



Geo-Environmental

INTERIM VERIFICATION REPORT (SOIL COVER SYSTEM)

for the site at

PLOTS 40-41, CORNFIELD CLOSE,

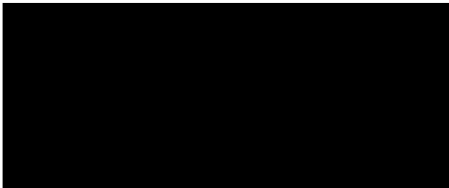
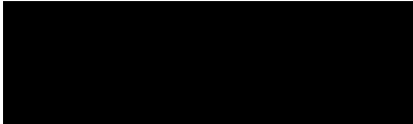
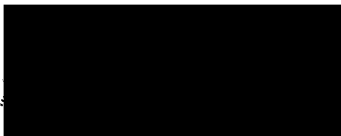
LITTLEHAMPTON,

WEST SUSSEX, BN17 6LD

on behalf of

THAKEHAM CLIENT LTD



Report:	INTERIM VERIFICATION REPORT (SOIL COVER SYSTEM)
Site:	PLOTS 40-41, CORNFIELD CLOSE, LITTLEHAM, WEST SUSSEX, BN17 6LG
Client:	THAKEHAM CLIENT LTD
Date:	19/03/2021
Reference:	GE18103/INTVR-SOIL/PLOTS 40-41/MAR21
Version:	1.0
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**AMENDMENT RECORD**

Revision ref.	Date	Reasons for amendment	Author's initials	Reviewed by	Authorised by
1.0	19/03/2021	First issue Soil Cover Validation for Plots 40-41 (Validation for Plots 1-15 (gas protection measures, soil cover system and groundwater), have previously been issued under separate cover, report ref: GE18103/VR/JAN21, Validation for Plots 16-49 (gas protection measures) issued under report ref: GE18103/INTVR/FEB21, and Validation for Plots 36-39 (soil cover system) issued under report ref: GE18103/INVR/MAR21)	FG	LL	SA



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FIGURES

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FIGURE 3	Validation Sample Location Plan (Plots 40-41)

APPENDICES

APPENDIX A	Topsoil Delivery Tickets and Topsoil/Subsoil Analysis (Provided by Client)
APPENDIX B	Visual Inspection Records of Soil Cover System Installation
APPENDIX C	Independent Geochemical Laboratory Test Results for Topsoil



1.0 INTRODUCTION

1.1 General

Following several phases of investigation and assessment for the site, as reported in the Phase I desk study (ref. GE16903-DSR-DEC17) baseline ground investigation (ref. GE16903-BGIR-JAN18) and further Phase II intrusive investigation (ref. GE17106- GAR/AP01/231018) undertaken and reported by Geo-Environmental Services Limited, together with subsequent development of a Remediation Strategy and Verification Plan (RSVP), referenced GE17106-RSVPv1.2-GE-NOV19 and Water Quality Monitoring Plan (WQMP), referenced GE18103/WQMP/NOV19, Geo-Environmental was instructed by Thakeham Client Ltd to prepare a Verification Report to compile the relevant information in relation to the residential development for Plots 36-39, Cornfield Close, Littlehampton, West Sussex, BN17 6LG, herein referred to as 'the site' (see Figure 1). This report relates specifically to the installation and validation of the soil cover system within Plots 36-39. At the time of reporting private gardens and areas of soft landscaping of further plots on site were not ready for final validation inspections and this, together with gas validation of further plots, will be validated within a separate verification (or updated) report in due course.

Previous phases of validation works onsite has already been undertaken and reported for the site under GE18103/VR/JAN21, which presented the validation of ground gas protection measures and soil cover systems associated with Plots 1-15 and groundwater analysis and controlled water requirements for the whole site, GE18103/INTVR/FEB21, which presented the validation of ground gas protection measures for Plots 16-49 and Block A only and GE18103/INTVR/MAR21, which presented the validation of the soil cover system installed within plots 36-39 only. This report does not duplicate the validation information already presented within these reports, but instead reports on works subsequently undertaken in relation to the installation of a soil cover system in Plots 40-41 finished in February 2021.

This report sets out the works undertaken to date to provide independent verification of the risk mitigation measures incorporated into the development to protect the development and end users thereof. This report provides final validation for works undertaken and independent inspection in relation to Plots 40-41 only with respect to the installed soil cover system.

1.2 Objectives

A desk study and ground investigation undertaken by Geo-Environmental identified the presence of potential hazards and through a risk assessment process a series of pollutant linkages were identified which require action to mitigate or otherwise reduce the risk. The Remediation Strategy and Verification Plan (RSVP) sets out the proposed remedial works to be undertaken on the subject site to support its development for a proposed residential end use. The Water Quality Monitoring Plan presents the monitoring works that would be undertaken prior to, during and following the intrusive element of development works (cut and fill and piling works).

This Verification Report (VR) presents the details and findings of inspection visits undertaken throughout the construction period by Geo-Environmental and/or to compile data provided by the Client with respect for Plots 40-41 in order to demonstrate that the soil risk mitigation measures were implemented within these Plots only.

1.3 Planning Permission

It is understood that a planning application has been approved for the site by Arun District Council under Planning Reference LU/330/18/PL. The following pre-occupation planning conditions have been attached to the application which relate to the validation of land contamination in relation the development. Where conditions required the submission and agreement of works pre-commencement it is understood that those elements of the conditions have been completed and agreed.



Condition 9:

Within 3 months of the start of the development, the Developer shall agree a timetable for submission of periodic verification reports to demonstrate the completion of works set out in the approved remediation strategy and the effectiveness of the remediation. The reports shall include a maintenance plan in respect of contamination, including a timetable of monitoring and shall be submitted to, and approved in writing, by the local planning authority. The report shall include results of sampling and monitoring carried out in accordance with the approved verification plan to demonstrate that the site remediation criteria have been met. The development shall proceed in accordance with approved details.

Reason: To ensure that the site does not pose any further risk to human health or the water environment by demonstrating that the requirements of the approved verification plan have been met and that remediation of the site is complete in accordance with Arun Local Plan policies QE SP1 and QE DM4

Condition 10:

If during development, contamination not previously identified, is found to be present at the site then no further development (unless otherwise agreed in writing with the Local Planning Authority) shall be carried out until a remediation strategy detailing how this contamination will be dealt with has been submitted to and approved in writing by the Local Planning Authority. The remediation strategy shall be implemented as approved.

Reason: To ensure that the development complies with approved details in the interests of protection of the environment and prevention of harm to human health in accordance with Arun Local Plan policies QE SP1 and QE DM4.

Condition 11:

Piling & investigation boreholes using penetrative methods shall not be carried out other than with the written consent of the Local Planning Authority. The development shall be carried out and completed in accordance with details so approved.

Reason: To prevent pollution of groundwater in accordance with Arun Local Plan policy W DM1.



2.0 BACKGROUND

This Validation Report has been produced in order to demonstrate that the works required and presented within the Remediation Strategy and Verification Plan (RSVP) and Water Quality Management Plan (WQMP) have been carried out. The RSVP and WQMP for the site were developed following several phases of investigation works for the site, including a Phase I desk study (ref. 16903-DSR-DEC17) baseline ground investigation (ref. 16903-BGIR-JAN18) and further Phase II intrusive investigation (ref. GE17106- GAR/AP01/231018) undertaken and reported by Geo-Environmental Services Limited. Whilst a summary of these reports is presented below, reference should be made to the full reports for further details.

2.1 Proposed Site Use

The proposed development comprised the construction of 77No. residential units with private gardens, soft landscaping, amenity space, parking, roadways and associated infrastructure.

2.2 Investigation and Assessment

A summary of the findings of previous investigations and reports is presented below:

- The site was most recently utilised as a caravan park comprising caravan plots and hardstanding from a former wash block. The northern most portion of the site comprised accommodation with the southern portion of the site recreational space;
- The ground conditions beneath the site generally comprised a thickness of Made Ground (depths up to 2.90m bgl) overlying the River Terrace Deposits over the Lewes Nodular Chalk Formation at depth;
- The encountered Made Ground materials were found to generally comprise landfill type material of mixed composition comprising sandy clay and silty sand with brick, glass, plastics, metal, china, ash, coal, concrete, black organic matter, shoes, fabric, timber and flint gravel;
- River Terraced Deposits were found to underlie the Made Ground and was generally found to comprise medium dense orange-brown sandy clay becoming orange brown sand with flint gravel with slight traces of chalk at depth.
- Groundwater was encountered within boreholes between depths of 7.50m and 9.00m bgl during the intrusive investigation works. Return monitoring between 28th August 2018 and 19th October 2018 encountered groundwater between depths of 6.00m and 7.10m bgl.
- Thirty-four soil samples were submitted for analysis of a comprehensive suite of commonly occurring contaminants augmented with speciated hydrocarbon analysis and asbestos screening. Nine of these samples were used for leachate testing. Ten additional samples were analysed for VOCs, SVOCs, PCBs and ammoniacal nitrogen. A further ten samples were analysed for Waste Acceptance Criteria tests.
- The testing showed that near surface soils were impacted by Arsenic, Lead, PCBs, VOCs, SVOCs and Asbestos.
- Remediation, or risk mitigation measures were recommended to be required to protect end users from the contaminants identified in the Made Ground within private gardens and areas of soft landscaping.
- Groundwater samples were analysed during the monitoring visits and were tested for a comprehensive suite of commonly occurring contaminants, VOCs, SVOCs, BOD, COD, electrical conductivity, suspended solids and PCBs.
- Groundwater testing showed isolated elevated concentrations of Selenium, PAHs and Boron within the groundwater.
- Based on the testing results and the development proposals to include the introduction of 50% hardcover (houses/roads etc.), together with the excavation of significant volumes of the Made Ground material to accommodate the development, it was considered that the proposed development would improve the site status in respect of the leaching of contaminants from the Made Ground/Landfill materials, and the development would provide a betterment in terms of groundwater contamination.



- It was considered that no specific measures with respect to protection of groundwater are required on the site. A Qualitative Piling Risk Assessment (QPRA), reference GE18103/QPRA/JUL19, dated 10th July 2019 and Water Quality Management Plan (WQMP), reference GE18103/WQMP/NOV19, dated 15th November 2019 were also undertaken for the site in relation to the proposed foundation solution to be utilised on the site.
- Ten cable percussive boreholes were installed with two monitoring standpipes within each location (BH101-BH110) during the intrusive investigation works. Spot monitoring was undertaken on a single occasion within each location. Continuous gas monitoring was undertaken within ten gas monitoring standpipes (BH101-BH110) for a period of 3 weeks. The monitoring locations were sited within the former landfill area.
- Spot monitoring detected methane at concentrations in the range 0-8.5%, carbon dioxide in the range 0-19.4% and oxygen in the range 0-19.4%. VOCs were detected up to 3.2ppm. Borehole flow rates were only detected within two monitoring standpipes, BH101d and BH102s, and ranged from 0.9l/hr to 3.0l/hr.
- The continuous gas monitoring identified methane in the range 0-6.53%, carbon dioxide in the range 0.52-25.2% and oxygen in the range 0.06-18.53%. Carbon monoxide was detected in the range 0-19.43ppm, hydrogen sulphide in the range 0-3.89ppm and VOCs in the range 0-1.7ppm.
- The gas assessment based on the monitoring data indicated that the sites gassing regime was representative of Characteristic Situation 2/ Amber 2, for which remediation measures were considered necessary.
- A discovery strategy was also developed for the site. Where unexpected conditions or contamination are encountered as part of the works these were to be addressed under the discovery strategy in place for the site.

2.3 Conceptual Site Model

The conceptual site model (CSM) developed as part of the risk assessment identified particular hazards, or potential hazards which were considered to require intervention (remediation) to mitigate the risk of harm.

2.4 Approach for Remediation, Monitoring and Validation

Remediation works were proposed to break the pathways of identified sources of contamination to receptors. The aim of the remediation was not necessarily to remove all contamination from the site but to provide betterment and to reduce the identified risk to an acceptable level with respect to relevant receptors, e.g. human health, the built environment and controlled waters.



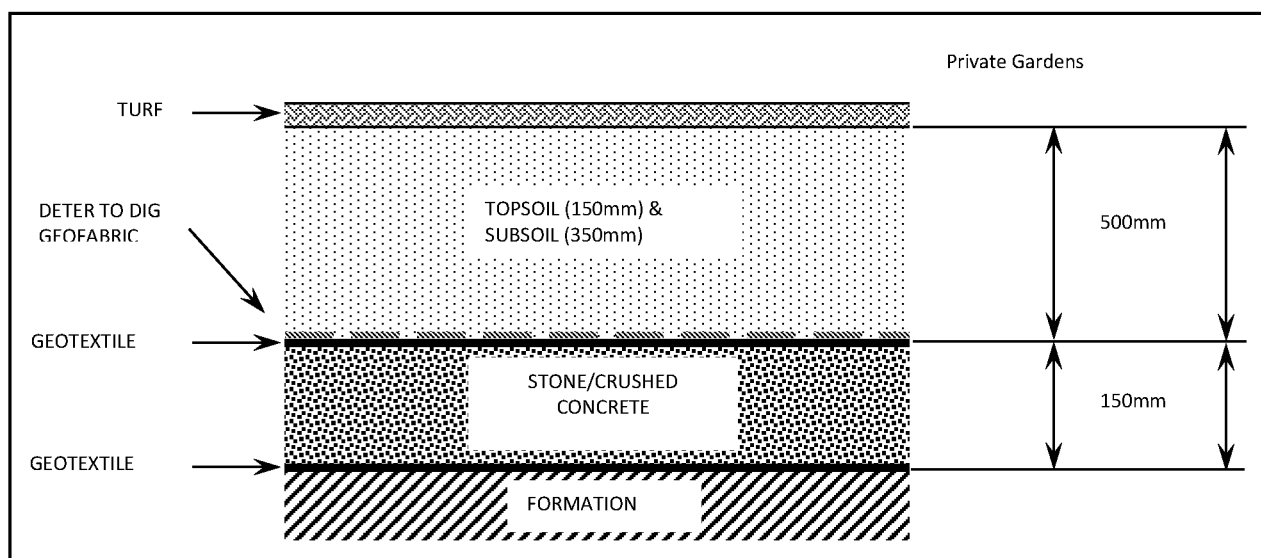
3.0 SOILS

3.1 End Users (Shallow Soils)

With reference to report Ground Appraisal Report for the site GE17106 - GAR/AP01/231018, through a process of statistical analyses on the results of chemical analyses on both deeper and near surface soil samples, it was considered that the near surface soils have been impacted by Lead, Arsenic, PCBs, SVOCs, VOCs and ACMs and remedial measures were deemed necessary to protect end users of the proposed properties from soil contamination within private garden and soft landscaped areas. Furthermore, the physical quality of all near surface soils was deemed unsuitable for inclusion in private gardens due to the presence of concrete, brick, and tarmacadam. In addition, ACMs and asbestos fibres have been identified both visually and within chemical analysis to be present within the Made Ground.

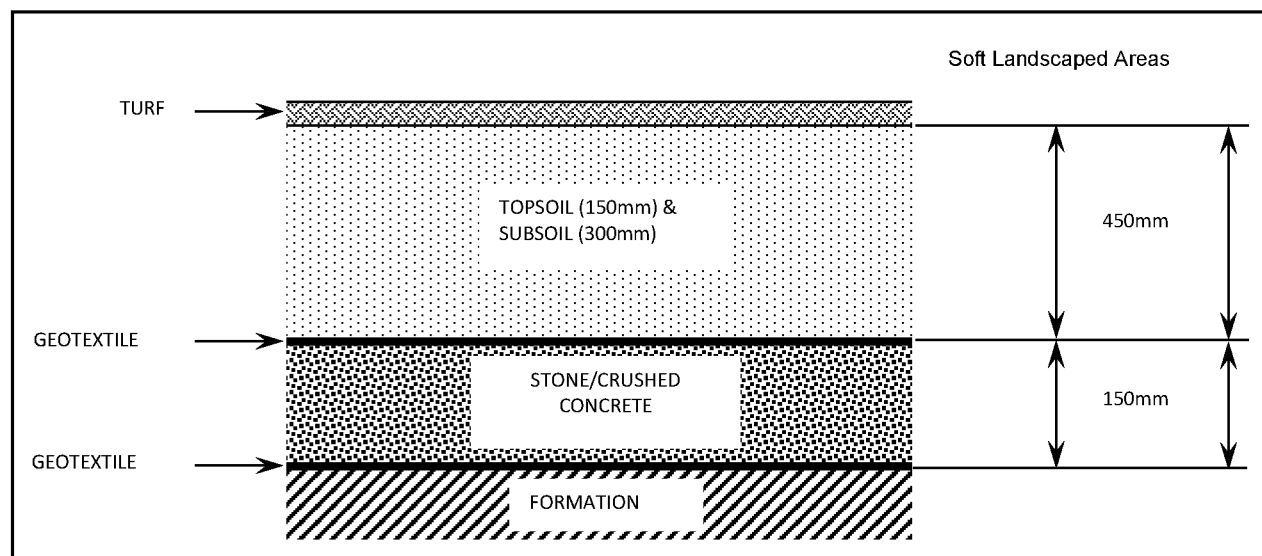
In areas remote from those designated for tree root protection it was recommended that the Made Ground beneath be removed or the site raised to a depth of 650mm and be replaced with chemically and geotechnically suitable material with a high visibility marker geotextile layer such as Terram High-Vis placed at the base between the imported soils and a capillary break layer comprising crushed stone or hardcore of 150mm and underlain by a further layer of Terram.

An example of the cover system for use in private gardens is provided below:





An example of the cover system for use in areas of soft landscaping is provided below:





4.0 IMPORTATION OF MATERIALS

4.1 Topsoil (Plots 40-41)

The chain of custody (COC) delivery certificates for Topsoil materials imported into site for use within Plots 40-41 were provided by to Geo-Environmental by Thakeham (the Client) and/or Bell (the Groundworks Contractor), copies of which are presented within Appendix A. Geochemical analysis was provided for the source site for the Topsoil materials prior to importation to site. A copy of this analysis is also presented in Appendix A. It should be noted that the entirety of the soil cover system within Plots 40-41 was formed of Topsoil.

Further independent sampling and analysis of this materials was undertaken by Geo-Environmental following the placement of this material with the private gardens of Plots 40-41. The results of this independent validation analysis testing are presented in Appendix C detailed and detailed and discussed within Section 5 of this report.

5.0 INSPECTION/VALIDATION (SOILS)



5.1 Validation inspection of Topsoil and sampling of Topsoil (cover system) placement associated within private gardens (Plots 40-41)

The inspection/ validation works of the cover systems installed within the private gardens were undertaken by a Geo-Environmental Engineer on the 25th February 2021. The visual inspection records including site photographs and hand pit logs are presented in Appendix B.

Inspection comprised two independent shallow hand pits (Plot 40- Plot 41) which were excavated by the ground workers under the supervision of an engineer from Geo-Environmental within each of the rear garden areas of Plots 40-41, to confirm the presence of a geo-textile type membrane and the thickness of the soil cover system. The location of these hand pits is presented on Figure 3, photographs and site inspection records taken during this inspection visit are presented in Appendix B, which confirm the depth of the installed Topsoil with the cover system installed, along with soil logs of the material encountered. It should be noted that at the point of inspection the Turf and the final 100mm of the soil likely associated with the turf placement had not been laid within any of the rear garden areas at the time of the inspection.

The inspection confirmed that in all inspected areas (hand pits Plot 40 and Plot 41) a deter-to-dig Geo-textile type membrane was present beneath the Topsoil and the Topsoil was found to be between 700mm and 750mm in thickness within all hand pits. Geo-Environmental were informed by the groundworkers and the Thakeham site managers that a capillary break layer was installed beneath the deter-to-dig membrane, however independent validation of this element was not undertaken by Geo-Environmental. It is understood that Thakeham have photographs of the placement of the capillary break layer but they have not be provided to Geo-Environmental to date.

Two soil samples, referenced Plot 40 at 0.4m bgl and Plot 41 at 0.1m bgl, were submitted to a UKAS accredited laboratory for testing for a suite of commonly occurring brownfield contaminants including asbestos screening. The laboratory test results are presented within Appendix C.

The results of the analyses were compared to the Suitable for Use (S4UL) Levels for 'private gardens with home-grown produce' (representative of the proposed development end use), which are summarised in Table 5.1 below:

Determinand	Soil Screening Value (mg/kg)	Sample Max. Conc. (mg/kg)	Below Screening Value?
Arsenic	37	21.9	Yes
Benzo(a)pyrene	2.7	1.0	Yes
Beryllium	1.7	1.0	Yes
Boron (Water Soluble)	290	1.3	Yes
Cadmium	11	<0.5	Yes
Chromium (Total)	130	54.5	Yes
Copper	2400	39.1	Yes
Hexavalent Chromium	6	<0.8	Yes
Lead	200	153	Yes
Mercury (inorganic)	40	<0.5	Yes
Nickel	180	36.9	Yes
Phenols	110	<6.0	Yes
Selenium	250	<1.0	Yes
Total Petroleum Hydrocarbons	110	36.7	Yes
Vanadium	410	66.2	Yes



Determinand	Soil Screening Value (mg/kg)	Sample Max. Conc. (mg/kg)	Below Screening Value?
Zinc	3700	139	Yes

Table 5.1 Summary of chemical analyses (Plots 40-41 Inspection Visit 25/02/2021)

The results indicated that all of the determinands tested, were below the limiting concentrations set within the Remediation Strategy and Verification Plan (RSVP).

All samples were submitted for asbestos screening and returned with no asbestos fibres identified.

In addition, the results of the speciated hydrocarbon analyses were all returned as either below the laboratory detection limits or below their respective human health screening values for the proposed end use.

A further two validation samples from Plots 40-41, Plot 40 at 0.1m bgl and Plot 41 at 0.4m bgl, were submitted for a nutrient testing suite. The results of the soils tested were compared to the Table 1 from BS3882:2015 entitled 'Specification for topsoil'.

The results are summarised in Table 5.2 below:

Parameters	Limits for Multipurpose Topsoil	Sample Range	Within acceptable Limits?
<u>Maximum Coarse Fragment Content (%)</u>			
Stones >2mm	30	9-19	Yes
Stones > 20mm	10	<1-5	
Stones >50mm	0	<1	
<u>Mass loss on ignition %</u>			
Clay 5% to 20%	3 to 20	2.55-3.85	Results are <3.0%
Soil pH	5.5 to 8.5	7.7-8.3	Yes
<u>Plant nutrient content</u>			
Total nitrogen %	>0.15	0.10-0.13	Results are <0.15% total for Nitrogen
Extractable phosphate mg/l	16 to 140	60-79	
Extractable potassium mg/l	121 to 1500	129-198	
Extractable magnesium mg/l	51 to 600	53-90	
Carbon:nitrogen ratio	<20:1	14.5-16:8	Yes
Electrical conductivity $\mu\text{S}\cdot\text{cm}$	<3300	2300-2520	Yes
<u>Potentially Phytotoxic Elements</u>			
Zn mg/kg	<200	59.7-139	Yes
Cu mg/kg	<135	14.0-39.1	
Ni mg/kg	<75	15.6-36.9	
<u>Visible contaminants</u>			
% m/m	<0.5	<0.01	Yes
...of which plastics	<0.25	<0.01	

Table 5.2 Summary of BS8332 Topsoil Analysis (Plots 40-41, Inspection Visit 25/02/2021)

The results demonstrate that the Topsoil soils analysed are in accordance with BS3882:2015 Multipurpose Topsoil, with the exception of a slight shortfall of mass loss of ignition in one sample and total Nitrogen. It may therefore be necessary to add a nitrogen based fertiliser to the Topsoil within Plots 40-41 prior to the laying of turf to increase the nitrogen levels to provide a suitable growing medium. However, these soils would still be considered to be suitable as a low fertility topsoil.



6.0 DISCOVERY STRATEGY

A discovery strategy remains in place throughout the development works on this site. Geo-Environmental have not been made aware of any discoveries having been made to date and thus the strategy, as set out in the RSVP did not require enacting. However, the strategy remains in place for the remainder of the development works.



7.0 VERIFICATION

In accordance with the Client's instruction, Geo-Environmental undertook routine and independent inspection during key stages of the construction process. The risk mitigation measures in relation to remedial measures, installation of a soil cover system for Plots 40-41, have been inspected and were considered to comply with the requirements of the design and Remediation Strategy and Verification Plan at the point of inspection. Further plots and validation works for the site will be reported via an updated report or under separate cover in due course.

The inspection of the installed soil cover system was undertaken by Geo-Environmental via the excavation of a selected number of hand pits. There was no visual evidence on the site to indicate that the areas remote from the pits undertaken were likely to differ significantly from the areas where the pits had been undertaken for inspection. However, the confirmation of the presence of a geo-textile membrane, the confirmation of depth and composition of subsoil and Topsoil has only been independently verified by Geo-Environmental within these hand pit locations. It has been assumed that these hand pits are representative of the imported soils within the garden areas of Plots 40-41.

Geo-Environmental can only verify the installation of a cover system at the locations and depths inspected at the time of inspections. Geo-Environmental accepts no liability for areas that have not been directly inspected or works that have subsequently been undertaken on the site following our inspection visit(s) that may in any way alter or affect the validation works inspected and reported herein.

The report relates solely to the validation of the soil cover system installed within Plots 40-41. Validation with respect the remaining Plots and other remedial measures will be presented under separate cover in due course.