gulley's, to maintain the current greenfield situation as much as possible. Some piped drainage would be necessary to prevent groundwater becoming trapped around the southern side of the dwelling by the new foundations and substructure, but this could be discharges via chambers or perforated pipes across the rear garden area. The ground levels are to be raised in the rear of the site by at least 2 m, which should be done using granular, free draining material, to take water away from the surface and to effectively store water below the ground.

Some additional testing may be required to prove the infiltration rate offered by the bedrock, which would be best done in the summer months when the ground will have dried out, and better access is available, and discussion will be needed with the regulators to confirm that there is no history of surface water flooding on the site.

Any soakaway chambers should be positioned away from the buildings and hard paved areas to prevent any potential settlement by inundation, caused by the more concentrated flows out of the chamber.

There is no existing connection in to the local sewer network, and therefore it is unlikely that the water company will accept a new connection. In any case, due to the proposed levels, a pumped connection would likely be required into the combined sewer within Brierley Road. Negotiations will be required with the regulators is the possibility of a piped surface water connection is to be considered, and on-site attenuation would more than likely be required.

8.0 REFINEMENT OF OUTLINE CONCEPTUAL MODEL

8.1 Source Characterisation

An outline conceptual model, detailing the possible sources and associated contaminants of concern, potential pathways and receptors identified in the Phase 1 was detailed in Section 4.0.

This section of the report documents the works undertaken to obtain information to test and refine this model enabling a risk assessment to be produced and, where significant risks are expected, remediation recommendations.

8.2 Ground Conditions

The site is covered with topsoil with inclusions of various debris, including wood, metal, glass, rubber, brick, sandstone and plastic. Beneath this made ground/possible made ground was encountered which comprised sandy gravelly clay and clayey sandy gravel and cobbles of sandstone, likely to be reworked natural ground.

The chemical analysis undertaken for the materials encountered are discussed in Section 8.5.

8.3 Ground Gas

The Envirocheck report states that the property is in a lower probability radon area, as less than 1% of homes are above the action level therefore no radon precautions are required.

No landfill sites were identified within 250 m of the site.

The made ground over 3 m deep was encountered, and will remain on site after development. However, no visible or olfactory evidence of degradable material or organic deposits were noted within the made ground, and therefore a significant risk is not expected.

8.4 Unexpected Contamination

No visual or olfactory observations of unexpected contamination were noted.

8.5 Chemical Testing

Five samples of topsoil/made ground and four samples of made ground/possible made ground were sent for testing. All of the samples were analysed for the suite of contaminants listed below:

Contaminant Type	Actual Contaminants
Metals/Metalloids	Arsenic, cadmium, chromium (VI and total), lead, mercury, nickel, selenium, copper and zinc
pH	pH
PAHs	Speciated PAH
Sulphates	Water soluble sulphate, total (acid soluble sulphate) and sulphur
Asbestos	Asbestos presence

8.6 Assessment Criteria

The proposed development of the site is to be a residential property. Therefore the assessment criteria relating to a residential end use have been used. Tables detailing the relevant assessment concentrations used are included in Appendix 5.

8.7 Chemical Test Results

Some preliminary risk assessment is undertaken in this section of the report where determinants can be readily discounted.

8.7.1 Topsoil/ Made Ground

Metals/Metalloids

None of the samples exceeded the residential assessment concentrations of any heavy metals/metalloids.

Polycyclic Aromatic Hydrocarbons (PAHs)

Two samples from TP1 and TP5 recorded elevated concentrations of a number of PAH compounds as follows:

Contaminant	Assessment Value (mg/kg)	Sample/Concentration (mg/kg)					Modified Mean Concentration (mg/kg)
		TP1 0.1m	TP2 0.1m	TP3 0.1m	TP4 0.1m	TP5 0.3m	
Benzo(a)anthracene	7.2	2.5	0.1	1.2	0.92	7.5	5.26
Benzo(b)fluoranthene	2.6	3.2	<0.1	1.4	0.91	9.1	6.40
Benzo(a)pyrene	2.2	2.8	<0.1	1.1	0.82	8.7	6.04
Dibenzo(a,h)Anthracene	0.24	0.19	<0.1	<0.1	<0.1	0.76	0.52

Elevated concentrations shown in **Bold**.

8.7.2 Made Ground/Possible Made Ground

None of the samples tested exceeded the recommended concentrations.

8.7.3 Asbestos

None of the samples recorded the presence of any asbestos containing materials.

8.7.4 Sulphates

The site has been taken as being a brownfield location in accordance with BRE Special Digest 1:2005 "Concrete in Aggressive Ground". Groundwater is expected to be mobile through the shallow soils.

Topsoil/Made Ground

Five samples of the topsoil/organic made ground were tested for sulphates. The total potential sulphate concentrations are calculated to be between 0.12% and 0.39%. A characteristic value of 0.33% is calculated. The samples were also tested for water soluble sulphate and a maximum 40 mg/l was recorded. pH values ranged between 5.6 and 8.2.

On the basis of both the total potential sulphate and water soluble sulphate concentrations, the topsoil/ made ground would be assigned a Design Sulphate Class of DS-2. The pH means that it should be assigned an ACEC class of AC-3z.

Made Ground/Possible Made Ground

Three samples of the clay/sand made ground were tested. The total potential sulphate is calculated to be up to 0.09%. The water soluble sulphate had a maximum of 53 mg/l. pH values ranged between 4.8 and 6.6.

On the basis of both the total potential sulphate and water soluble sulphate concentrations, the made ground would be assigned a Design Sulphate Class of DS-1. The pH means that it should be assigned an ACEC class of AC-3z.

8.8 Significant Pollutant Linkages

The significant pollutant linkages consequently identified are thus documented in the table below.

Source	Pathway	Receptor
PAHs in topsoil/made ground	- Ingestion, inhalation, direct contact - Downward migration	- Site workers - Future residents and visitors to site. - Secondary A aquifer
	Direct contact	Water supply pipes
- Sulphates in the topsoil/made ground. - Low pH values within the soils on site.	Direct contact	Below ground concrete
Ground gas from deep made ground on site	Migration into building and subsequent Inhalation	Future site end users

9.0 RISK ASSESSMENT

9.1 Human Health – Site End Users (Future residents and visitors)

Two samples of the current organic made ground/topsoil which encountered at surface were found to contain slightly elevated concentrations of PAH compounds, including benzo(a)pyrene and dibenz(a,h)Anthracene. The modified mean concentrations of the elevated contaminants was generally found to be approximately 2.5 times the relative assessment value. It is therefore considered that a potential risk to human health could be presented by these contaminants where this material remains on site.

It is possible that the elevated concentrations are due to the inclusions of deleterious/fly tipped items within the soils, and screening the topsoil material prior to reuse will remove the debris and may remove some of these contaminants. However, further testing would be required to prove the cleanliness of the screened material, and some elevated concentrations could still be encountered.

It is therefore recommended that a capping layer of imported, inert topsoil is placed above the site won material. This should be a minimum of 600 mm thick. Alternatively, the existing 'topsoil/organic made ground' could be excavated and removed from site, which will negate the need for the capping layer.

9.2 Human Health – Construction Workers

Ground workers employed during the construction phase of the development are most at risk of harm due to them having direct contact with the affected soils. However, the contact is generally of short duration, and all competent ground workers will be aware of the potential risks associated with soils of this nature.

All ground workers employed on the site should be made aware that elevated concentrations of PAHs are present and normal site procedures such as the wearing of gloves when handling soils, and the washing of hands prior to eating should be implemented.

Any unusual, brightly coloured, ashy or odorous material encountered during construction should be brought to the attention of the site staff and investigated.

9.3 Plants

No elevated concentrations of any phytotoxic contaminants were recorded within any of the samples tested. Therefore a significant risk to plants is not anticipated.

The proposed capping layer should be constructed of inert topsoil to promote plant growth and maintain a suitable drainage rate through the soils. However, if the site won topsoil is removed, and the capping layer is no longer needed, a growing medium of topsoil of at least 150 mm thickness will still be required.

9.4 Controlled Waters

The site overlies a Secondary A aquifer and the nearest surface water feature is a tertiary river around 87 m away. The site does not lie within a Groundwater Source Protection Zone.

The elevated PAH concentrations noted in the samples of topsoil/made ground are not expected to be particularly mobile, as shown by the samples taken below this layer, which did not recorded any elevated concentrations of the contaminants. Controlled waters are therefore not expected to be at significant risk from materials on site.

9.5 Ground Gas

No radon precautions are required at the site.

Made ground is present on the site which is around 3 m deep on average. However, this does not include a significant proportion of organic material, and no hydrocarbon or other degradable or odorous materials have been encountered. Therefore, it is not considered that any significant volume of gas will be generated within these materials.

The proposed dwelling will use a precast concrete floor with a ventilated void below. We have specified that the void be at last 250 mm in height, which is greater than the 150 mm minimum height assumed by CIRIA/NHBC guidance. This will therefore offer an increased dilution rate for any low levels of gas which do migrate from the ground beneath the buildings, and thus dissipate the gas before it can permeate through the floor slab. In addition, there will be a polythene damp proof membrane installed within the floor slab above the precast planks and below the screed. Although this will not be sealed, and is not a dedicated gas resistant membrane, it will offer a very limited additional resistance to gas ingress.

It is therefore our conclusion that the site is not at significant risk from ground gas generation or migration, and that the measures already proposed within the building's substructure will offer adequate protection against any low volumes of gas that could be present. Additional measures such as proprietary gas membranes are not considered necessary.

This will need to be agreed with the regulators, however.

9.6 Construction Materials

As discussed in Section 8.7.4, the topsoil/ made ground would be assigned a Design Sulphate Class of DS-2. The pH means that it should be assigned an ACEC class of AC-3z, The underlying made ground/possible made ground would be assigned a Design Sulphate Class of DS-1. The pH levels again mean that it should be assigned an ACEC class of AC-3z.

The chemical test results will need to be forwarded to the water supply company to determine the level of pipe protection required. However, we expect that the pipes will be laid within the made ground below the topsoil, where no significant contamination was recorded. It is therefore not expected at this stage that protective supply pipes will be required.

9.7 Unexpected Contamination Encountered During Groundworks

It is considered unlikely that further significant contamination will be encountered during the construction works on the site.

Should any unusual, brightly coloured, ashy or odorous material be encountered during construction this should be brought to the attention of the site staff and investigated.

10.0 CONTAMINATION - RECOMMENDATIONS AND APPROVALS

1. The current topsoil/made ground on the site contains elevated concentrations of PAH compounds, including benzo(a)pyrene. It is recommended that a 600 mm capping layer of topsoil is placed above the existing material where it remains on site. Alternatively, the existing site won material can be excavated and removed.
2. A negligible risk of gas generation may be presented by the made ground on the site, However, the plot is to use a suspended ground floor, with a ventilated void below. This is considered adequate to mitigate the risk of gas entering the dwelling and no other protective measures are proposed.
3. No protective measures against the ingress of radon are required.
4. The topsoil/ made ground would be assigned a Design Sulphate Class of DS-2 and an ACEC class of AC-3z. The made ground would be assigned a Design Sulphate Class of DS-1 and an ACEC class of AC-3z, due to the low pH levels recorded.
5. The chemical test results should be submitted to the water supply company to determine the appropriate type of supply pipe.
6. Should any unusual, brightly coloured, ashy or odorous material be encountered during construction this should be brought to the attention of the site staff and investigated.
7. The conclusions made in this report in relation to contamination are subject to agreement by the approving bodies such as the Local Authority and any warranty provider.

Appendix 1

‘Exploratory Hole Location Plan’, drawing reference 39496-001
Site Photographs

INFORMATION WITHIN THIS DRAWING IS NOT NECESSARILY PRODUCED TO SCALE.
ALWAYS USE FIGURED DIMENSIONS AND CO-ORDINATES - IF IN DOUBT, ASK.

NOTES

KEY:



- Soakaway on 08/02/15



- Trial pit excavation on 08/02/15

A	First Issue.			
REV	DESCRIPTION	SIG	CHK	DATE

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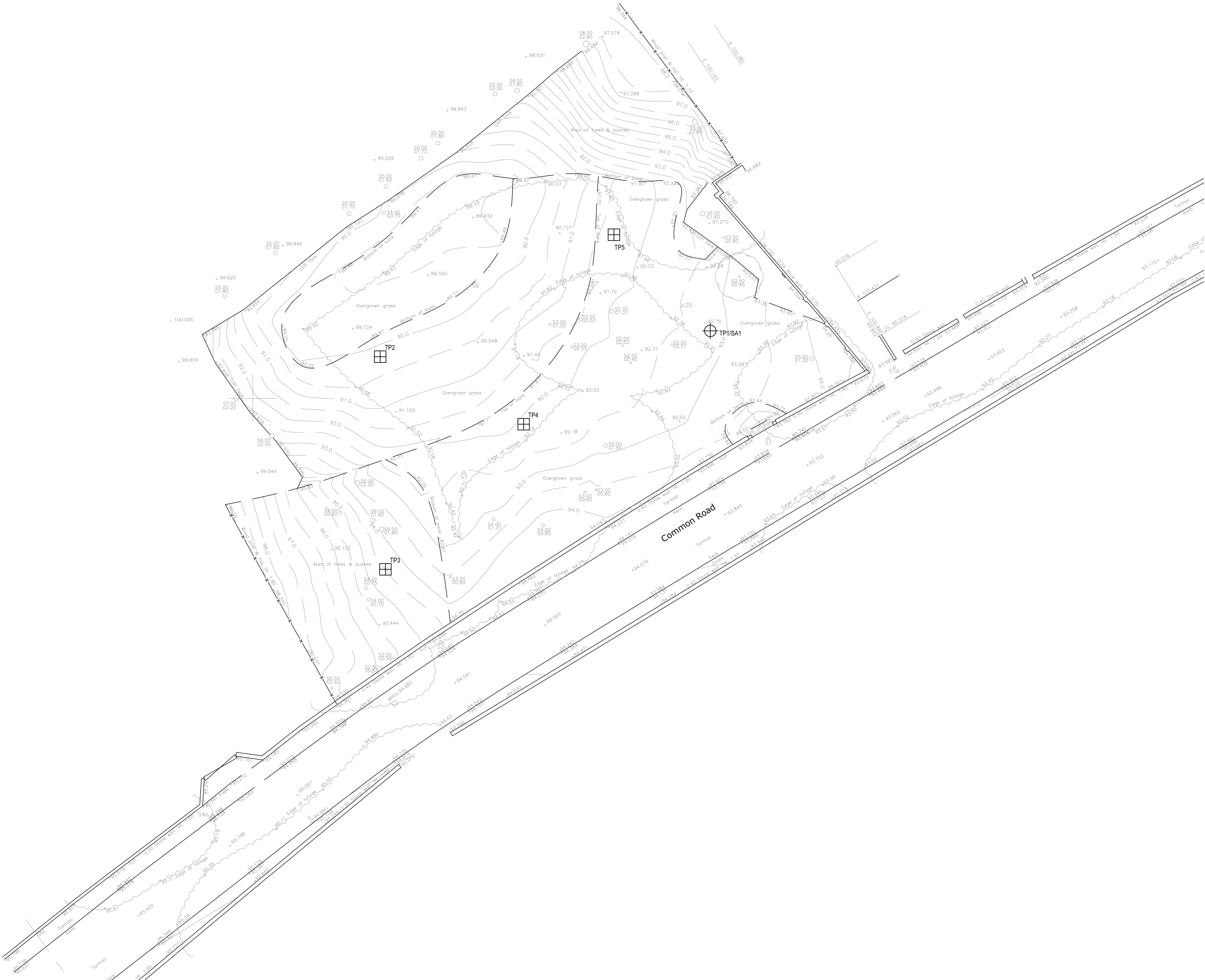
SCALE WHEN PLOTTED AT A1

1:200

DRAWING STATUS

PRELIMINARY

DRAWN	CHECKED	DATE	DRAWING NUMBER	REV
CHH	SRI	09.02.16	39496/001	A



Overview of the north-west corner of the site and the retaining wall at the northern boundary of the site.



Tipped material at the north-east corner of the site.



Prepared	SRI	Checked	AJK	Date	24.02.16	Photograph No	1&2
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SITE INVESTIGATION PHOTOGRAPHS