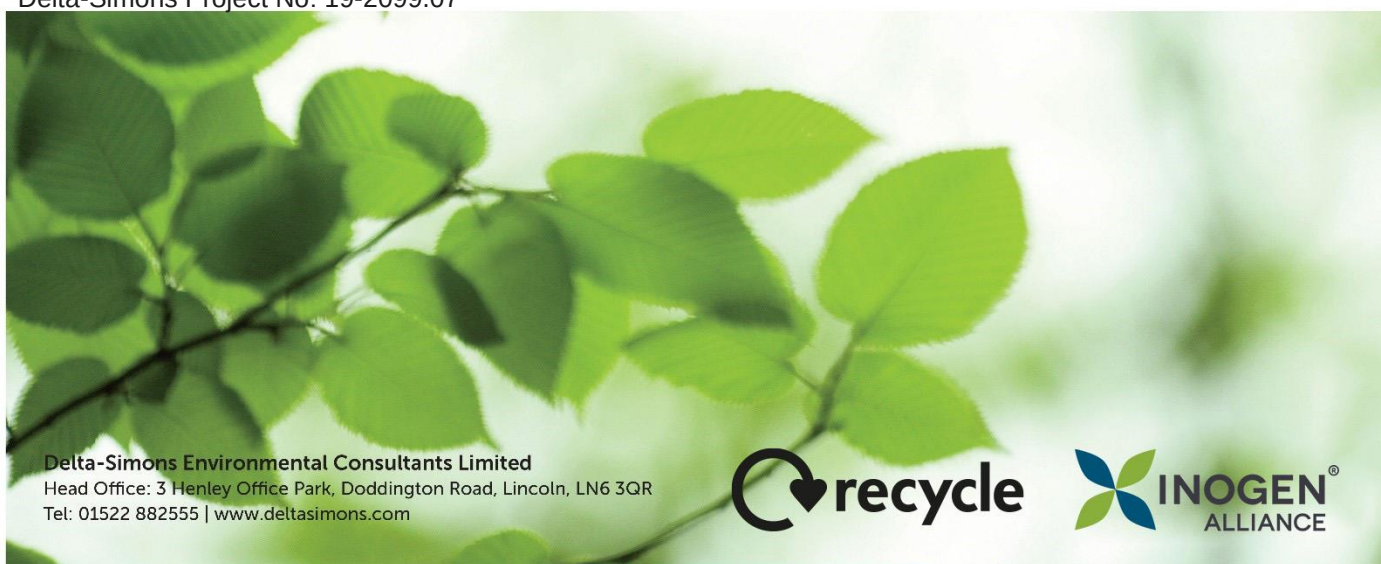




Remediation Options Appraisal & Verification Strategy
Former Brockhampton West Landfill, North of Harts Farm Way, Havant
Presented to: Clowes Developments (UK) Ltd

Issued: November 2021

Delta-Simons Project No: 19-2099.07



Delta-Simons Environmental Consultants Limited
Head Office: 3 Henley Office Park, Doddington Road, Lincoln, LN6 3QR
Tel: 01522 882555 | www.deltasimons.com



Report Details

Client	Clowes Developments (UK) Ltd
Report Title	Remediation Options Appraisal & Verification Strategy
Site Address	Former Brockhampton West Landfill, North of Harts Farm Way, Havant, PO9 1HS
Project No.	19-2099.07
Delta-Simons Contact	David Jackson (david.jackson@deltasimons.com)

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				Liane Baiao Senior Consultant	Sabine Sargeant Principal	Richard Lawless Unit Director

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As part of Lucion Services, our combined team of 500 in the UK has a range of specialist skill sets in over 50 environmental consultancy specialisms including asbestos, hazardous materials, ecology, air and water services, geo-environmental and sustainability amongst others.



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Executive Summary

Brief	Delta-Simons Environmental Consultants Limited (“Delta-Simons”) was instructed by Clowes Developments (UK) Ltd (the “Client”) to undertake the preparation of a Remediation and Verification Strategy (RVS) for the former Brockhampton West Landfill, North of Harts Farm Way, Havant, PO9 1HS (the “Site”). The Site is registered for outline Planning Permission reference APP/21/00189 and is to be developed for commercial purposes (logistics warehousing)
Site Setting	The Site is currently an undeveloped parcel of grassland that was previously part of a wider landfill Site with limited areas of hardstanding in the centre, previously used as a vehicle turning circle.
Ground Conditions	The typical ground conditions comprise topsoil overlying a variable thickness of re-engineered cover system, underlain by landfill waste, River Terrace Deposits and the Lewes Nodular Chalk Formation. Monitoring data suggests that the groundwater is tidally influenced and there are likely two groundwater bodies present beneath the Site, within the landfill waste and the Chalk. The data indicates groundwater flows generally south toward Langstone Harbour and in the east of the Site in an easterly direction towards the Hermitage Stream.
Land Contamination Assessment	<u>Human Health</u> Asbestos was detected locally within the re-engineered cover system and landfill waste. The main exposure pathway is inhalation and therefore, the potential health risks to future site users from impacted soils can be mitigated via the presence of buildings and hardstanding, which will satisfactorily address direct contact exposure pathways. Where areas of soft landscaping are proposed, the contaminant linkage can be broken by the installation of a clean cover system (existing soils/imported soils subject to appropriate further testing). <u>Controlled Waters</u> Slightly elevated ammonium concentrations have been detected at low tide in the Hermitage Stream on both monitoring occasions, but at concentrations below the relevant Environmental Quality Standard. There is no evidence that the Site is having an unacceptable impact to the quality of the Hermitage Stream as it flows through the Site based upon the monitoring/modelling data obtained to date. Risks of contaminants migrating to the south through the further landfill materials to the Harbour and causing significant harm have been discounted. The proposed development is considered to result in overall betterment in terms of the risks posed to surface and groundwater receptors (and thus Langstone Harbour) due to the reduced infiltration rates (and consequentially lower leachate generation rates) from building footprints and increased hardstanding provision compared to the present situation. The degree of this betterment (via reduction in contaminant load on the stream) has also been modelled and demonstrated. <u>Built Environment</u> Design Sulphate Class DS-3 and ACEC Class AC-3 for soils and groundwater, is considered the most appropriate type of concrete to be used at the Site in order to resist chemical attack from elevated sulphate present in the soils (assuming mobile groundwater in potentially pyritic soils). However, the groundwater data suggests that the concentrations of ammonium (predominantly the perched groundwater within the landfill waste and River Terrace Deposits) present ‘highly aggressive’ conditions with regard to buried concrete and the guidance suggests that specialist advice should be sought in this instance.

	<u>Ground Gas</u> Monitoring of hazardous ground gases indicates elevated concentrations of both methane and carbon dioxide to be present on a Site-wide basis whilst gas flow rates are considered to be low. Based on the data obtained to date, there is considered to be a plausible risk from hazardous ground gases on the Site; therefore, protection measures will be required as part of the proposed development to adequately mitigate such risks to future Site users. It is considered prudent to adopt gas protection measures in line with Characterisation Situation (CS3) as a precautionary approach.
Geotechnical Assessment	It is understood that earthworks will be required as part of the proposed development, which will include the re-use of existing Made Ground soils (the existing re-engineered cover soils) in a Site wide cut and fill operation. These works need to be coordinated with the ground improvement specification and methodology adopted for the Site. A piled foundation and slab solution using pre-cast concrete driven piles with sacrificial cones transferring loads to competent Chalk geology may be suitable for the expected design loads, utilising both skin friction and end bearing capacity.
Remedial Options Appraisal	Various practicable techniques for providing betterment / risk reduction to the stream have been assessed in relation to time, cost, degree of betterment, environmental impact, sustainability and regulatory approval likelihood. The only viable remedial technique is considered to be via reducing rainwater infiltration. The reduced infiltration that will be achieved via the proposed development (provision of hard standing, buildings and formal surface water drainage network) is considered to represent the preferred remedial option.
Remediation Works Overview	<u>Enabling Phase Works</u> ▲ Locate and remove any relict land drainage, particularly in the east of the Site; ▲ Decommissioning of any previous boreholes installed into natural strata, in accordance with Environment Agency guidelines. This should be documented and verified; ▲ As part of the cut and fill programme, material intended for reuse will need to be segregated, tested (if necessary) and stored appropriately in line with the requirements detailed in the Materials Management Plan; ▲ A watching brief should be employed during the earthworks, specifically in areas of Site level reduction. All observations during the watching brief should be recorded in order to provide evidence to confirm no unanticipated / gross contamination is present within the cut material, beyond what is expected. <u>Construction Phase Works</u> ▲ Provision of ground gas protection measures in accordance with BS 8585:2015 CS3 with verification by a specialist contractor; ▲ Provision of a clean cover system in soft landscaped areas of the Site where Made Ground (landfill waste and re-engineered cover system specifically) is present at the surface; ▲ Verification of the clean cover system by an environmental consultant to confirm depth and chemical / physical suitability of the clean cover system; ▲ Installation of clean service corridors and upgraded water supply pipes; and ▲ A verification report to be produced upon completion of the remedial works to confirm that the work was undertaken in accordance with this remediation strategy, relevant legislation and planning conditions.

This is intended as a summary only. Further detail and the limitations of the assessment are provided within the main body of the Report.

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1.0 Introduction

1.1 Appointment

Delta-Simons Environmental Consultants Limited (“Delta-Simons”) was instructed by Clowes Developments (UK) Ltd (the “Client”) to undertake the preparation of a Remediation and Verification Strategy (RVS) for the former Brockhampton West Landfill, North of Harts Farm Way, Havant, PO9 1HS (the “Site”). The Site is registered for outline Planning Permission reference APP/21/00189.

1.2 Context & Purpose

The purpose of this document is to

- ▲ Present a summary of remediation requirements;
- ▲ Contribute to a sustainable development “*which meets the needs of the present without compromising the ability of future generations to meet their own needs*” as advocated by, for example, GPLC2¹;
- ▲ Provide a formal statement for the likely scope of remediation requirements to facilitate the proposed development at the Site; and
- ▲ Support the outline planning application / discharge of planning conditions relating to land contamination.

For information on the Site setting, and full details of intrusive investigations undertaken at the Site, this Remediation Strategy and Verification Strategy should be read in conjunction with Delta-Simons’ previous report as follows:

- ▲ *Preliminary Geo-Environmental Risk Assessment* by Delta-Simons dated February 2021 (ref: 19-2099.01);
- ▲ *Factual Site Investigation Report* by Delta-Simons dated June 2021 (ref: 19-2099.04); and
- ▲ *Geo-Environmental Assessment* by Delta-Simons dated November 2021 (ref: 19-2099.04).

1.3 Scope of Works

The scope of works undertaken for this assessment was to:

- ▲ Summarise the site setting and confirmed contaminant linkages;
- ▲ Identify data gaps and uncertainties for consideration;
- ▲ Outline the remediation objectives;
- ▲ Assess remedial options for the Site; and
- ▲ Present the remediation and verification strategy.

1.4 Limitations

This document sets out the measures that will be carried out during the construction to mitigate potentially significant risks as identified by the Site investigations in the context of the proposed end-use of the Site, it does not provide a verification or completion statement for the works. The standard limitations associated with this assessment are presented in Appendix A. In addition, there are the following specific limitations that apply to this assessment:

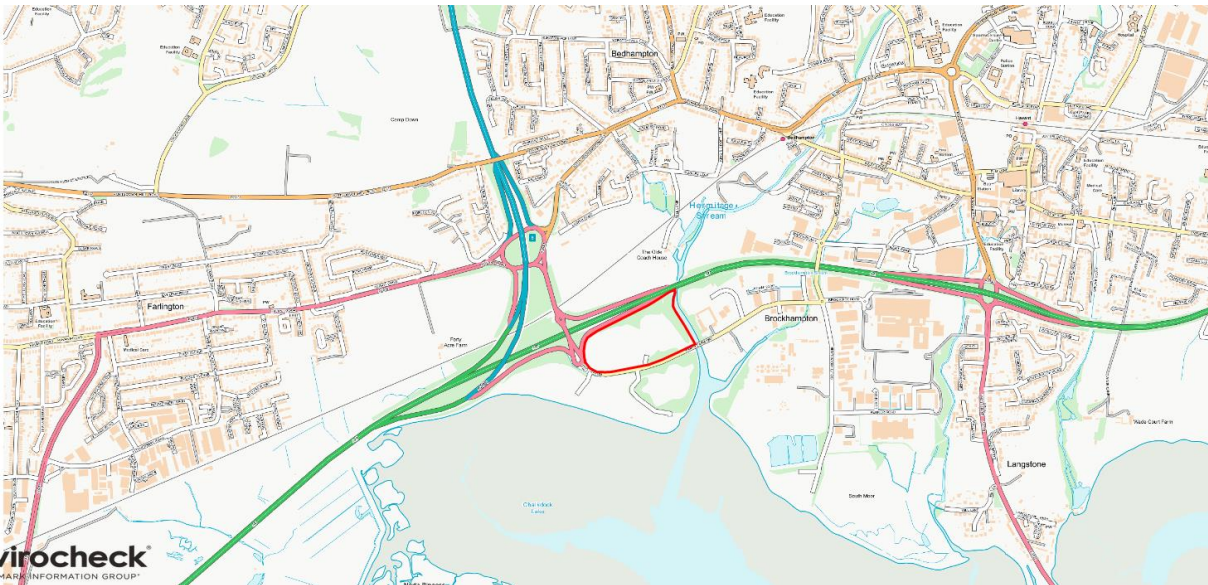
- ▲ This document is a strategy document and more detailed documentation in terms of a Contractor’s Remediation Method Statement may need to be prepared; and
- ▲ Due to the presence of slow worms on-Site and the drilling works commencing during their hibernation period, the drilling locations were limited to the pre-existing tracks where the grass was already short. This, as well as the proposed exploratory hole location plan was agreed with the project ecologist Applied Ecology. Whilst this constraint was present, Delta-Simons do not consider the placement of the exploratory holes to have impacted the overall aims and objectives of the ground investigation or this strategy document;

<https://assets.publishing.service.gov.uk/GPLC2>

- ▲ Dense vegetation around the perimeter of the Site limited access to these areas;
- ▲ Steep slopes on-Site limited the placement of the borehole locations due to the requirement for a level, stable platform for the drilling rig; and,
- ▲ The overhead power line on-Site, adjacent to the southern boundary, required a 15 metre standoff zone for all plant and vehicles. As such, no exploratory locations were undertaken within this standoff zone.

2.0 Site Context

2.1 Site Information

Site Overview			
 Contains OS data © , Crown Copyright and Database Right (2016)			
Co-ordinates	Centred approximately at National Grid Reference 470150, 105700.	Elevation (approx..)	3.0 – 14.0 m AOD
		Area	8.3 Ha
Site Address and Location	The Site is located to the south of the Havant Bypass (A27) towards the western outskirts of Havant, approximately 7.0 km north-east of Portsmouth. Google Maps Link		
Site Description	The Site is currently an undeveloped parcel of grassland that previously was part of a wider landfill Site with limited areas of hardstanding in the centre. The Site comprises a small access road branching from Harts Farm Way in the southern central area of the Site. The Site is occupied by trees and shrubs along the perimeter.		
Site History	Historically, the Site comprised tidal / estuarine mud flats until circa 1969, when the area was subjected to land reclamation via waste disposal. Authorised waste included concrete waste, construction and demolition wastes, household waste and incinerator residues. Landfilling ceased at the Site by circa 1987 and the Site was briefly used as playing fields, after which no further developments have taken place.		
Proposed Development Description	The proposed development for the Site is for new employment units to provide up to 29,000 sq m (gross internal area) for flexible use across use classes E (light industrial), B2 and B8 with ancillary offices, car parking, service yards, drainage works, landscaping and associated works to prepare the Site for development.		

	A proposed development plan is attached at the rear of the report as Drawing 1. The redevelopment of the Site will require earthworks to be undertaken comprising a cut and fill operation. The earthworks will therefore need to be undertaken under a Materials Management Plan (MMP) in accordance with the CL:AIRE Code of Practice to facilitate the reuse of these materials.
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2.2 Planning

An application for outline planning permission has been submitted for the redevelopment of the Site for commercial use (reference: APP/21/00189).

2.3 Environmental Setting

Geology	A variable thickness of re-engineered cover system was recorded during the investigation, underlain by landfill waste (maximum proven thickness 12.4 metres), River Terrace Deposits and the Lewes Nodular Chalk Formation. Limited alluvium was encountered in two locations in the west. The Site was divided into two landfill cells (east cell and west cell) based on the topography of the Site and the general composition of the waste. These cells are indicative and are assumed to extend to the boundaries of the Site specifically the exiting road network and the stream to the east. The wider landfill (including other likely cells for disposal) is known to extend to the south and west. The landfill waste within the east cell appeared to consist of more 'household waste' items including containers, kitchen waste, glass bottles, newspapers and books. The waste within the west cell comprised less common household items and notably more 'industrial' items including large tyres, wood, metal and large-scale deposits of metal baby-powder containers. Ash was identified in the landfill waste within the west cell however, the ash content was notable greater and more widespread in the east. The west cell is also lower topographically, with regard to the east cell, which, along with the differences in waste types, supports the idea of two separate waste cells with differing dates of deposition.
Hydrogeology	The EA classify the bedrock (Chalk) as a Principal Aquifer and the superficial geology (River Terrace Deposits) as a Secondary A Aquifer. Monitoring data suggests that the groundwater is tidally influenced and there are likely two groundwater bodies present across the Site, within the landfill waste and the Chalk. There is limited and variable vertical separation of the two groundwater bodies, with evidence of direct connectivity.
Hydrology	The nearest surface water feature is Hermitage Stream that flows along the eastern boundary of the Site and flows southwards into Storehouse Lake (Langstone Harbour). This is a tidal watercourse with flow direction reversing during rising tides. Langstone Harbour is a site of significant ecological importance with designations including a Ramsar Site, a Site of Special Scientific Interest (SSSI), a Special Area of Conservation (SAC) and a Special Protection Area (SPA). The data indicates groundwater flows south / south-east toward the Langstone Harbour and Hermitage Stream.

2.4 Environmental Findings and Recommendations

The key findings of the Geo-Environmental Assessment by Delta-Simons dated November 2021 (ref: 19-2099.04). are summarised below; for further details, the report should be read in full:

- ▲ Asbestos was detected within the re-engineered cover system and the landfill waste. In general, potential health risks from shallow impacted soils can be mitigated via the presence of buildings and hardstanding, which will satisfactorily address direct contact exposure pathways;
- ▲ In areas of proposed soft landscaping, it is recommended that a cover layer system of clean soils (either imported or reused existing topsoil where fully characterised) where Site re-engineered cover system materials or landfill wastes are likely to be exposed at surface on the re-developed Site, to mitigate potential health risks to future Site users;
- ▲ There are no other exceedances when soil determinants are screened against commercial GAC criteria, and contaminant concentrations reported in soils are not considered to represent a significant risk to human health in the context of risk to future construction workers or operational Site personnel;
- ▲ Groundwater contamination, as a result of landfill leachate migration, has been identified across the Site within the Chalk aquifer. However, the data has demonstrated that not all contamination is Site derived and, notably that natural attenuation is likely to be occurring in the sub landfill strata / Chalk aquifer in conjunction with dilution in the stream corresponding to concentrations within the stream below Environmental Quality Standard (EQS) values;
- ▲ It is evident is that the Site is likely to be discharging ammoniacal nitrogen into a eutrophic environment, albeit at concentrations within the stream that are below the adopted EQS values. However, the proposed development is considered to provide environmental betterment by virtue of limiting rainfall infiltration into the waste mass, thereby limiting contaminant leaching and migration to off-Site sensitive controlled waters receptors. This would apply not only for the Hermitage Stream but also for the Langstone Harbour which is a site of significant ecological importance including a Natura 2000 site, Ramsar Site, a Site of Special Scientific Interest (SSSI), a Special Area of Conservation (SAC) and a Special Protection Area (SPA); and
- ▲ Monitoring of hazardous ground gases indicates elevated concentrations of both methane and carbon dioxide to be present on a Site-wide basis. Ground gas monitoring indicates the Site can be classified as CS3. On analysis of the data, with maximum steady carbon dioxide and methane readings of 31.8 % and 98.2 % respectively albeit with generally low flow readings, it is considered prudent to adopt gas protection measures in line with CS3 as a precautionary approach across the Site.

2.5 Conceptual Site Model

The following linkages have been previously confirmed as being relevant to the proposed development and warranting mitigation.

Confirmed Linkages	Source Descriptions	Pathway	Receptor
Linkage 1	Asbestos within the Re-Engineered Cover System and Historical Landfill	Inhalation, ingestion, direct contact	End Users of the Site
Linkage 2			Construction-phase staff
Linkage 3	Historical Landfill – Ground Gases and Dissolved Methane	Indoor exposure via enclosed space accumulation of gas	Buildings and End Users of the Site
Linkage 4	Piling through the Historical Landfill	Preferential migration of contaminants into groundwater	Principal Aquifer (Chalk) /

			Hermitage Stream
		Preferential migration of ground gases resulting in accumulation of gas in enclosed space	Buildings and site end users
Linkage 5	Outfall in the north-east of the Site (likely to form part of the A27 surface water drainage system)	Potential for preferential migration of contamination/leachate if connected to the landfill.	Hermitage Stream

The following linkage was not assessed to be a substantial risk, however, in consultation with the regulators, betterment / risk reduction should be undertaken where viable:

Confirmed Linkages	Source Descriptions	Pathway	Receptor
Linkage 6	Nitrates (including ammonium) within the landfill	Migration of contaminants into the groundwater due to the dilute and disperse nature of the landfill	Hermitage Stream

2.6 Data Gaps and Uncertainties

The reader is advised to consider:

- ▲ The investigation was limited by steep topography in the centre of the Site and around the perimeter, existing dense vegetation (particularly around the perimeter of the Site) and the presence of slow worms / nesting birds. This is especially limited in the east of the Site adjacent to the Hermitage Stream;
- ▲ The potential to encounter unexpected / not previously encountered contamination given the nature of the heterogenous landfill waste i.e., hydrocarbon hotspots and large volumes of asbestos waste;
- ▲ The potential risk posed by piling / foundation works particularly in regard to risks associated with the proposed buildings (ground gases) and to the Hermitage Stream / Langstone Harbour (preferential pathways for leachate); and
- ▲ The potential for relict drainage / unknown land drains, particularly within the east of the Site, that may facilitate the mobilisation and direct migration of leachate into the watercourse during the enabling works. These should be located and treated at the earliest opportunity to ensure a migration pathway does not exist for any leachate that may be mobilised during the works.

3.0 Remediation Objectives

3.1 Stakeholders

Parties Anticipated to be Involved	Function / Interest
Client (Clowes Developments (UK) Ltd)	Purchaser / Developer
Principal Contractor (TBC)	Delivery of Development / MMP – CEMP permitting
Project Management (Knight Webb)	Overall Project Management
Geo-Environmental Consultant (Delta-Simons Environmental Consultants Ltd)	Consult on Environmental Matters
Architect (MSA Architects)	Design of the Proposed Development / Submission of Planning Documents
Structural / Civil Engineer (Burrows Graham)	Engineer Design
Environment Agency (Technical Specialist - (Groundwater Quality and Contaminated Land))	Regulation relating to Controlled Waters and Waste
Havant Council (Environmental Control Officer)	Regulation relating to Human Health & Controlled Waters

3.2 Sustainability Objectives

Current UK guidance requires due consideration of sustainability indicators in the appraisal of remediation options. Reference has been made to LCRM and the SURF UK framework and this options appraisal and consideration of relevant technical factors broadly reflects the approach in those documents.

Noting that remediation has the potential to cause adverse environmental, economic and social impacts, these have been considered to ensure the following high-level sustainability objectives:

- ▲ The benefit of doing remediation is greater than its impact;
- ▲ A balanced decision-making process has been used to select the optimum remediation solution;
- ▲ The activities do not cause greater adverse effect on climate change than the contamination being addressed;

- ▲ The remediation manages the unacceptable risks in a safe and timely manner, and maximises the overall environmental, social and economic benefits.

3.3 Regulatory Drivers/Objectives

Delta-Simons have undertaken consultation with the regulators both prior to the ground investigation being undertaken and via a previous version of the Geoenvironmental Assessment Report (July 2021). The main drivers/objectives from their perspective are as follows:

- ▲ In line with the National Planning Policy Framework the Site should be suitable for its intended use after development and as a minimum the land should not be capable of being determined under Part 2a of the Environmental Protection Act 1990;
- ▲ In terms of controlled waters the risks to the Hermitage Stream are considered the primary risk driver, specifically nitrogen species (including ammonium);
- ▲ That the development and construction phase should not adversely impact sensitive receptors e.g. Hermitage Stream/Langstone Harbour; and
- ▲ Where viable, risk reduction / betterment to the impact on the stream from specifically ammonium would be welcomed.

3.4 Stakeholder Objectives

The following high-level stakeholder objectives are relevant to the options appraisal:

Remedial Works Consideration	Site Specific Consideration
Investor Acceptability	Tolerable levels of risk mitigation
Timescales	The length of the on-site remedial works will need designing to limit the period of disturbance to adjacent landowners/operators as far as is reasonably possible
Operational constraints	Odour control may be required during the cut and fill programme due to exposure of the landfill waste.
Remediation durability	Ensure the remediation provides a suitable solution to the problem.
Public relations	Accommodate local resident/businesses concerns in a reasonable manner.
Local/neighbourhood sensitivities	SSSI and SAC / SPA adjacent to the south.

3.5 Constraints/Opportunities

It is suggested the following elements are considered:

Remedial Works Constraint	Site Specific Constraint
Enabling Works	A significant cut and fill programme is required.
Existing structures & services	Overhead electricity cables in the south of the Site, adjacent to Harts Farm Way. The potential for unknown drainage, particularly in the east of the Site, which may act as a direct pathway for any mobilised leachate into the Hermitage Stream.

Existing site features	Dense vegetation around the perimeter of the Site. Ecological constraints - Slow worms and nesting birds.
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3.6 Remedial Options Appraisal

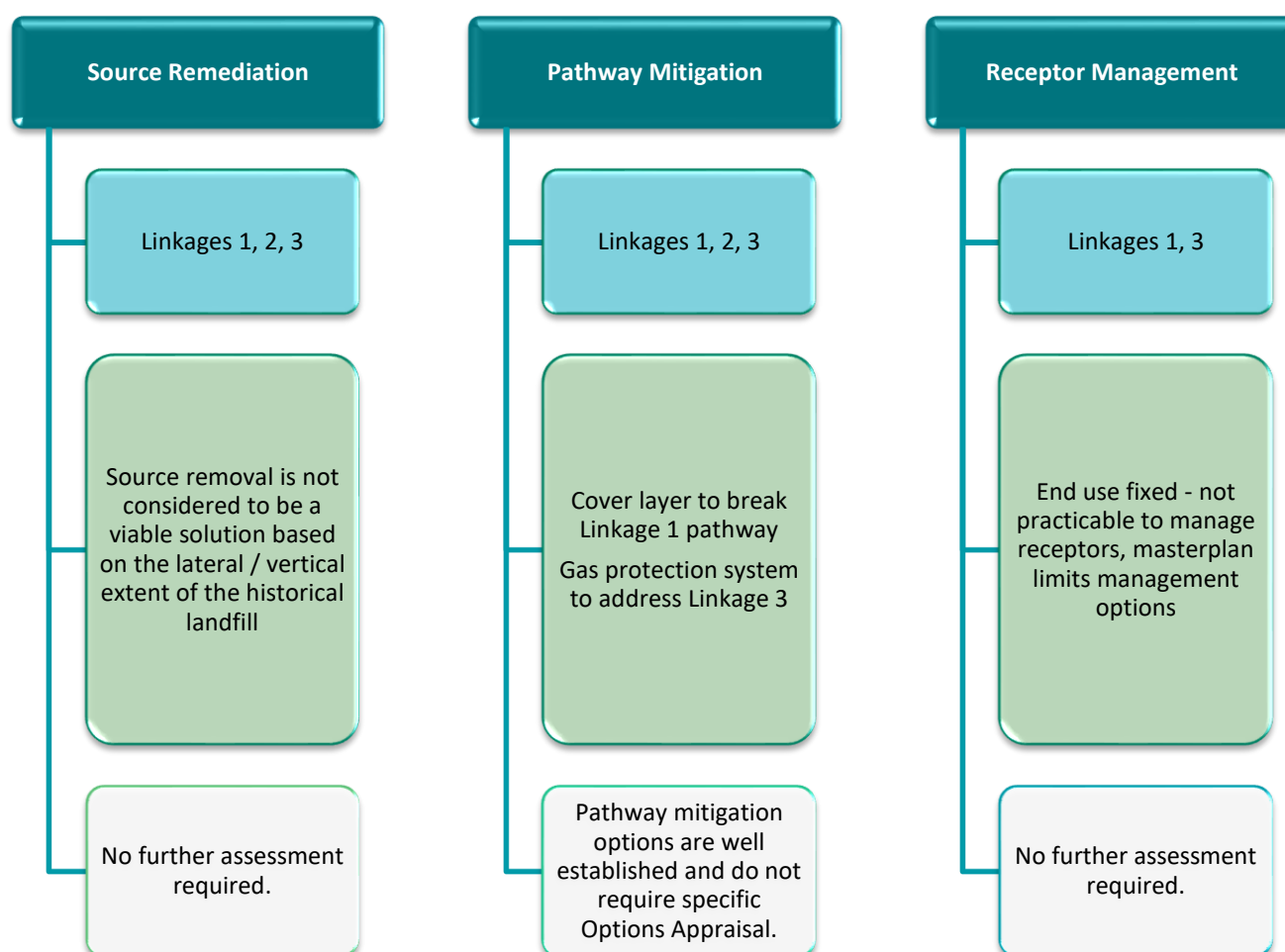
Remediation options fall into one of three categories:

- ▲ Undertaking remediation of the contamination source;
- ▲ Mitigation of migration pathways; or,
- ▲ Receptor management.

Remediation strategies may incorporate a combination of techniques across the three categories to achieve the most effective and sustainable solution.

3.6.1 Identified Linkages – High Level Screen

The following table provides a high-level screen of remedial approaches to the identified linkages:



Linkage 4: A Piling / Foundations Works Risk Assessment should be undertaken as a separate exercise to ensure risks to sensitive receptors, principally gas migration risk from piles and mobilisation of contaminants from the piling, are mitigated as appropriate.

Linkage 5: The outfall in the north-east of the Site into the Hermitage Stream should to be surveyed by CCTV as part of the remedial works to assist in determining its purpose and extent. Should this be connected at all

to the drainage of leachate from the landfill then this would require remedial treatment in the form of permanently blocking the outfall/pipe.

3.6.2 Providing Risk Reduction/Betterment to the Hermitage Stream – Options Appraisal

The following practicable remediation techniques were considered appropriate to provide betterment / reduce risks of primarily ammonium to the Hermitage Stream:

- ▲ Excavation and removal of waste to another landfill facility
- ▲ Waste stabilisation
- ▲ Capping
- ▲ Cut off wall to the east
- ▲ Cut off wall to the south and east
- ▲ Cut off wall to the north
- ▲ Permeable Reactive Barrier (PRB)

The following table provides a remedial options appraisal of the above practicable remedial techniques that would provide risk reduction/betterment to Linkage 6.

Remediation	Risk Reduction/ Betterment	Time Frame	Env. Impact	Sustainability	Regulatory Approval	Cost	Cost vs Env Benefit	Assessment Summary	Viable?
Do Nothing – No development occurs	None	n/a	n/a	n/a	Part 2a ?	n/a	n/a	- Under a scenario where development does not proceed, clearly the migration of contaminants into the stream will continue at existing rates - Significant loss of economic benefit of development - Considered worst outcome for the Site	Yes
Source removal	High	Long term	Moderate	Poor	?	£££££	x	- Significant amount of waste would require disposal at another landfill Site - Technically difficult within saturated zone - Site ecology would be significantly affected to allow removal of waste on the periphery of the Site - Would still leave the larger landfill to south and west as an unmitigated source of contamination to the stream/harbour - Significant carbon costs associated with transporting waste materials - Regulatory approval for transport of significant volumes of waste offsite uncertain - Significant cost compared to level of impact identified	No
Source stabilisation	Moderate to High	Medium term	Low to Moderate	Poor	Yes	££££	x	- Site ecology would still be adversely affected to allow pumping/mixing of cement at depth although more easily mitigated than source removal - Still leaves larger landfill to the south and west - Significant carbon costs of cement (est. 750,000t of carbon)	No

Remediation	Risk Reduction/ Betterment	Time Frame	Env. Impact	Sustainability	Regulatory Approval	Cost	Cost vs Env Benefit	Assessment Summary	Viable?
								• Significant cost compared to level of impact identified	
Capping of landfill via development	Low to Moderate	Short term	Low	Good	Likely	£	☑	• Significant capping of landfill via development i.e. hardstanding and buildings proven to mitigate risk to controlled waters from landfills • Majority of hardstanding/buildings are not load bearing on the waste • Residual risks i.e. soft landscaping managed by run off from bunds • Easily incorporated into development • Ecology impacts can be more easily managed • Sustainable as required for development in any event i.e. no additional energy/carbon costs	Yes
Capping of landfill via development + Sheet pile wall – eastern periphery	None – likely adverse effect	Medium term	Moderate	Fair	Unlikely	£££	x	• Could be used with other remediation techniques e.g. capping • The walls would need to be keyed into impermeable strata to avoid tidal flushing est. to be 20m bgl. • Would likely divert groundwater/contamination to south-east corner of the Site i.e. point/concentrated discharge in the stream closer to the SAC • Groundwater/leachate likely to backup and overtop sheet pile wall in the north-east. • Eastern woodland (to be maintained as part of the development) would be lost	No

Remediation	Risk Reduction/ Betterment	Time Frame	Env. Impact	Sustainability	Regulatory Approval	Cost	Cost vs Env Benefit	Assessment Summary	Viable?
								Carbon cost for the steel alone would be c.2,200t.	
Capping of landfill via development + Sheet pile wall – to include southern periphery (Encapsulation)	Moderate	Medium term	Moderate	Fair	?	££££	x	- As above plus: - Significant additional cost - Significant issue of groundwater/leachate backing up behind the wall - Contaminant travel time c.250m average to harbour → marginal betterment - Significant dilution in the harbour i.e. not a narrow channel - Cost disproportionate to impact identified	No
Capping of landfill via development + Sheet pile wall – northern periphery	Moderate	Medium term	Low to Moderate	Fair	?	££££	x	- Still leaves infiltration of rainfall/leachate production (although reduced through hardstanding) - Still leaves tidal flushing of the waste mass - Development northern boundary only approx. 60% of total northern boundary of landfill which will not mitigate risks of remaining landfill to the west and south - Groundwater backing up behind wall could cause significant flooding of the A27.	No
Permeable Reactive Barrier (PRB)	Low to Moderate	Medium term	Low to Moderate	Good	Likely	££ to £££	Possible	- Ammonia not treated by PRBs - Could utilise existing sheet pile wall (wall or land not owned by the developer) - Long term maintenance required - May require sheet pile wall along southern boundary to be effective	No

Remediation	Risk Reduction/ Betterment	Time Frame	Env. Impact	Sustainability	Regulatory Approval	Cost	Cost vs Env Benefit	Assessment Summary	Viable?
								• Southern/western landfill still remains a unmitigated source of contamination • Complexities with tidal flushing as a passive system • Residence time of groundwater in the PRB unlikely to be sufficient to reduce contaminant load • Probably not technically feasible	

Based on the above table the only viable remedial technique to provide betterment/risk reduction to the Hermitage Stream is the capping of the landfill provided by the development construction i.e., building, hardstanding and a suitable surface water drainage network.

4.0 Remediation Strategy

4.1 Overview

The Site Remediation Strategy had been devised based on the intrusive investigation undertaken between February and April 2021 to mitigate the risks posed by the identified contaminants of concern and break potential contaminant linkages allowing the redevelopment of the Site for a commercial end use. The key features of the remedial strategy are summarised below:

Enabling Phase Works

- ▲ Locate, survey and fill / remove any relict land drainage, particularly in the east of the Site if it is considered to be connected to the landfill material. As indicated in the Geoenvironmental Report it is considered likely that the feature is associated with the A27.;
- ▲ Decommissioning of any previous boreholes currently on-Site, in accordance with Environment Agency guidelines. This should be documented and verified by a suitable qualified person;
- ▲ As part of the cut and fill programme, material intended for reuse will need to be segregated, tested (if necessary) and stored appropriately in line with the requirements detailed in the MMP;
- ▲ A watching brief should be employed during the earthworks, specifically in areas of Site level reduction. All observations during the watching brief should be recorded in order to provide evidence to confirm no gross contamination is present within the shallow material, beyond what is expected.

Construction Phase Works

- ▲ Provision of ground gas protection measures in accordance with BS 8585:2015 CS3 with verification by a specialist contractor (Section 6.4);
- ▲ Provision of a clean cover system in soft landscaped areas of the Site where Made Ground (landfill waste and re-engineered cover system specifically) is present at the surface;
- ▲ Verification of the clean cover system by an environmental consultant to confirm depth and chemical / physical suitability of the clean cover system;
- ▲ Installation of clean service corridors and upgraded water supply pipes; and
- ▲ A verification report to be produced upon completion of the remedial works to confirm that the work was undertaken in accordance with this remediation strategy, relevant legislation and planning conditions.

5.0 Pre-Construction Remedial Works

5.1 Background

A groundworks contractor (The 'Contractor') will be appointed by the Client to undertake the pre-construction Site enabling and remedial works. It is understood that earthworks will be required as part of the proposed development, which will include the re-use of existing re-engineered cover system materials in a significant Site wide cut and fill operation. Considering the proposed indicative level changes across Unit 1 and Unit 2, the cut and fill plan therefore suggests that the eastern area of the Site will undergo a net reduction in levels, whilst western areas of the Site will undergo a net increase in levels.

Earthworks will be undertaken under a Material Management Plan (MMP) in accordance with the CL:AIRE Code of Practice to facilitate the reuse of site-won materials. The Contractor will produce the MMP, with the sign-off to be completed by a Qualified Person.

This section of the report outlines the remedial works required prior to commencement of the construction phase of the development.

5.2 Demolition and Site Clearance

The Site should be cleared of all residual debris, fly-tipped materials and vegetation that is required to be removed to facilitate the redevelopment of the Site. All material shall be removed to a suitably licensed landfill.

5.3 Excavation, Breaking and Processing of Sub-Surface Structures

5.3.1 Relict foundations, slabs and utilities etc.

All natural or man-made hard materials including hardstanding etc. at or below the surface shall be broken out from beneath the development platform. The location and depth of all below ground obstructions remaining during the remedial works / earthworks shall be recorded by the Contractor on the final as built drawing.

All hard materials and arisings recovered during the works which are intended for re-use shall be processed and stockpiled for chemical testing to demonstrate they are suitable for re-use within the proposed redevelopment. Though, given the only hardstanding is a limited area in the central-south of the Site, this is not likely to be a significant volume.

Site-won re-engineered cover material reused within the development as part of the proposed cut and fill programme shall not require further chemical analysis, as it is considered sufficient characterisation has already been completed.

Testing may be required for any arisings recovered that are intended to form part of the cover system for areas of soft landscaping (i.e. topsoil), this is discussed further in Section 6.0.

5.3.2 Relict Drainage

The condition and location of existing surface drainage is currently unknown, particularly within the east of the Site. An outfall into the Hermitage Stream has been observed north-east of the Site. It is recommended a CCTV survey should be undertaken to confirm the route of the drainage feeding the outfall and to demonstrate the drains are clean prior to break out commencing.

This will ensure the drainage system will not hold any potential contaminative substance which could be released during the earthworks and breakout operations.

This will also confirm the route of the drainage and if it is fed directly from the Site. Should there be land drains on-Site that are connected to the outfall (which deposits directly into the watercourse) they should be blocked up as necessary. This is to prevent any mobilised contamination directly entering the watercourse.

Additional to this, a search should be undertaken, specifically in the east of the Site, in order to establish if there are any other land drains directly depositing into the Hermitage Stream. These will also need blocking up prior to the works beginning, in order to prevent the formation of a contaminant pathway into the watercourse.

5.3.3 Health and Safety

Groundworkers and sub-surface maintenance workers should be made aware of the possibility of encountering contaminated soils through toolbox talks and in particular the potential presence of asbestos and an appropriate protocol to mitigate exposure of the workforce and general public should be in place.

The Contractor will need to prepare a risk assessment which identifies a safe system of work to handle the asbestos containing soils which is likely to include asbestos awareness training, a protocol for unexpected finds (should gross asbestos material be identified) as well as safe working procedures such as damping down of excavations and stockpiles in line with general dust generation mitigation. The risk assessment will need to identify the appropriate levels of PPE and/or RPE required. This recommendation should be captured in Site health and safety documentation and in maintenance plans.

5.3.4 Decommission of Boreholes

The boreholes, installed as part of the previous intrusive investigation into natural strata (undertaken by Delta-Simons and WYG), should be decommissioned in accordance with Environment Agency guidance. A filling specification should be produced in accordance with Environment Agency guidance. This should be documented and verified.

5.4 Disposal of Water

Any waters encountered within the formation of earthworks excavations shall be treated and disposed of in accordance with legislation either off-site or through obtaining a discharge consent which should be issued by the appropriate authority.

Any perched water showing significant contamination should also be appropriately managed and removed from Site, potentially via localised de-watering of the Made Ground.

5.5 Environmental Management

During the remedial works, it will be the responsibility of the Contractor to ensure that the works are managed in an appropriate way as not to further contaminate the ground and/or watercourses (Hermitage Stream / Langstone Harbour) and pose a risk to off-site receptors.

The works will involve the disturbance of soils which may contain contaminants including asbestos. The Contractor shall prepare a Construction Environmental Management Plan (CEMP) which shall include measures to prevent the emission of contamination to air and into the wider environment to include (but not limited to):

- ▲ Damping down of dry soils/Made Ground materials;
- ▲ Odour suppression as necessary during excavation of contaminated materials – damping down and / or misting as appropriate;
- ▲ Asbestos in air monitoring during earthworks (including boundary and personal monitoring);
- ▲ Surface water quality monitoring in the Hermitage Stream during any groundworks (including installation of Controlled Modulus Columns, piling and significant reduced level excavations into the waste material);
- ▲ Use of a wheel wash or roadsweeper to address mud on roads;
- ▲ Control of water including surface water run-off and water in excavations to prevent escape to adjacent watercourses;
- ▲ Operation of works only within the times permitted under the planning permission; and
- ▲ Details of incident recording procedures.

The CEMP shall include a detailed Asbestos Management Plan (AMP) and Surface Water Quality Monitoring Plan (SWQMP). Full details of the measures to be taken shall be communicated to the relevant staff during the Site Induction.

The CEMP shall be available for inspection on Site during operating hours.

5.6 Addressing Previously Unidentified 'Hotspots' of Contamination

5.6.1 Background

As with any 'Brownfield' development, there is a possibility that unknown localised areas of soil contamination (a 'Hotspot') may be encountered during development works. As such, a 'hotspot' protocol is required during the construction phase of the development. The purpose of the protocol is to provide a ready reference should such an area of contamination be identified by visual or olfactory means during the works.

Given the nature of the Site, it is likely limited contamination (i.e. moderate waste type odours) will be encountered within the landfill waste during the development, which is to be anticipated given the biodegradable nature of some of the wastes and the general range of likely waste types deposited at the Site. As such, the hotspot protocol should be reserved for occasions where evidence of potential significant contamination is observed, particularly in areas of site level reduction where the landfill waste will remain in-situ near surface. In short, the hotspot protocol should be adopted when evidence of potential contamination, more significant and beyond what is to be expected within a former landfill, is encountered.

For example, it is understood the landfill waste mostly comprises household waste and so significant volumes of asbestos or asbestos-containing materials (ACMs) are not anticipated. Should such materials be encountered, the hotspot protocol should be implemented and the compliance with the MMP should be re-assessed. Another key example for consideration would include encountering a clear point source of organic contaminants i.e. drums of hydrocarbon fuels/lubricants or organic solvents.

5.6.2 Protocol

Should an area of significant contamination be identified by visual or olfactory means during development works, the following procedure shall be followed:

- ▲ Immediately stop all works in the area where notable contamination is suspected e.g. asbestos or ACMs, drums of unknown substances, free product;
- ▲ Immediately inform the Site Agent who should then contact the Environmental Consultant;
- ▲ The Environmental Consultant shall provide a verbal response outlining immediate actions with regard to Site Health and Safety and to limit the potential for contaminants to migrate;
- ▲ The Environmental Consultant shall judge each occurrence on merit and should it be deemed necessary the Environmental Consultant shall attend Site to oversee the removal of the 'hotspot' and collect validation samples;
- ▲ Any excavated material should be isolated from all other material at the Site, on plastic sheeting and covered with plastic sheeting until the material can be tested for contamination and an appropriate disposal route can be identified;
- ▲ Any 'hotspot' stockpiles and excavations should be fenced off, have appropriate signage and their locations recorded on a Site drawing;
- ▲ Should any excavated material be required to be disposed of at an off-Site location, the material shall be isolated from all other material at the Site prior to disposal at a suitably licensed facility. All documentation associated with the movement and disposal of any such material shall be supplied to the Environmental Consultant shall, including waste transfer documentation;
- ▲ Subject to appropriate Site Health & Safety controls (typically comprising fencing off the excavation) the excavation will remain open until the validation has been completed. Alternatively, for Site Health & Safety reasons, it may be necessary to backfill the excavation with Site derived material. In this case, the location of the excavation will be accurately recorded and the excavation reopened if required, based on the validation results; and
- ▲ The Regulatory Authorities shall be informed by the Environmental Consultant shall of any remedial activities required and associated validation testing results. Representatives of these organisations may also wish to visit the Site.

Implementation of appropriate measures to deal with such finds remain the Contractor's responsibility.

A copy of the protocol is also presented in Appendix C to be extracted and used on-Site.

5.7 Materials Management

5.7.1 Materials Management for Earthworks

The redevelopment will include earthworks which will require the excavation and placement of Made Ground / soils which contain contamination, albeit the concentrations within these soils are not considered to preclude them from re-use. No further testing of the soils on site is considered to be required.

The earthworks will therefore need to be undertaken under a Materials Management Plan (MMP) in accordance with the CL:AIRE Code of Practice to facilitate the reuse of these materials. The Contractor shall be responsible for the preparation of a MMP and obtaining appropriate sign off from a Qualified Person prior to the commencement of earthworks.

Consideration will need to be given to the storage of material during the earthworks. It is anticipated topsoil, re-engineered capping material and landfill waste will be excavated as part of the cut and fill programme.

The topsoil is likely to be reused as part of the clean cover system and for general fill. The re-engineered cover material is likely to be used within the cut and fill programme. Any landfill waste that is excavated as part of the works will be removed from the Site.

As such, careful management will be required to ensure the material is suitably segregated and stored for its intended purpose. Whilst it is anticipated the landfill waste will be transported off-Site following excavation, the potential for temporary short-term storage should be considered. If the landfill waste is stockpiled for a brief time before off-Site transportation, it will need to be effectively managed. This will include segregation and prevention of cross contamination. For example, placement on a non-permeable surface to prevent cross contamination with the ground and covering of the stockpile with non-permeable sheeting to prevent any contaminated runoff.

Additionally, testing may be required to ensure any material movement is in line with the requirements of the MMP. Throughout the works, conformity with the MMP should be continually assessed to ensure it is being complied with accordingly.

5.7.2 Asbestos in Soils - Earthworks

The assessments undertaken have identified that asbestos is present within the re-engineered capping layer and the landfill waste, but not at concentrations which would preclude the use of the materials for earthworks purposes.

The groundworks Contractor should be made aware of the possibility of encountering potential Asbestos Containing Materials (ACM) within the Made Ground across the Site and an appropriate protocol to mitigate exposure of the workforce and general public should be in place with due respect to his duties under the Control of Asbestos Regulations 2012 and with reference to the Joint Industry Working Group Asbestos in Soil and Construction & Demolition (C&D) Materials guidance (published by CL:AIRE) titled "Control of Asbestos Regulations 2012: Interpretation for Managing and Working with Asbestos in Soil and Construction & Demolition materials: Industry Guidance" (shortened name CAR-SOILTM). The document was prepared with the support of the Health and Safety Executive and presents the definitive explanation of how the legal requirements of the CAR 2012 have been interpreted to apply to work with asbestos contaminated soil and construction & demolition materials. The guidance is underpinned by the fundamental requirements expressed in the Regulations, in relation to the protection of employees from risks related to exposure to asbestos but is set within a carefully considered framework designed specifically for soil and C&D materials contaminated with asbestos.

The Contractor will need to prepare a risk assessment which identifies a safe system of work to handle the asbestos containing soils which is likely to include asbestos awareness training, a protocol for unexpected finds (should gross asbestos material be identified) as well as safe working procedures such as damping down of excavations and stockpiles in line with general dust generation mitigation. The Contractor should determine the need for appropriate levels of PPE and/or RPE and any associated air monitoring as required.

The Contractor shall be responsible for providing appropriate documentation for inclusion within the Verification Report including details of any significant asbestos material encountered.

5.7.3 Asbestos in Soils – Post Earthworks

Any areas of proposed soft landscaping, with landfill waste or re-engineered cover layer at the surface, will require a clean cover to prevent exposure to the asbestos impacted materials. The requirement for a clean cover layer in the southern area of the Site is detailed further in Section 6.

6.0 Construction-Phase Remediation Works

6.1 Certified Clean Topsoil / Subsoil Layer - Cover System

Delta-Simons consider that a clean cover system should be placed for all proposed soft landscaped areas where Made Ground (re-engineered cover layer and landfill waste specifically) is present at surface, to break the identified pollutant linkage and to facilitate the growing of flora. This requirement is also inclusive of the proposed bunds in the south of the Site.

Where the ground will remain undisturbed, no remedial measures are deemed necessary aside from the provision of a minimum 150 mm topsoil layer in soft landscaped areas.

For areas where a clean cover system is required, the following criteria are recommended:

- ▲ A high visibility membrane or hard-dig layer should be installed on top of Made Ground upon which the cover layer will then be placed. This is to provide a physical break of a potential pathway between Made Ground and the cover system;
- ▲ Within proposed areas of soft landscaping, the clean cover layer shall be a minimum thickness of 450 mm, consisting of 300 mm subsoil and 150 mm topsoil; and
- ▲ Where trees are to be planted as part of landscaping, the cover system will be deepened to accommodate the root-ball.

In accordance with BS 3882:2015, the depth of topsoil shall not exceed 300 mm but the depth of subsoil should be at least double the depth of the topsoil.

Based on the proposed Landscape Plan included as Drawing 1, it appears the east of the Site will remain undisturbed. As such, a clean cover system would not be required in this area and any other area that will remain undisturbed as part of the development. The requirement for a clean cover is negated and a suitable growing medium of at least 150 mm of topsoil should be provided in these areas.

The landscape plan also indicates significant tree planting will be undertaken as part of the proposed development. Therefore, large areas may require deepening of the clean cover system as per the requirements listed above.

6.2 Verification of Topsoil Stripped from the Site

6.2.1 General

It is recommended that the topsoil should be stripped for reuse across the Site. Noting that, by virtue of Article 2 Para 1c of the WFD (2008), naturally occurring uncontaminated topsoil and subsoil sourced and used on site would not be a waste, the stripped topsoil can be relocated for reuse as fill in an alternative location to be identified by the Developer.

Samples shall be analysed for a minimum suite of:

- ▲ Asbestos screening;
- ▲ pH, heavy metals;
- ▲ Total petroleum hydrocarbons; and
- ▲ Speciated Polyaromatic Hydrocarbons (16 PAH).

Sample results shall be considered against appropriate Generic Assessment Criteria for a Residential with Plant Uptake land use. It should be noted that the topsoil is intended for reuse within the clean cover system and as general fill. Only topsoil reused as part of the clean cover system will require testing.

The table in Section 6.2.2 below outlines the testing requirements for site-won topsoil. This comprises 1 sample per 100m³ or a minimum of 6 samples (whichever is greater). To date, Delta-Simons have already tested 7 topsoil samples as part of the previous investigation. No contaminant concentrations exceeded the GAC for either commercial or residential end use with plant uptake.

6.2.2 Verification

The Contractor will need to provide the following information for topsoil stripped in these areas (to be incorporated within the Validation Report):

- ▲ Details of the locations from which topsoil has been stripped;
- ▲ Records on quantities of materials relocated; and
- ▲ Details of the location to which the Topsoil has been placed.

6.3 Imported Materials and Verification

6.3.1 Pre-Importation Testing

In the event that any soils are required to be imported to the Site to be used in cover systems a detailed understanding of the provenance of such materials is to be provided to the Environmental Consultant ahead of any further investigation or import. As a minimum, this should include:

- ▲ The materials source location;
- ▲ The supplier details and proposed quantities for import; and,
- ▲ A description of how the soils have been generated (e.g. stockpiled for removal from a site or manufactured at a recognised supplier).

Soil materials being considered for importation shall be sampled at their source or manufacture location prior to import to Site. The soil samples shall be analysed at a UKAS accredited laboratory for the required laboratory chemical analyses and the results of these analyses (as detailed in Appendix D) shall be provided to the Environmental Consultant. Written approval from the Environmental Consultant shall be obtained prior to importing the soil to Site.

Some soil materials that are suitable for use on site may also be wastes (not products). Examples of such soils may include soils stripped from other developments prior to construction, soils sourced from third party sites and some manufactured soils. Care is needed when considering these materials for import. Further understanding of the provenance of these materials, additional laboratory chemical analyses and an exemption, permit or other form of regulatory control are likely to be required to be able to utilise these materials within the cover system. Adherence to the Duty of Care Regulations will also likely be required if waste soils are to be recovered in the scheme. The Environmental Consultant should be consulted well in advance of when these types of material are to be utilised. The Environmental Consultant will advise on the acceptability or otherwise of such materials and agree the pathway to be followed.

If chemical data for the soil cannot be provided, then the Contractor shall procure the Environmental Consultant to undertake appropriate testing prior to importation:

Samples shall be analysed for a minimum suite of:

- ▲ Asbestos screening;
- ▲ pH, heavy metals;
- ▲ Total petroleum hydrocarbons; and
- ▲ Speciated Polyaromatic Hydrocarbons (16 PAH).

The samples shall be truly representative of the soil to be offered.

It is assumed that imported soil will be provided from a greenfield or manufactured source, therefore, one representative sample shall be taken for every 250 m³ of imported soil to be used, with a minimum of 3 samples of each soil type shall be tested from each source/supplier. Site-won soils should be tested on a minimum 6 sample or 1 sample per 100m³ (whichever is greater) frequency.

The chemical criteria against which any imported soils shall be assessed is based on relevant Generic Assessment Criteria applicable at the time of the works for a residential end use, alternatively, Delta-Simons Human Health Generic Assessment Criteria as presented in Appendix C shall be used.

Type	Number of Samples	Testing Suite	Acceptance Criteria
Virgin quarried material	1 or 2 depending on the type of stone utilised, to confirm the inert nature of the material	Standard metals suite (As, Cd, Cu, Cr / Cr (VI), Pb, Hg, Ni, Zn)	Verified in accordance with Delta-Simons adopted Human Health Generic Assessment Criteria for Residential Housing end-use which are presented in Appendix D
Crushed hardcore, brick, concrete	Minimum 1 per 1,000m ³	Standard metals suite 16 PAHs Asbestos screen	
Greenfield / manufactured topsoil (off-Site source)	Minimum 3 or 1 per 250m ³ (whichever is greater)	Standard metals suite 16 PAHs Asbestos screen TPHCWG	
Brownfield / Site-won soils	Minimum 6 or 1 per 100m ³ (whichever is greater)	Standard metals suite 16 PAHs Asbestos screen TPHCWG	

The chemical criteria against which any imported soils shall be assessed is based on relevant Generic Assessment Criteria applicable at the time of the works for a residential end use (regardless of the intended use as materials should be free from contamination), alternatively, Delta-Simons Human Health Generic Assessment Criteria as presented in Appendix D shall be used.

Any materials which fail the verification testing shall be removed from the Site and replaced with suitable materials by the Contractor.

The verification information shall be included within the verification report.

6.3.2 Post-Placement Verification

Following the placement of the clean cover system in soft landscaped areas, the depth of cover must be physically inspected to confirm the minimum thicknesses detailed in Section 9.1 have been achieved.

The inspection is to be undertaken by the Environmental Consultant and will comprise (at least) inspection pits on a 25 m grid in soft landscaped areas.

It is anticipated that subsoil and topsoil may have been tested for chemical suitability prior to placement. However, as detailed in Section 9.2.2, for any areas where this is not the case, topsoil and subsoil shall be sampled from each inspection pit within soft landscaping areas.

These will be tested to confirm compliance with the GAC for a commercial end use.

The location of the inspection pits is to be determined by the Environmental Consultant to ensure a good spatial coverage.

The Environmental Consultant will record the overall depth of the clean cover along with the thickness of topsoil and subsoil, and the presence of a membrane or hard-dig layer. A photographic record of the excavation, with suitable scale, will be obtained for the Cover System Validation Report.

Should soils fail the applied criteria, then they shall be replaced by the Contractor with alternatively sourced soils and retested.

The inspection pit and testing frequencies required are summarised in Table 1 below. A copy is also presented in Appendix E; it is recommended that this is distributed to the Contractor for use on-Site during the groundworks.

	Soft Landscaping Requirements (required in all soft landscaping areas)
Clean cover thickness where Made Ground is present (must comprise chemically and physically validated subsoil and topsoil)	450 mm minimum cover consisting of: - 150 mm topsoil - 300 mm subsoil
Inspection Pit frequency (to confirm cover thickness and membrane depth, where required)	25 m grid: A minimum of 1 inspection pit per 25 m grid is required in soft landscaped areas
Testing frequency (coverage to be determined by Environmental Consultant)	Topsoil and subsoil: Samples required from each inspection pit on a 25 m grid in soft landscaped areas
If Made Ground is present at surface (Made Ground identified Site-wide)	Membrane required: Where Made Ground is present, a high visibility membrane or hard-dig layer should be installed to break a potential pathway to asbestos containing materials
If Made Ground is not present at surface (considered unlikely– contact Delta-Simons if no Made Ground is considered present)	No membrane required: Where the Made Ground has been removed in its entirety, the requirement for a clean cover system is negated and a suitable growing medium of at least 150 mm of topsoil should be provided

6.3.3 Cover systems and other potentially interacting site works

Careful consideration should be given to the programming of in-ground Site works with the potential to disturb the cover system once it has been placed. For example:

- ▲ Erection of fencing (where post holes are to be created and arisings generated);
- ▲ Planting of trees (considered to be significant);
- ▲ Services installation.

Ideally, these works (or similar), which would result in made ground being brought to surface, should be programmed to occur *before* installation of the cover system to avoid disturbance/cross-contamination of the cover soils.

In the event such works occur after placement of the cover system, care should be taken to control arisings to avoid such cross-contamination. Evidencing of the absence of cross contamination may be required.

6.4 Ground Gas Protection

Based on the former landfill underlying the Site and the heterogeneity of the landfill waste mass a CS3 classification was considered most suitable for the Site, and risk-protective of future Site users.

As such, gas protection measures will be required across the Site. This is including, but not limited to; proposed buildings, service corridors and service inspection chambers. Consideration should also be given to external areas of the proposed development. The external areas will need to allow some form of venting to prevent ground gas migration to the buildings. This could include permeable paving or limited areas of soft landscaping. This should be considered in the design of the development by the ground gas specialist.

6.4.1 Ground Gas Risk Summary

The ground gas data indicated elevated concentrations of both methane and carbon dioxide to be present on a Site-wide basis. This was attributed to the former landfill underlying the Site, the heterogeneity of the landfill waste mass and the varying proportions of biodegradable material.

As such, there is considered to be a plausible risk from hazardous ground gases on the Site and protection measures will be required as part of the proposed development to adequately mitigate such risks to future Site users.

6.4.2 Installation of Ground Gas Protection Measures

Ground gas protection measures (where required) shall be installed in accordance BS8485:2015 guidance as appropriate and should be agreed with the Local Authority prior to adoption.

It is recommended that the design and installation of the gas protection measures is required be carried out by a suitably qualified and experienced subcontractor to meet the requirements of the Local Authority and BS 8485:2015.

The design of the ground gas protection measures should be bespoke to the proposed buildings.

BS:8485 provides a scoring system to determine the appropriate protection measures for a proposed development in accordance with the identified ground gas regime. Table 3 of BS:8485 summarises typical UK building types, which for this development will comprise Type C (commercial office / retail). Table 4 details the points required for the Characteristic Situation, which for CS3 is 3. This can be achieved by a combination of the following:

- ▲ Structural barriers (Table 5);
- ▲ Ventilation (Table 6); and
- ▲ Gas Membrane (Table 7).

The above should be considered in conjunction with the proposed foundation / floor slab design to achieve the minimum score required within BS:8485. It is recommended that the installer of the membranes should have the appropriate qualifications (NVQ Level 2 'Gas Membrane Installations'). This installation requirements are discussed in further detail in Section 7.4.4 below.

6.4.3 Verification of Ground Gas and Soil Vapour Protection Measures

In order to meet the requirements of BS 8485:2015, it is recommended that the installation of the gas protection measures is verified by a suitably qualified and experienced specialist independent of the developer.

It is imperative that third party inspection of the membrane and ventilation installation is undertaken, whilst the gas membrane is visible.

Engineer's drawings confirming the inclusion of gas protection measures shall be included within the Verification Report.

The developer shall commission independent verification certification/integrity testing as outlined in BS 8485:2015 and photographs of the installed gas protection measures, copies of which should be provided for inclusion within the Verification Report. The frequency of independent inspection of gas protections should be undertaken in accordance with CIRIA C735.

The verification requirements are outlined in Section 7.4.4 below.

6.4.4 Gas Protection Installation & Verification Requirements

Pre Construction

- ▲ The Principal Contractor (PC) must hire an experienced contractor(s) to design (the "Designer") and to install (the "Installer") the ground-gas mitigation system (the "System") if there is insufficient capability with the PC;
- ▲ The proposed ground-gas/vapour mitigation system plan, design, and specifications should be submitted to the Local Planning Authority for review, approval via the discharge of conditions processes. This will provide formal evidence of its regulatory acceptance;

- ▲ The contractor conducting the installation of the membrane will ensure an independent 3rd party ground gas mitigation system verification company (the “System QA/QC Advisor”) is employed to conduct weekly verification Site visits (as a minimum), and as required and set out in a ‘Verification Plan’ document to be prepared by the System QA/QC Advisor in accordance with CIRIA document C735 ‘*good Practice on the Testing and Verification of Protection Systems for Buildings against Hazardous Ground Gases*’. The QA/QC testing frequency and techniques should be dictated by the System QA/QC Advisor. In the UK, the System QA/QC Advisor will be a member of the [British Verification Council](#). Detailed reporting of all Site visits including adverse findings and corrective actions must be completed;
- ▲ The membrane must be specifically designed for ground-gas mitigation. Prior to selection, the membrane specifications (from the manufacturer) must be provided to the Designer for review and must specify chemical resistance & vapour permeability/transmissivity;
- ▲ The PC delivering the construction phase will provide a Membrane Protection Plan (MPP) for approval by the Designer. The MPP will detail how the construction phase will be designed, staged and implemented to mitigate against damage to the membrane following installation. Particular attention will be given to:
 - The integration, at design stage, of the membrane installation, together with other elements of the proposed gas mitigation measures (e.g. venting) into the other construction activities on Site to minimise the risk of damage;
 - Concrete pours delivered in a manner to minimise/avoid trafficking of the membrane. If trafficking in localised areas is unavoidable suitable additional protection will be used;
 - Elimination of other vehicle trafficking on the membrane (with the exception of laser screed vehicles);
 - Limiting post-installation surface contamination of the membrane;
 - Limiting footfall on the membrane;
 - Appropriate working methods of concrete reinforcement mesh (rebar) installation, including avoiding working on, or cutting rebar on or close to, unprotected membrane and avoiding cutting methods which would generate sparks;
 - The working practices of follow-on trades, in particular ensuring suitable management of work areas and materials. In particular waste and equipment/tools storage will not be acceptable upon the membrane unless appropriate protection methods are adopted; and
 - The communication to staff working on or near the membrane and their (confirmed) understanding of the importance of membrane protection through, for example Site induction and toolbox talks.

Construction Phase

- ▲ The subgrade preparation will be in strict accordance with the membrane manufacturer’s requirements as set out in the materials data sheets. The membrane will be laid in accordance with manufacturer’s specification. It is the responsibility of the Installer to ensure that the subgrade is free of materials or other elements that could damage the membrane prior to its installation. A suitably compacted, fine-grained granular blinding layer or suitable geotextile must be placed below the membrane prior to concrete pour to protect it from damage;
- ▲ The Installer will notify the System QA/QC Advisor that the area on which the membrane has to be installed is acceptable. The Installer will also provide a ‘Certificate of Acceptance’ to a nominated representative of the groundwork contractor prior to commencement of the membrane installation in the specified area;
- ▲ The membrane must be placed under the entire building. Any sub-grade structures (elevator pits, sumps, loading docks) must also be sealed;
- ▲ Seams should be preferably heat welded in accordance with the membrane manufacturer’s specification;
- ▲ Following membrane installation, Site work will aim to minimise surface contamination of the membrane with coarse or angular particles, or other debris, which could cause damage if pressed into the membrane by for example the Laser Screed or staff walking on the membrane. Surface contamination will be removed prior to placement of the geotextile protection layer;

- ▲ The membrane must be protected from penetration from rebar during and following installation of the mesh. This would usually be achieved by placing a suitably protective geotextile protection layer/surface protection boarding over the membrane after verification but prior to rebar placement and concrete pour;
- ▲ Formwork systems with stakes which inevitably damage the membrane and require follow-on repairs which would include adhesive patches and/or application of a liquid sealing compound;
- ▲ Concrete pumping must be utilized to pour concrete. No traffic, other than the Laser Screed, is allowed on membrane post installation;
- ▲ While the use of a Laser Screed on the membrane is acceptable:
 - It must not be used or moved on top of rebar;
 - It must be set up at each location in such a way that the membrane is protected, for example by use of load-spreading pads below outrigger/stabiliser feet;
 - Excessive slewing of the Laser Screed should be avoided to minimise the risk of displacement/damage to the membrane or overlying protection measures;
- ▲ Ancillary buildings and any other full-time occupied structures on the Site:
 - Must be equipped with ground-gas mitigation; OR,
 - Must be raised off the ground;
 - Additionally, conduits, penetrations, and sub-surface utilities entering Site structures must be sealed/booted; and
- ▲ The PC will provide to the Designer (likely via the System QA/QC Advisor) regular well-organised and timely updates regarding installation and inspection/verification of the membrane.

Post Construction

- ▲ The PC will be responsible for ensuring appropriate independent verification inspection, reporting and provision to Delta-Simons for inclusion within the Verification Report. Where required under planning, achieving regulatory sign-off/discharge of relevant planning conditions relating to ground gas/soil vapour mitigation measures will remain the responsibility of the PC. Issues with discharge of planning conditions should be addressed by the PC and their appointed subcontractors;
- ▲ Post-construction, the PC must complete and provide the Client with an operation, maintenance, and monitoring (OMM) Plan for the installed ground-gas mitigation system; and
- ▲ The owner/operator is required to implement the OMM Plan for the installed System for the duration of their operation of the facility.

6.5 Water Pipes and Below Ground Utilities / Structures

6.5.1 Background

Concentrations of organic contaminants in soils represent a potential risk to standard plastic water supply pipes. Following the 1992 Foundation for Water Research (FWR) report an update Guidance for the Selection of Water Supply Pipes used in Brownfield Land (UKWIR 2010) has been produced.

Careful selection, design and installation of water supply pipes is required on potentially contaminated sites to ensure that pipelines are satisfactorily installed.

To fully comply with the guidance a specific and detailed investigation of each pipe route is considered to be required, at the time of the investigations, no information on the specific pipe routes was available.

It is likely that a more detailed assessment based on proposed water supply routes will be needed to satisfy the requirements of the local water supplier, the following general comments are provided.

6.5.2 Standard Pipe Materials / Upgraded Pipe Material Requirements

It is recommended that the local water undertaker is consulted by the Client prior to ordering and placement of pipes in order to specify their specific requirements, however, given the contamination identified on Site it is considered likely that a barrier pipe material will need to be adopted.

Details of any upgraded pipework should be provided to the Environmental Consultant for inclusion within the Verification Report.

6.5.3 Clean Service Corridors

Services and utility corridors should be backfilled with clean site won materials. In the event that imported materials are required, all material imported to Site for this use should be tested on a ratio of 1 sample per 250 m³ for a range of contaminants appropriate to the source of the material but to include testing for the presence of asbestos as a minimum.

The Contractor shall be responsible for providing the documentation associated with the testing of the imported service trench fill to the Environmental Consultant.

6.5.4 Ground Gas Protection for Below Ground Services

Consideration should be given to the prevention of hazardous ground gas accumulation in service corridors and service inspection chambers. These structures will need sufficient protection in order to prevent accumulation and also preferential migration of ground gases to the building.

Protection of the below ground services and associated structures should be designed by a suitably qualified specialist.

6.5.5 Sulphate Resistant Concrete

A requirement for sulphate resistant concrete Class DS-3 has been identified and the Contractor shall review and confirm the needs for sulphate resistant concrete.

The data suggests that the concentrations of ammonium within the groundwater present 'highly aggressive' conditions with regard to buried concrete and the guidance suggests that specialist advice should be sought in this instance.

7.0 Verification Reporting & Regulatory Approvals

7.1 General

Following completion of works detailed in Sections 4.0 to 7.0, for each phase of development, and Environmental Consultant shall prepare an Environmental Verification Report on the works for submission to the Local Authority to satisfy relevant planning conditions.

7.2 Verification - Enabling Phase

The Pre-Construction Phase Verification Report shall be produced upon completion of the Site demolition, remediation and earthworks. This report will include as a minimum:

Summary of works undertaken;

- ▲ Details of waste disposal of any material from the Site including waste transfer documentation and details of the receiving treatment/landfill facility;
- ▲ Confirmation of the chemical results, and transfer notes detailing the place of origin of any imported fill including any stockpiles left for the subsequent cover system; and,
- ▲ A record of any 'hotspots' found during construction and groundworks and the associated actions taken to remove them. This will include details of the chemical analysis of samples taken from these areas, verification that the entire hotspot has been removed as necessary, appropriate classification of the waste, waste transfer documentation, and details of the receiving disposal facility.

7.3 Verification – Construction Phase

The Construction Phase Verification Report shall be produced upon completion of the proposed development. This report will include as a minimum:

- ▲ Details of the placement of clean cover including the placement of geotextile, topsoil and subsoil through a verification record as described in this strategy;
- ▲ Confirmation of the chemical results, and transfer notes detailing the place of origin of any imported topsoil/ subsoil;
- ▲ Details of the ground gas protection measures installed along with the required verification information; and,
- ▲ Details of the final water pipe material utilised within the development.

7.4 Regulatory Approvals and Planning Condition Discharge

It is intended that this report be submitted to Havant Council to support the outline planning application / discharge relevant contaminated land planning conditions (in conjunction with earlier technical reports).

Figures

Figure 1 – Site Location Map

Figure 2 – Exploratory Hole Location Plan

Drawings

Drawing 1 – Proposed Landscape Plan

Appendices

Appendix A – Limitations

Limitations

This Report was prepared by Delta-Simons Environmental Consultants Ltd (Delta-Simons) for the sole and exclusive use of the Client and for the specific purpose for which Delta-Simons was instructed. Nothing contained in this Report shall be construed to give any rights or benefits to anyone other than the Client and Delta-Simons, and all duties and responsibilities undertaken are for the sole and exclusive benefit of the Client and not for the benefit of any other party. Delta-Simons does not intend, without its written consent through a formal letter of reliance or warranty, for this Report to be disseminated to any party other than the named Client or to be used or relied upon by any party other than the named Client. Use of the Report by any other party is unauthorised and such use is at the sole risk of the user. Any party using or relying upon this Report, other than the Client, agrees by virtue of its use to indemnify and hold harmless Delta-Simons from and against all claims, losses and damages (of whatsoever nature and howsoever or whensoever arising), arising out of or resulting from the performance of the work by Delta-Simons. Unless explicitly agreed otherwise, in writing, this Report has been prepared under Delta-Simons' Standard Terms and Conditions as included within our proposal to the Client.

The recommendations contained within this Report represent Delta-Simons professional opinions, based upon the information detailed within the Report, exercising the reasonable skill and care to be expected of a professional consultant holding itself out as having the competence, experience and resources necessary for the purpose of carrying out similar work in scope and character to the services performed. The Report needs to be considered in the light of the proposal and associated limitations of scope. The Report needs to be read and considered in full and isolated sections cannot be used without full reference to other elements of the report and any previous works referenced within the Report.

Where Delta-Simons has obtained, reviewed and evaluated information in preparing this Report from the Client and others and Delta-Simons conclusions, opinions and recommendations has been reasonably determined using this information, Delta-Simons does not warrant the accuracy of the third-party information provided to it and cannot be responsible for any opinions which Delta-Simons has expressed, or conclusions which it has reached in reliance upon information which is subsequently proven to be inaccurate.

Site surveys document the conditions encountered at the time of survey only and conditions may change due to natural processes or human intervention. As such, surveys represent an assessment at a specific point in time and Delta-Simons cannot be responsible for adverse conditions which arise or become apparent after the time of the survey or for conditions which sit outside the scope for which the survey or Report was commissioned.

Where intrusive investigations have been completed, information, comments and opinions given in this report are based on the ground conditions encountered during the site work period and on the results of laboratory and field tests performed during the investigation. Ground conditions are inherently variable such that no investigation can be exhaustive to the extent that all adverse conditions are revealed. Conditions may therefore be present beneath the site that were not apparent in the data reviewed or obtained as part of this assessment. It should be noted that groundwater levels vary due to seasonal and other effects and may at times differ to those measured during the investigation. Delta-Simons does not warrant or guarantee that the Site is free of hazardous or potentially hazardous materials or conditions. Where risk assessment is undertaken, this is based upon the standards, guidance and common practice at the time of the assessment and Delta-Simons cannot be responsible for conditions which become apparent following changes in guidance or practice or advancements in scientific knowledge which change the position in relation to assessment of risk.

No aspect of this Report constitutes a design. Where this information is used in design, the designer should verify the information has been used appropriately.

Where budgets are prepared and presented within the Report, these are for information only to indicate the likely magnitude of a cost and do not represent an invitation to treat for the works. All budgets and programmes presented should be reviewed and verified by appropriately qualified and experienced independent Project Managers and Cost Consultants.

Appendix B - 'Hotspot' Protocol

Protocol for Addressing Previously Unidentified 'Hotspots' of Contamination

As with any Brownfield development, there is a possibility that an unknown area of soil contamination may be encountered during excavation works. Should an area of contamination be identified by visual or olfactory means the following procedure will be followed:

- ▲ Immediately stop all works in the area where contamination is suspected;
- ▲ Immediately inform the Site Agent who should then contact the Environmental Consultant;
- ▲ The Environmental Consultant will provide a verbal response outlining immediate actions with regard to Site Health and Safety and to limit the potential for contaminants to migrate;
- ▲ The Environmental Consultant will judge each occurrence on merit and should it be deemed necessary. The Environmental Consultant will attend Site to oversee the removal of the 'hotspot' and collect validation samples;
- ▲ Any excavated material should be isolated from all other material at the Site, on plastic sheeting and covered with plastic sheeting until the material can be tested for contamination and an appropriate disposal route can be identified;
- ▲ Any 'hotspot' stockpiles and excavations should be fenced off, have appropriate signage and their locations recorded on a Site drawing;
- ▲ Should any excavated material be required to be disposed of at an off-Site location, the material will be isolated from all other material at the Site prior to disposal at a suitably licensed facility. All documentation associated with the movement and disposal of any such material will be supplied to The Environmental Consultant, including waste transfer documentation;
- ▲ Subject to appropriate Site Health & Safety controls (typically comprising fencing off the excavation) the excavation will remain open until the validation has been completed. Alternatively, for Site Health & Safety reasons, it may be necessary to backfill the excavation with Site derived material. In this case, the location of the excavation will be accurately recorded and the excavation reopened if required, based on the validation results; and
- ▲ The Regulatory Authorities shall be informed by the Environmental Consultant of any remedial activities required and associated validation testing results. Representatives of these organisations may also wish to visit the Site.

Appendix C – Imported Soils Assessment Criteria

The following Generic Assessment Criteria shall apply as absolute limits for all soils imported for re-use as clean cover **regardless of the end use of the Site**.

The criteria selected are based on Residential with Plant Uptake land use scenario on the basis that imported clean cover soils should be 'clean' and not result in an increase in contaminant loading. It may be possible, in some circumstances, to agree alternative, higher criteria with the appropriate regulatory body, however, this is outside of the scope of this assessment.

Soils shall be tested for a suite of contaminants appropriate to the source land use but as a minimum for the contaminants stated below unless otherwise stated within this strategy. The below criteria assume a minimum of 1% Soil Organic Matter.

In addition to meeting the criteria below, imported materials shall be free from deleterious inclusions and shall be free from invasive weeds (Japanese Knotweed).

Any testing for asbestos must be from a UKAS accredited laboratory and the only acceptable criteria is 'Not Detected'. Any detected asbestos, even is reports as <0.001% is not acceptable. Asbestos containing soils must not be used for clean cover materials.

Criteria for Imported Materials			
Compound	GAC	Source	Comment
Arsenic	37	C4SL	
Cadmium	11	LQM	
Chromium (III)	910	LQM	
Chromium (VI)	6	LQM	
Copper	2400	LQM	
Lead	200	C4SL	
Mercury (inorganic)	40	LQM	
Nickel	130	LQM	
Selenium	250	LQM	
Zinc	3700	LQM	
Acenaphthene	210	LQM	
Acenaphthylene	170	LQM	
Anthracene	2400	LQM	
Benzo[a]anthracene	7.2	LQM	
Benzo[a]pyrene	2.2	LQM	
Benzo[b]fluoranthene	2.6	LQM	
Benzo[ghi]perylene	320	LQM	
Benzo[k]fluoranthene	77	LQM	
Chrysene	15	LQM	
Dibenz[ah]anthracene	0.24	LQM	
Fluoranthene	280	LQM	
Fluorene	170	LQM	
Indeno[123-cd]pyrene	27	LQM	
Naphthalene	2.3	LQM	
Phenanthrene	95	LQM	

Criteria for Imported Materials			
Compound	GAC	Source	Comment
Pyrene	620	LQM	
Benzene	0.2	C4SL	
Toluene	130	LQM	
Ethylbenzene	47	LQM	
Xylene – m/p	56	LQM	
Xylene - o	60	LQM	
Total Petroleum Hydrocarbons (TPH)	500		Professional judgement.
Aliphatic EC5-EC6	42	LQM	
Aliphatic >EC6-EC8	100	LQM	
Aliphatic >EC8-EC10	27	LQM	
Aliphatic >EC10-EC12	130	LQM	
Aliphatic >EC12-EC16	500	LQM	Capped at 500 - professional judgement
Aromatic >EC5-EC7	70	LQM	
Aromatic >EC7-EC8	130	LQM	
Aromatic >EC8-EC10	34	LQM	
Aromatic >EC10-EC12	74	LQM	
Aromatic >EC12-EC16	140	LQM	
Aromatic >EC16-EC21	260	LQM	
Aromatic >EC21-EC35	500	LQM	Capped at 500 - professional judgement
Asbestos	Not Detected		

The respective sources are:

- ▲ Soil Guidance Values (**SGV**) published by the EA;
- ▲ Category 4 Screening Levels (**C4SLs**) published by DEFRA;
- ▲ The 2014 Land Quality Management (**LQM**) / Chartered Institute of Environmental Health (CIEH) Suitable for Use Levels for Human Health Risk Assessment (S4ULs);
- ▲ The guidance values produced by the Environmental Industries Commission (**EIC**), the Association of Geotechnical and Geoenvironmental Specialists (AGS) and Contaminated Land: Application in Real Environments (CL:AIRE) in December 2009; and
- ▲ In house Generic Screening Values (**DS-GACs**) derived by Delta-Simons.

Appendix D – Inspection Pit and Testing Frequencies

Inspection pit and testing frequencies required are summarised below.

It is recommended that this is distributed to the Contractor for use on-Site during the groundworks.

	Soft Landscaping Requirements (required in all soft landscaping areas)
Clean cover thickness where Made Ground is present (must comprise chemically and physically validated subsoil and topsoil)	450 mm minimum cover consisting of: - 150 mm topsoil - 300 mm subsoil
Inspection Pit frequency (to confirm cover thickness and membrane depth, where required)	25 m grid: A minimum of 1 inspection pit per 25 m grid is required in soft landscaped areas
Testing frequency (coverage to be determined by Environmental Consultant)	Topsoil and subsoil: Samples required from each inspection pit on a 25 m grid in soft landscaped areas
If Made Ground is present at surface (Made Ground identified Site-wide)	Membrane required: Where Made Ground is present, a high visibility membrane or hard-dig layer should be installed to break a potential pathway to asbestos containing materials
If Made Ground is not present at surface (considered unlikely– contact Delta-Simons if no Made Ground is considered present)	No membrane required: Where the Made Ground has been removed in its entirety, the requirement for a clean cover system is negated and a suitable growing medium of at least 150 mm of topsoil should be provided