Pell Frischmann

Finchley Road

Remediation Strategy

Land Contamination Risk Management

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Site name and location

Finchley Road (O2 Masterplan site)

London, NW3 6LU (National Grid Reference: 525650, 184730)

Development proposals

Mixed use residential/commercial development set within areas of landscaped public open space (including raised podium gardens, rooftop terraces, ground level soft landscaping and play areas)

Aims of the remediation strategy

The aims of this report are to summarise the 'remediation option appraisal' process and to describe the 'remediation strategy' for the proposed development.

- Remediation options appraisal includes setting remediation objectives and criteria and identifying a suitable remediation option that 'can be implemented in practice'.
- The remediation strategy is a record 'of how you will meet and carry out the remediation objectives' and includes a verification plan setting out compliance criteria and the records and 'lines of evidence' that need to be captured during or after remediation.

Reason for remediation

The generic quantitative risk assessment (GQRA) identified two potentially Relevant contaminant linkages associated with the Made Ground onsite.

CL	Source	Pathway	Receptor	Risk rating	CL status
101	PAH compounds and lead within Made Ground onsite	Ingestion, inhalation and dermal contact associated with areas of ground-level soft landscaping only	Human health of end users	Moderate	***Relevant***
201	Asbestos in soils (within the Made Ground onsite)	Inhalation of liberated respirable fibres associated with areas of ground-level soft landscaping only	Human health of end users	Moderate	***Relevant***

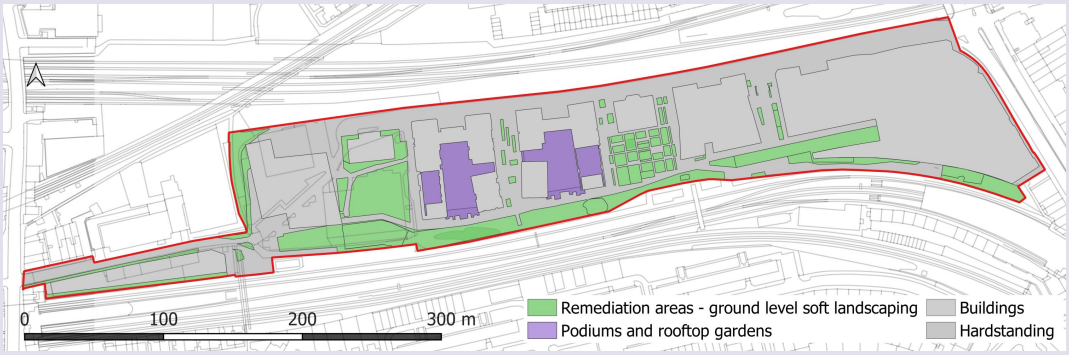
The GQRA was based on a limited data set as the site investigation works were restricted to accessible areas only. Additional phases of investigation are planned.

While the PAH and lead contamination may or may not ultimately warrant remediation, it is considered that the existing data is sufficient to determine that remediation will be required for CL201 - specifically within soft landscaped areas.

Remediation strategy

Composite cover system comprising a 'high visibility' geotextile base layer, laid over the existing Made Ground followed by the placement of a suitable thickness of clean cover soils (above the geotextile).

The GQRA determined that *remediation would only be required in areas of proposed soft landscaping onsite* (i.e. across any parts of the site not covered by hardstanding, such as roads, buildings, paved paths etc)). However, soil suitability extends to additional 'above ground' landscaping including podiums and roof gardens.



Playground areas – remediation will not be required in the multi-use games area (MUGA) and other playground areas where the surface finish is not soft landscape such as natural grass. However, remediation will be required in any play areas with soil, mulch or other soft landscaping ground cover.

WS03 – specific watching brief required during excavation in this location for potential hydrocarbon contamination. Further testing, analysis and assessment may be required.

Verification plan

Detailed records will need to be maintained and remediation verification inspections will need to be undertaken (by an experienced contamination consultant) to ensure that suitable records and evidence are available for inclusion in the Remediation Verification Report. The verification report will form part of the Health and Safety File for the development and will need to include relevant details to ensure that the remedial measures are maintained during the site operation.

1 Introduction

1.1 Commission

Pell Frischmann have been commissioned by LS (Finchley Road) Limited ('the client') to prepare a land contamination Remediation Strategy (LCRS), for the proposed Finchley Road (O2 Masterplan Site) development. The proposed development comprises a mixed use residential and commercial development set within areas of landscaped public open space. The Finchley Road site (the *site*) lies between Finchley Road (east) and West End Lane (west), in the London Borough of Camden, and includes the O2 centre and associated car park, Homebase store, car showrooms and a Builder's Merchant, as shown in Figure 1.

Figure 1 Site location

Site location	
	
Ordnance Survey (OS) Open Mapping	Google Satellite Image
Site information	**Details**
Site area	5.75 hectares (Ha)
National Grid Reference (centre of the site) (NGR)	525650, 184730
Nearest postcode	NW3 6LU

This report is part of a wider engineering and environmental commission for the development and follows on for a preceding sequence of Land Contamination Risk Management reporting undertaken by Pell Frischmann, including the following:

- Land Contamination Desk Study and Preliminary Risk Assessment (March 2021) [site wide], and
- Land Contamination Generic Quantitative Risk Assessment (GQRA) (January 2022) [for part of the site].

The GQRA determined that *remediation would only be required in areas of proposed soft landscaping onsite* (i.e. across any parts of the site not covered by hardstanding, such as roads, buildings, paved paths etc), see Section 2.2).

1.2 Scope of work

When quantitative land contamination risk assessment (Generic - GQRA or Detailed - DQRA) identifies *unacceptable risks for one or more contaminant linkage/s then remediation or mitigation will be required.* The aims of this report are to summarise the 'remediation option appraisal' process and to describe the 'remediation strategy' for the proposed development.

- Remediation options appraisal includes setting remediation objectives and criteria and identifying a suitable remediation option that '*can be implemented in practice'*.
- The remediation strategy is a record '*of how you will meet and carry out the remediation objectives'* and includes a verification plan setting out compliance criteria and the records and 'lines of evidence' that need to be captured during or after remediation.

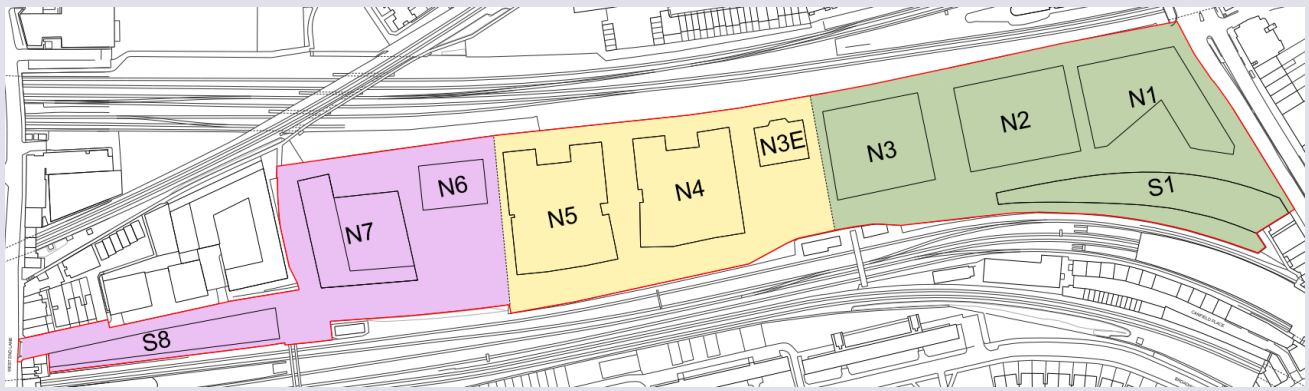
1.3 Proposed development overview

The proposed development comprises a mixed use residential and commercial development set within areas of landscaped public open space (including raised podium gardens, rooftop terraces, ground level soft landscaping and play areas), as summarised in Figure 2. The landscape design referenced in this report is taken from the '*Finchley Road O2 Stage 2+ Report*' (ref. 230-EAST-XX-ZZ-R-L-Stage 2+ Report) by the Landscape Architect (East Architecture Landscape Urban Design Ltd).

Figure 2 Proposed development summary (continued overleaf)

Proposed development

Lower ground floor plan (above), example building and podium cross sections (below)

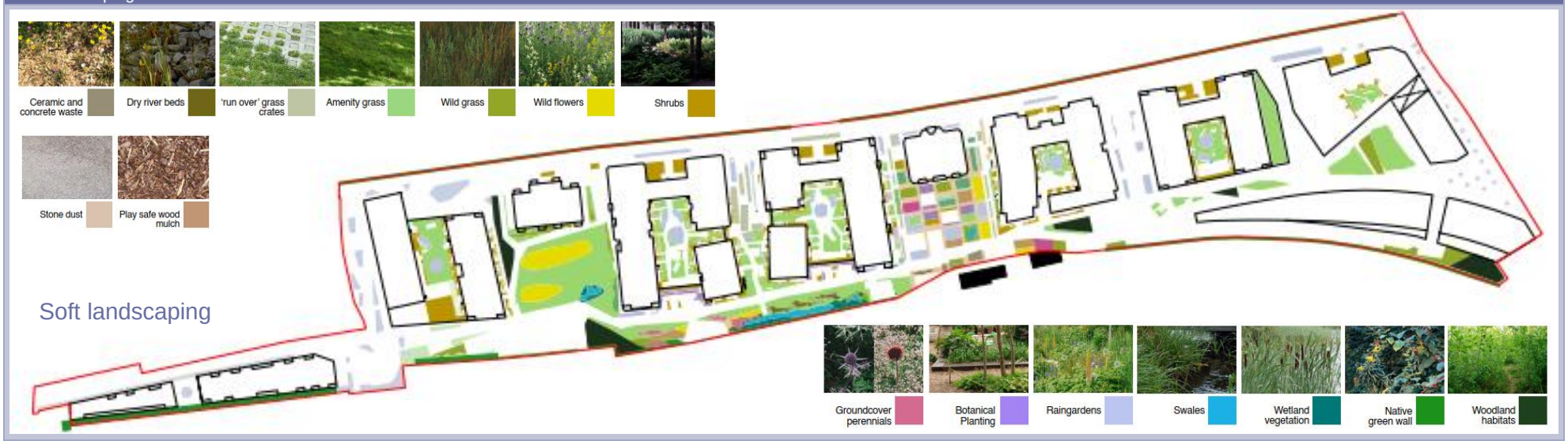


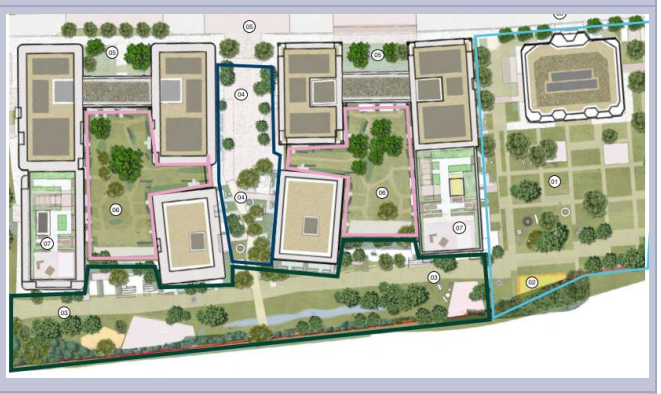
Development plots (for reference)

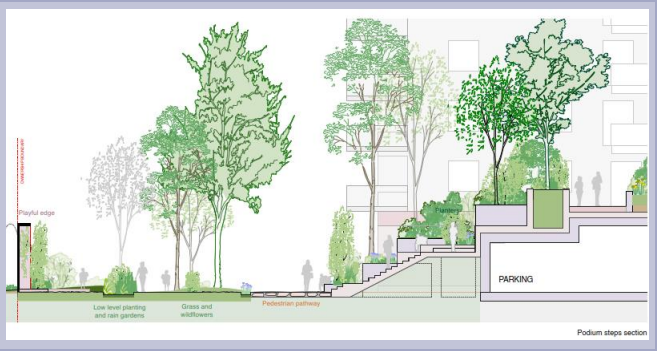
Proposed development summary (continued)

Lower ground floor plan (above), example building and podium cross sections (below)

Soft landscaping







2 Background

2.1 Land Contamination Risk Management

The Environment Agency 'Land Contamination Risk Management' guidance (LCRM, 2020) sets out the process that should be followed for managing the risk from land contamination, including within the planning regime. LCRM should be used to:

- *Identify and assess if there is an unacceptable risk*
- *Assess what remediation options are suitable to manage the risk*
- *Plan and carry out remediation*
- *Verify that remediation has worked*

LCRM includes three risk-based stages 'risk assessment', 'remediation options appraisal' and 'remediation and verification'. Figure 3 presents Pell Frischmann's simplified summary of the LCRM process.

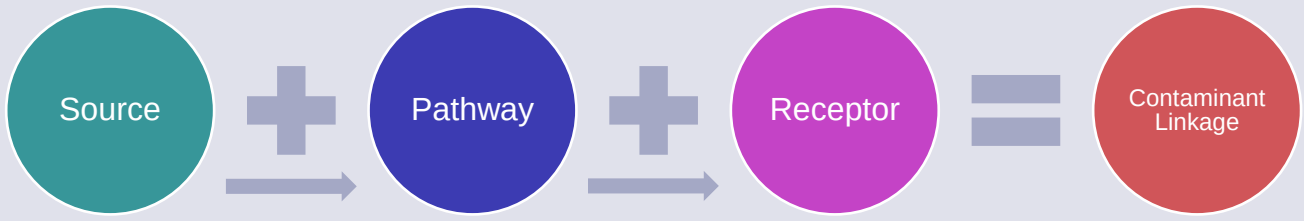
Figure 3 LCRM simplified summary

Risk based stages: Risk Assessment			Options appraisal	Remediation and verification	
Preliminary risk assessment	Site investigation scheme	Land contamination risk assessment	Remediation options appraisal	Remediation strategy & verification plan	Verification
LCDS & PRA	Quantitative risk assessment		LCROA	LCRS	LCRV
	SIS	LCRA	*[this report]*		
Desk study to identify sources of contamination and sensitive receptors. Preliminary Risk Assessment to identify potential S-P-R contamination linkages (CLs)	Investigate potential sources and receptors and provide data for quantitative risk assessment	Quantitative and qualitative risk assessment to assess risks for each CL to identify and assess if any CLs present unacceptable risks that require remediation	Identify remediation option to address unacceptable risks	Strategy: steps and measures required to implement remediation onsite. Verification plan: activities and records that must be kept during remediation	Record of all remediation activities as evidence that remediation has been successful

Conceptual Site Models (CSMs) are an integral part of land contamination risk management. CSMs collate contamination information for a site or proposed development, including a series of Contaminant Linkages (i.e. relationships between contaminants, pathways and receptors based on the source-pathway-receptor (S-P-R) approach summarised in Figure 4), together with interpretation, assumptions, hypotheses and recognition of gaps and uncertainties.

Figure 4 Contaminant Linkages (S-P-R)

Contaminant Linkage - Source-Pathway-Receptor relationships



Term	Definition
Source	A contaminant that is in, on or under the land and has the potential to cause harm or pollution
Pathway	A route by which a receptor is or could be affected by a contaminant
Receptor	Something that could be adversely affected by a contaminant for example a person, controlled waters, an organism, an ecosystem or Part 2A receptors such as buildings, crops or animals.
Contaminant linkages	The presence and S-P-R relationship between contaminants, pathways and receptors. *If any element is missing (i.e. no pathway or receptor) then the linkage is not complete and there is not a risk, even if a contaminant is present.*

CSMs are part of an iterative process and need updating throughout the land contamination risk management process for a site/proposed development. As stated in the LCRM guidance, the CSM should be used to "*inform the basis of your initial assessment and all future decisions as you progress through Land Contamination Risk Management"* (LCRM, 2020). During the risk assessment stage, the term '*potential* contaminant linkage' is used until the CLs have been confirmed/excluded. The term '*relevant* contaminant linkage' is used to describe linkages where quantitative risk assessment indicates that remediation is required to address unacceptable risks.

2.2 Land contamination risk management process to date.

Preliminary risk assessment (PRA): A site wide preliminary risk assessment for the development was presented in the Pell Frischmann *Land Contamination Desk Study (report ref.*1*04878-PEF-ZZ-XX-RP-GG-600002, March 2021)*. The report included a *preliminary* Conceptual Site Model (CSM) summarising *potential* 'source-pathway-receptor' Contaminant Linkages (CLs) for the proposed development along with uncertainties and recommendations for further investigation and assessment to address these uncertainties.

- Eight *potential* Contaminant Linkages (CLs) were identified and assigned a qualitative risk rating (based on the 'severity of the consequence and the 'probability or likelihood').
- All eight potential CLs were assigned '***moderate'*** risk ratings, as summarised in Table 1.
- Controlled water, ecological system and geologically sensitive receptors were not identified and therefore were excluded from the CSM.
- Generic quantitative risk assessments for human health and ground gas (including a scheme specific site investigation scheme) were recommended to investigate uncertainties and to test and refine the *potential* contaminant linkages identified by the PRA.

Generic Quantitative Risk Assessment (GQRA): An initial GQRA for *part of the site* was presented in the Pell Frischmann *Land Contamination Risk Assessment (LCRA, report ref. 104878-PEF-ZZ-XX-RP-GG-600003, January 2022)*. Quantitative risk assessment typically starts with generic quantitative risk assessment (GQRA), which uses site investigation data, generic assessment criteria and assumptions to assess **if** one or more of the *potential* contaminant linkages identified by the preliminary risk assessment could present unacceptable risk/s that need remediation. A scheme specific site investigation scheme (SIS) was designed and implemented in 2021 to provide data for GQRA. The scope of the SIS was limited to accessible parts of the site, with a follow-up site investigation scheme and supplemental GQRA planned for later in the project programme.

The results of the GQRA resulted in or indicated the following,

- the qualitative risk ratings for five out of the eight potential Contaminant Linkages were reduced from **moderate** to '**moderate/low**' or '**low'**, as summarised in Table 1.
- the ground gas risk assessment concluded that ground gas protection measures were not required.
- the overall risk rating for the proposed development reduced from moderate to moderate/low.

Moderate risk ratings remained for three linkages: CL101, CL201 and CL501.

- **CL501** relates to health and safety of site preparation and construction works for which the contractor will need to determine appropriate mitigation measures during construction.
- **CL101** and **CL201** were identified as '***relevant* contaminant linkages'** that were likely to require remediation (see Table 1) and are the subject of this Remediation Strategy.

Table 1 Contaminant linkages - risk assessment stage risk ratings

Qualitative Risk ratings							
LCRM	*Very high*	*High*	*Moderate*	*Moderate/Low*	*Low*	*Very low*	*No linkage*
PRA			8 CLs				
GQRA			3 CLs	2 CLs	1 CL	2 CLs	

2.3 Relevant contaminant linkages

The '*relevant* contaminant linkages' CL101 and CL102, identified by the GQRA, are summarised Table 2, and are the subject of this Remediation Strategy. The remediation options appraisal process for these CLs is described in Chapter 3.

Table 2 *Relevant* contamination linkages (GQRA - part 1)

CL	Source	Pathway	Receptor	GQRA risk rating	CL status
101	PAH compounds and lead within Made Ground onsite	Ingestion, inhalation and dermal contact associated with areas of ground-level soft landscaping only	Human health of end users	Moderate	***Relevant***
201	Asbestos in soils (within the Made Ground onsite)	Inhalation of liberated respirable fibres associated with areas of ground-level soft landscaping only	Human health of end users	Moderate	***Relevant***
Extracted from the GQRA report (2022)					

A copy of the 'GQRA stage CSM' from the GQRA report is included in Appendix B. In addition to the risk ranking updates, the GQRA stage CSM include refinements to the sources, pathway, receptor details and the comments sections (compared for the PRA stage CSM, reported in the land contamination desk study).

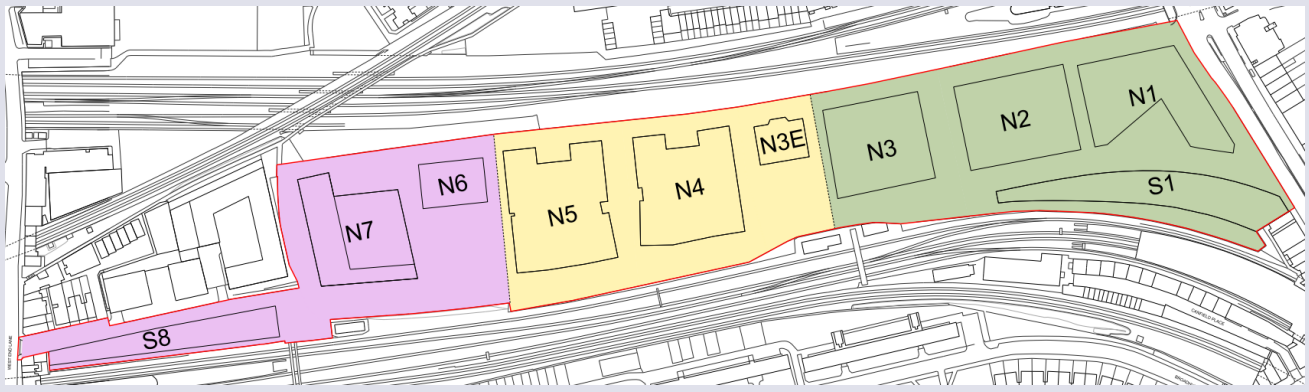
2.4 Planning application and proposed development

A hybrid planning application for the Finchley Road 'O2 masterplan' development was submitted to the local planning authority (LPA) in February 2022, and subsequently revised in September 2022. The planning application includes detailed and outline information depending on the development plot or groups of development plots (ten plots in total) as detailed below:

- **Detailed phases**: The first three Development Plots (N3E, N4 and N5), located in the centre of the site, were submitted in detail, and form the first phase - "Detailed Phases".
- **Outline phases west**: Development Plots S8, N7 and N6 located in the west of the site were submitted in Outline and form the Second Phase - "Outline Phases West".
- **Outline phases east**: Development Plots N3, N2, N1 and S1 located in the east of the Site were submitted in Outline and form the third Phase - "Outline Phases East".

Figure 5 Development plots

Development plots



Detailed planning details	Plots N3E, N4 and N5 (in the centre of the site)
Outline planning details	Plots N1, N2, N3 and S1 (in the east) and N6, N7 and N8 (in the west)

Any future Planning Conditions relating to land contamination (including Remediation Strategy requirements) will need to be reviewed and included in future issues of this report, where relevant.

3 Remediation options appraisal

3.1 Remediation areas

The GQRA determined that *remediation would only be required in areas of **proposed soft landscaping** onsite* (i.e. across any parts of the site not covered by hardstanding, such as roads, buildings, paved paths etc), due to viable exposure pathways.

The Preliminary Risk Assessment identified Made Ground onsite as a potential source of contamination. The GQRA process was able to refine and reduce the potential contamination risks to just three Contaminants of Concern (CoC) within the Made Ground:

- **CL101**: polyaromatic hydrocarbons and lead
- **CL201**: asbestos in soils (AiS)

The end-users and residents (human health receptors) would need to be in direct contact or proximity to the Made Ground for dermal contact, ingestion or inhalation pathways to exist. With respect to the specific CoC identified, hardstanding ground cover will effectively cap the Made Ground and break the pathways. Therefore, residual risks will be limited to areas where soil/Made Ground could remain at or near the final ground surface i.e., areas of proposed ground level landscaping.

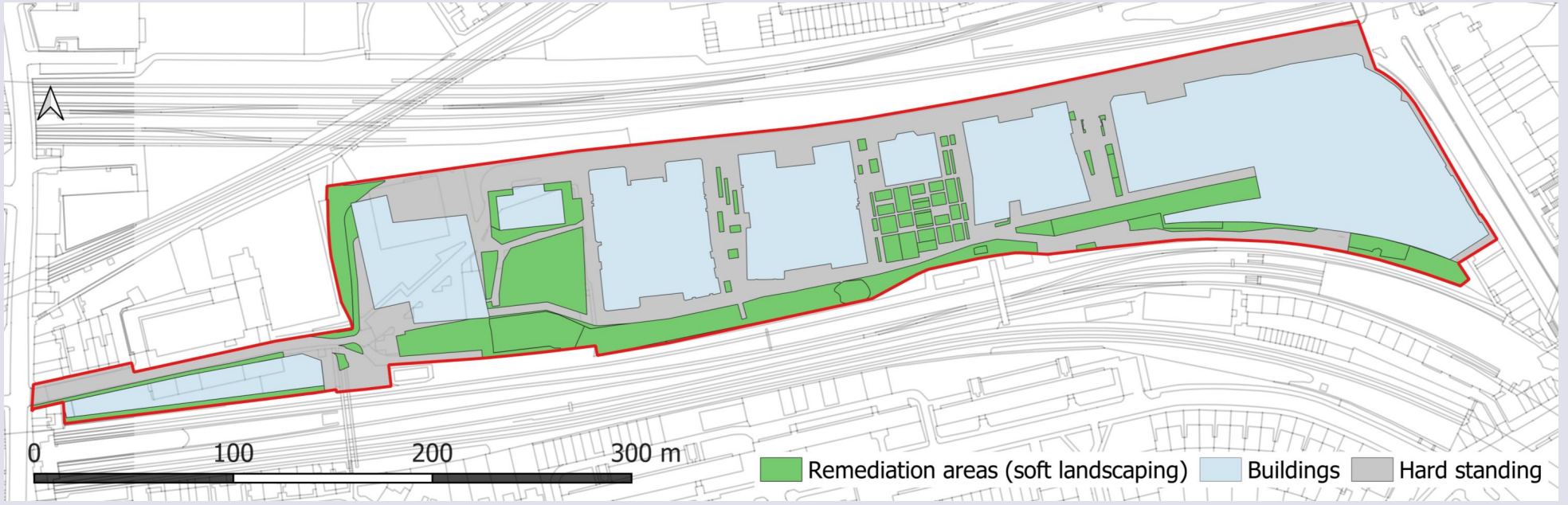
The proposed development has been divided into the following zones (see Figure 6 overleaf) to highlight the areas that require remediation:

- **Remediation areas**: areas of proposed ground level softcover/landscaping that will require remediation (green).
- **Hardstanding areas**: including building footprints (blue) and areas of ground level hardstanding (grey) including roads, footways, cycleways, vehicle loading bays/drop-off points.

If the development proposals change – these zones will need to be reviewed and updated where required.

Figure 6 Remediation Zones

Remediation zones



If the development proposals change, these zones will need to be reviewed and updated where required

3.2 Contaminants of concern

As introduced above, the GQRA process was able to refine and reduce the potential contamination risks to just three Contaminants of Concern (CoC) within the Made Ground:

- **CL101**: polyaromatic hydrocarbons and lead
- **CL201**: asbestos in soils (AiS)

Polyaromatic hydrocarbons (PAH) (CL101): Elevated concentrations of the PAH compounds benzo(b)fluoranthene (14.7mg/kg) and dibenzo(a,h)anthracene (1.41mg/kg) above POS_{resi} GACs (7.2mg/kg and 0.57mg/kg retrospectively) were identified in a single Made Ground sample (TP03 @0.75m bgl).

Lead (CL101): Elevated lead concentrations of 1,640mg/kg and 964mg/kg (above POS_{resi} GAC of 630mg/kg) were recorded in two Made Ground samples (TP02 @1.0mbgl and WS06 @1.0m bgl).

Access constraints limited the distribution and number of exploratory holes across the site that could be formed during the 2021 site investigation scheme (SIS). Therefore, the initial GQRA was based on a partial/limited number of soil samples. As a result, there were too few samples in each dataset:

- to enable statistical analysis to be used as part of the quantitative risk assessment, and
- to consider the likelihood that elevated PAH and lead concentrations could reside at other locations and depths within areas of proposed soft landscaping not yet investigated.

Asbestos in soils (CL201): Asbestos in soils, including brown (amosite) and while (chrysotile) asbestos, was detected in seven out of the 26 Made Ground soil samples analysed.

- A measurable concentration of amosite (brown) asbestos was recorded in WS03 @0.40mbgl (0.0072%).
- Asbestos concentrations were below detection limits (<0.001%) in the remaining six samples.

The Joint Industry Working Group (JIWG) 'Decision support tool' for the 'qualitative risk ranking of work activities and receptors involved in or exposed to asbestos in soils and construction & demolition materials' (JIWG & CL:AIRE, 2017) was used to qualitatively assess the potential risk to end-users of the development in areas of soft landscaping within the development. Recording a Medium risk if the existing soils were to remain near the surface where they could potentially 'be disturbed during non-construction/ routine use of land'. The JIWG tool was also used to evaluate appropriate remediation options. Providing a suitable thickness of clean cover soils (above the Made Ground) was shown to lower the risk ratings and offer suitable remediation.

It is considered that the asbestos in soils results warrant remediation, regardless of the limited PAH and lead datasets.

3.3 Remediation options appraisal

Potential remediation options for ground contamination within shallow Made Ground would typically comprise 'breaking' the contaminant linkage by either 'removing the source' of contamination or 'breaking the pathway/s'. The remediation options process also need to include identifying the best practicable means to remediate the site without compromising safety while promoting sustainable remediation solutions. On this basis the following remediation options were considered.

a) *Source removal* excavating and removing the full depth of Made Ground from across the areas of the proposed landscaped/soft cover would break both contaminant linkages (CL101 and CL201). However, this option would incur high costs and is not considered to offer a sustainable solution (including consideration of the waste hierarchy). Source removal would require substantial plant movements, followed by offsite transportation (carbon) and the resulting waste would take-up capacity at local waste facilities. The presence of asbestos in soils would also limit the potential for the resulting waste soil arisings to be treated and reused.

b) *Breaking the 'pathway'* by means of introducing a barrier or clean cover system between the Made Ground and the future end users would achieve the remediation objectives by ensuring that the landscaped areas will be 'suitable for use'. The existing landscape designs include the import and placement of a thickness of subsoil and topsoil therefore the introduction of the clean cover system is unlikely to substantially increase the volume of soil required. Option B would also avoid the need to excavate the existing Made Ground thus substantially reducing the quantities of waste soil arisings compared to Option A.

Overall, it is considered that a clean cover system will offer a cost effective and sustainable remediation option for the site. Undertaking the remediation in collaboration with the proposed landscaping scheme will also optimise resource efficiency and minimise waste. This option also demonstrates the benefits of considering and applying the waste hierarchy during the decision-making process.

3.4 Preferred remediation option

As introduced above, the placement of a clean cover systems across the soft-landscaped areas has been selected as the preferred Remediation Solution to break the contamination pathways for CL101 and CL102.

Remediation cover systems: Remediation cover systems are a well-established technique that are used routinely and offer good long-term solutions. The cover system can also be designed to complement the landscaping design for the development which will minimise additional costs and enable the works to be completed within the project programme.

Cover system type: cover systems can comprise (1) a suitable thickness of (imported) cover soils, or (2) a composite system including geotextiles and cover soils. The cover soils will need to meet 'suitable for use' criteria.

Composite cover system: Due to the presence of asbestos in soils (within the Made Ground), it is considered that a composite cover system should be used in the areas of soft landscaping. Laying a suitable geotextile at the base (directly over the Made Ground) of the cover system will prevent mixing (between the Made Ground and cover soils) and will also provide a visual and physical marker for future ground maintenance which will help to preserve the longevity of the cover system.

Details of the proposed composite cover system are provided in Chapter 4.

4 Remediation strategy

***Remediation strategy**: introduce a composite cover system across the soft-landscaped areas to break the contamination pathways for CL101 and CL201, including a geotextile base layer overlain by a suitable thickness of imported cover soils that are 'suitable for use'.*

4.1 Introduction

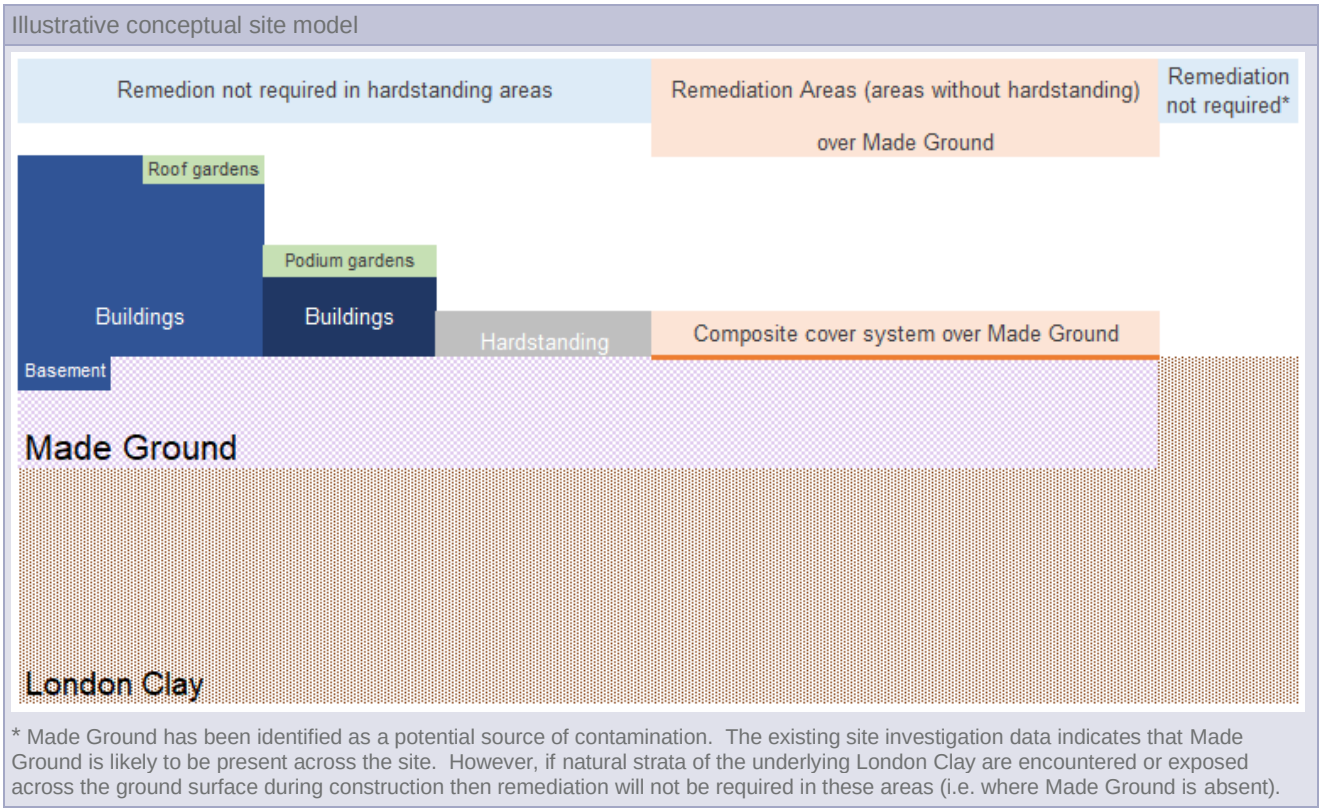
As described above, '**composite cover system'** has been selected as the preferred remediation option to mitigate residual contamination risks across the soft-landscaped areas across the Finchley Road development. This remediation strategy chapter:

- describes key information about the composite cover system that will need to be implemented onsite to achieve the remediation objectives; and
- includes a verification plan setting out compliance criteria and the records/'lines of evidence' that need to be captured during or after remediation and for subsequent inclusion in the remediation Verification Report.

4.2 Remediation strategy stage - conceptual site model (CSM)

A simple illustration of the land contamination remediation strategy (LCRS) stage conceptual site model (CSM) is provided in Figure 7 to summarise where remediation will and will not be required for the proposed development.

Figure 7 LCRS stage CSM



* Made Ground has been identified as a potential source of contamination. The existing site investigation data indicates that Made Ground is likely to be present across the site. However, if natural strata of the underlying London Clay are encountered or exposed across the ground surface during construction then remediation will not be required in these areas (i.e. where Made Ground is absent).

4.3 Composite cover system

The ***composite cover system*** will include two key elements:

1. A 'high visibility' geotextile base layer - laid over the existing Made Ground, and
2. The placement of a suitable thickness of clean cover soils over the geotextile.

4.4 Remediation areas

The GQRA determined that *remediation would only be required in areas of* ***proposed soft landscaping*** *onsite* (i.e. across any parts of the site not covered by hardstanding, such as roads, buildings, paved paths etc), due to viable exposure pathways. As introduced in Section 3.1, the proposed development has been divided into zones (see Figure 8) to highlight the areas that require remediation:

- **Remediation areas**: areas of proposed ground level softcover/landscaping that will require remediation.
- **Hardstanding areas**: including building footprints and areas of ground level hardstanding (including roads, footways, cycleways, vehicle loading bays/drop-off points).

4.5 Podiums and roof gardens

The development includes several 'above ground' areas of soft landscaping - podium landscaping and roof gardens. The podium landscaping areas are shown in Figure 8. Remediation (specifically the non-woven geotextile) will not be required in these areas (as they are underlain by hardstanding and not Made Ground).

However, imported soils for these areas will need to meet human health 'soil acceptability criteria' to ensure that the soils are 'suitable for use' (and cannot present a new land contamination risk). Therefore, evidence to confirm that the soil meets the soil acceptability criteria (specified in this remediation strategy) will need to be gathered and included in the remediation verification report.

Figure 8 Remediation areas and podium soil placement

4.6 Surface preparation

The surface of the Made Ground will need to be prepared to ensure that the geotextile base layer won't be damaged or punctured for example by sharp objects, metal fragments, angular stones including during deployment or as the cover soils are placed above. In localised areas it may be beneficial to prepare the ground surface with the placement of suitably fine/well graded site won soils to create a suitable surface for the geotextile.

4.7 Geotextile base layer

Geotextile base layer, a suitable non-woven geotextile will need to be placed over the prepared Made Ground surface to create the lower layer of the composite cover system**.** The main purpose of the geotextile is to prevent mixing between Made Ground and the overlying clean cover soils. The placed geotextile shall:

- Comprise a suitable non-woven geotextile,
- Be clearly identifiable to provide a visual deterrent and physical obstruction to future excavation (for example during future landscape maintenance works), and
- Inhibit root penetration and burrowing animals to prevent soil mixing.

Table 3 provided parameters for the non-woven geotextile which will need to be specified and selected by the contractor, it is anticipated that 'Terram Hi-Vis'/or similar will be suitable. Note: the geotextile will need to be permeable to allow for pluvial infiltration. The selected geotextile will need to be laid into the earthworks in accordance with the supplier's installation guidelines appropriate for the deployment scenario. The contractor shall keep detailed records including product datasheets, delivery tickets, deployment location details (including plan and elevations) and photos of all the geotextile laid.

Table 3 Non-woven geotextile parameters

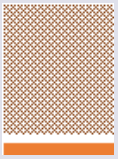
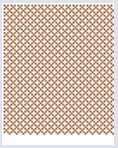
Property	Unit	Value	Test Method
Mass per unit area	g/m^2	>120	BS EN 965
Tensile strength at peak	kN/m	>7.5	EN ISO 10319
Tensile elongation at max. load	%	28	EN ISO 10319
Trapezoidal tear resistance	N	>275	ASTM D4533
Pore Size - Mean AOS O_{90}	Mm	130-160	EN ISO 12956
Permeability @ 5cm head	l/m^2s	80-110	EN ISO 11058

The presence, location and purpose of the geotextile will need to be communicated to future maintenance and groundwork contractors to reduce the likelihood of accidental damage in the event of future excavation to greater depths.

4.8 Cover soils - thickness

A suitable thickness of clean cover soils will need to be placed above the geotextile base layer as part of the composite cover system. The required thickness depends on key factors including breaking the contaminant pathway/s, the likely depth of future soil mixing, and protecting the underlying geotextile. Table 4 summarises the specified cover soil thickness for the site.

Table 4 Cover soil thicknesses

Areas	Soft landscaping areas		Swale and rain gardens only		Podiums and roof gardens	
Cover soil thickness	0.6m (600mm)		0.45m (450mm)		n/a (depth to be determined by landscape requirements)	

The use of a composite cover system means that 'breaking the pathways' is not solely reliant on the thickness of cover soils. The geotextile base layer will prevent direct contact, mitigate dust generation and prevent natural soil mixing between the underlying Made Ground and the overlying cover soils. Therefore, preventing man-made soil mixing and protecting the underlying geotextile become the driving factors.

- Reference to the landscape design indicates that the landscaping soil depths across most of the development will total at least 600mm (topsoil+subsoil). It is considered that soil cover of 600mm will protect the underlying geotextile and therefore mitigate man-made soil mixing associated with the proposed planting and general use.
- The landscaping design indicates that the soil thickness around the proposed swale and rain gardens will total 400mm (topsoil+subsoil). It is considered that a soil thickness of 450mm combined with the underlying geotextile will provide suitable for remediation for these localised areas. Therefore, the landscaping soil design will need to be amended to increase the soil thickness in this area.

Where the landscape design requires a total soil thickness greater than 600mm (for example around tree pits) the landscaping design and site teams will need to ensure that the geotextile is either placed at the 'deeper' Made Ground/Imported soil interface or at 600mm below the final soil surface to maintain a continuous presence of the composite cover system across the remediation area. Detailed records will need to be maintained to inform the remediation Verification Report.

4.8.1 Landscape design information

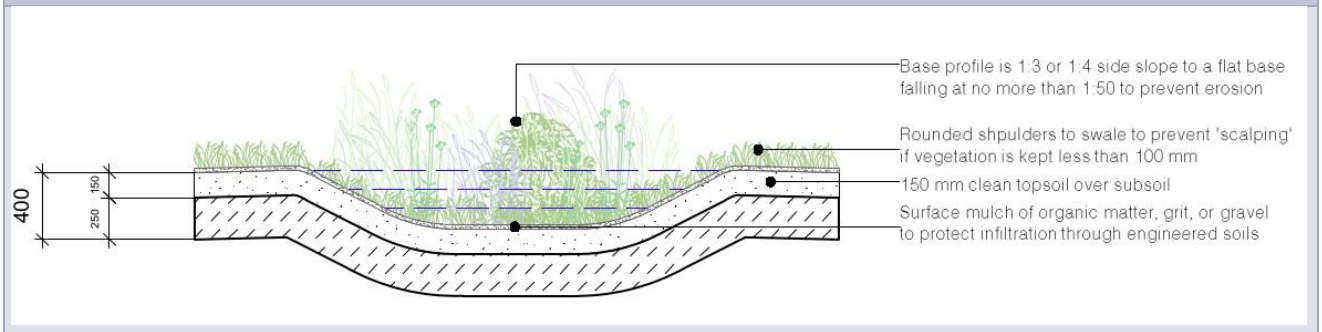
The landscaping design details referenced in the report are based on drawing '*Detailed soft landscape sections and tree pits'* (ref. 230-FL-L-10-100) by the Landscape Architect (East Architecture Landscape Urban Design Ltd). A copy of the drawing is included in Appendix C and extracts from the drawing are shown in Figure 9. The landscaping design can be broadly subdivided into four groups as described below:

- **Soft landscape:** Areas of soft landscaping (including turf/grass areas), with 850mm thick build-up to include clean topsoil, subsoil and substrate layers over a drainage and protection mat.
- **Swale and rain garden**: The swales, wetlands and basin areas only include 400mm of soil (150mm topsoil over 250mm subsoil). *It is recommended that the soil depth is increased in these areas*.
- **Shrub plantings:** Areas of shrubs are proposed to have 690mm thick build-up to include clean topsoil, subsoil and substrate over a drainage layer.
- **Tree pits:** Unlike the other areas there is no overarching design for tree pits, and the depth and formation of these vary significantly depending on whether the tree is situated within areas of; soft standing; rain gardens; raised mounds; hardstanding or surrounded by paving slabs.

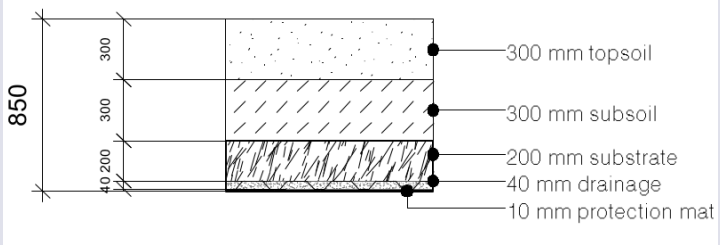
The landscape team will need to review and amend the landscape designs to ensure that the remediation requirements are incorporated into the landscape design and site works across the site. In some areas minor variations to the remediation design may be acceptable e.g. the use of gravel break layers in place of a non-woven geotextile, however any changes will need to be agreed with the remediation design team.

Figure 9 Landscaping sections and tree pits

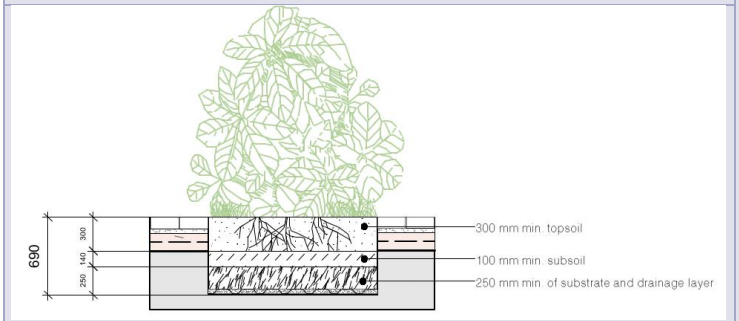
Landscaping sections and Tree pits



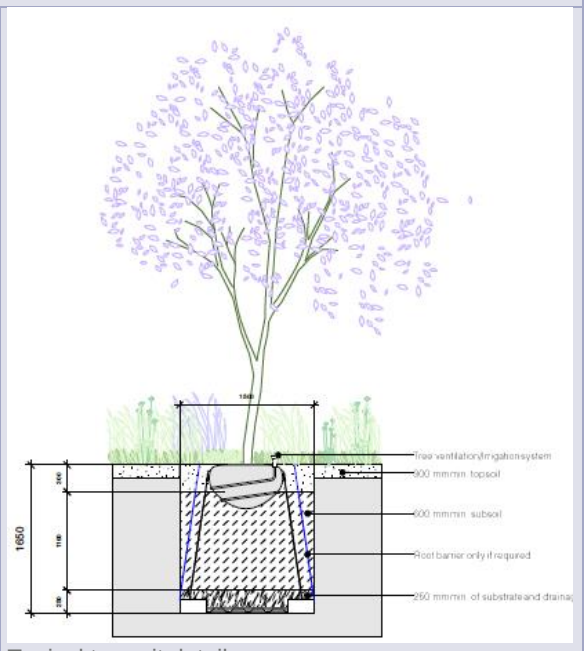
Typical swale and rain garden build-up allowance



Typical soft landscape build-up allowance



Typical shrub planting build-up



Typical tree pit detail

4.9 Cover soils - suitability (import and geochemical thresholds)

Clean cover soils (including topsoil and subsoil) that are **geochemically 'suitable for use'** will need to be sourced, imported and placed within the soft landscaped 'remediation areas' as part of the composite cover system. Soils will also need to be sourced, imported and placed within podium landscaping/planters (though not as part of land contamination remediation).

The geochemical suitability requirements for the imported cover soils including soil acceptability criteria (SAC) are detailed in the Pell Frischmann *Remediation Strategy: Cover soils* datasheet (4602_001-PEF-XXX-XXX-RP-GG-600005) in Appendix A. The soil acceptability criteria represent maximum geochemical threshold concentrations that shall not be exceeded within the imported cover soils used in remediation area and for podium landscaping.

The cover soils datasheet also includes a soil import flow chart, which includes key decision gateways relating to the supply, inspection and acceptability of the imported soil. This information has been produced as a separate datasheet/guide for ease of reference during construction.

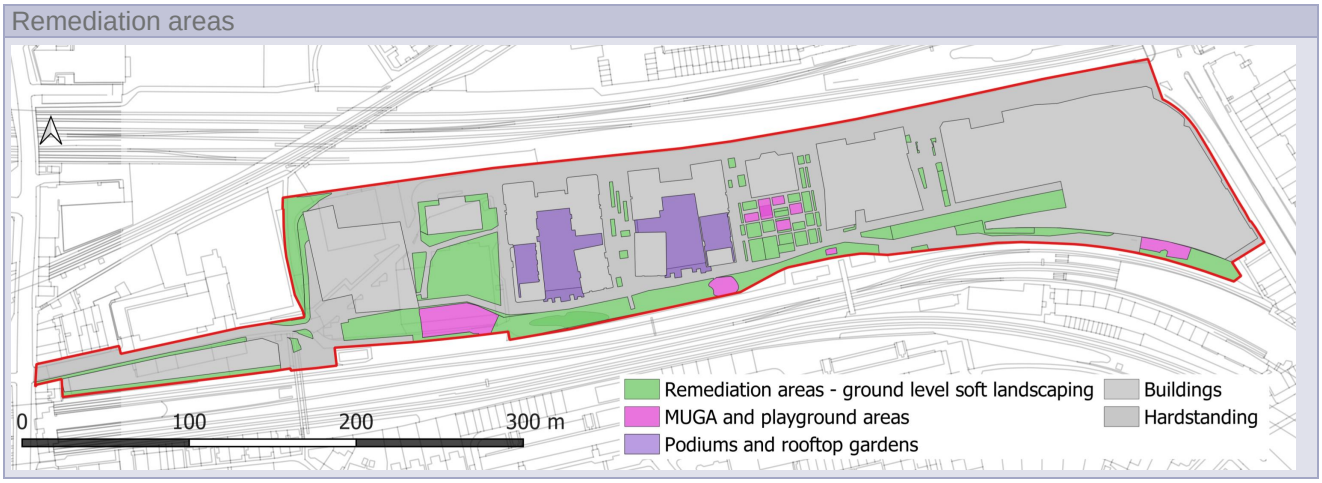
The imported soils and the process of importing soil will need to comply with all relevant legislation. This remediation strategy has been prepared on the basis that soil will be sourced from a recognised topsoil/soil provider as part of a direct purchase arrangement. *However, if the soil is sourced by any other means, for example from another development/construction site or soil recycling facilities then additional procedures will need to be implemented to ensure compliance with 'End of Waste' (EoW) procedures; such as "*The Definition of Waste: Development Industry Code of Practice*, (CL:AIRE, 2011)" and the use of a Materials Management Plan (MMP). Note MMPs must be in place prior to the movement or transfer soils)*

4.10 Playground areas

The need for remediation in playground areas will depend on the type of proposed surfacing. Remediation will not be required in the multi-use games area (MUGA) and other playground areas with surface finish such as hardstanding, macadam, wet pour, polymeric rubber, or synthetic grass, as these surfaces will break the contaminant pathway/s. If any of the playground areas are to have soft finishing such as soil, mulch or natural grass, then remediation comprising the composite cover system will be required.

The known MUGA and Playground areas are shown in pink in Figure 10

Figure 10 MUGA and playground areas



4.11 Site preparation and construction stage contaminant linkage

The contractor responsible for site preparation, construction and remediation (including the landscape team) will need to consider health and safety with respect to any contamination present onsite including for example any personal protective equipment (PPE) that may be required. Therefore, the following observations are provided for information only.

Table 5 summarises key potential contaminant linkages that were identified as part of the preliminary risk assessment and GQRA with respect to the health and safety of site preparation and construction workers.

Table 5 Site preparation and construction workers

CL	Source	Pathway	Receptor
401	Contaminants within Made Ground or ground contamination onsite	Ingestion, inhalation and dermal contact	Health and safety (H&S) of site preparation and construction workers
501	Asbestos containing soils (ACSs)	Inhalation of liberated respirable fibres	H&S of site preparation and construction workers

CL401: There are no published GACs for construction workers. The ground investigation reported a variable thickness of Made Ground onsite ranging between 0.70m and 2.95m bgl, with an average thickness of 1.87m. A single occurrence of faint hydrocarbon odour was identified in one location within the Made Ground, however visual or olfactory evidence of obvious ground contamination was not identified, and the laboratory testing recorded generally low or only moderately elevated concentrations of TPH and PAHs. More notable concentrations of PAH and Lead were identified in three of 29 samples. Potential ground contamination risks to construction and site maintenance workers associated with these types of contaminants can typically be mitigated by the adoption of suitable working methods, utilising appropriate personal protective equipment (PPE) and maintaining good hygiene.

CL501: Amosite and chrysotile asbestos was respectively identified in 5 of 23 and 2 of 23 samples of Made Ground at concentrations ranging from <0.001% to 0.0072%. Visible ACM was not identified. While it is not known if asbestos is present in other locations between the existing sample locations, 30% of the Made Ground samples identified asbestos presence. Preliminary reference to the JIWG Work Categories tools indicates that respiratory protective equipment (FFP3 disposable masks) and manual/localised dust suppression and localised and basic personal decontamination facilities may be required based on non-licenced work.

4.12 Unexpected contamination

Should any previously unidentified contamination (by visual or olfactory means) be encountered during development, then appropriate actions will need to be implemented to ensure that additional remediation actions can be taken (if required). The Contractor will be responsible for ensuring that suitable 'unexpected contamination' procedures are in place. An initial *Remediation Strategy: 'Unexpected Contamination – Preliminary Guide'* datasheet (4602_001-PEF-XXX-XXX-RP-GG-600006) is included in Appendix A, which includes key considerations and a decision tree (flow chart).

Watching Brief: A specific watching brief is required during works in the vicinity of exploratory hole location WS03, to consider and identify potential hydrocarbon-impacted soils and/or organic material in line with the Local Planning Authority site specific requirements. This is due to the site investigation (2021) recording a faint hydrocarbon odour in WS03 within a layer of Made Ground described as *'Soft dark grey slightly gravelly silt CLAY. Gravel is fine to medium subrounded to subangular brick and flint'*. This layer of Made Ground was red between 0.9 and 1.3mbgl.

It is recommended that the geoenvironmental consultant is present during the watching brief in this area as, if potential contamination or organic materials are encountered, then these materials will need to be sampled, analysed and assessed to determine if contamination is present, in addition the Local Authority Environmental Health team will need to be informed if contamination is encountered in this area.

Depending on the findings of the assessment, the ground gas risk assessment and/or remediation strategy may need to be revised and updated. It is recommended localised excavation is undertaken in this area (with the watching brief) as early in the construction process as possible to determine if further actions are required or not (and to avoid delays should amendments be required to the remediation strategy).

5 Verification plan

5.1 Introduction

The remediation activities described above will need to be verified and reported to demonstrate that the remediation strategy has been fully implemented and to provide a permanent record of the remediation works undertaken onsite.

The verification report will form part of the Health and Safety File for the development and will also need to include relevant details to ensure that the remedial measures are maintained during the site operation. The report should also describe any key details that would be relevant to the redevelopment of the soft landscaping should this be proposed in the future.

5.2 Record keeping

It is essential that the contractor collates and maintains accurate records of the remediation onsite for inclusion in the verification report. A list of the required records is summarised in the verification report section below (note this list is not exhaustive).

5.3 Verification inspections and sampling

Remediation verification inspections will need to be undertaken by a suitably experienced land contamination consultant during the remediation works. The following verification activities will need to be undertaken and recorded:

- Attendance during watching brief in area surrounding WS03. Potential sampling, analysis and assessment of soils if further contamination is encountered.
- Inspection and sampling, analysis and assessment of soils (against the soil acceptability criteria) to confirm geochemical suitability of the cover soils.
- Inspection and mapping of geotextile to confirm presence and correct placement.
- Inspection of placed cover soils to confirm depth/thickness (based on inspection pits, with photographs showing a scaled marker indicating that the necessary thickness has been achieved).

5.4 Verification reporting

A remediation verification report will need to be prepared once remediation is complete. The Verification Report will need to include:

Watching brief / unexpected contamination:

- Evidence that a watching brief was undertaken during excavation in the area of WS03.
- Details of any sampling, analysis and assessment of soils if unexpected contamination is encountered.
- Records of any further works required in this area should additional remediation be required.

Non-woven high visibility geotextile:

- Manufacturer's supply records including product information datasheets, technical specification details and available manufactures testing records.
- Delivery tickets (dates and quantities).
- Material deployment records, including a plan and photographs showing the location and installation of the geotextile.
- Records of any deviations/defects and the actions/measures undertake to rectify these issues.

(Continued overleaf)

Imported soils

- Pre-import geochemical analyses and approval documentation for all identified sources of imported topsoil and subsoil materials.
- Supplier details including company name and address and source site name and address.
- Delivery notes for all imported soils including dates and quantities (and confirmation of source site).
- Copy of the Materials Management Plan (if used).
- Site records recording the location where soil has been deployed over time (if multiplier suppliers are use the location of soil placement will need to be recorded for each supplier)
- Verification sampling and inspection plans, photos and records including
    - cover soil thickness confirmation (at each location)
    - soil sample dates, locations and depths
    - Geochemical laboratory analysis results
- Assessment of the soil sample geochemical results against the Soil Acceptability Criteria
- Records of any deviations/soil quality failures and the corrective actions taken.
- Where applicable, waste transfer note/consignment notes for excavated arisings sent offsite.

Additional records

- Summary of remedial work undertaken including details of any variations to the remediation strategy.
- Copies of all appropriate correspondence including regulators agreements.
- Details of unexpected contamination encountered, including plan showing locations and depths and records of the actions taken.
- Any additional records to demonstrate/verify that the remedial works have been undertaken in accordance with the remediation strategy.

Appendix A Remediation strategy plans and datasheets

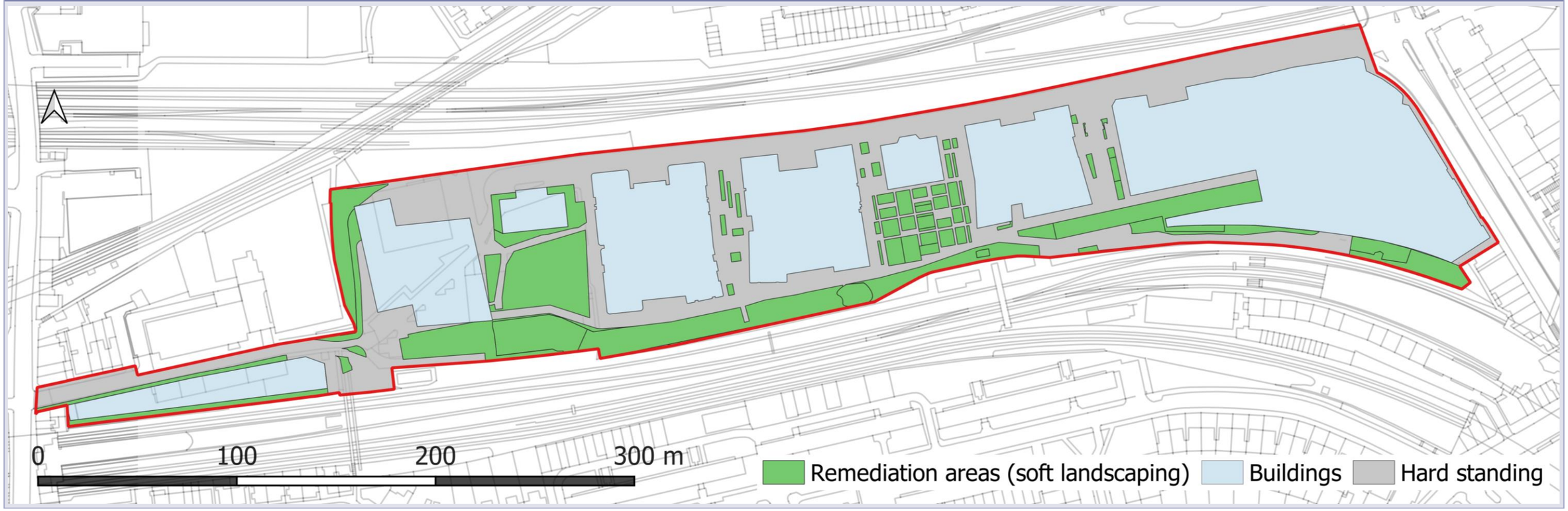
Including:

Remediation Strategy: Cover soils (import and soil acceptability criteria)

Remediation Strategy: Unexpected contamination – preliminary guide

Remediation figures

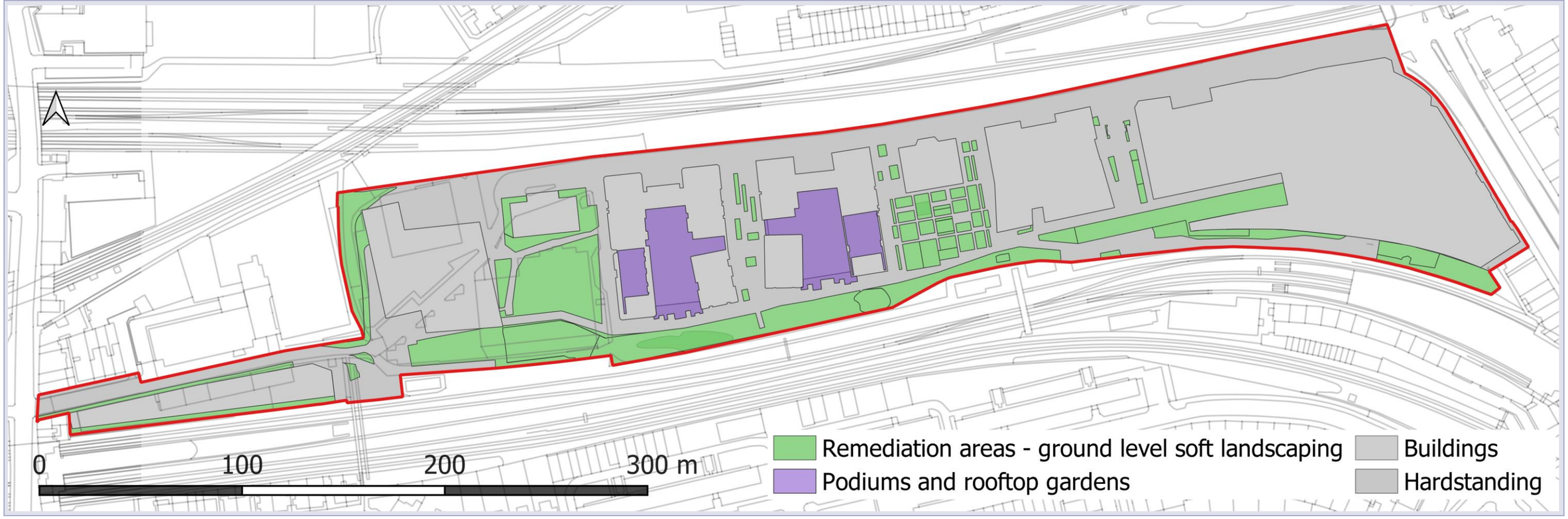
Remediation zones



Remediation zones - if the development proposals change these zones will need to be reviewed and updated

Remediation figures

Imported soil - placement areas

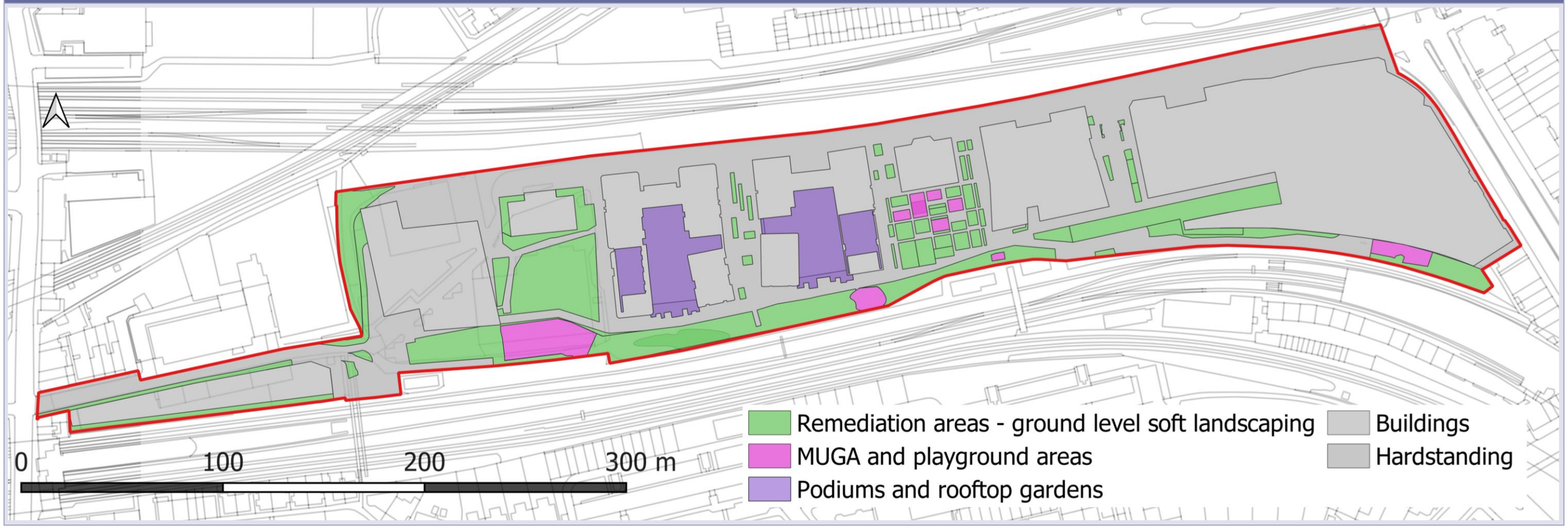


Cover soil thicknesses

Areas	Soft landscaping areas		Swale and rain gardens only		Podiums and roof gardens	
Cover soil thickness	0.6m (600mm)		0.45m (450mm)		n/a (depth to be determined by landscape requirements)	

Remediation figures

Remediation areas, MUGA, play spaces (and podiums)



Appendix B GQRA stage Conceptual site model

GQRA (January 2022) – Part 1 Conceptual site model and qualitative risk ratings

CL Ref.	Source/s	Pathway/s	Receptor/s	Probability	Consequence	Risk rating	Comments
101	Contaminants within Made Ground onsite	Ingestion, inhalation and dermal contact	Human health of end users	Likely to low likelihood	Medium	Moderate	The site investigation was spatially confined by current site use, so is not considered sufficient to cover the entire proposed development. A variable thickness of Made Ground onsite ranging between 0.70m and 2.95m bgl, with an average thickness of 1.87m. Elevated concentrations of lead and polycyclic aromatic hydrocarbon (PAH) compounds have been locally identified onsite, however, GAC exceedances were not widespread. Viable exposure pathways have been identified in areas of proposed ground level soft landscaping but have not been identified in areas of proposed hardstanding (including below buildings and roads) On this basis, lead and PAH compounds have been identified as residual CoC in areas of proposed ground level soft landscaping. These CoC will require further consideration. **Recommend**: further SI works, and soil testing is needed to assess the whole development, particularly regarding areas of proposed soft landscaping. Following this, the GQRA should be updated to account for further data (including the use of statistical analysis) prior to the LCRM process progressing to remediation options appraisal and a Remediation Strategy if needed. A watching brief during any prior construction activities is also recommended in case unexpected contamination is encountered during site clearance and construction.
201	Asbestos containing soils (ACSs)	Inhalation of liberated respirable fibres	Human health of end users	Likely	Medium	Moderate	Soil samples screened for 'Asbestos in soils' identified the asbestos detections within 7 of the 23 Made Ground samples. Amosite (brown) asbestos was identified in 5 samples and chrysotile (white) asbestos was identified in 2 samples. Quantification analysis indicated concentrations of <0.001% for 6 of the 7 positive asbestos identifications. A single sample (WS03 @ 0.40m bgl) had a quantification of 0.0072% for amosite. The results indicate that asbestos (while at low concentrations and with no visible ACM identified) is present within approximately 30% of the Made Ground samples. While it is not known if asbestos is present in other locations between the existing sample locations, given that laboratory testing identified asbestos within 30% of the Made Ground samples, its presence more widely in other locations across the site cannot be discounted. While the presence of hardstanding will break viable exposure pathways, viable pathways could exist within areas of ground-level soft landscaping. Therefore, asbestos in soils has been identified as a potential CoC with respect to ground level soft-landscaped areas. This risk assessment considers soils risks only and does not cover risks from fugitive dust during demolition or construction of existing buildings or structures. **Recommend:** While further investigation may provide improved resolution, it is likely that the LCRM process will need to progress to remediation options appraisal and a Remediation Strategy for areas of proposed soft landscaping. Contractors will need to determine appropriate H&S measures including reference to Control of Asbestos Regulations (CAR 2012) and CAR-SOIL guidance.
301	Ground gas associated with historic waste activities on site (localised parts of the site)	Inhalation of indoor air	Human health of end users	Unlikely	Mild	Very low	While Made Ground was identified across the site the nature and generally limited thickness of this material does not indicate a likely ground gas source. No evidence of landfill material was recorded within any locations across the site and the existence of infilled ground or buried waste at the site was not identified. Negligible concentrations of methane were detected during the ground gas monitoring to-date and limited carbon dioxide concentrations were recorded. The ground gas risk assessment suggests ground gas conditions indicative of BS8485 Characteristic Situation 1 (CS1) conditions, whereby no special gas protection measures are considered necessary. **Recommend**: Based on the ground conditions and gas monitoring information no further action proposed.
302		Migration and accumulation	Building and structures	Unlikely	Mild	Very low	
401	*Contaminants within Made Ground onsite*	*Ingestion, inhalation and dermal contact*	*Health and safety (H&S) of site preparation and construction workers*	*Low likelihood*	*Medium*	*Moderate / low*	See pCL101 comments. Variable concentrations of PAH, TPH and lead have been identified within the Made Ground at the site. Potential ground contamination risks to construction and site maintenance workers associated with these types of contaminants can typically be mitigated by the adoption of suitable working methods, utilising appropriate personal protective equipment (PPE) and maintaining good hygiene. The final measures will need to be determined and implemented by the contractor during construction as part of the health and safety plan. **Recommend**: contractors to consider nature of Made Ground as part of their H&S procedures.
501	*Asbestos containing soils (ACSs)*	*Inhalation of liberated respirable fibres*	*H&S of site preparation and construction workers*	*Likely*	*Medium*	*Moderate*	See pCL201 comments. With respect to the health and safety of site preparation and construction workers, preliminary reference to the JIWG Work Categories tools indicates that respiratory protective equipment (FFP3 disposable masks) and manual/localised dust suppression and localised and basic personal decontamination facilities may be required based on non-licenced work. **Recommend**: contractor to undertake and prepare appropriate risk assessments and method statements (including reference to the Control of Asbestos (CAR) regulations and CAR-soil guidance).
502			*H&S of neighbouring users (dust migration) during demolition/ construction*	*Low likelihood*	*Medium*	*Moderate / low*	
601	*Ground gas associated with historic waste activities on site (localised parts of the site)*	*Inhalation of outdoor air within trenches /excavations*	*Health and safety (H&S) of site preparation and construction workers*	*Unlikely*	*Medium*	*Very low*	See pCL301 comments.
701	Hydrocarbon contamination within Made Ground	Migration through water supply pipes (depending on material type) into potable water.	Health of end-users following consumption of potable water	A thickness of Made Ground is present onsite, TPH concentrations were encountered within the Made Ground, with a maximum concentration (EC10-EC21) of 170mg/kg and (EC21-EC40) of 619mg/kg. Due to the presence of these PE water supply pipes are unlikely to be suitable for the development and barrier pipes should be considered. Pipe selection should be determined in line with Thames Water new mains and connections processes and guidance **Recommend**: consult with Thames Water			

Note: while most asbestos containing materials (ACMs are legally required to be removed from buildings before demolition, some ACMs may remain. Residual ACMs (or unrecorded ACMs) that remain in-situ during demolition may increase the risk of future asbestos is soil e.g. from future stockpile placement and re-use of demolition arisings onsite.

Risk matrix

Risk = probability x consequence		Consequence			
		Severe	Medium	Mild	Minor
Probability	High likelihood	Very high	High	Moderate	Moderate/ low
	Likely	High	Moderate	Moderate/ low	Low
	Low likelihood	Moderate	Moderate/ low	Low	Very low
	Unlikely	Moderate/ low	Low	Very low	Very low
	No linkage	Without a linkage, there is not a risk – even if a contaminant is present (LCRM 2020)			

Based on the CIRIA good practice guide (C552, 2001).

Appendix C Detailed soft landscape sections and tree pits