Engineering Desk Study

Land to rear of Maes Meurig, Meliden, Cymru

SOIL AND STRUCTURES

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Report Status

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Report Author

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Appointment

Soil and Structures Ltd were instructed by Kingscrown Land & Commercial Ltd (*the Client*) in December 2022 to prepare an Engineering Desk Study (*the Report*) to support the development of a parcel of land to the rear of Maes Meurig, Meliden, Cymru (*the Site*).

Development proposals include for the construction of 35 residential dwellings with associated hard and soft landscaping areas.

Reliance on the advice presented herein rests solely with the Client.

Scope and Context

The Engineering Desk Study offers advice in relation to a wide range of ground-related hazards potentially affecting the proposed development of the Site.

The legal context of this advice relates to an assessment of:

i) Potential ground-related hazards that may affect the development (including coal mining related risk) that is governed by health and safety law (various acts and regulations); and,

ii) The suitability of the Site for its proposed end use that is rooted within national planning policy guidance (the Planning Policy Wales) that is governed by planning law (various acts). The assessment of 'suitability' relates specifically to ground-related hazards of contamination, pollution and ground gases as set out within both the Environment Protection Act 1990 : Part 2A (2012) and Environment Agency guidance 'Land Contamination Risk Management' (LCRM) (2020) that also applies to Wales.

For further information on the context and scope of the Engineering Desk please refer to the Annexes.

Background to this Report

This Report is not preceded by existing ground-related reporting for the Site.

References

The Engineering Desk Study has been written with reference to various sources of information. These are either appended or included as footnotes at the base of each respective page.

Reference is also made to the 'Engineer' within this Report that relates to the appointed design engineer (structural and/or civil).

1.0 The Site and Proposed Development

1.1 The Site

Location and size: The Site comprises the existing plot of open variably vegetated land north of Maes Meurig Meliden (Figure 1) that covers an area of around 1.1 ha.

Access: The Site does not appear to be accessible at present with access likely being formed from the south via Maes Meurig (road).

Surface cover: The surface of the Site is covered by variable vegetation cover including numerous established trees.

Topography: The Site has a topography that falls from around 25 mAOD in the southern corner to between 14 and 16 mAOD along northern boundary of the Site (lower across the north-western portion of the Site).

Utilities: Existing utility alignments are not apparent on satellite imagery or historical mapping for the Site, e.g. overhead power lines.

Existing reports: No existing ground-related reports have been located on the planning portal or made available for review.

1.1 The Proposed Development

Development proposals include for the construction of 35 residential dwellings with associated hard and soft landscaping areas.

Development focused risk assessment: *An appreciation of the construction processes is essential for development-related risk assessments given the groundworks stand to meaningfully alter the level of risk, e.g. potentially harmful soils being removed or moved by earthworks, or potentially unstable slopes being removed.*

To enable this development, the following groundworks will be required, N.B. listing is outline only.

> Enabling: Shallow surface strip of topsoil.

> Earthworks: Re-profiling the slope to suit formation levels.

> Utility Excavations: Excavation of drainage and other utility alignments.

> Foundations: Construction of sub-structure (foundations and ground floor slabs) followed by super-structures.

> Surfacing: Formation of new hardstanding and soft landscaping areas.

Human health risk assessment*: The development comprises a change of use from former agricultural land (open fields) to residential – generally representing an increase in the sensitivity of the end user whereby end users (residents) are more likely to spend time using the land for outdoor play and home-grown produce. However, the former use of the Site as open fields is unlikely to have resulted in potentially harmful or polluting material being deposited on Site.*

Figure 1: Site Location Plan

> *Extract from 1994 Ordnance Survey mapping (appended)*
> *Approximate Site boundary illustrated by the red line.*
> *INSERT: Development plan (appended)*

2.0 Site Setting

2.1 History

The Site has been subject to one phase of use since the 1870s (the date of the earliest available ordnance survey mapping):

> **The first phase** (Figure 2 with additional historical mapping plans appended): occurred between the 1870s and the present day when the Site was occupied by open field.

Evidence of potentially harmful material and *evidence of potentially gas generating material:* Through this phase of use it is considered unlikely that potentially harmful or degradable material would have been introduced into the Site's soils.

Evidence of mining activities: No evidence of coal or non-coal mining features, e.g. old shafts or soughs, is recorded on the Site or immediately around this Site over this period.

It is however noted that Meliden has a rich mining history predominantly extracting lead as well as sulphur from the limestone formations that themselves, lie to the south-east of the Site.

Evidence of unexploded ordnance: Military land use: There is no evidence of the Site having been put to a military land use since the 1850s. *History of bombing:* Whilst North Wales was targeted[1] there is no evidence of Meliden being directly targeted during the Second World War with no evidence found through web-searches.

The surrounding area was historically characterised by land uses consistent with a predominantly rural economy (as well as mining to the south-east; Figure 2) before seeing an increase in residential development over the intervening years (Figure 1).

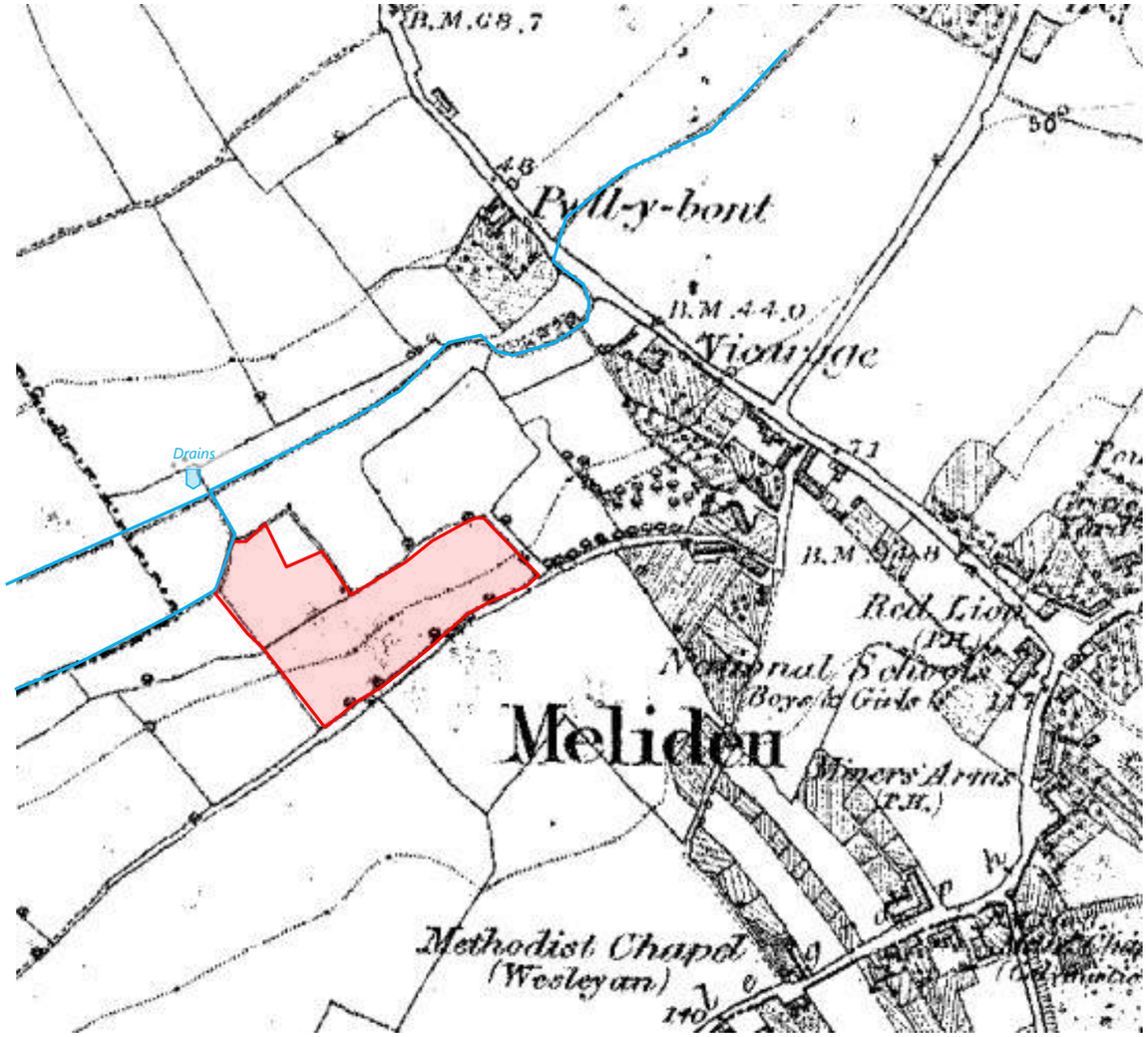


Figure 2: First Phase of Use - extract from appended 1878 Ordnance Survey mapping

> *Approximate Site boundary identified by red line*
> *Key hydrogeological features identified in blue.*

[1] *BBC - When bombs dropped on Bangor, Llandudno and Holyhead*

2.2 Geology

Recorded geology: The Site is underlain by both Alluvium (*clay silt sand and gravel*) across the north-western edge of the Site and Till (*typically clay soils with variable granular content and granular lenses*) across the remainder. The underlying bedrock is Pennine Coal Measures (*interbedded sandstone, siltstone, mudstone and coal deposits*).

Structural geology: A fault is recorded running across the Site in a north-north-east to south-south-west direction.

Exploratory holes: Exploratory hole records not available for the Site or immediate surrounding area.

Geological mapping confidence: The geological mapping records offers reasonable confidence in the geological succession beneath the Site however, intrusive investigation would be recommended to confirm this.

Geological hazards: Based on this recorded geology, the potential for geological hazards to adversely impact the Site (dissolution, collapse, compressible) is considered generally likely given the presence of Alluvium that can give rise to a variety of hazard scenarios. Within the Till deposits potential geological hazards are less but can give rise to a potential shrink-swell hazard.

Coal and non-coal mining: No coal or non-coal mining is recorded below the Site[2,3] that is expected to affect surface stability. As noted in Section 2.1, Meliden has a rich mining history predominantly extracting lead as well as sulphur from the limestone formations that themselves, lie to the south-east of the Site. The potential for instability to affect the Site's surface stability, even accounting for potential geological mapping inaccuracies is considered low – limestone mine formations typically benefit from high levels of support from the parent rock (limestone).

Mineral resources: The Till and Alluvium are not considered to be of economic value for recovery however the Topsoil deposits may be of extractable value (transfer to another development Site with appropriate documentation).

2.3 Recorded Hydrogeology & Hydrology

A water catchment is divided into two main elements; groundwater (hydrogeology) and surface water (hydrology). The groundwater regime is primarily governed by the geology and the surface water regime by the topography and surface cover. For any given site, these regimes are likely to influence each other and be influenced by off-site factors, e.g. groundwater levels being 'recharged' higher up a catchment.

The Site's groundwater regime is influenced by: its low elevation; proximity to two unnamed drains to the north; 'soft' cover across the entire Site that is to be reduced as part of the proposed development with a net decrease in direct infiltration to ground; likely low permeable Till deposits (Secondary undifferentiated); variably permeable Alluvium deposits (Secondary A)[4]; variably permeable bedrock deposits (Secondary A)[5]; the Site not being located within a Source Protection Zone (SPZ) [5]; and, groundwater likely to be 'shallow' (within 3 m of the surface) across the lower elevations of the Site.

The Site's surface water regime is influenced by the topographical level falls towards the north-west, resulting in a tendency surface water run-off towards the unnamed drain to the north.

The unnamed 'drain' immediately north-west of the Site and flows in a general west to east direction.

The Site is classified as being at low risk with respect to surface water flooding with localised areas of low risk flooding within the north-western portion of the Site.

The Site is classified as low to high risk of river (fluvial) flooding across the Site's north-western portion[5].

2.4 Environmental Setting

The environmental setting relates to land designations either on-site or within the surrounding area that have the potential to influence or present a risk to the proposed development.

Landfills (historic and active) are not recorded within 250 m of the Site[6,7], the distance across which viable pathways for gas migration are more likely.

Historic infilled land, e.g. ponds and quarries (excluding landfills detailed above) are not evidenced on Site or within 100 m of the Site.

Historic and current industrial sites no past or current industrial Sites are recorded adjacent to the Site or within 100 m of the Site.

Statutory protected areas, e.g. SSSI are not recorded on the Site[8].

Radon is emitted from naturally sources within a range of geologies. The United Kingdom Health Security Agency (UKHSA) data[8] and more accurate British Geological Survey data (appended) indicates between 10 to 30 % of dwellings are expected to be above the Action Level (200 Bq m^{-3}) for the majority of the Site

This translates to a high potential of the Site being affected by radon.

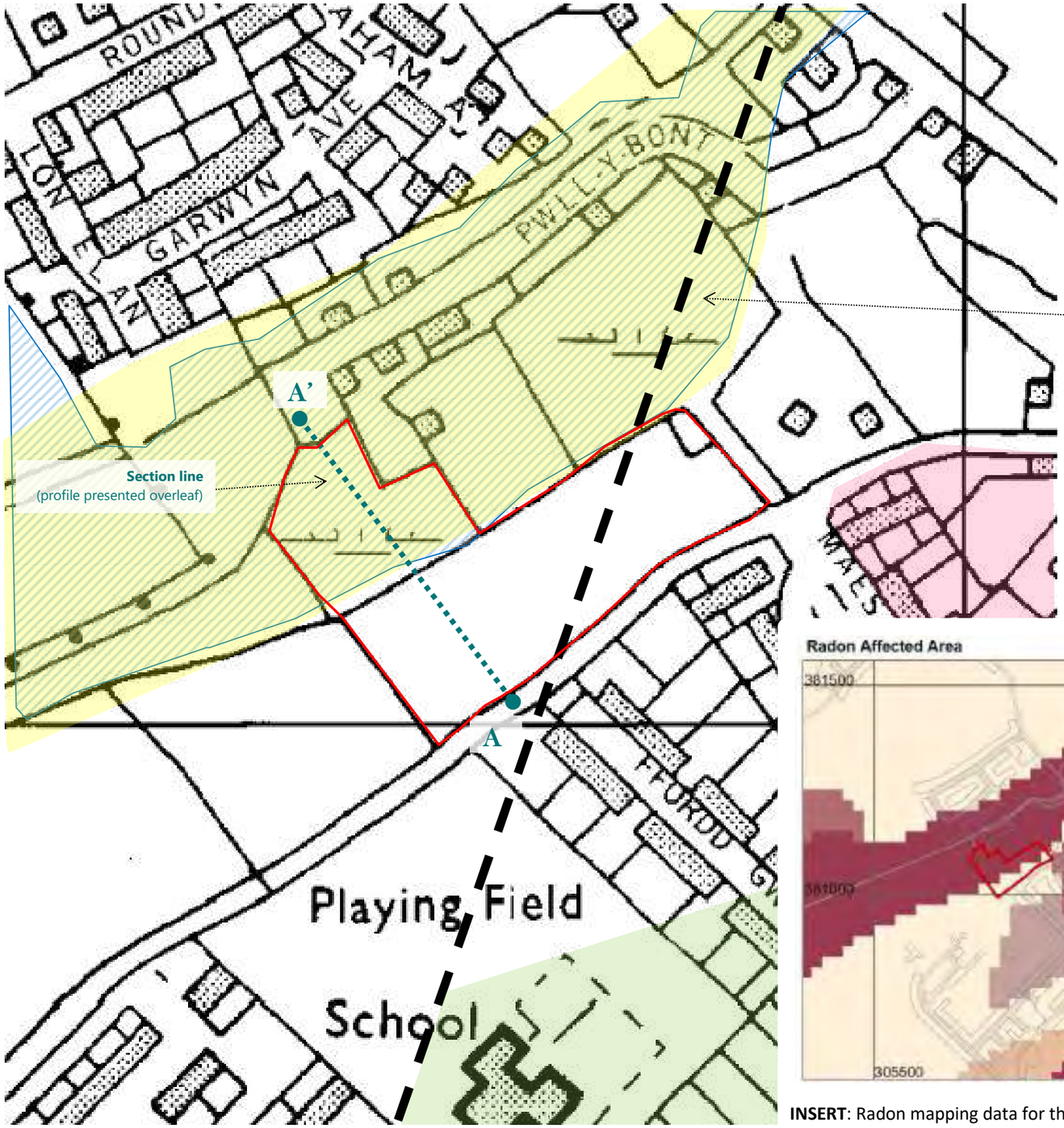
3.0 Ground Conditions

Anticipated ground conditions: The Site characterisation (Section 2.0) indicates the presence of three main materials beneath the Site: (1) Topsoil over; either, (2) Till deposits likely characterised by cohesive (clay) soils but local granular (sand and gravel) soils commonly with 'moderate' strength but can vary; or, (3) Alluvium deposits likely characterised by variable and commonly low strength soils; underlain by, (4) weathered Pennine Coal Measure bedrock at unknown but likely 'deep' (>3.0 m) depth. The bedrock deposits, if encountered, will vary across the fault but are from the same group of rocks.

The Preliminary Ground Model for the Site (plan and profile) is presented in Section 4.0 and includes further commentary on the ground conditions.

[2] *Interactive Map Viewer | Coal Authority (bgs.ac.uk)*
[3] *GeoIndex - British Geological Survey (bgs.ac.uk)*
[4] *Geocortex Viewer for HTML5 (cyfoethnaturiolcymru.gov.uk)*
[5] *Geocortex Viewer for HTML5 (cyfoethnaturiolcymru.gov.uk)*
[6] *New map | DataMapWales (gov.wales)*
[7] *Geocortex Viewer for HTML5 (cyfoethnaturiolcymru.gov.uk)*
[8] *UKradon - UK maps of radon*

4.0 Preliminary Ground Model - Plan



Key

- Alluvium deposits
- Glaciofluvial deposits

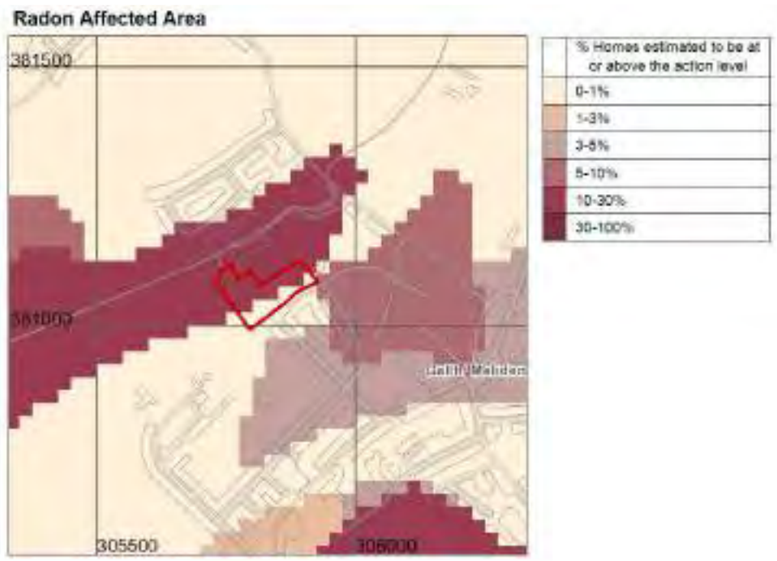
Where unidentified, soils are Till deposits.

- Limestone deposits

Where unidentified, bedrock is Pennine Coal Measures

- Approximate extent of fluvial flooding

Geological fault *(approximate alignment)*



INSERT: Radon mapping data for the Site.

General Commentary

> Ground conditions are expected to become more varied across the north-western portion of the Site where Alluvium is recorded. Within the Till deposits, that appear to occupy the majority of the Site, ground conditions are expected to be more consistent.

> Groundwater is may be encountered within 3 m of the ground surface given the presence of local drains and indicators of hardy, possibly marshy ground within the north-western portion of the Site.

Geotechnical Commentary

> Topsoil deposits (if present) are expected to be recoverable for re-use as landscaping fill (Class 4).

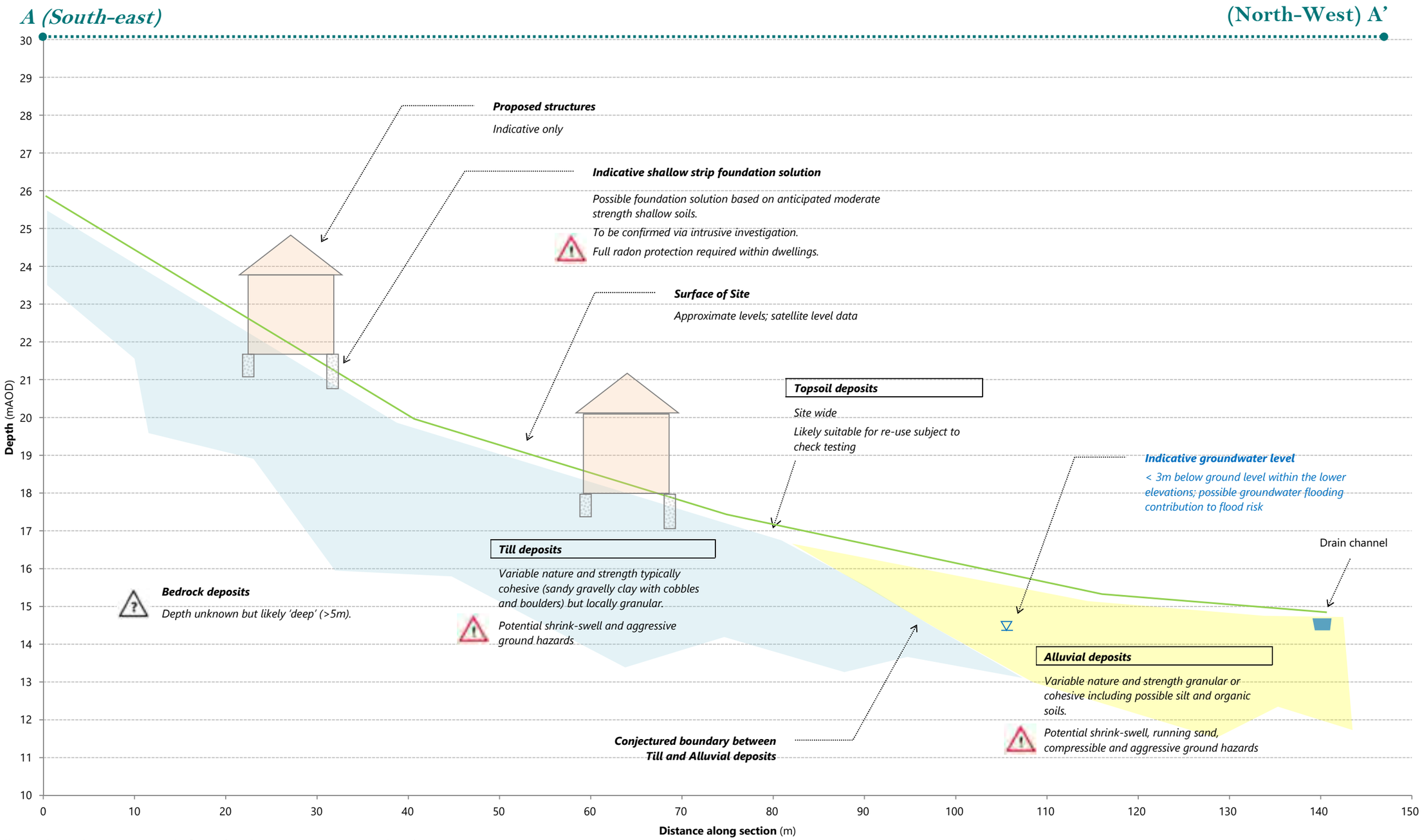
> Till deposits are likely to be cohesive (Class 2) but may include variable thickness granular lenses and variable granular content. Their strength characteristics are likely to be 'moderate' and support shallow spread foundations.

> Alluvial deposits could be granular (Class 1) or cohesive (Class 2) and may include organic content, e.g. organic silts or peat. Their strength characteristics are likely to be varied but tending towards being low strength and potentially guiding the requirement for alternative foundations to shallow spread footings.

Environmental Commentary

> The chemical quality of the shallow soils is not expected to have been degraded.

4.0 **Preliminary Ground Model** – Profile (shallow)



> *Illustrative only > Do not scale from drawing > Note compressed scales*
> *Key questions highlighted with question marks (?) and select hazards highlighted with exclamation marks (!)*

5.0 Engineering Considerations

The following sub-sections offer advice on ground-related matters for the engineering works required as part of planned development works.

This advice is based on available opensource data that, whilst offering a reasonable level of confidence in the anticipated ground conditions, should be used to inform the scoping of the recommended intrusive investigation and not relied upon to inform design decisions.

The development design is outlined Section 1.2 together with the likely groundworks activities required as part of the development.

The main design considerations include, but are not limited to;

> Likely low imposed loads of the proposed structures;

> The variable but likely moderate strength of the shallow Till deposits that may support a shallow spread foundation solution; and,

> The variable but likely low strength of the shallow Alluvial deposits that may necessitate an alternative foundation solution to shallow spread footings.

5.1 General Groundworks

Excavation progress is likely to be at typical rates through the shallow soils employing a medium sized excavator, e.g. 3CX or larger.

Excavation stability is unlikely to warrant short-term temporary support if the Till deposits are consistently 'firm to stiff'. Localised granular pockets may be present that could give rise to instability. Instability within the Alluvial deposits is more likely. Access to any excavations by personnel should be prohibited unless suitable temporary support is provided and other risks assessed by a suitably qualified person, e.g. ground gases. Further guidance is available[9].

Excavation conditions will be affected by inclement weather (increased instability and softening of clays; more likely in Alluvial soils) with open excavations potentially holding water due to predicted low rates of drainage within the Till deposits and likely shallow groundwater across the lower elevations of the Site. Groundwater is may be encountered within 3.00 m of the Site surface across the north-western portion but otherwise 'perched' groundwater may exist within the shallow granular lenses in the Till that could be encountered as seepages in excavations. Further guidance is available for excavation design and safety[10].

Excavation stability (slopes) may be a consideration for both temporary and permanent works along the southern edge of the Site where slopes are locally steeper.

Material suitability for re-use (geotechnical and environmental) is discussed below and in Section 7.0.

> *Topsoil deposits* are likely to be suitable for use for landscaping fill (Class 4) with confirmation testing of its chemical suitability potentially required by the local planning authority;

> *The Till deposits* present on Site are considered likely to be variably-graded and generally cohesive. A next 'cut' (removal) of material is likely with the Till potentially suitable for as a general fill (Class 1 or 2);

> *The Alluvial deposits* present on Site are considered likely to be variably-graded and variable in nature (Class 1 or 2) and commonly not suitable as an engineering fill on this basis;

> For material re-use as an engineering or load-bearing fill the Engineer's approval will be required, e.g. selection of a suitable compaction regime; and,

> For all scenarios, developing a strategy for management of materials/soils in advance of the works is advised to minimise handling and maintain soil conditioning.

Waste classification of excavation arisings for any material surplus to requirements (requiring disposal) will need to be agreed with the groundworks contractor in line with current guidance[11].

Natural soils requiring disposal off Site will likely class as EWC 20 02 02 (soil and stones).

Mineral resources include recovered Topsoil that may have a value within local markets.

5.2 Structural Engineering

Foundations are likely open to all options however, the recorded presence of Till suggests that a traditional strip foundation may be viable across the majority of the Site. The presence of Alluvial soils across the north-western portion of the Site may necessitated alternative foundation solutions, e.g. rafts or piled foundations. It is noted that no properties are planned across this portion of the Site with determining the extent of the Till and Alluvium soils being a key objective of the recommended intrusive investigation.

Attention should be given to:

> The presence of slopes along the southern edge of the Site that may need Engineered design depending on the angles / levels proposed; and

> The potential influence of existing or planned vegetation.

The recorded presence of a geological fault running across the Site is not considered to present a constraint or hazard to the development unless a shallow bedrock profile is present on Site. This seems unlikely in this setting but cannot be ruled out. If and where shallow bedrock is present, then provision of rafted foundations to any plots spanning the fault zone is recommended with slip-planes provided to the underside (sand layers).

Floor slab options are likely open (ground bearing or suspended) but will be guided by; the selection of foundation solution; any flood risk mitigation necessary; the requirement for full radon protection measures to be incorporated within dwellings; and, the influence of vegetation. Taken together, suspended ground floor slabs are likely to be required.

Proof rolling of the formation and treatment of any soft spots (or hard spots, e.g. boulders) through either excavation and replacement with suitable granular fill is a general advisory but less likely to be required across the Site.

[9] *CIRIA Report 97 - Trenching Practice - Second Edition (1992)*
[10] *CIRIA Report No C515 Groundwater Control (2001)*
[11] *Waste classification technical guidance - GOV.UK*

6.3 Civil Engineering

Earthworks (cut and fill) may be required as part of the proposed development to create development plateaus.

Hard-standing sub-grades or formations will be subject to final design levels being agree however, in general, when taken down through the existing Topsoil will likely comprise a cohesive (clay) sub-grade across the majority of the Site (formed onto the Till). The Alluvial deposits may present as a lower strength or more varied sub-grade of both granular and cohesive material.

It is considered unlikely that pre-treatment of the sub-grade will be necessary across the Till deposits (inferring a CBR value of >2.5 %) however, some pre-treatment may be necessary across the Alluvial deposits.

Proof rolling of the formation and treatment of any soft spots (or hard spots, e.g. boulders) through either excavation and replacement with suitable granular fill is a general advisory across the Site.

Drainage of the existing Site is expected to be defined by a low permeability soils (Till) that likely have 'poor' drainage characteristics (f ~ 10^{-6} to 10^{-9}) and a groundwater table that is generally expected to deeper than 3 m below ground level.

A shallower groundwater surface is expected across the lower elevations of the Site where Alluvial deposits are present and may offer increased rates of drainage. However, if and where present, a shallow groundwater surface is likely to be a limiting factor for drainage to ground across this portion of the Site.

These factors may combine to limit the potential for drainage to ground to be included for as part the proposed drainage strategy. Shallow infiltration systems, e.g. permeable paving, may be viable.

The presence the unnamed drain along the northern edges of the Site is an obvious discharge point (as shown on Figure 1) with any shallowly percolating and infiltrating surface water expected to be readily transported to this watercourse.

Water supply pipes on Site will likely be laid within natural Till or Alluvial deposits.

Soft landscaping comprising public open space and private gardens is likely proposed as part of the development.

Based on the existing grass cover of the Site, sufficient Topsoil is expected to be recovered from Site that is likely to be suitable for use within the development based on the history of the Site.

Confirmation of the Topsoil's suitability for use is commonly requested by the local planning authority.

It is recommended that at least 150 mm of Topsoil[12] is placed in all soft landscaping areas and attention given to not over work or compact the soil to maintain its condition.

[12] *BS3882:2015 - Specification for Topsoil and requirements for use.*

6.0 **Ground Related Risk Management** – Hazard Screening and Preliminary Risk Assessment

Hazard Screening	Indicators?	Action	Commentary
Geological Hazards			
Collapsible soils	No	Responsive	No evidence of Blown Sand revealed on Site (ref. Section 4.0 and 5.0).
Compressible soils	**Yes**	**Assess risk**	Evidence of potential compressible soils (organic soils or low strength soils) revealed on Site (ref. Section 4.0 and 5.0).
Ground dissolution	No	Responsive	No evidence of rocks liable to dissolution revealed on Site (ref. Section 4.0 and 5.0).
Running sand	**Yes**	**Assess risk**	Evidence of potential fine sand and saturated silt soils revealed on Site (ref. Section 4.0 and 5.0).
Sensitive clays	**Yes**	**Assess risk**	Evidence of soils susceptible to shrink-swell revealed on Site (Till and Alluvium) (ref. Section 4.0 and 5.0).
Slope instability	Possibly	**Assess risk**	Existing slopes on Site (around 1{v}:20{h}) with possible steeper sections along the southern boundary (ref. Section 1.0).
Natural ground gas	**Yes**	**Assess risk**	Evidence of potential gas generating soils on Site (ref. Section 4.0 and 5.0).
Radon	**Yes**	**Assess risk**	Radon can be present across the UK. In this setting less between 10 and 30 % of properties are predicted be recorded above the action level (ref. Section 2.0).
Aggressive geology	**Yes**	**Assess risk**	Evidence of potentially aggressive soils revealed on Site (ref. Section 4.0 and 5.0).
Hydrogeological & Hydrological Hazards			
River and sea flooding	**Yes**	Seek advice	High to low risk locally along northern edge of Site (ref. Section 2.0).
Surface water flooding	**Yes**	Seek advice	Low risk in north-western portion of Site (ref. Section 2.0).
Groundwater flooding	**Yes**	Seek advice	Groundwater is may come within 3 m of the surface during prolonged rainfall and flooding events across the north-western portion of the Site (ref. Section 2.0).
Watercourses	**Yes**	Seek advice	Open watercourse running along the north-western boundary of the Site (ref. Section 2.0).
Historical Hazards			
Contamination (on-site)	No	Responsive	Former use of Site that is unlikely to have resulted in potentially harmful material entering the shallow soils on Site. (ref. Section 2.0).
Contamination (off-site)	No	Responsive	No evidence of potentially contaminative land uses adjacent to the Site that could have plausibly impacted soil quality on Site. (ref. Section 2.0).
Pollution (waters)	No	Responsive	Former use of Site that is unlikely to have resulted in potentially polluted material entering the shallow soils on Site. (ref. Section 2.0).
Landfill gas	No	Responsive	No landfill recorded within 250 m of the Site (ref. Section 2.0).
Mining (incl. mine gas)	No	Responsive	No evidence of probable or recorded shallow mining activities below the Site (ref. Section 2.0).
Sub-surface structures	No	Responsive	No clear evidence of sub-structures, e.g. cellars or basements, on Site (ref. Section 2.0)..
Unexploded ordnance	No	Responsive	No evidence of military land uses recorded on Site or evidence of bomb damage on Site or immediately adjacent to Site on post-war mapping (ref. Section 2.0).
Archaeological interests	**Yes**	Seek advice	Evidence of archaeological features recorded on historical mapping for the Site, i.e. 'Stones'.
Utilities (above or below)	Possibly	Seek advice	No evidence of above ground utilities on the Site, possible below ground utilities on Site.
Ecological Hazards			
Sensitive land uses	No	Seek advice	Site not designated as statutory protected area, e.g. SSSI.
Invasive species	Possibly	Seek advice	To be confirmed.
Protected species	Possibly	Seek advice	Potential habitats present on Site and where necessary, to be confirmed.

Preliminary Risk Assessment	Risk	Outline detail of recommended action *N.B. responsibility rests with the Contractor for the implementation of any responsive action*

N.B. The levels of risk detailed below may change subject to the findings of any further assessment that is recommended. For further information on the risk assessment's rationale, please refer to the annexes.

Geological Hazards		
Collapsible soils	Low	Collapsible soils (blown sand) are very unlikely to be present in this geological setting - no further action recommended.
Compressible soils	**Low**	Alluvial soils are mapped within the north-western portion of the Site. These soils can include find sand or silt soils that, when loaded, can be subject to high levels of consolidation. **Localised risk:** Further assessment: intrusive investigation to confirm ground conditions locally to north-western portion of Site.
Ground dissolution	Low	Rocks prone to dissolution are very unlikely to be present in this geological setting - no further action recommended.
Running sand	**Low**	Alluvial soils are mapped within the north-western portion of the Site. These soils can include find sand or silt soils that, when saturated, lead to running sand conditions developing and rapid and extensive instability within excavations. **Localised risk:** Further assessment: intrusive investigation to confirm ground conditions locally to north-western portion of Site.
Sensitive clays	**Low**	Alluvial and Till soils are mapped across the Site. These soils can include clay soils that are sensitive to volume change seasonally. **Site wide risk:** Further assessment: intrusive investigation to confirm ground conditions and classify clay soils.
Slope instability	**Low**	**Localised risk:** Further assessment: intrusive investigation to confirm ground conditions locally to southern edge of Site.
Natural ground gas	**Low**	Alluvial soils are mapped within the north-western portion of the Site. These soils can include organic material that has the potential to generate or liberate ground gas. In general, given the often river-side setting of these soils, they are commonly saturated and therefore have reduced potential to store and release ground gas on a more continuous basis. Notwithstanding this, pockets of gas can be present that when intercepted or disturbed, stand to release ground gas. For example, piling works in Alluvial soils can result in bubbling groundwater conditions once the pile is advanced (burst 'bubble' of ground gas) that general stabilises within 24 to 48 hrs or re-seals itself. Whilst the likelihood of gas generating soils cannot be evaluated at this stage, the lower lying location of these soils, proximity to the drain and extent of fluvial flooding suggest these soils are likely to be saturated with a shallow (< 3 m below ground level) groundwater surface. This may vary seasonally but is expected to limit the likelihood of large volumes of ground gas being present. **Localised risk:** Further assessment: intrusive investigation to confirm ground conditions locally to north-western portion of Site with gas monitoring if and where unsaturated organic soils present. **Localised risk:** Risk mitigation (inherent): the requirement for full radon protection measures (see below) is expected to mitigate the risk presented by natural ground gas in all but the most severe scenarios, e.g. presence of unmapped peat bog on Site or bubbling groundwater conditions, but should be confirmed with the Engineer.
Radon	**High**	Full radon protection measures recommended within all dwellings in line with current guidance (referenced in Section 7.0).
Aggressive geology	**Low**	Alluvial and Till soils are mapped across the Site. These soils can include compounds that are aggressive to concrete. Till can contain pyrite or gypsum; Alluvium can contain sulphur-rich soils. **Site wide risk:** Further assessment: intrusive investigation to confirm ground conditions and classify sulphate content and pH of formation soils.

Historical Hazards		
Contamination (on-site)	Low	Responsive action: Potentially harmful soils are unlikely to be present in this setting – notify Engineer if and where any evidence of potentially harmful material is encountered in the soils e.g. stained, discoloured or odorous soils.
Contamination (off-site)	Low	Responsive: Notify Engineer if any evidence of potentially harmful or polluting material is observed near the boundaries of the Site, e.g. stained, discoloured or odorous soils.
Pollution (waters)	Low	Responsive: Notify Engineer if any evidence of potentially polluting material is observed in the soils on the Site, e.g. stained, discoloured or odorous soils or water.
Landfill gas	Low	Responsive: Notify Engineer if any evidence of potentially degradable material is encountered in the ground or evidence of bubbling groundwater is encountered.
Mining (incl. mine gas)	Low	Responsive: Notify Engineer if any evidence of circular or square brick lined structures or voids are revealed in the ground.
Sub-surface structures	Low	Responsive: Notify Engineer if any evidence of relic walls or voids are revealed in the ground.
Unexploded ordnance	Low	Responsive: Notify Engineer if any evidence of rounded metal or glass objections are revealed in the ground.

7.0 Conclusion and Recommendations

Based on available information and the scope of this Report the Site ground conditions are considered to be; reasonably well-characterised with; intrusive investigation recommended to support further assessment of risk and support the engineering design.

In conclusion, the Engineering Desk Study finds that;

> At this stage, based on the available lines of evidence, the risk rating for the ground conditions on Site is considered to be 'low' overall with the exception of radon risk that is assessed to be 'high'.

Further assessment is recommended to: confirm the ground conditions across the Site with specific attention given to establishing the boundary between the Alluvial and Till deposits; and, confirm the geotechnical characteristics of the soils / rocks.

Risk mitigation is recommended to: reduce the risk presented by radon to acceptable levels (full radon protection measures required in all dwellings).

> The anticipated moderate strength of the shallow soils across the majority of the Site may support the adoption of shallow, spread foundations. The Alluvial soils across the north-western portion of the Site may be more variable or lower strength and direct the need for alternative foundation solutions.

Recommended follow-on work includes:

1. Review of the risk register herein;
2. Submission of the Engineering Desk Study to the project design team and, where necessary, the local planning authority.
3. Further assessment is recommended at this stage the in the form of an intrusive ground investigation the outline scope of works for which includes:
    - Machine excavated trial pits to enable; mass logging of soils and, bulk and disturbed sample recovery; and,
    - Geotechnical testing of the soils across the Site (classification and where necessary, strength).

    Confirming the extent of the Alluvium and Till deposits should be a key objective of the ground investigation and, if and where Alluvium is present higher up the slops (further south) then ground gas monitoring may be necessary to establish the level of risk presented by ground gases, e.g. 'swamp gas' (methane).

    It should be borne in mind that at full radon protection measures will be required within the proposed properties that, where suitably installed, will offer inherent protection against low to moderate levels of all ground gases. It is also noted that the sloping nature of the Site, presence of existing vegetation and modern design practices will invariable guide the adoption of a suspended ground floor slab with a 150 mm open void offering 'very good' ventilation resulting in Amber 1 levels of ground gas protection being inherent within the design.

    If and where any evidence of potentially harmful or polluting material is encountered, appropriate screening of this material should be undertaken with sampling and testing conducted in line with current guidance[13].
4. Risk mitigation is recommended at this stage including the provision of full radon protection measures in line with current guidance[14]. Additional risk mitigation measures may be required subject to the findings of the recommended ground investigation.
5. Production of a Ground Investigation Report to enable the preliminary risk assessment presented herein to be revised and to confirm engineering design requirements.

[13] *BS 10175 (2011 + 2017) Investigation of potentially contaminated sites. Code of practice.*

[14] *BRE Report BR211 (2015) Radon: Protective measures for new buildings*

WIP

REV	DESCRIPTION	DATE	BY
F	PLOTS 5-12 REVISED	28/04/23	OR
E	PLOTS 1-2 AMENDED	25/04/23	OR
D	WILDLIFE CORRIDOR ADDED + SITE LAYOUT AMENDED	24/04/23	OR
C	AMENDMENTS DUE TO CCTV SURVEY + AMENITY SPACE CALCULATED	20/04/23	OR
B	ROAD AMENDED TO SUIT FOCUS COMMENTS + PLOTS 3-11 MOVED FORWARD A METRE TO AVOID TREES RPA	11/04/23	OR
A	ROAD RE-MODELLED TO SUIT SITE CONTOURS + PLOT LEVELS ADJUSTED	05/04/23	OR

HOUSING KEY

		PLOT NO.
8 No.	4P2B HOUSE	26, 27, 28, 29, 30, 31, 32, 33, 34.
6 No.	4P2B SPLIT LEVEL HOUSE	7, 8, 9, 10, 11, 12.
2 No.	5P3B SIDE ENTRY HOUSE	25, 35.
4 No.	5P3B WIDE HOUSE SPLIT LEVEL	3, 4, 5, 6.
4 No.	5P3B SPLIT LEVEL HOUSE	13, 14, 15, 16.
10 No.	2P1B WALK UP APARTMENT	1, 2 , 17-24.

TOTAL:
35no. UNITS

PROJECT
LAND OFF MAES MEURIG, MELIDEN
for KINGSCROWN PROPERTIES

DRAWING TITLE
INDICATIVE SITE LAYOUT FROM MAES MEURIG OPT 3

SCALE	DATE	DRAWN	CHECKED
1 : 500 @A3	21/03/23	OR	SV

DRAWING STATUS: PRELIMINARY

JOB No	DRAWING No	REVISION
C1109	009	F

AINSLEY GOMMON ARCHITECTS
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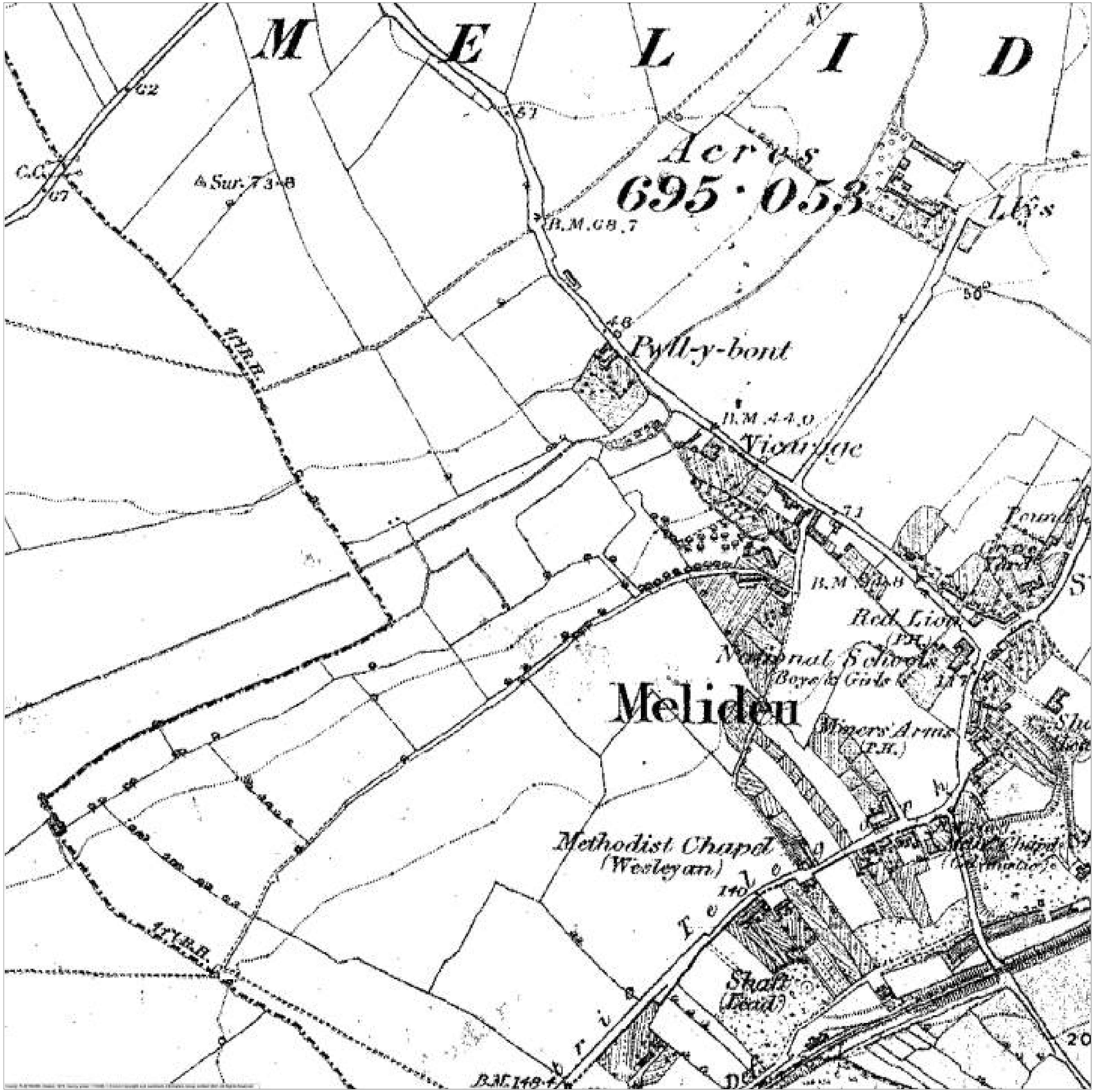
A3



Landmark
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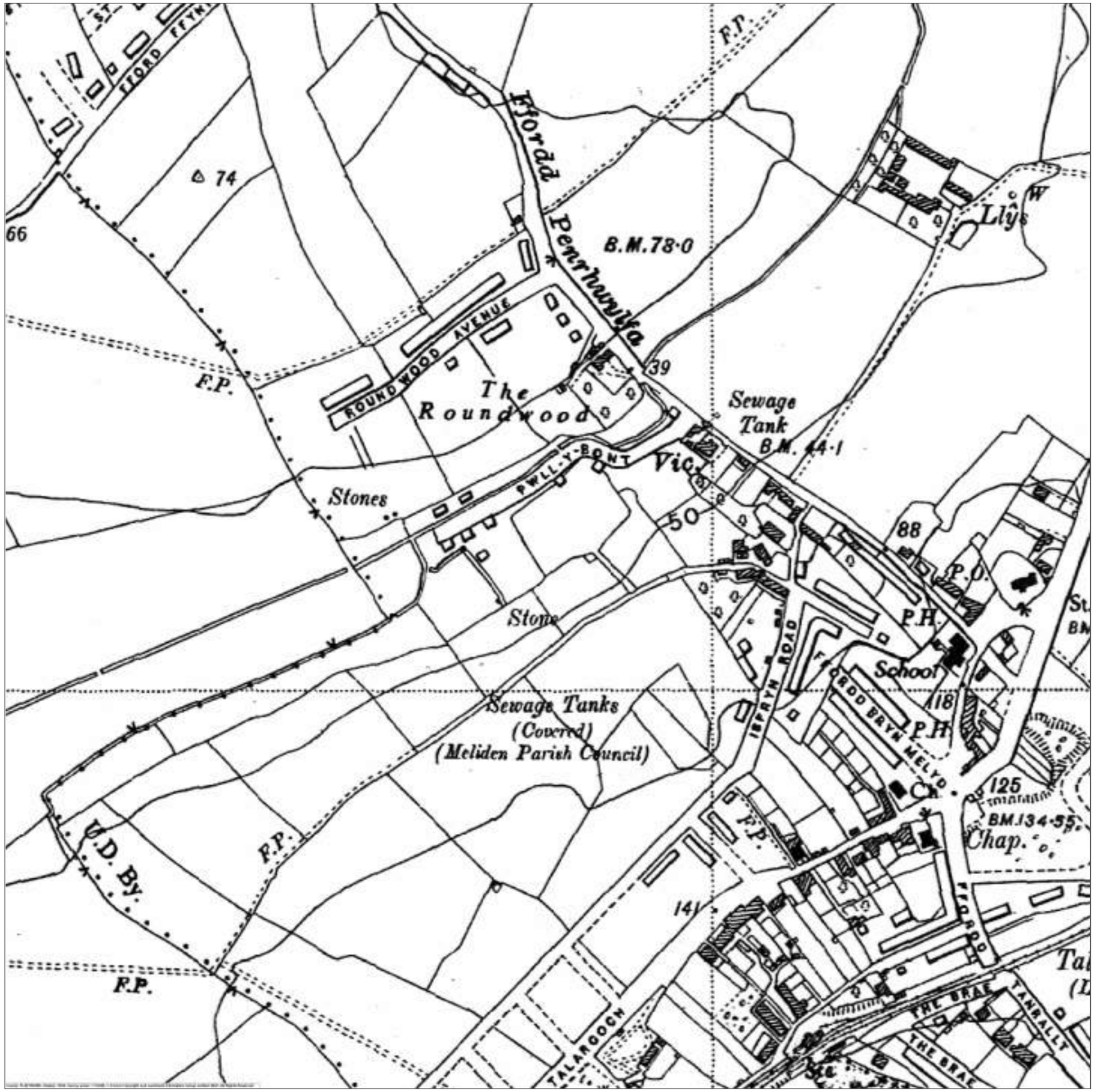
Landmark Historical Map
County: FLINTSHIRE
Published Date(s): 1878
Originally plotted at: 1:10,560



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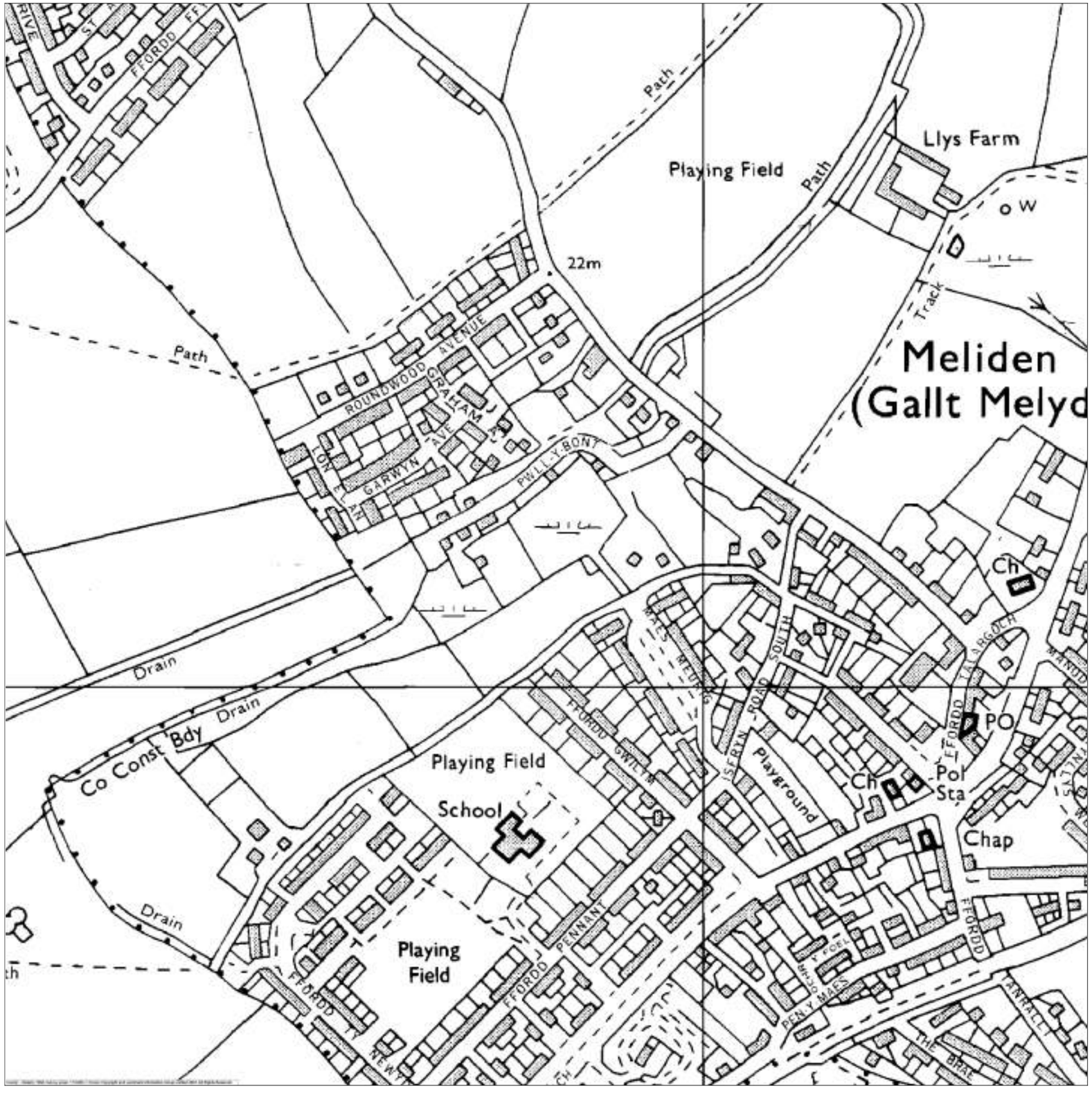

Landmark
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Landmark Historical Map
County:
Published Date(s): 1994
Originally plotted at: 1:10,000

GeoReports

British Geological Survey

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Radon Report

Advisory report on the requirement for radon protective measures in new buildings, conversions and extensions to existing buildings. The report also indicates whether a site is located within a radon Affected Area

Report Id: ***BGS_329974/40667***

Client reference: 20228

Search location

Contains OS data © Crown Copyright and database right 2023. OS OpenMap Local: Scale: 1:5 000 (1cm = 50 m)
Search location indicated in red

This report describes a site located at National Grid Reference 305830, 381058. Note that for sites of irregular shape, this point may lie outside the site boundary. Where the client has submitted a site plan the assessment will be based on the area given.

Radon Report: UK

When extensions are made to existing buildings in high radon areas, or new buildings are constructed in these areas, the Building Regulations for England, Wales, Scotland and Northern Ireland require that protective measures are taken against radon entering the building.

This report provides information on whether radon protective measures are required. Depending on the probability of buildings having high radon levels, the Regulations may require either:

1. No protective measures
2. Basic protective measures
3. Full protective measures

This is an advisory report on the requirement for radon protective measures in new buildings, conversions and extensions. The report also indicates whether a site is located within a radon Affected Area

Requirement for radon protective measures

The determination below follows advice in *BR211 Radon: Guidance on protective measures for new buildings (2015 edition), which also provides guidance on what to do if the* result *indicates that protective measures are required.*

Is the property in an area where radon protective measures are required for new buildings or extensions to existing ones as described in publication BR211 (2015 edition) Radon: Guidance on protective measures for new buildings?

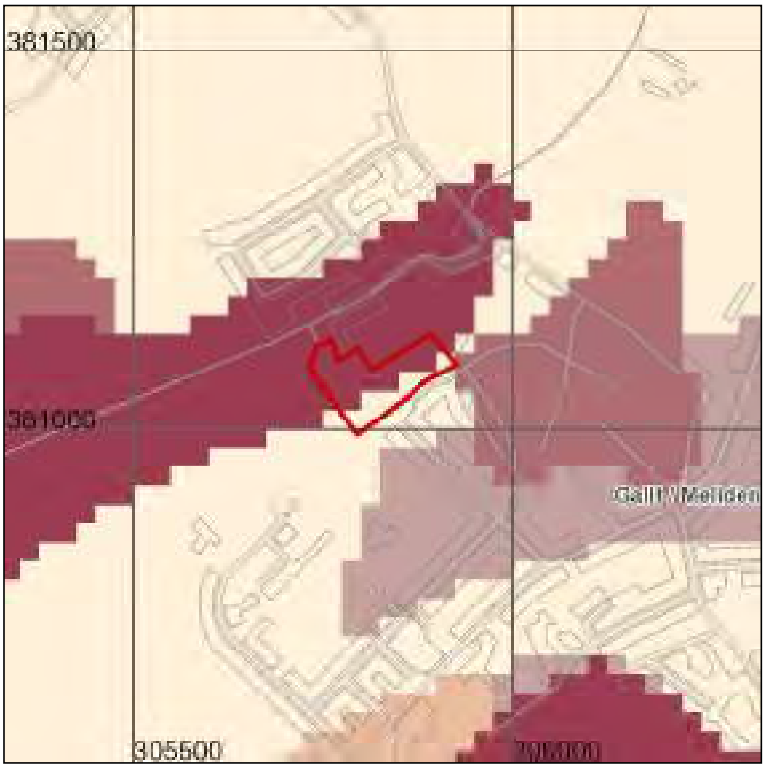
FULL RADON PROTECTIVE MEASURES ARE REQUIRED FOR THE REPORT AREA.

More details of the protective measures required are available in *BR211 Radon: Guidance on protective measures for new buildings (2015 Edition)*. Additional information and guidance is available from the Building Research Establishment website (http://www.bre.co.uk/radon/).

Whether or not the radon level in a building is above or below the radon Action Level can only be established by having the building tested. The UKHSA provides a radon testing service which can be accessed at www.ukradon.org or by telephone (01235 822622).

If you require further information or guidance, you should contact your local authority building control officer or approved inspector.

Radon Affected Area



	% Homes estimated to be at or above the action level
	0-1%
	1-3%
	3-5%
	5-10%
	10-30%
	30-100%

Scale: 1:10 000 (1cm = 100 m)
Search area indicated in red

Is the property in a radon Affected Area as defined by the UK Health Security Agency (UKHSA) and if so what percentage of homes are estimated to be at or above the Action Level? **YES**

Additional Information

THE PROPERTY IS IN A RADON AFFECTED AREA WHERE 10 TO 30% OF HOMES ARE ESTIMATED TO BE AT OR ABOVE THE ACTION LEVEL.

The UKHSA recommends a radon 'Action Level' of 200 Becquerels per cubic metre of air (Bq m^{-3}) for the annual average of the radon gas concentration in a home. Where 1% or more of homes are estimated to be at or above the Action Level the area should be regarded as a radon Affected Area.

This report informs you whether the property is in a radon Affected Area and the percentage of homes that are estimated to be at or above the radon Action Level at this location. Being in an Affected Area does not necessarily mean there is a high radon level within the property; the only way to determine the radon level is to carry out a radon measurement.

The UKHSA advises that radon gas should be measured in all properties within radon Affected Areas and that homes with radon levels at or above the Action Level (200 Bq m^{-3}) should be remediated. Householders with levels between the Target Level (100 Bq m^{-3}) and Action Level should seriously consider reducing their radon level, especially if they are at greater risk, such as if they are current or ex smokers. Whether or not a home is in fact above or below the Action Level or Target Level can only be established by having the building tested. The UKHSA provides a validated radon testing service which can be accessed at www.ukradon.org.

The information in this report provides an answer to one of the standard legal enquiries on house purchase in England and Wales, known as Law Society CON29 Enquiries of the Local Authority (2016); 3.14 Radon Gas: Do records indicate that the property is in a “Radon Affected Area” as identified by the UKHSA. The data can also be used to advise house buyers and sellers in Scotland and Northern Ireland.

If you are buying a new build property in a Radon Affected Area, you should ask the builder whether radon protective measures were incorporated in the construction of the property.

If you are buying a currently occupied property in a radon Affected Area, you should ask the present owner whether radon levels have been measured in the property. If they have, ask whether the results were at or above the radon Action Level and if so, whether remedial measures were installed, radon levels were re-tested, and if the results of re-testing confirmed the effectiveness of the measures.

Further information on radon is available from the UKHSA at www.ukradon.org.

What is radon?

Radon is a naturally occurring radioactive gas, which is produced by the radioactive decay of radium which, in turn, is derived from the radioactive decay of uranium. Uranium is found in small quantities in all soils and rocks, although the amount varies from place to place. Radon released from rocks and soils is quickly diluted in the atmosphere. Concentrations in the open air are normally very low and do not present a hazard. Radon that enters enclosed spaces such as some buildings (particularly basements), caves, mines, and tunnels may reach high concentrations in some circumstances. The construction method and degree of ventilation will influence radon levels in individual buildings. A person's exposure to radon will also vary according to how particular buildings and spaces are used.
Inhalation of the radioactive decay products of radon gas increases the chance of developing lung cancer. If individuals are exposed to high concentrations for significant periods of time, there may be cause for concern. In order to limit the risk to individuals, the Government has adopted an Action Level for radon in homes of 200 becquerels per cubic metre (Bq m^{-3}). The Government advises householders that, where the radon level is at or above the Action Level, measures should be taken to reduce the concentration.

Radon in workplaces

The Ionising Radiation Regulations 2017 require employers to take action when radon is present above a defined level in the workplace. Advice may be obtained from your local Health and Safety Executive Area Office or the Environmental Health Department of your local authority. The BRE publishes a guide (BR293)**: Radon in the workplace.** BRE publications may be obtained from the BRE Bookshop, Tel: 01923 664262, email: bookshop@bre.co.ukwebsite: www.brebookshop.com

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- Note that for some sites, the latest available records may be historical in nature, and while every effort is made to place the analysis in a modern geological context, it is possible in some cases that the detailed geology at a site may differ from that described.

Report issued by
BGS Enquiry Service

Annex

Context and Scope of the Desk Study

SOIL AND STRUCTURES

Context

The purpose of site investigation is to reduce uncertainty in the ground.

For all site investigations the legal imperative for reducing uncertainty is primarily governed by health and safety law; identifying hazards and, where present, limiting their potential for harm. In addition, the reduction of uncertainty also applies to: various environmental laws (relating to the prevention of pollution and harm); as well as, the commercial risk of potential abnormal groundwork costs.

Current UK planning policy, the National Planning Policy Framework (NPPF)[1], makes reference to the need to ensure that '*a site is suitable for its proposed use taking into account of ground conditions and any risks arising from land instability and contamination*' (Paragraph 178). The NPPF also makes reference to the need to adopt Mineral Safeguarding Areas (Paragraph 204).

In practice, this policy is implemented through planning conditions. Where applied, these conditions compel the developer to demonstrate the site is 'suitable for its proposed use' with respect to contamination and, in former mining areas, with respect to stability. Within Mineral Safeguarding Areas, planning conditions may also compel the developer to evaluate the viability of prior-extraction of a mineral before a development 'sterilises' the ground.

Warranty providers may also impose conditions on the development.

The assessment of other ground-related hazards, e.g. slope stability or collapsible soils, is typically not conditioned (unless a specific hazard locally) but rather an inherent part of the engineering design.

Scope

The first stage of 'site investigation' is invariably a desk-based exercise, the Desk Study. As the first stage, the scope of the Desk Study is naturally broad, and includes both: i) an assessment of ground-related risk; as well as, ii) preliminary advice relating to ground engineering.

The assessment of risk is guided by a series of international standards including ISO 31000:2018[2] 'Risk Management – Guidelines'. The Desk Study is developed with reference to this guidance and other additional UK and sector-specific guidance that includes; the Construction (Design and Management) Regulations (2015)[3] and, the Environment Agency's 'Land Contamination Risk Management (LCRM)[4].

The preliminary advice relating to ground engineering covers three engineering disciplines; structural, civil and mechanical. Their inclusion is designed to offer practical advice and, alongside a description of the development design, offer a fuller picture of the likely changes that the site's ground will undergo. This feeds into the risk assessment with groundwork changing a site's risk profile.

The value of a Desk Study is in the early identification and assessment of uncertainty in the ground. A well-undertaken Desk Study is the most cost-effective way to reduce uncertainty. The Desk Study also identifies potential opportunities in the ground such as: the potential for material recovery as part of the works, e.g. topsoil, subsoil or building stone or, the viability of ground source heat pumps.

[1] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810197/NPPF_Feb_2019_revised.pdf

[2] https://www.iso.org/iso-31000-risk-management.html

[3] http://www.hse.gov.uk/construction/cdm/2015/index.htm

[4] https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm

Annex

Context and Scope of the Desk Study

SOIL AND STRUCTURES

Whilst factual advice is offered with respect to the following areas the following exclusions apply to the Desk Study:

> The flood risk setting of the Site, this Report does not constitute a flood risk assessment and the advice of a suitably qualified civil engineer or flood risk assessor should be sought to confirm the risk rating and requirement, if any, for mitigation.

> The condition of the existing structure and associated infrastructure, e.g. utilities, to inform risk assessments, this Report does not constitute a building or structural survey. The advice of a RICS qualified surveyor or suitably qualified structural engineer should be sought if and where a survey or change in loading, e.g. new fixed plant, is required.

> The possible presence of non-native invasive species and protected species, this Report does not constitute an ecological survey. The advice of a suitably qualified ecologist should be sought if and where a survey is required.

> The possible presence of archaeological features, this report does not constitute an archaeological survey. The advice of a suitably qualified archaeologist should be sought if and where a survey is required.

Risk is rated with respect to the routine detailed within *CIRIA C552 – Contaminated Land Risk Assessment; a guide to good practice (2001)*.

The following tables are adapted from CIRIA C552 and serve as the routine by which risk is assessed within the Report and the corresponding definitions of the different classifications.

Risk is assessed with respect to the condition of the Site at the point of issue that can therefore be subject to change over time.

		Consequence			
		Severe	**Medium**	**Mild**	**Minor**
Likelihood	**High Likelihood**	Very High Risk	High Risk	Moderate Risk	Moderate / Low Risk
	Likely	High Risk	Moderate Risk	Moderate / Low Risk	Low Risk
	Low Likelihood	Moderate Risk	Moderate / Low Risk	Low Risk	Very Low Risk
	Unlikely	Moderate / Low Risk	Low Risk	Very Low Risk	Very Low Risk

Very High	• There is a high probability that severe harm could arise to a designated receptor from an identified hazard, OR, there is evidence that severe harm to a designated receptor is currently happening. • This risk, if realised, is likely to result in a substantial liability. • Urgent investigation (if not already undertaken) and risk mitigation is likely to be required.
High	• Harm is likely to arise to a designated receptor from an identified hazard. • Realisation of the risk is likely to present a substantial liability. • Urgent investigation (if not already undertaken) is required and risk mitigation may be necessary in the short term and is likely to be required over the longer term.
Moderate	• It is possible that harm could arise to a designated receptor from an identified hazard. However, it is relatively unlikely that such harm would be severe, of if any harm were to occur, it is more likely that the harm would be relatively mild. • Investigation (if not already undertaken) is normally required to clarify the risk and to determine the potential liability. Some and risk mitigation may be necessary in the longer term.
Low	It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would be mild at worst.
Very Low	There is a low probability that harm could arise to a receptor. In the event of such harm being realised it is not likely to be severe.

Annex

Background Threat and Risk

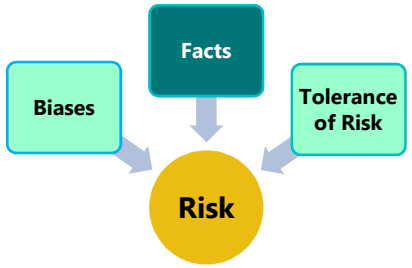
SOIL AND STRUCTURES

This annex offers further reading and background information relating to the referencing of 'background threat' within the risk assessment process.

The ratings presented herein **do not** reflect site-specific risk.

Introduction

Risk is an inherent part of all decisions and everyone has an appreciation of risk. How risk is assessed by both individuals and organisations is guided by three main influences; facts, biases and tolerance of risk.



Acknowledgement of this interplay is important given that, as well as informing the assessment; it also informs the response to risk – the practical outcome of the theoretical process. To support greater ownership of the assessment and any recommended actions, risk assessments should therefore aim to be; clear, proportionate and transparent (evidence-based).

Risk Assessment Influences

Biases: There are many types of biases that affect decisions or judgements including: i) *commercial bias*; does a given risk rating confer commercial opportunities or benefits on the person undertaking the assessment?; or, ii) *confirmation bias*; has the assessor not encountered any problems in similar scenarios and therefore generalised or under-assessed the risk rating.

Facts: The most important and ideally, guiding factor for the assessment of risk. Facts need to be evidenced and assessed by a competent person[1].

Tolerance of Risk[2]: Is informed by both societal and individual factors. Societal factors may include: is the hazard acceptable at all, e.g. locating nuclear power stations within urban areas; or, balancing scientific and technological advances with possible burdens to society and the economy. An example of this for land contamination is the reduction of 'excess lifetime cancer risk (ELCR)' as part of generic assessment criteria for soil testing (society accepting more risk). Individual factors may include: how a given risk affects them, their family and their values; or, accepting a higher risk for a greater reward.

Background Threat

Referencing 'background threat' as part of the Risk Assessment is intended to offer further detail on the hazards as well as an indication of the relative threats they pose. This aims to support; clarity, transparency and proportionality and help the reader better contextualise the risk and thus take greater ownership of it and any recommended action. Proportionality is central to effective risk management. Being over protective erodes the value of the process and adds unnecessary cost; being under protective exposes people and places to real risk.

Within the following tables, details on plausible routes or 'exposure pathways' by which a hazard may result in harm or other outcomes are detailed together with commentary on the assigned 'background threat' levels. The rating of 'background threat' is traffic-lighted between; high, moderate and low, with the nuances of the rating drawn more fully out within the commentary provided.

[1] http://www.legislation.gov.uk/uksi/2015/51/contents
[2] http://www.hse.gov.uk/risk/theory/r2p2.pdf

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Geological Risks			
Collapsible soils[3] *Deposits that can collapse when saturated or loaded. Generally isolated to South-East England*	**High**	**Harm:** burial and crushing. **Other impacts:** time-delays and damage to plant, structures and sub-structures.	Incident data for harm and other impacts is not readily available however, collapsible soils are widely distributed within the UK and the rapidly developing nature of the hazard means that the threat does carry immediacy. Public perception of the threat 'collapsible soils' pose is likely varied given its technical nature. **Harm:** With links to excavation collapses which account for a high proportion of year-on-year fatal and non-fatal injuries within the construction sector[4], the threat of harm is considered **high**. **Other impacts:** With potentially large time and cost implications (on a site-by-site basis) for responding reactively to the adverse affects of collapsible soils the threat of other impacts is also considered **high**.
Compressible soils[5] *Deposits that are very soft or degradable.*	**Moderate**	**Harm:** none that are directly linked or obviously plausible. **Other impacts:** time-delays and damage to structures and sub-structures.	Incident data for harm and other impacts is not readily available. The slowly developing nature of the hazard means that the threat does not carry immediacy. However, with compressible soil's links to subsidence, one of the most damaging geo-hazards in the UK[6] that is on the rise largely due to the influence of clay soils[7] and, with their extensive distribution across the UK, other impacts are significant. Public perception of the threat 'compressible soils' pose is likely varied given its technical nature. **Harm:** The slowly developing nature of the hazard means the threat of harm is considered **low**. **Other impacts:** With potentially moderate time and cost implications (on a site-by-site basis) for responding reactively to the adverse affects of compressible soils the threat of other impacts is considered **moderate**.

[3] https://www.bgs.ac.uk/products/geosure/collapsiblePHI.html
[4] http://www.hse.gov.uk/statistics/tables/index.htm#riddor
[5] https://www.bgs.ac.uk/products/geosure/compressiblePHI.html
[6] https://www.bgs.ac.uk/research/engineeringGeology/shallowGeohazardsAndRisks/shrinking_and_swelling_clays.html
[7] https://www.crawco.com/assets/uploads/docs/Crawford-Subsidence-The-Silent-Surge-vFinal.pdf

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Geological Risks, continued			
Ground dissolution[8] *Soluble rocks.*	**Moderate**	**Harm:** falls into open or partially open dissolution features. **Other impacts:** time-delays and damage to plant, structures and sub-structures.	Incident data for harm and other impacts is not readily available. The rapidly developing nature of the hazard (sinkholes) means that the threat does carry immediacy. Ground dissolution is a geology/region specific hazard and therefore threat levels vary across the UK. The frequency with which incidents take place is likely to be relatively constant with possible increases due to extreme weather events and probable increases due to urban sprawl into ground dissolution prone areas, making incidents more likely. Public perception of the threat 'sinkholes' pose is likely to be relatively high. **Harm:** The rapidly developing nature of the hazard but lack of evidence of fatalities or injuries attributed to sinkholes means the threat of harm is considered **moderate**. **Other impacts:** With potentially moderate time and cost implications (on a site-by-site basis) for responding reactively to the adverse affects of ground dissolution albeit likely on a small scale (sinkholes are likely to be localised) the threat of other impacts is considered **moderate**.
Running sand[9] *Loosely packed sand that can become fluid or 'run' when wet and support is withdrawn, e.g. when excavated.*	**High**	**Harm:** burial and crushing. **Other impacts:** time-delays and damage to plant.	Incident data for harm and other impacts is not readily available however, fine-grained / saturated sands are widely distributed within the UK and the very rapidly developing nature of the hazard means that the threat does carry immediacy. Public perception of the threat 'running sand' poses is likely varied given its technical nature. **Harm:** With links to excavation collapses which account for a high proportion of year-on-year fatal and non-fatal injuries within the construction sector[10], the threat of harm is considered **high**. **Other impacts:** Time and cost implications (on a site-by-site basis) for responding reactively to the adverse affects of running sands is varied but very dependent on their extent. The threat can be **high,** e.g. reactively changing foundation solution and adverse excavation conditions.

[8] https://www.bgs.ac.uk/products/geosure/solublePHI.html
[9] https://www.bgs.ac.uk/products/geosure/running_sandPHI.html
[10] http://www.hse.gov.uk/statistics/tables/index.htm#riddor

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Geological Risks, continued			
Sensitive clays[11] *Fine grained (clay) soils that can shrink and swell when wetted or dried respectively.*	**Moderate**	**Harm:** none that are directly linked or obviously plausible. **Other impacts:** damage to structures and sub-structures.	Incident data for harm and other impacts is not readily available. The slowly developing nature of the hazard means that the threat does not carry immediacy. However, with sensitive clays direct links to subsidence, one of the most damaging geo-hazards in the UK[12] that is on the rise and, with their extensive distribution across the UK, other impacts are significant. Public perception of the threat 'subsidence' poses is likely to be relatively high. **Harm:** The slowly developing nature of the hazard means the threat of harm is considered **low**. **Other impacts:** With potentially moderate time and cost implications for responding reactively to the adverse affects of sensitive clays the threat of other impacts is considered **moderate**.
Slope instability[13] *Falls, topples, slides or flows of soils or rocks generally due to gravity but controlled by various other factors, e.g. drainage.*	**High**	**Harm:** falls from height, burial and crushing. **Other impacts:** time delays and damage to plant, structures and sub-structures.	Aggregated incident data for harm and other impacts is not readily available however there are relatively frequent case-studies of landslips taking place[14][15] with some nationally significant incidents[16] resulting in significant changes to assessment and design. The slow to very rapidly developing nature of the hazard means that the threat does carry immediacy. Slope instability can occur anywhere throughout the UK. Public perception of the threat 'landslides' pose is likely to be relatively high. **Harm:** The potentially very rapidly developing nature of the hazard means the threat of harm is considered **high**. **Other impacts:** With potentially high time and cost implications for responding reactively to the adverse affects of slope instability the threat of other impacts is considered **high**.

[11] https://www.bgs.ac.uk/products/geosure/shrink_SwellPHI.html
[12] https://www.bgs.ac.uk/research/engineeringGeology/shallowGeohazardsAndRisks/shrinking_and_swelling_clays.html
[13] https://www.bgs.ac.uk/products/geosure/landslidesPHI.html
[14] https://www.bgs.ac.uk/research/engineeringGeology/shallowGeohazardsAndRisks/landslides/home.html
[15] https://www.bgs.ac.uk/landslides/casestudies.html
[16] https://www.bgs.ac.uk/research/engineeringGeology/shallowGeohazardsAndRisks/landslides/aberfan.html

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Geological Risks, continued			
Natural ground gas[17] *Methane and carbon dioxide primarily (though can include other gases) given off as part of natural bio-geo-chemical processes.*	**Moderate**	**Harm:** ingress and accumulation of asphyxiant, toxic or explosive gases into occupied spaces. **Other impacts:** damage to structures and sub-structures through explosion.	Aggregated incident data for harm and other impacts is not readily available however nationally significant incidents have taken place[18] with the threat carrying an immediacy. However, the frequency with which this hazard manifests is considered to be low. Public perception of the threat 'natural ground gases' pose is likely varied given its technical nature. **Harm:** The rapidly developing nature of the hazard means the threat of harm is considered high however the low frequency of incidents reduces this to **moderate**. **Other impacts:** With potentially high cost implications for responding reactively to the adverse affects of natural ground gas the threat of other impacts is considered high however the low frequency of incidents reduces this to **moderate**.
Radon[19] *Naturally occurring radioactive gas that is emitted from soils and rocks to varying degrees (depending on their composition) .*	**High**	**Harm:** ingress and accumulation of radioactive air and dust into occupied spaces. **Other impacts:** none that are directly linked or obviously plausible.	Incident data for harm is readily available[20] with radon being a significant contributory factor to lung cancer deaths across affected areas of the UK and with a risk of death that is the same order of magnitude as all deaths within the construction sector[21]. The slowly developing nature of the hazard means that the threat does not carry immediacy however the radioactive nature of the hazard does. Radon can occur anywhere throughout the UK but affects certain geological areas more so than others. Public perception of the threat 'radon' pose is likely low despite the high background threat. **Harm:** The slowly developing but significantly hazardous nature of the hazard means the threat of harm is considered **high**. **Other impacts:** The cost of mitigation is low if the risk is unacceptable and addressed proactively whereas responding reactively will incur moderate costs (retrospective fitting of protection). Overall however, the threat of other impacts is considered **low**.

[17] https://www.bgs.ac.uk/products/geohazards/methane.html
[18] http://www.hse.gov.uk/comah/sragtech/caseabbeystead84.htm
[19] http://www.ukradon.org.uk/
[20] https://www.ukradon.org/information/risks
[21] http://www.hse.gov.uk/risk/theory/r2p2.pdf

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Geological Risks, continued			
Aggressive geology[22] *Primarily concerned with acidic conditions arising from sulphate compounds in the ground with the potential to degrade buried concrete. Can include other conditions, e.g. saline or solvents.*	**Low**	**Harm:** none that are directly linked or obviously plausible. **Other impacts:** damage to structures and sub-structures.	Incident data for harm and other impacts is not readily available. The slowly developing nature of the hazard means that the threat does not carry immediacy. However, when aggressive geologies are present, damage to buried concrete can be severe[21]. Aggressive geology is typically, though not always, linked to sulphide bearing geologies that results in the hazard being geology/region specific and therefore threat levels vary across the UK. Public perception of the threat 'aggressive geology' pose is likely low given its technical nature. **Harm:** The slowly developing nature of the hazard means the threat of harm is considered **low**. **Other impacts:** With potentially high cost implications for responding reactively to the adverse affects of aggressive geology the threat of other impacts is considered high however, on a site-by-site basis, the low frequency of incidents and ease of management reduces this to **low**.
Hydrogeological and hydrogeological risks			
All flood risk carries high background threats. It is recommended that the advice of a suitably qualified competent person is sought for more information.			

[22] https://www.bgs.ac.uk/research/environmentalModelling/GeoProperties/SulphatesSulphides.html

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Historical Risks			
Contamination (on-site and off-site) *N.B. within the sub-surface environment there is invariably interplay between soil (contamination) and water (pollution) systems with these two risks commonly interacting with one another.*	**Moderate**	**Harm:** dermal contact with, or ingestion and inhalation of dust or vapours of, harmful material by either workers during construction or end users of the site (various depending on development). **Other impacts:** time-delays, damage to structures, sub-structures and ecology.	Aggregated incident data for harm and other effects is not readily available although the Environment Agency's enforcement register does offer an indication[23]. Case law also exists that directly relates contaminated land (airborne dust) to harm[24] as well as other impacts[25][26]. Harm is time-dependent; acute (short term) or chronic (long term). Acute risks for workers are generally informed by well-developed science of exposure limits for short and long term conditions[27]. Acute risks for end users are less well understood but an area of ongoing research[28]. Chronic risks are better understood and supported by established research including that undertaken by central government[29]. Public perception of the threat 'contamination' poses is likely varied given its technical nature. Contamination can occur in any location however former industrial land or waste depositories naturally carry a higher threat with increased volumes of potentially harmful material. Naturally geologies can also contain harmful material however these generally contribute to 'normal background concentrations' that local populations are exposed to. **Harm (acute risk):** For acute risk, the rapidly development nature of the hazard means the threat of harm is high however, the low frequency of incidents reduces this to **moderate**. **Harm (chronic risk):** For chronic risk an assessment of 'threat' is difficult not least as the threat can vary highly within a site itself. In general however, the slowly developing nature of the hazard means the threat of harm is lower than acute risk but not low. Whilst the frequency of chronic risk incidents resulting in harm is low in the UK, the potential for harm raises this to **moderate**. **Other impacts:** With potentially high cost implications for responding reactively to the adverse affects of contamination the threat of other impacts is considered **moderate**.

[23] https://environment.data.gov.uk/public-register/view/search-enforcement-action e.g. Groundwater Regulations, Environmental Protection Act 1990, Environment Act 1995
[24] http://www.environmentlaw.org.uk/rte.asp?id=266
[25] https://www.freeths.co.uk/2017/01/13/case-law-update-contaminated-land-liabilities/
[26] http://www.environmentlaw.org.uk/rte.asp?id=228
[27] http://www.hse.gov.uk/coshh/basics/exposurelimits.htm
[28] https://sobra.org.uk/about-us/sub-groups/
[29] http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=18341

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Historical Risks, continued			
Pollution (waters) *N.B. within the sub-surface environment there is invariably interplay between soil (contamination) and water (pollution) systems with these two risks commonly interacting with one another.*	**High**	**Harm:** pollution of sensitive water bodies, e.g. Controlled Waters[30] with potential for harm to water users. **Other impacts:** damage to ecology.	Aggregated incident data for harm and other effects is readily available that directly relates pollution to harm[31] with other impacts also reported[32] however discerning where this harm arises from historic, unused sources such as those more commonly encountered on land development is difficult. Harm varies according to the nature of the incident, e.g. a recent spillage of a large volume of potential pollutants versus an ongoing seepage of an unknown volume of potential pollutants. For land development, it is commonly seepages that are encountered. These seepages can be from either; a single point-source, e.g. an old storage tank, or diffuse source, e.g. a large area of soils leaching pollutants, e.g. a landfill. Public perception of the threat 'pollution' poses is likely to be relatively high. **Harm:** The slowly developing nature of the hazard but potentially large impacts means the threat of harm is considered moderate however, the relatively high frequency with which these incidents take place result in the threat being considered **high**. **Other impacts:** With potentially high cost implications for responding reactively to the adverse affects of pollution the threat of other impacts is considered **high**.

[30] https://www.legislation.gov.uk/ukpga/1991/57/section/104
[31] https://environment.data.gov.uk/public-register/view/search-enforcement-action e.g. Groundwater Regulations, Environmental Protection Act 1990, Environment Act 1995
[32] https://www.bbc.co.uk/news/uk-england-devon-49242485

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Historical Risks, continued			
Mining risks are varied and can carry high background threats. It is recommended that the Coal Mining Risk Assessment, if required for the site, is consulted.			
Landfill gas	**Moderate**	**Harm:** ingress and accumulation of asphyxiant, toxic or explosive gases into occupied spaces. **Other impacts:** damage to structures and sub-structures through explosion.	Aggregated incident data for harm and other impacts is not readily available however nationally significant incidents have taken place[33][34][35] with the threat carrying immediacy. However, the frequency with which this hazard manifests is considered low. Public perception of the threat 'landfill gas' poses is likely varied given its technical nature. **Harm:** The rapidly developing nature of the hazard means the threat of harm is considered high however the low frequency of incidents reduces this to **moderate**. **Other impacts:** With potentially high cost implications for responding reactively to the adverse affects of landfill gases the threat of other impacts may be considered high however the low frequency of incidents reduces this to **moderate**.
Sub-surface structures *i.e. tunnels, basements and cellars and not mine shafts or underground mine workings*	**Moderate**	**Harm:** falls from height, burial and crushing. **Other impacts:** time delays and damage to plant.	Incident data for harm and other impacts is not readily available. The rapidly developing nature of the hazard (surface collapses) means that the threat does carry immediacy. The frequency with which incidents take place is likely to be relatively constant. Public perception of the threat 'old basements' pose is likely to be relatively high and linked to 'sinkholes'. **Harm:** With links to excavation collapses which account for a high proportion of year-on-year fatal and non-fatal injuries within the construction sector[36], the threat of harm may be considered high however, the ease of management reduces this to **moderate**. **Other impacts:** With potentially moderate time and cost implications (on a site-by-site basis) for responding reactively to the adverse affects of sub-surface structures the threat of other impacts is also considered **moderate**.

[33] http://users.ox.ac.uk/~ayoung/LF/cwm039b.pdf
[34] CIRIA document ref. "Assessing risks posed by hazardous ground gases to buildings (revised)" (C665) – Loscoe case study
[35] https://inews-co-uk.cdn.ampproject.org/c/s/inews.co.uk/news/uk/council-houses-torn-down-burning-coal-seam-carbon-monoxide-derbyshire-826029?amp
[36] http://www.hse.gov.uk/statistics/tables/index.htm#riddor

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Historical Risks, continued			
Unexploded ordnance	**Moderate**	**Harm:** explosion damage (direct or indirect; on site and off site). **Other impacts:** time delays and damage to plant, structures and sub-structures.	Aggregated incident data for harm and other impacts is not readily available however incidents are well reported in national and regional news as well as on enthusiast websites[37] with the threat carrying immediacy. No deaths are directly attributed to unexploded ordnance since 1949. The frequency with which this hazard manifests varies across land used for military purposes and land used for military purposes but possibly bombed, with the former being likely and the latter a low likelihood. Public perception of the threat 'unexploded ordnance' poses is likely to be relatively high due compared to a lower background threat. **Harm:** The rapidly development nature of the hazard means the threat of harm is high however, the low frequency of incidents on land not used for military purposes reduces this to **moderate**. **Other impacts:** With potentially high cost implications for responding reactively to the adverse affects of aggressive geology the threat of other impacts is considered high however, on a site-by-site basis, the low frequency of incidents reduces this to **moderate**.
Archaeological interests can carry high background threats. It is recommended that the advice of a suitably qualified competent person is sought for more information.			
Utilities can carry high background threats. It is recommended that the advice of a suitably qualified competent person is sought for more information.			
Ecological Risks			
Ecological risk can carry high background threats. It is recommended that the advice of a suitably qualified competent person is sought for more information.			

[37] http://bombfuzecollectorsnet.com/page14.htm