GEOLOGICAL
GEOTECHNICAL
GEOENVIRONMENTAL
DATA ACQUISITION
CONSULTANCY

Remediation and Validation Strategy

LOCATION	146 Commercial Road, Skelmanthorpe, Huddersfield HD8 9DS
ISSUE DATE	March 2022
CLIENT	Silverwood and GNS Property Development Ltd
CLIENT REF.	
OUR REF.	G22092

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1. Introduction

Findings of the intrusive Phase 2 site investigation (G20242, February 2022) confirmed the presence of elevated concentrations of lead contamination* within the existing topsoil located within proposed gardens which would require remedial works prior to redevelopment.

*The word *contamination* in this context is used to describe instances where potential contaminants are present at levels in excess of the allowable limits for residential land use. This does not necessarily mean that the site would be classed as contaminated land as per the Environmental Protection Act 1990: Part 2A definition or that it poses immediate danger to persons on site and neighbouring sites, only that the soils do not meet the required standards for the proposed residential development. However, for this site in particular, a potential risk to the adjacent water course *was* identified.

Alhtough no formal Phase 1 Desk Study has been carried out Historical Mapping suggests that the principal potential source of contamination is likely to be in connection with the construction and use of the existing property which dates from at least circa 1900. Additionally, a potential ground gas risk may be present at the site from nearby mine-working activities.

A Coal Mining Risk Assessment CMRA has been carried by Geoinvestigate out for the site (Ref: G21162-April 2021), which highlighted there are no known worked coal seams below the site. However possible unrecorded shallow workings may be present potentially within the Penistone Green Coal which is considered to underly the site at shallow depth although this does not outcrop within 250m radius of the site.

The Coal Mining Risk Assessment was followed up with a Rotary Borehole Site Investigation Report (Ref: G21377, December 2021) which comprised of three (3) 30m depth open rotary boreholes which proved shallow sandstone with horizons of poor coal below 2.40m, BH3 also lost flush below 12.60m. The report concluded that due to the foundations should be reinforced as a precaution.

Based the Phase 2 Report, three of the four samples tested, returned elevated concentrations of lead which may be linked the presence of brick and coal fragments within the made ground from construction of the current building. The presence of this contaminant would necessitate that a remediation exercise will therefore need to be carried out to deem the site as a whole, to be fit for purpose as a residential development.

- It was concluded that presence of the elevated levels of lead within near surface soils may represent a potential hazard with regard to human health, specifically to the end users of the site (residents) over potentially long-term exposure.
- The source of the identified contamination is unknown, but is speculated to be associated with brick, and coal fragments present within the made ground.
- No significant risk is anticipated to personnel employed in the remediation of the site or the construction of the new development.
- No evidence has been found to date, that would suggest any risk to ground and surface waters in the local area as the soils are otherwise clean and uncontaminated. See Phase 2 site investigation report G22042 for additional details.

Note that only garden and soft landscaped areas highlighted will require remediation works. In addition, it is anticipated that soils below buildings and hardstanding will not pose a risk to end users of the site, as no human contact will be possible, and as such, may remain in situ.

In addition, although only shallow (<0.90m) made ground was present at the site, the Gas Monitoring exercise and initial results (Section 7.2 – Hazardous Gas in G22042 report) has suggested that the site is classified as requiring no Gas Mitigation Measures in line with "Green" of the NHBC Traffic light System however full monitoring has not been complete. Also, no Radon Protection Measures are required.

2. Options Appraisal

Consideration has been given to a number of possible solutions or technologies with the following emerging as the most cost effective and implementable option:

A cover (capping) system is likely to be most appropriate given the thickness of topsoil encountered (up to 0.90m), in order to confine the contamination source (made ground) at depth. The purchase and placing of clean fill material is normally required as part of this exercise in order to restore original site levels (or those required by the planned development). New certified clean topsoil and potentially stone fill is likely to be required to be brought into the site as part of the development works, though any requirement for topsoil is likely to be much later in the development schedule. The cover system should be a minimum of 600mm thick (300mm of topsoil and 300mm of clean imported fill or natural clay).

Validation sampling and analyses may be required to confirm sufficient thickness of clean cover and in order to confirm the final condition of the site.

Current landfill legislation is aimed at reducing volumes of material going to landfill. Consequently, in the interests of minimising waste and cost, by not removing the full thickness of made ground, in terms of landfill tax, transport and purchase of clean replacement material, and the relatively small quantity of implicated soils (and therefore disproportionately high cost of soil treatment relative to cost of disposal), the use of this technique is considered most appropriate.

Other methods of remediation considered for the site included:

- A "dig and dump" strategy, whereby the full thickness of contaminated material is excavated under proper supervision and transported to appropriate landfill (determined by the levels of contaminants present). Given that the affected soils persist to depths of up to 0.90m, the full excavation and replacement with clean soils would comprise significant wasteful over-excavation.

- Bioremediation and/or Soil washing: As noted above the quantity of affected soils was insufficient for this to be a financially viable option.

- Soil stabilisation: The large plant required for this method together with the cost and relatively small site (and even smaller remediation area) would render this method economically and operationally difficult. Additionally, the areas in question will need to comprise garden areas and soils treated using this method would not comprise a suitable growing medium.

3 Remediation Exercise

3.1 Scope of Remediation Exercise

The near surface made ground encountered has been found to contain contamination in the form of lead present at levels that are unacceptable in the proposed residential use of the site. Note that:

- Topsoil (containing brick and coal fragments) was encountered to a maximum depth of 0.90m.
- Contamination (in the form of elevated lead concentrations) was encountered in only three of the four samples of the made ground at the site.
- The soils pose no risk to ground or surface waters and do not pose any risk to human receptors where they will be present under buildings/hardstanding.
- Only the garden / soft landscaped areas of the site will require remediation.

As discussed in Section 2 a cover (capping) system method is considered to be the most viable means of removing the identified pollutant linkages at the site due to the thickness of made ground encountered.

This will require the safe and successful excavation of the top 600mm of topsoil. However, excavation can be terminated where natural strata is encountered. In this case, this would be the light brown sandy gravelly clay horizon.

Further details and methodology are outlined in Section 3.3 below. As well as visual inspection of soils, further soil sampling and analysis *may* be used as part of the ongoing validation process to supplement the existing knowledge of the site and aid in the direction of the remedial excavation works but will not necessarily be a requirement.

The areas requiring remediation is outlined on the site plan included in Appendix 1.

It is estimated that the area requiring remediation is approximately 560m^2 in area and as such the total volume of soil to be removed will be 196m^3 assuming a constant 350mm depth (average made ground thickness) of material, however this may be a slightly pessimistic estimate if natural material is encountered during the site strip.

3.2 Objectives

The site investigation report (G22042) indicated that elevated concentrations of lead are within the soft landscaping. As 600mm of soil requires removal from the proposed garden areas, the excavation exercise should be simple to complete successfully.

All other soils at the site are not currently considered to be contaminated (see site plan in Appendix 1).

The exercise is to involve the excavation of the topsoil to a depth of 600mm below the existing ground levels. However, if the underlying natural strata (light brown sandy gravelly clay) is encountered before excavation reaches 0.60m, then soil removal may be terminated, as the soils with the elevated lead concentrations (source soils) would have been removed from site.

Successful excavation will be followed by the restoration of site levels (if necessary) prior to development with proven clean, uncontaminated fill. This may initially only be anticipated to comprise the placing of gravel as a safe surface for the construction site, with new topsoil being required towards the end of the development works. As such, the final validation of the site might not be possible until later in the development when the topsoil is finally delivered (though it could feasibly be tested at an earlier stage), though confirmation of contaminant source removal will be possible at an earlier date. However, if topsoil was purchased and stockpiled on site before it is required, the validation could be completed without having to wait for the development to be finished.

Where new soils or stone is required at the site, validation sampling and analysis will be carried out prior to installing the new material in order to confirm contaminants in the replacement material are below acceptable levels prior to the soil being placed onsite. This sampling is best done at the source/wholesaler prior to the movement of the material in order to avoid potentially wasted transport costs. Validation sampling will be carried out in accordance with YALPAG (Yorkshire and Lincolnshire Pollution Advisory Group) guidance.

3.3 Chronology of Plan

Commencing from a yet to be determined date, a chronological summary of the objectives of such a remediation exercise is as follows:

1. Identification of areas to be remediated – see section 3.1 above and site plans in Appendix 1 of this report for areas/volumes currently anticipated to required remediation. As discussed above potential remains for this area to change during the works based on the findings of the excavations; the uncovering of previously unidentified serious contamination may require additional excavation or even a re-evaluation of existing pollutant linkages and the remediation strategy.

2. Safe and successful excavation of potentially contaminated material by an appropriately qualified and experienced contractor to a depth of 600mm in the identified (this may be reduced if natural clay is encountered), allowing for additional excavation should any obvious serious contamination hotspots or additional areas of concern (i.e. beyond the inferred area already identified) be encountered based on visual and olfactory evidence. It should be noted that Geoinvestigate should be contacted for further assessment if any evidence of additional contamination, such as large fragments of asbestos containing materials (ACMs) or hydrocarbon residues/odours, is encountered.

No sorting, separation, temporary stockpiling, treatment or re-use of excavated soils is intended at the site. Nor is it anticipated that any such activity would prove useful/feasible.

Wheel washing of vehicles taking the soils from the site may be necessary as it is likely that wagons will be loaded/unloaded on site, particularly if the site becomes untidy/muddy due to adverse weather conditions and potentially street cleaning should be considered.

It is anticipated that, given the estimated volume of soils to be removed from the site may be in the region of 196m^3, an estimate of 20 wagon loads may be necessary (assuming a 10m3 maximum capacity for each load). It possible that traffic control measures will be needed at the site.

3. Complete, safe exportation of identified contaminated made ground to a suitable licenced landfill or disposal/recycling facility with necessary measures taken to prevent the spread of dust and loose material both on- and off-site (i.e. washing of wagon wheels etc. if necessary); this should include collation of copies of relevant consignment/waste transfer notes for provision to Geoinvestigate Ltd.

4. Validation sampling and analyses. If and where new soils are brought into site to make up levels, to provide a stone surface for the building site, or to provide topsoil for soft landscaping (i.e. private gardens) these should be sampled and tested in accordance with YALPAG* guidance, details of which are included in figure 2 later. Once proven to meet adopted assessment criteria and be fit for purpose in a residential context the new soil will be placed in the excavated locations (where required) whereupon the pollutant linkages identified in the conceptual ground hazard model (CGHM) below will have been deemed to have been broken via the removal of the contamination source.

*Yorkshire and Lincolnshire Pollution Advisory Group

5. Provision of a factual and interpretative report detailing the works undertaken and presenting the following evidence which will confirm the successful implementation of this remediation strategy:

- Site plan detailing areas and depths excavated as well as any validation sample locations.
- Photographic record of works undertaken and excavated areas showing all work has been carried out safely and thoroughly.
- Results of any validation analyses to show that all soils at the site following excavation works are fit for purpose in the proposed residential end use.
- Results of analyses of any new soil to be brought into the site, including stone for site surfacing and topsoil for finished gardens (and soils sourced from elsewhere within the farm), to show that all soils at the site in its final condition are fit for purpose.
- Copies of consignment notes for material removed from/brought into site (to be provided to Geoinvestigate by the developer).

- On completion of the above works no discernible pollutant linkage would remain at the site –

There are not considered to be any circumstances likely to occur which would prevent the removal of the contamination source to sufficient depth unless significantly different ground conditions or contaminants to those previously encountered were to be uncovered by the works. Given the findings of previous site investigation works this is thought to be highly unlikely.

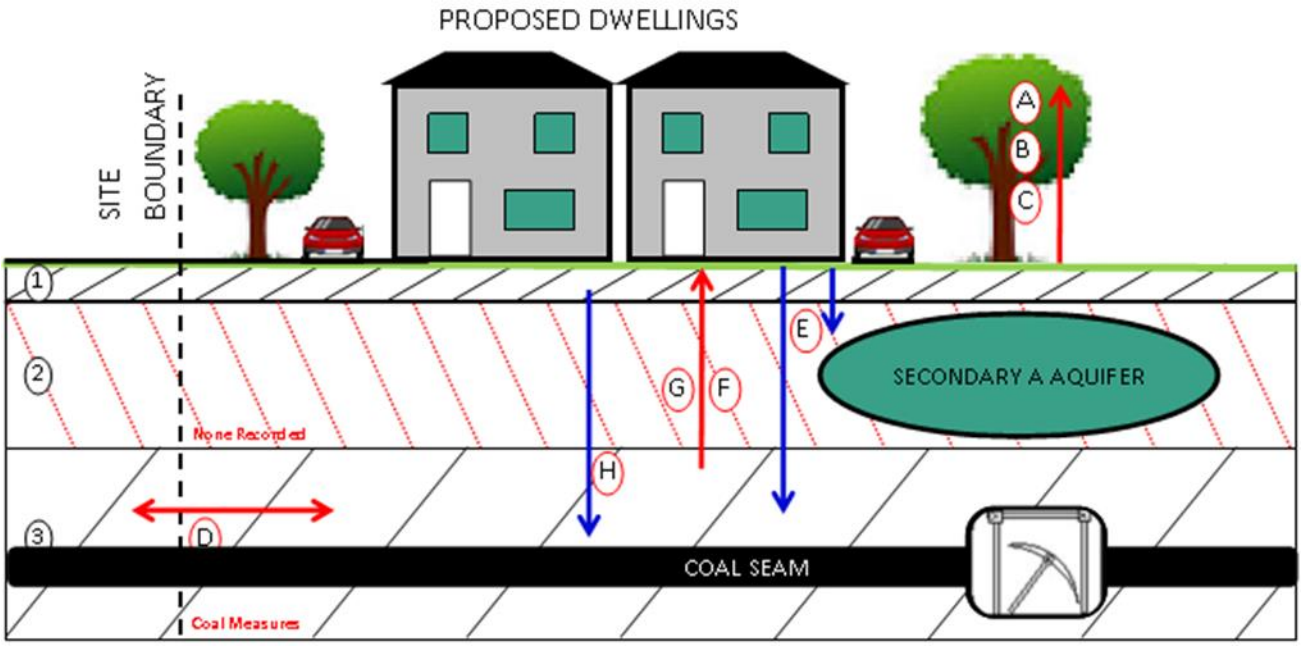
Nor is there anticipated to be any requirement for ongoing monitoring of the site as the contaminant source is proposed to be removed in its entirety where required and is immobile elsewhere, and therefore no ongoing addition of contamination is expected to be possible to the relevant areas.

4 Pollutant Linkages

The conceptual ground hazard model (CGHM) presented on the following page in Figure 1 outlines the pollutant linkages currently considered to exist at the site and potentially posing risk to receptors identified. This is the same CGHM presented in the Phase 2 S.I report (G22042). As specified in report G22042, the presence of elevated concentrations of lead in made ground may pose a potentially unacceptable risk to end users. No risk has been identified to underground waters.

Consideration to plant uptake has been considered and it is possible that fruit/vegetables may be cultivated for consumption. Regardless, no significant risk in this regard will be expected following removal of the implicated soils and replacement with proven uncontaminated material.

Figure 1: Conceptual Ground Hazard Model Identifying Pollutant Linkages to be removed.



(1) MADE GROUND—TOPSOIL AND MADE GROUND ENCOUTERED

(2) SUPERFICIAL GEOLOGY— COHESIVE MATERIAL ENCOUTERED

(3) BEDROCK GEOLOGY—SANDSTONE PROVEN AT SHALLOW DEPTHS

IDENTIFIED HAZARDS Including Potential CONTAMINATION SOURCES

-Shallow made ground proven as topsoil

-Potential hazardous gasses sourced from made ground and coal mine-workings.

-Past and current land use on and nearby to the site.

IDENTIFIED RECEPTORS and ASSOCIATED PATHWAY

A— End Users through Direct Contact / Inhalation / Ingestion. Buildings and hard standing will encompass some of the site, removing any pathway to end users through direct contact in these areas.

B— Plants and Trees through uptake, possible given the intended end use of the site.

C— End Users through cultivation and consumption of vegetables / fruit. Possible given the intended end use of the site.

D— Neighbouring Sites through lateral migration (in soil and water, including surface water run off).

E— Ground water through leaching of sub-soil.

F— Buildings and services through direct contact.

Linkages A—F are confirmed due to elevated lead levels within 3 out of 4 samples tested and remediation required. No risk determined to controlled or surface waters

G— End users and buildings through ground gas migration.

Gas monitoring results to date show no elevated ground gas concentrations—likely to fall within Green of NHBC traffic light system.

H— Ground surface instability due to coal mining legacy. Programme of drilling and grouting required at the site to ensure stability of new structure.

Rotary probing encountered no voids but lost flush in one borehole, foundations should be reinforced as a precaution.

5. Validation and Risk assessment

Validation of the cover (capping) system by way of a hand dug trial pits in the completed proposed garden areas will be required to confirm that a sufficient thickness of capping has been placed (including a suitable 300mm topsoil growing medium) and to confirm that the material placed are fit for end use. This may include the chemical validation of placed soils to confirm the placed materials are "clean'' and uncontaminated with regards to the proposed residential end use.

Geoinvestigate Ltd. generally uses a combination of assessment criterion provided by the environment agency, DEFRA, and the Chartered Institute of Environmental Health in order to assess the presence of potentially harmful chemicals within soils and water. These are; EA Soil Guideline Values (SGVs), Site Specific Assessment Criteria (SSAC) generated using CLEA software version 1.06 site specific risk assessment modelling, DEFRA Category 4 Screening Levels (C4SLs), Land Quality Management / Chartered Institute of Environmental Health (LQM/CIEH) Safe for Use Levels (S4ULs), and Environmental Quality Standards (EQSs) from the Environment Agency database (for leachates and water). However, SSAC in this instance are not considered necessary as there are no unusual circumstances at the site that would render the generic residential values inappropriate, and no further assessment of water or leachate is considered necessary.

In this case the site is intended to be developed as a new residential development and as such has a residential end-use for the purposes of soil assessment criteria selection. As it is possible that residents may cultivate vegetables / fruit for consumption, consideration of plant uptake has been included.

Contamination analyses will be undertaken on samples of soil wherever necessary to confirm that relevant contaminants in all soils which will remain at the site following its redevelopment are within acceptable limits with regard to human health.

Where soils are to be brought into the site to restore previous levels these should be sampled in accordance with the recommendations of the YALPAG guidance referred to earlier in this document and in Figure 2 at the end of this report (**NOTE**: this should be carried out with results confirmed **prior** to the placing of the material in the excavations to prevent a repeat exercise being necessary should soils fail to meet the required standard).

Results from the soil analyses that will be carried out will be compared to the limit values from the above sources (presented in Table 1 below) and where they fall below these limit values, will be deemed safe for a residential end use. For consistency, the adopted assessment criteria are the same as those adopted for the quantitative risk assessment of the preceding S.I. G22042.

Should any analyses return concentrations exceeding the chosen assessment criteria, an assessment of the source and available pathways and receptors will be carried out to determine whether further investigation or remediation will be necessary. The likely outcome will be the returning of imported stone/soils to the supplier for replacement or continued excavation of potentially contaminated soils (depending on which material has returned exceedances); for this reason, it is essential that all testing and confirmation of the quality of soils takes place prior to placing of any material in the excavations to allow for this contingency action should soils fail to meet the required criteria. Any material brought into site should be stockpiled on site and covered while chemical analysis results are pending though normal practice would be to sample the soils at their source prior to being brought to the study site in order to prevent potentially wasted transport costs and emissions.

No mitigation measures or ongoing monitoring are considered necessary for the new development as the contamination source is considered to be historical in nature and hence no ongoing addition of or exposure to contamination is anticipated at the site following removal of made ground from the implicated area(s).

Table 1: Assessment Criteria – Soils

	SGV (EA)* (mg/kg)	S4UL (LQM/CIEH)* (mg/kg)	C4SL (DEFRA)* (mg/kg)
Asbestos	Any presence unacceptable		
Arsenic	**32/37*** **	**37**	**40**
Boron		290	
Cadmium	10/26***	11	149
Chromium VI	21***	6	21
Chromium III		910	
Copper		2,400	
Lead	200***		310
Mercury (elemental)	**1**	**1.2**	
Nickel		180	
Selenium	350	250	
Zinc		3,700	
pH	See Report Section 7.3 "Concrete Design"		
Water Soluble SO_4			
Phenol		1100	
Total PAH			
PAH Naphthalene		13	
PAH Acenaphthylene		920	
PAH Acenaphthene		1100	
PAH Fluorene		860	
PAH Phenanthrene		440	
PAH Anthracene		11000	
PAH Fluoranthene		890	
PAH Pyrene		2000	
PAH Benzo(a)anthracene		13	
PAH Chrysene		27	
PAH Benzo(b)fluoranthene		**3.7**	
PAH Benzo(k)fluoranthene		100	
PAH Benzo(a)pyrene		**3**	
PAH Indeno(123-cd)pyrene		41	
PAH Dibenz(a,h)anthracene		**0.3**	
PAH Benzo(ghi)perylene		350	
TPH Aromatic C7-C8		660	
TPH Aromatic C8-C10		190	
TPH Aromatic C10-C12		380	
TPH Aromatic C12-C16		660	
TPH Aromatic C16-C21		930	
TPH Aromatic C21-C35		1700	
TPH Aromatic C35-C44		1700	
TPH Aliphatic C5-C6		160	
TPH Aliphatic C6-C8		530	
TPH Aliphatic C8-C10		150	
TPH Aliphatic C10-C12		760 (283)**	
TPH Aliphatic C12-C16		4300 (142)**	
TPH Aliphatic C16-C35		110000	
TPH Aliphatic C35-C44		110000	

**with an* allowance for consumption of homegrown produce with soil organic matter to be determined and S4ULS chosen accordingly.

**Estimates soil saturation limit, above which potential for free phase contamination might exist.

Figure 2: Testing requirements (reproduced from the YALPAG guidance) for various new fill material types are as stated below:

Type	Number of Samples	Testing Schedule	Assessment Criteria
Virgin Quarried Material	1 or 2 depending on the type of stone utilised, to confirm the inert nature of the material.	Standard metals/metalloids	This needs to be agreed with the Local Authority. The Assessment criteria needs to be UK based, e.g. SGV's, LQM or other similarly derived GAC's.
Crushed Hardcore, Stone, Brick	Minimum 1 per 1000m^3	Standard metals/metalloids PAH (speciated) Asbestos Leachate analysis	
Greenfield Soils	Minimum 3 or 1 per 250m^3 (whichever is greater)	Standard metals/metalloids PAH (speciated) Asbestos	
Brownfield Soils	Minimum 6 or 1 per 100m^3 (whichever is greater)	Standard metals/ metalloids Chromium VI PAH (speciated) TPH (speciated) Asbestos Any additional analysis dependant on the history of the donor site.	

END OF REPORT

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APPENDIX 1

Excavation Location Plan and Proposed Remediation Area Plan

GEOINVESTIGATE Ltd.

OUR REF: G22042	YOUR REF:	SITE PLAN (NOT TO SCALE)
DATE: 31/01/2022	LOCATION: 146 Commercial Road, Skelmanthorpe HD8 9DS	

Key

BH8 Window Sample Borehole Location

TPC Trail Pit Location

Elevated Lead Hot Spot Location

Proposed Remediation areas highlighted in green, with figures indicating size of area for each section.