



CCG-C-21-12273

**COMBINED PHASE I-II GEOENVIRONMENTAL REPORT
FOR LAND AT MOSS GREEN CLOSE
HUYTON
LIVERPOOL
L36 3RG
MAY 2021**

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1.0 INTRODUCTION

CC GEOTECHNICAL LIMITED (CCG) is providing consultancy services to **BUILT GROUP LIMITED** (the *Client*) in connection with the proposed redevelopment of land fronting on to Green Moss Close, Huyton Liverpool, L36 3RG.

It is understood that the site is to be redeveloped for residential use by the construction of a 2-storey apartment block forming 8nr self-contained apartments with associated car parking bays and areas of communal landscaping, together with 6nr 2-storey residential properties constructed in traditional brick elevations under pitched roofs, each with private driveway and private front and rear gardens. The development will include a new paved access road

The proposed site layout is shown on the **LEVEL 2 ARCHITECTS** plan contained herein.

The proposed development falls within the administrative jurisdiction of **KNOWSLEY METROPOLITAN BOROUGH COUNCIL**.

A combined desk study and ground investigation report was prepared, to provide environmental and geotechnical data relevant to the planning, design, and construction of the project.

The findings of these studies and investigations are discussed hereunder.

This report should be read in conjunction with the Notes on Limitations, given in Appendix L.

2.0 PURPOSE & AIMS OF THE STUDY & INVESTIGATION

The primary aim of the Phase I Desk Study was to assess whether the site is likely to be affected by contamination, to an extent that it may pose a risk to human health and/or the built environment and/or the wider natural environment or is affected by any other natural or artificial feature which may impact on the proposed development. Specific tasks undertaken to achieve this were as follows:

- A review of available information including historical mapping, commercial environmental databases, and Environment Agency Data
- The undertaking of a site walkover
- The development of a Preliminary Conceptual Model

The main purpose of the Phase II Intrusive Investigation was to confirm the conclusions of the desk study, with reference to:

- The assessment of the nature and extent of contamination in relation to potential risks to human health for end users, construction workers, and worker occupants of adjacent properties
- The assessment of the nature and extent of contamination in relation to potential risks to controlled waters
- The assessment of the nature and extent of contamination in relation to potential risks to the fabric of buildings and services
- The refinement of the Preliminary Conceptual Model confirming pollution linkages that have been demonstrated to be present
- The identification of feasible remediation measures to remove or break the identified pollution linkages
- The provision of information and interpretative comment on ground conditions in relation to foundation selection, design, and construction

3.0 SITE DATA

3.1 Site Location

The study site is located immediately to the west of Green Moss Close, Liverpool, L36 3RG, as shown on **CCG** Drawing No. CCG-C-21-12273-1 and Aerial Plate No. CCG-C-21-12273-2 contained herein. The **ORDNANCE SURVEY** co-ordinates for the approximate site centre are 342889, 391933

3.2 Site Description & Walkover Observations

The site was visited in April 2021 on completion of a review of historical mapping and environmental data presented herein.

It was observed that the site is situated within a mixed commercial / residential context and occupies an irregular shaped parcel of land which extends to the approximate dimensions of 64m x 46m, its long axis being on a north south alignment.

It is bound to the north by a mature development of commercial / retail units fronting on to Liverpool Road (A57), and to the south by residential properties fronting on to Huyton House Road. Its eastern boundary is adjoined by residential properties located within the curtilage of Moss Green Close, with the land to the west comprising a parcel of vacant land.

The surface topography across the site was seen to be sensibly flat with surface cover comprising generally partially vegetated made ground deposits with lesser areas of hard standing to the north.

Given that the site has previously been developed and given the presence of adjoining commercial / residential properties, there is a potential for the presence of buried services to exist

Vehicle / pedestrian access to the site via its Liverpool Road frontage to the north.

The information obtained from the visit is summarised in Table 1 hereunder.

Table 1: Summary of Walkover Observations

FEATURE	OBSERVATION
Current use of proposed development Land	Vacant land
Context	Residential / commercial context
Surface & Topography	The surface topography across the site was seen to be sensibly flat with surface cover comprising generally partially vegetated made ground deposits with lesser areas of hard standing to the north.
Dimensions	64m x 46m, its long axis being on a north south alignment
Access	Vehicle / pedestrian access to the site via its Liverpool Road frontage to the north.
Buildings Adjacent to the Site	Mixed residential / commercial buildings adjoining the study site
Services	Given that the site has previously been developed and given the presence of adjoining commercial / residential properties, there is a potential for the presence of buried services to exist
Material storage	None observed
Waste disposal	None observed
Other potential contamination	None observed

4.0 SITE HISTORY

history of the site and its immediate surrounds was investigated by consultation with a range of archive resources. Geographical information, historical mapping and environmental data were primarily based on a GroundSure Reports (CMAPS-AAG-951883-4165-060421) dated April 2021) presented in Appendix J, along with accompanying historical mapping data.

Table 2: Historical Map Review

YEAR	SCALE	ON SITE	ADJACENT TO SITE	<250M
1850 1891 1892-93 1906	1:10,560 1:10,560 1:2,500 1:10,560	Undeveloped / vacant land	NW: Land associated with Huyton House	Much of the land surrounding the site is undeveloped / vacant land c.50m SE: Pond c.70m S: Land associated with Huyton Farm c.100m N: Few properties delineating Stockbridge Lane to the SE c.100m NW: Eagle and Child [public house] c.105m SW: Pond c.210m E: Pond c.240m W: Pond
1907	1:2,500	No significant change	No significant change	c.85m N: Tramway established along Liverpool Road
1925 1925 1927	1:10,560 1:10,560 1:2,500	Development of three very small unspecified properties [possibly nurseries], located at the approximate site centre, along the S boundary and along the W boundary	No significant change	No significant change
1937 1938	1:2,500 1:10,560	No significant change	N: Residential properties delineating Liverpool Road to the N E: Residential properties	Much of the land surrounding the site is developed for residential land use c.25m NW: Hall

			delineating Huyton House Close to the E S: Residential properties delineating Huyton House Road to the S	c.100m S: Recreation Ground adjacent Shelter to the N and Children's Playground to the S c.120m NW: Bowling Greens with Pavillion, associated with Eagle and Child c.180m W: Methodist Chapel
1950-51 1950-51 1951-52 1956 1965	1:1,250 1:2,500 1:1,250 1:10,560 1:10,560	Ruin located in the W portion of the site Unspecified property recognised in the N portion of the site	N: Post Office recognised	c.50m E: Electric Sub-Station, in close proximity to Pumping Station to the S c.140m N: Police Station
1967-68 1967-68 1967-69	1:1,250 1:2,500 1:2,500	Ruin no longer recognised	No significant change	c.170m N: Garage c.210m N: Electric Sub-Station recognised
1973-78 1978	1:1,250 1:10,000	No significant change	W: Depot	No significant change
1983-87 1989 1986-91 1991-93 1993 1993 2001 2003 2010	1:1,250 1:10,000 1:1,250 1:1,250 1:1,250 1:1,250 1:10,000 1:1,250 1:10,000	Unspecified property no longer recognised in N portion of the site	W: Depot no longer recognised	c.170m NW: Electric Sub-Station
2021	1:10,000	No significant change	E: Moss Green Close [redevelopment of road and properties layout]	Land immediate to the E of the site is redeveloped as Moss Green Close

5.0 ENVIRONMENTAL SETTING

5.1 Geology

The geology of the site was researched by reference to the 1:50000 scale **BRITISH GEOLOGICAL SURVEY (BGS)** Sheet 097 Runcorn (Solid and Drift Editions: 1977 1980).

The **BGS 1:10, 000** Scale Drift Geological map indicate that the study site is underlain by impermeable diamicton (*boulder clay*) comprising gravel sand silt and clay deposits of glacial origin (*Pleistocene Epoch - Late Quaternary - Devensian Sub Age*).

The solid geology is documented to comprise the Chester Formation (*formerly Chester Pebble Beds Formation*) of the Sherwood Sandstone Group comprising red – brown horizontally-bedded conglomerate with subordinate lenticular beds of trough cross-bedded pebbly sand with localised argillaceous mudstone bedding of the Early Triassic Period (*Olenekian Age*).

There are no documented geological lines of weakness within 250m of the study site.

The 'Indicative Atlas of Radon in England and Wales' (Miles. J.C.H *et.al*, 2007) Map 13 'Northern Welsh Marches and Liverpool', shows the site to be situated within an area where it is believed that less than 1% of the properties within the area are affected by Radon, hence no Radon Protection Measures will be required for new structures in contact with the ground.

As with many previously developed sites superficial made ground deposits of an unknown composition thickness and extent associated with the development of the site and its immediate environs may underlie the site.

Geological Information obtained from the GroundSure Environmental Report is presented in Appendix J, and summarised hereunder:

Table 3: Summary of Geological Data from GroundSure Report

GEOLOGY		
Data	Distance	Comments
Artificial Ground	On Site	Artificial ground and/or reworked ground deposits associated with the development of the site & its immediate surroundings.
Superficial Deposits / Drift Geology	On Site	Diamicton of glacial origin
Permeability of Diamicton	Maximum Permeability	High
	Minimum Permeability	Low
Bedrock and Solid Geology	On Site	Chester Formation
Permeability of Bedrock: On Site	Maximum Permeability	High
	Minimum Permeability	High
Geological Lines of Weakness	On Site	No records

	<250m	No records
Radon Affected Area	On Site	The site is not in a Radon Affected Area, less than 1% of properties are above the Action Level
Radon Protection	On Site	No radon protective measures are necessary
MINING, GROUNDWORKINGS AND NATURAL CAVITIES		
Data	Distance	Comments
Natural cavities	<500m	No records
BritPits	<500m	290m N: Woolfell Heath Brick Works [Clay & Shale] - Ceased
Surface ground workings	<250m	242-43m N: Pond
Underground workings	<1000m	No records
Historical Mineral Planning Areas	<500m	No records
Non-coal mining	<1000m	No records
Mining cavities	<1000m	No records
Coal mining	On Site	No records
Brine areas	On Site	No records
Gypsum areas	On Site	No records
Tin mining	On Site	No records
Clay mining	On Site	No records
HAZARDS		
Data	Distance	Comments
Maximum shrink swell clays	On site	Very Low
Maximum running sands	On site	Very Low
Maximum compressible deposits	On site	Negligible
Maximum collapsible deposits	On site	Very Low
Maximum landslides	On site	Very Low
Maximum ground dissolution of soluble rocks	On site	Negligible

5.2 Mining

The appended environmental data, **BGS** mapping data and **COAL AUTHORITY** Gazetteer confirm that the site is not located within an area which is believed to be underlain by productive coal measures which may have been worked in the past and therefore a **COAL AUTHORITY** mining report was not procured.

5.3 Hydrology and Hydrogeology

Information on hydrology and hydrogeology obtained from a GroundSure Environmental Report is presented in Appendix J, and summarised hereunder:

Table 4: Summary of GroundSure Environmental Report

HYDROGEOLOGY AND HYDROLOGY		
Aquifer within Superficial Drift Deposits (Boulder Clay)	On site	Diamicton: Secondary Undifferentiated: Assigned where it is not possible to attribute either category A or B to a soil type. In general, these layers have previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the soil type
Aquifer within Bedrock Deposits	On site	Chester Formation - Principal: Geology of high intergranular and/or fracture permeability, usually providing a high level of water storage and may support water supply/river base flow on a strategic scale. Generally principal aquifers were previously major aquifers
Groundwater Abstraction Licenses	<1000m	No records
Surface Water Abstraction Licenses	<1000m	No records
Potable Water Abstraction Licences	<1000m	No records
Source Protection Zones	<500m	On Site: Type 3 [Total catchment]
Source Protection Zones (confined aquifer)	<500m	No records
Water Network (OS Mastermap)	<250m	No records
Surface water features	<250m	No records
WFD Surface water body catchments	On Site	On Site: River WB catchment [Alt]
WFD Surface water bodies	<250m	No records
WFD Groundwater bodies	<250m	On Site: Lower Mersey Basin and North Merseyside Permo-Triassic Sandstone Aquifers. Overall rating: Poor [2015 & 2016]
FLOODING		
Risk of Flooding from Rivers and Sea (RoFRaS)	<50m	No records
Historical Flood Events	<250m	No records
Flood Defences	<250m	No records
Areas Benefitting from Flood Defences	<250m	No records
Flood Storage Areas	<250m	No records
Flood Zone 2	<50m	No records
Flood Zone 3	<50m	No records
Surface water flooding: Highest risk	On Site	1 in 1000 year, 0.1m – 0.3m

	<50m	1 in 30 year, 0.1m – 0.3m
Groundwater flooding: Highest risk	On Site	Moderate
	<50m	Moderate - High

For simplified interpretation, the geological succession underlying the site may be regarded as a series of discrete units in terms of their hydrogeological significance, as illustrated hereunder:

Table 5: Hydrogeological Interpretation

UNIT	PROPERTIES	HYDROGEOLOGICAL DESIGNATION
Made / Reworked Ground	If present, likely to be generally granular and permeable and will permit vertical and lateral transmission of groundwater.	Unproductive Aquifer
Diamicton	These are drift deposits with low permeability that have negligible significance for water supply or river base flow	Secondary Undifferentiated
Chester Formation	Geology of high intergranular and/or fracture permeability, usually providing a high level of water storage and may support water supply/river base flow on a strategic scale. Generally principal aquifers were previously major aquifers	Principal Aquifer

6.0 FURTHER ENVIRONMENTAL DATA

Environmental data was researched using several sources including Environment Agency Maps and GroundSure EnviroSight Report presented in Appendix J and is summarised in Table 6 hereunder.

Table 6: Further Environmental Data

POTENTIALLY CONTAMINATIVE USES IDENTIFIED FROM 1:10,000 SCALE MAPPING		
Data	Distance	Comments
Historical industrial land uses	<250m	59m NW: Smithies [1965] 93-99m N: Smithies [1891-1938] 121m NW: Weighing Machine [1851] 121m N: Smithies [1925] 127m N: Police Station [1955-76] 145m N: Smithies [1955] 208m N: Nursery [1955-65] 210m N: Smithies [1989] 247m SW: Nursery [1955]
Historical tanks	<250m	No records
Historical energy features	<250m	33m W: Electric Sub-Station [1951-93] 64m E: Electric Sub-Station [1993] 164m NW: Electric Sub-Station [1987-97] 183-84m N: Electric Sub-Station [1987-97] 193m N: Electric Sub-Station [1950-68] 244m S: Electric Sub-Station [1983-93]
Historical petrol stations	<250m	No records
Historical garages	<250m	164-67m N: Garage [1978-97]
Historical military land	<250m	No records
Records of Current Industrial Land Use		
Data	Distance	Comments
Recent industrial land uses	<250m	17m W: Pumping Station [Water Pumping Stations] 17m W: Sewage Pumping [Waste Storage, Processing and Disposal] 38m W: Electric Sub-Station [Electrical Features] 67m E: Electric Sub-Station [Electrical Features] 152m NW: Electric Sub-Station [Electrical Features] 160m NW: Mast [Telecommunications] 163m W: A1 Auto Repair Center [Vehicle Repair, Testing and Servicing] 180m NE: Electric Sub-Station [Electrical Features] 181m SE: A & A Travel [Vehicle Hire and Rental] 191m N: Panda Tyres [Vehicle Parts and Accessories] 194m N: F R Foster Ltd [Vehicle Parts and Accessories] 204m N: Electric Sub-Station [Electrical Features] 222m N: Mast [Telecommunications]
Current or recent petrol stations	<250m	181m N: SPOT [Obsolete]
Electricity cables	<250m	No records
Gas pipelines	<250m	No records
Sites determined as Contaminated Land	<250m	No records
Control of Major Accident Hazards (COMAH)	<250m	No records
Regulated explosive sites	<250m	No records
Hazardous substance storage/usage	<250m	No records
Historical licensed industrial activities (IPC)	<250m	No records
Licensed industrial activities (Part A(1))	<250m	No records
Licensed pollutant release (Part A(2)/B)	<250m	No records

Radioactive Substance Authorisations	<250m	No records
Licensed Discharges to controlled waters	<250m	No records
Pollutant release to surface waters (Red list)	<250m	No records
Pollutant release to public sewer	<250m	No records
List 1 Dangerous Substances	<250m	No records
List 2 Dangerous Substances	<250m	No records
Pollution Incidents (EA/NRW)	<250m	No records
Pollution inventory substances	<250m	No records
Pollution inventory waste transfers	<250m	No records
Pollution inventory radioactive waste	<250m	No records
WASTE AND LANDFILL		
Data	Distance	Comments
Active or recent landfill	<500m	No records
Historical landfill (BGS records)	<500m	No records
Historical landfill (LA/mapping records)	<500m	No records
Historical landfill (EA/NRW records)	<500m	No records
Historical waste sites	<500m	No records
Licensed waste sites	<500m	No records
Waste exemptions	<500m	204m NE: Woolfall Heath Avenue [Treating waste exemption] 227m E: Wood Farm [Using / Storing / Disposing waste exemption] 334m NE: 27 Woolfall Heath Avenue [Treating waste exemption]
ENVIRONMENTAL DESIGNATIONS		
Data	Distance	Comments
Sites of Special Scientific Interest (SSSI)	<500m	None
Conserved wetland sites (Ramsar sites)	<500m	None
Special Areas of Conservation (SAC)	<500m	None
Special Protection Areas (SPA)	<500m	None
National Nature Reserves (NNR)	<500m	None
Local Nature Reserves (LNR)	<500m	None
Designated Ancient Woodland	<500m	None
Biosphere Reserves	<500m	None
Forest Parks	<500m	None
Marine Conservation Zones	<500m	None
Green Belt	<500m	None
Proposed Ramsar sites	<500m	None
Possible Special Areas of Conservation (PSAC)	<500m	None
Potential Special Protection Areas (pSPA)	<500m	None
Nitrate Sensitive Areas	<500m	None
Nitrate Vulnerable Zones	<500m	On Site: Alt NVZ [Surface Water – Existing]

7.0 ARCHAEOLOGICAL DATA

Examination of historical maps indicates no features of significant archaeological interest in the general vicinity of the site.

8.0 PREVIOUS SITE INVESTIGATIONS / REPORTS

Searches and consultations have not established evidence of previous site investigations having been undertaken on the subject site.

9.0 PRELIMINARY QUALITATIVE RISK ASSESSMENT (TIER 1)

9.1 Introduction

The risk assessment methodologies adopted by CCG are based on current available guidance from several sources and are included in Appendix K.

The Tier 1 Risk Assessment and Preliminary Conceptual Model (PCM) were formulated using the information discussed above and based on the following assumptions:

- It is understood that the site is to be redeveloped for residential use by the construction of a 2-storey apartment block forming 8nr self-contained apartments with associated car parking bays and areas of communal landscaping, together with 6nr 2-storey residential properties constructed in traditional brick elevations under pitched roofs, each with private driveway and private front and rear gardens. The development will include a new paved access road

The proposed layout of the development is shown on the **LEVEL 2 ARCHITECTS** plan contained herein.

- Drinking water will be from a mains supply.

In constructing the Preliminary Conceptual Model (PCM), **CCG** applied the guidance contained in CIRIA C552: 2001. This recommends use of a Risk Matrix which classifies risk based on the product of Probability of a source being present, and the Consequence of receptors being exposed to the source. Guidance tables setting out the classifications of probability and consequence together with a risk matrix are given in Tables 7-9 hereunder. In using this approach **CCG** generally recommends actual intrusive investigation of any Risk Classification of "Moderate" or over. In the case of residential housing, risk ratings of 'Low' may also warrant investigation.

Table 7: Matrix of consequences against probability to gain a risk classification [CIRIA C552, 2001]

		CONSEQUENCE			
		SEVERE	MEDIUM	MILD	MINOR
Probability	High Likelihood	Very High Risk	High Risk	Moderate Risk	Moderate / Low Risk
	Likely	High Risk	Moderate Risk	Moderate / Low Risk	Low Risk
	Low Likelihood	Moderate Risk	Moderate / Low Risk	Low Risk	Very Low Risk
	Unlikely	Moderate / Low Risk	Low Risk	Very Low Risk	Very Low Risk

9.2 Preliminary Conceptual Model

By application of the risk assessment methodology outlined above, the following PCM was constructed.

Table 8: Preliminary Conceptual Model (PCM)

POLLUTANT LINKAGE	SOURCE	PATHWAY	RECEPTOR	PROBABILITY	CONSEQUENCE	RISK RATING
1	Broad spectrum of heavy metals, aggressive pH, hydrocarbons, PAH's in Made Ground associated with the development of the site	Soil and / or soil dust ingestion	Construction workers Future occupants (adults & infants) Offsite receptors Flora	Likely	Medium	Moderate
2	Asbestos containing materials (ACM) in made ground soils associated with the development of the site	Fibre Inhalation	Construction workers Future occupants (adults & infants) Offsite receptors	Likely	Severe (ACM)	High
3	Inhalation of vapours associated with potential made ground deposits etc.	Inhalation	Future residents	Unlikely	Medium	Moderate
4	Inhalation of ground gases from onsite or offsite sources i.e. made ground soils etc.	Inhalation	Future residents	Unlikely	Medium	Moderate
5	pH & Sulphate attack on concrete	Future building	Future building	Likely	Mild	Moderate / Low
6	Organic contamination	Direct contact with water mains	Potable water supply	Unlikely	Medium	Moderate

The contaminants of concern associated with those risks which require intrusive investigation were researched by reference to published industry profiles, and are summarised hereunder:

Table 9: Summary of Contaminants of Concern based on PCM

LINKAGE NO.	METALS	NON-METALS	ORGANICS	GASES	OTHERS
PL1, PL2, PL4, PL5	Cd, Cr, Ni, Cu, Pb, Hg, Se, Zn	As, sulphates	TPHCWG, PAH's, BTEX, Volatiles (by PID) & PCB's	-	pH Asbestos
PL3	-	-	-	CH ₄ , CO ₂ , H ₂ S	-
PL1-PL5	Cd, Cr, Ni, Cu, Pb, Hg, Se, Zn	As, sulphates	TPHCWG, BTEX PAH's, Volatiles (by PID) & PCB's	CH ₄ , CO ₂ , H ₂ S	pH Asbestos

9.3 Summary of Risks

The foregoing analysis identified several potential risks, and if present, these could adversely impact on human or environmental receptors. Given no previous site investigation has been undertaken, an intrusive phase of investigation was undertaken to determine whether the postulated pollutant linkages are present on site.

10.0 SCOPE OF PHASE II INTRUSIVE INVESTIGATION

Based on the findings of the Phase I desk study and taking account of the potential presence of pollution linkages an intrusive investigation was undertaken. The Phase II Intrusive Investigation provided for exploratory boreholes and trial pits to be excavated through made ground

into the underlying natural strata to allow for sampling of soils and groundwater if present.

The primary objectives of the investigation were to obtain enough soil and groundwater contamination data to reliably assess risks to human and environmental receptors, and to provide engineering parameters on which suitable foundation solutions could be selected.

11.0 FIELDWORK

11.1 Introduction

A programme of fieldwork investigation was undertaken in April 2021 and comprised:

- The manual excavation and CAT scanning of 8nr borehole starter extending from GL-1.2mbgl
- The subsampling of borehole arisings for soil contamination analyses
- The advancement of each borehole starter pit using light dynamic sampling methods
- The subsampling of borehole arisings for soil classification testing
- The installation of 50mm HDPE plain and slotted well-tube complete with non-lime pea gravel surround and bentonite seals together with associated headworks at 3nr borehole position
- The instigation of a gas – groundwater monitoring programme comprising 6nr rounds over a 3-month period

The fieldwork was planned in accordance with BS10175: 2011 and carried out in accordance with BS10175: 2011 and BS5930: 2015, and the sampling and monitoring methodologies employed by CCG as presented in Appendix C, insofar as they related to the scope of the investigation.

The layout of the proposed investigation is as annotated on CCG Drawing No. CCG-C-21-12273-3 'Site Investigation Layout Plan' contained herein.

11.2 Borehole Drilling & Monitoring Installations

11.2.1 Light Dynamic Sampling Boreholes

In accordance with the ground investigation plan, 8nr boreholes were sunk using light dynamic sampling methods using a Dando Terrier 2000 rig deploying 100mm casings and associated tools.

Each borehole location was positioned clear of all overhead services and scanned for buried electrical services using CAT cable avoidance scanner before and during hand excavation of a starter pit extending to 1.2mbgl.

Boring tools were decontaminated prior to commencement.

In this method of investigation samples of subsoils are recovered by driving and extracting a series of reducing diameter 1m long steel tubes. Standard penetration test's (SPT's) were undertaken at regular depth increments. This method of sampling recovers relatively "undisturbed" soil profiles in Perspex tubes, which are used to line the steel tubes. The Perspex tubes were split and carefully logged and subsampled. Subsamples for potential chemical analysis were removed at appropriate positions from the profile and transferred to chilled amber glass jars and vials for laboratory analysis.

The logs of the light dynamic sampling boreholes, annotated with sampling details, SPT 'N' values and details of standpipe construction is presented in Appendix D.

11.2.2 Monitoring Installations

Standpipes comprising 50mm diameter HDPE plain and slotted well-tube set in bentonite and non-limestone pea gravel surround were installed at each borehole position. Each standpipe was fitted with a gas valve connector and was protected by a flush cover set in concrete.

Details of standpipe installations are provided on the relevant borehole logs in Appendix D and summarised in the tabulation hereunder:

Table 10: Borehole Installation Details

BOREHOLE	DEPTH OF BOREHOLE (mbgl)	DEPTH OF STANDPIPE [mbgl]	RESPONSE ZONE	
			FROM [mbgl]	TO [mbgl]
WS1	5.0m	4.7m	0.4m	4.7m
WS2	5.0m	4.0m	0.5m	4.0m
WS7	5.0m	4.5m	0.5m	4.5m

The standpipe installations were periodically monitored for flow rate and composition of ground gas using a Geotechnical Instruments GA infra-red analyser. The installations were also monitored for standing water levels with an electronic dip meter.

The results of the gas and groundwater monitoring, together with calibration certificates of the monitoring instruments are given in Appendix E.

12.0 OBSERVED GROUND CONDITIONS

The stratigraphy of the boreholes was generally consistent with the documented geology. The succession may be generalised as tabulated hereunder:

Table 11: Observed Stratigraphy

Location	STRATIGRAPHY
WS1	Superficial made ground deposits comprising very gravelly sands extending to 0.5mbgl. The sequence thereafter continues in natural drift deposits comprising light brown boulder clay to 0.9mbgl, very loose sands to 1.8mbgl, firm becoming stiff brown boulder clay to 5mbgl. Slight water ingress at around 4mbgl
WS2	Superficial made ground deposits comprising dark brown clayey sands to 0.2mbgl. The sequence thereafter continues in natural drift deposits comprising firm becoming stiff brown boulder clay to 4.1mbgl, then loose to medium dense brown sands thereafter, proven to 5mbgl. Slight water ingress from c.3mbgl.
WS3	Grassed topsoil overlying superficial made ground deposits comprising dark brown gravelly sands to 0.65mbgl. The sequence thereafter continues in natural drift deposits comprising firm becoming stiff brown boulder clay, proven to 5mbgl. Borehole reported to be dry on completion
WS4	Grassed topsoil overlying superficial made ground deposits comprising loose dark brown clayey sands to 0.5mbgl. The sequence thereafter continues in natural drift deposits comprising soft becoming firm then stiff brown boulder clay, proven to 5mbgl. Borehole reported to be dry on completion
WS5	Grassed topsoil overlying made ground deposits comprising dark brown clayey gravelly sands extending to 0.9mbgl. The sequence thereafter continues in natural drift deposits comprising firm locally stiff brown boulder clay, proven to 2mbgl. Borehole reported to be dry on completions.
WS6	Grassed topsoil overlying superficial made ground deposits comprising dark brown gravelly sands extending to 0.5mbgl. The sequence thereafter continues in natural drift deposits comprising firm becoming firm to stiff brown boulder clay thereafter, proven to 5mbgl. Borehole reported to be dry on completion
WS7	Grassed topsoil overlying made ground deposits comprising loose dark brown clayey gravelly sands extending to 1mbgl. The sequence thereafter continues in natural drift deposits comprising firm locally firm to stiff brown boulder clay, proven to 5mbgl. Borehole reported to be dry on completion
WS8	Grassed topsoil overlying superficial made ground deposits comprising dark brown gravelly clay extending to 0.3mbgl. The sequence thereafter continues in natural drift deposits comprising firm locally stiff brown boulder clay, proven to 5mbgl. Borehole reported to be dry on completion.

There was no visual evidence of contamination and/or biodegradable materials affecting the near surface soils at any exploratory position.

12.2 Groundwater Regime

Slight seepages were reported at some exploratory sampling positions during the ground investigation with monitored standing water levels being in the order of 0.67mbgl > 0.97mbgl during the ongoing standpipe monitoring programme. These levels are not considered indicative of a water table, but more likely to indicate perched rainwater infiltration resting on the natural clay deposits.

13.0 CONTAMINATION TESTING

13.1 Soil – Groundwater Contamination Analyses

A programme of soil chemical analyses was undertaken at a UKAS / MCERTS accredited laboratory:

- 6nr subsamples of made ground soils were analysed to a broad-spectrum suite of contaminants including metals, non-metals, heavy metals, speciated PAH's
- 6nr subsamples of made ground soils were analysed for hydrocarbons to the TPHCWG methodology
- 6nr subsamples of made ground soils were screened for asbestos containing materials (ACM's)
- 6nr subsamples of soil were analysed for soil pH and water-soluble sulphate content

- Groundwater recovered from 1nr borehole position (WS1) was analysed for a broad range of contaminants including metals, non-metals, heavy metals, speciated PAH's
- Groundwater recovered from 1nr borehole position was analysed for hydrocarbons to the TPHCWG methodology

The soil / groundwater contamination test results and certificates are presented in Appendix F.

13.2 Soil Classification Testing

The following programme of soil geotechnical testing was undertaken at the UKAS laboratory associated with CCG.

- Determination of Particle Size Distribution in accordance with BS 1377-2: 1990
- Determination of soil moisture content in accordance with BS: 1377: Part 2: 1990
- Determination of Atterberg Limits in accordance with BS: 1377: Part 2: 1990

The soil engineering test results are presented in Appendix I.

14.0 RISK ASSESSMENT FOR THE PROTECTION OF HUMAN HEALTH

14.1 Generic Quantitative Risk Assessment (Tier 2 / GQRA)

An assessment of the soil analysis data was carried out in accordance with the guidance presented in CLR11 and in accordance with current guidance and legislation.

The Human Health Risk Assessment was carried out in accordance with the CCG methodology for assessing soil contamination data as contained in Appendix K, and since it is proposed that the site be developed for residential land use, the assessment was based on criteria contained in publication LQM/CIEH S4UL's for Human Health Risk Assessment (2015) (CCG licence S4UL3233), applicable to the "Residential" 'With' plant uptake land use scenario'. This document does not provide criteria for Lead, for which the results were compared to the C4SL published by DEFRA SP1010 Development of Category 4 Screening Levels.

14.2 Assessment of Contamination Data

Based on a Soil Organic Matter content of 2.5%, the assessment of the soil data is summarised in the tabulations hereunder, and presented on the worksheets in Appendix G.

14.2.1 Assessment of Metal Data

The assessment of the metal data is presented hereunder:

Table 12: Assessment of Metal Data

Contaminant	LQM / CIEH S4UL (mg/kg)	Maximum (mg/kg)	Exceedances	
			(mg/kg)	Location
Cadmium	11	1.6		
Chromium	910	40.6		
Copper	2400	184		
Lead	200	382	214	WS3
			223	WS4
			382	WS5
			236	WS7
			290	WS8
Mercury	1.2	0.8		
Nickel	180	83.4		
Zinc	3700	430		

The above assessment confirms the presence of elevated concentrations of Lead contamination at 5nr sampling positions, hence a potential risk to human health is indicated.

14.2.2 Assessment of Non-Metal Data

The assessment of the non-metal data is presented hereunder:

Table 13: Assessment of Non-Metal Data

Contaminant	LQM / CIEH S4UL (mg/kg)	Maximum (mg/kg)	Exceedances	
			(mg/kg)	Location
Arsenic	37	53.8	53.8	WS8
Selenium	250	<1.0		
Total Cyanide	22	<1.0		

The above assessment confirms the presence of elevated Arsenic contamination at 1nr sampling position, hence a potential risk to human health is indicated.

14.2.3 Assessment of Polycyclic Aromatic Hydrocarbon [PAH's] Data

The assessment of the Polycyclic Aromatic Hydrocarbon (PAH's) data is presented hereunder:

Table 14: Assessment of PAH Data

Contaminant	LQM / CIEH S4UL (mg/kg)	Maximum (mg/kg)	Exceedances	
			(mg/kg)	Location
Naphthalene	5.6	3.1		
Acenaphthylene	420	3.5		
Acenaphthene	510	7.1		
Fluorene	400	7.4		
Phenanthrene	220	72.8		
Anthracene	510	6.9		
Fluoranthene	560	67.5		
Pyrene	1200	57.6		
Benz(a)anthracene	11	26.9	26.9	WS5
			26.8	WS8
Chrysene	22	30.9	30.9	WS5
			29.6	WS8
Benzo(b)fluoranthene	3.3	21.5	19.5	WS5
			5.8	WS7
			21.5	WS8
Benzo(k)fluoranthene	93	23.2		
Benzo(a)pyrene	2.7	24.6	22.9	WS5
			6.3	WS7
			24.6	WS8
Indeno(123-cd)pyrene	36	20.2		
Dibenzo(ah)anthracene	0.28	4.8	0.4	WS4
			4.0	WS5
			1.9	WS7
			4.8	WS8
Benzo(ghi)perylene	340	16.3		

The above assessment confirms the presence of Benz(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(a)pyrene and Dibenzo(ah)anthracene in soils, hence a potential risk to human health is indicated.

14.2.4 Assessment of Total Petroleum Hydrocarbon [TPH's] Data

The assessment of TPH data is presented hereunder:

Table 15: Assessment of Hydrocarbon Data

Contaminant	LQM / CIEH S4UL (mg/kg)	Maximum (mg/kg)	Exceedances	
			(mg/kg)	Location
Aromatic EC5-EC7	140	<0.01		
Aromatic EC7-EC8	290	<0.01		
Aromatic EC8-EC10	11	1.3		
Aromatic EC10-EC12	180	3.4		
Aromatic EC12-EC16	330	33.4		
Aromatic EC16-EC21	540	137		
Aromatic EC21-EC35	1500	639		
Aliphatic EC5-EC6	78	<0.01		
Aliphatic EC6-EC8	230	<0.01		
Aliphatic EC8-EC10	65	2.1		
Aliphatic EC10-EC12	330	2.8		
Aliphatic EC12-EC16	2400	4.8		
Aliphatic EC16-EC35	92000	39.2		

The above assessment confirms that no soil contaminant exceeds its respective soil guideline criteria and therefore no risk to human health is indicated.

14.2.5 Assessment of BTEX Data

All BTEX compounds were reported to be below their limit of detection and therefore no risk to human health is indicated.

14.2.6 Assessment of Asbestos Data

Asbestos containing materials (ACM's) were not detected in any soil analysed and therefore no risk to human health is indicated.

14.2.7 Summary of Human Health Risk Assessment

The above human health risk assessment confirms the presence of elevated concentrations of:

- Lead at 5nr sampling position
- Arsenic at 1nr sampling position
- Benz(a)anthracene at 2nr sampling positions
- Chrysene at 2nr sampling positions
- Benzo(b)fluoranthene at 3nr sampling positions
- Benzo(a)pyrene at 3nr sampling positions
- Dibenzo(ah)anthracene at 4nr sampling positions

Based on the above, a potential risk to human health is indicated. Exposure risk associated with these contaminants arise via the dermal and ingestion pathways and as such remedial works are required to mitigate these risks. Suitable forms of remediation are discussed in Table 16 hereunder.

15.0 POST INVESTIGATION CONCEPTUAL MODEL

Based on the findings of the investigation, a conceptual model could be constructed illustrating proven pollution linkages and summarising the conceptual remediation recommendations discussed above, as tabulated hereunder.

Table 16: Conceptual Model

Source	Pathway	Receptor	Remedial Options
The above human health risk assessment confirms the presence of elevated concentrations of: • Lead • Arsenic • Benz(a)anthracene • Chrysene • Benzo(b)fluoranthene • Benzo(a)pyrene • Dibenzo(ah)anthracene hence a potential risk to human health is indicated.	Oral / ingestion / dermal pathways	Construction works Future residential residents (adults / children)	No remedial works required under areas of permanent hard standing. Site levels in all gardens to be reduced to 600mm below proposed finished garden levels, with site levels then being reconstructed by the placement of 600mm of clean imported topsoil, placed under a strict validation regime comprising a 1nr analyses per 50m³ with a minimum of 4nr analyses per material source. Where made ground remaining in place beyond 600mm, imported topsoil is to be placed on a suitable geotextile fabric such as Terram 1000, or similar. Cover thickness on all gardens / soft landscaping is to be independently validated by excavation and photography for inclusion in a Validation Report. Imported soils are to comply with the analysis criteria contained in Appendix G

As with all developments, disturbance of the ground may uncover unanticipated features which may give rise to considerations of contamination insofar as the exposed conditions may have the potential to impact on receptors including inter alia humans, animals, controlled waters, or the fabric of buildings. Any such encounters will require the contractor to halt work, isolate the risk area, and summon CCG to site to determine the nature of the exposure and to determine an appropriate course of action. Any such incidents will be fully documented in a detailed site Remediation Report.

16.0 SPECIFICATION OF BURIED CONCRETE

The data obtained in the investigations was assessed against the guidance given in BRE Special Digest 1: 2005, as summarised hereunder:

Table 17: Design Chemical Class Based on Soil Data

CONCRETE SPECIFICATION DATA SHEET		
Is the site Brownfield or Greenfield?	Brownfield	
Is the water table static or mobile?	Static	
Highest water-soluble Sulphate results	40mg/l	Design Sulphate Class of DS-1 Class of AC-1s
Lowest pH result	7.2	
Intended Working Life	50 years	Adopt Design Chemical Classification of DC-1

Based on the foregoing assessment, concrete in the ground should be specified to conform to the compositional requirements of Design Chemical Class DC-1, as defined in BRE Special Digest 1: 2005.

17.0 ASSESSMENT OF RISK FROM GROUND GASES

Standpipes were constructed such that response zones were within the permeable made ground strata. Using the data gathered in the monitoring programme, a gas risk assessment was undertaken in accordance with the ground gas risk assessment methodology (See Appendix K) employed by CCG. The ground gas risk assessment methodology conforms to current UK guidance on the assessment of risks posed by ground gases.

The potential sources of gas identified in the desk study were generally considered as sources of “Low” generation potential, and high sensitivity, resulting in a programme of monitoring comprising of 6nr rounds distributed over a 3-month period.

A gas risk assessment was undertaken in accordance with current UK guidelines set out in CIRCA C665 2007 “Assessing Risk Posed by Hazardous Gases to Buildings”. The CIRIA risk assessment methodology uses typical maximum soil gas concentrations and worse case borehole flow rates to define a “Characteristic Situation” for the shallow gas regime.

The volumetric gas flow rate used by the risk assessment is termed “Gas Screening Value (GSV)” in the guidance and is defined below.

$$\text{Where: GSV (litres/hr)} = \text{borehole flow rate (litres/hr)} \times \text{gas concentration.}$$

There are also two stages to the assessment method proposed in CIRIA C665; compliance with a GSV Threshold Value and secondly, compliance with additional factors such as maximum permissible gas concentration. A summary of the gas monitoring data is presented hereunder and presented in Appendix E.

Table 18: Summary of Gas Monitoring Data

Position No Monitoring Visits	WS1 1	WS2 1	WS5 1
Highest CH ₄ (%)	Nil	Nil	Nil
Highest CO ₂ (%)	1.6	0.4	<0.1
18.1Lowest O ₂ (%)	18.6	19.9	20.1
Highest H ₂ S (ppm)	Nil	Nil	Nil
Highest CO (ppm)	Nil	Nil	Nil
Highest Flow (l/hr)	<0.1	<0.1	<0.1
Water Levels (m)	0.67	0.90	0.97
Highest PID response	0.0	0.0	0.0
Pressure Range (mb)	1006mbar		

After 1nr round of monitoring, a preliminary Gas Screening Value (GSV) of 0.0016l/hrs is calculated for CO₂.

Using these GSV values, the risk to the proposed development was assessed in line with Situation A as defined in CIRIA C665, and on this basis the site complies with Characteristic Situation 1 and based on this classification gas protection measures are not required.

It must be borne in mind that the remaining 5nr monitoring visits will be required to conclude the assessment which will be documented via an addendum report.

19.0 PRELIMINARY WASTE CLASSIFICATION

A waste classification exercise was undertaken in relation to potential offsite disposal of excavation arisings. The first stage entailed the assessment of the basic soil contamination data via the **HAZWASTE** online program. The output data from this basic assessment is provided in Appendix H. This program generates the baseline ‘Hazardous / Non-Hazardous’ classification of soils.

The appended **HAZWASTE** report classifies all soils analysed as being ‘Non-Hazardous Waste’. However, should be noted that the final decision

on waste classification is at the discretion of the accepting landfill, and it is recommended that consultation with landfill operators be undertaken during the development of the waste management plan.

20.0 NEW WATER MAINS SUPPLY

The specification for new water mains at this site was based on the criteria specified in Paper 10/WM/03/21 'Guidance for the selection of Water Supply Pipes to be used in Brownfield Sites' published by UK Water Industry Research (UKWIR) January 2011.

The findings indicate that the soil concentrations of pertinent hydrocarbon contaminant species are below the threshold concentrations permitted under the UKWIR guidance and hence new water mains may be specified as standard PE pipe construction. Good practice requires that mains be laid in a remediated alignment comprising of clean granular fill extending to 600mm + pipe diameter and to 300mm below pipe underside.

Pipes should be laid in accordance with BS EN 12201-2 'Plastic piping systems for water supply, and for drainage and sewerage under pressure – Polyethylene (PE) as stated in UKWIR guidance.

Notwithstanding the above preliminary assessment, the developer should contact the relevant water supply company (**UNITED UTILITIES**) to obtain concurrence with the recommendations given above and may be required to return a completed Risk Assessment.

21.0 FOUNDATIONS & FLOOR SLABS RECOMMENDATIONS

21.1 Introduction

It is understood that the site is to be redeveloped for residential use by the construction of a 2-storey apartment block forming 8nr self-contained apartments with associated car parking bays and areas of communal landscaping, together with 6nr 2-storey residential properties constructed in traditional brick elevations under pitched roofs, each with private driveway and private front and rear gardens. The development will include a new paved access road

21.2 Foundations & Ground Slabs

Taking account of the observed ground conditions and borehole SPT 'N' values, and given the loads imposed, the underlying ground conditions are suitable for the adoption of traditional strip (spread) foundations. The borehole data indicates conditions generally suitable for strip or partial trench fill at Plots 1, 2, 3, 4 and the Apartment block, with foundations recommended to extend to 1.5mbgl and be designed on a Presumed Bearing Value of 120kN/m². WS1 suggests that conditions at Plots 5 and 6 may be unsuitable for trench fill and strip foundations may require a deeper excavation to around 2mbgl at which depth a Presumed Bearing Value of 120kN/m² may be adopted.

Strip foundations should be constructed to a minimum thickness of 300mm. No special precautions are required for foundation concrete.

Where strip foundations span 2-differing founding strata, it is strongly recommended that foundations be reinforced in the bottom third.

It is important that all foundation excavations be inspected by a competent ground engineer to ensure that the predicted founding strata has been encountered.

Suspended beam and block floors are preferred. However, in the observed ground conditions, a ground bearing slab may be considered subject to rigorous preparation of the subgrade. Such preparation should include as a minimum:

- Reduction in ground levels to 450mm below slab underside, ensuring all organic soils has been removed
- Thorough compaction at reduced level with any areas exhibiting excessive deflection being grubbed out in 200mm increments and in-filled with thoroughly compacted DTp Type 1 subbase
- Placement and compaction of 3 x 150mm layers DTp Type 1 subbase
- Construction of blinding sand, dpm, slab, screed, and finishes

21.4 Excavations

Excavations may be undertaken by light hydraulic excavators.

Excavations deeper than 1.2mbgl will require side support.

21.5 Groundwater Management

Slight seepages were reported at some exploratory sampling positions during the ground investigation with monitored standing water levels being in the order of 0.67mbgl > 0.97mbgl during the ongoing gas – groundwater monitoring programme. These levels are not considered indicative of a water table, but more likely to indicate perched rainwater infiltration resting on the natural clay deposits. In these conditions where perched water accumulations are likely, a prudent contractor would allow for some minor pumping to maintain dry working conditions during foundation / service installations during periods of heavy and/or prolonged periods of precipitation.

22.0 CONCLUSIONS & RECOMMENDATIONS

The conclusions and recommendations hereunder are based on the salient sections of the report and should not be referred to in isolation of the relevant sections of the text. All recommendations are subject to Regulatory Authority review.

Table 19: Conclusions & Recommendations

Soil Contamination	The above human health risk assessment confirms the presence of elevated concentrations of some contaminants in the superficial soils and therefore a potential risk to human health is indicated. Exposure risk associated with these contaminants includes ingestion / dermal / inhalation pathways.
	The incidence of contamination detected in the investigation indicates that it is not reasonable to consider differing levels of garden / soft landscaping protection, and a consistent approach is recommended.
	In areas of private gardens / soft landscaping, existing ground levels are to be reduced to 600mm below finished garden level, with site levels being reconstructed by the placement of 600mm of clean imported subsoil / topsoil, placed under a strict validation regime comprising 1nr analyses per 50m ³ with a minimum of 4 analyses per subsoil / topsoil source.
	Where made ground soils remain at 600mm below finished site levels, then a suitable hi-vis' geotextile fabric, such as Terram 1000, or similar, must be placed at the interface of in-situ made ground soils & imported cover systems. Independent validation inspections will be required to confirm the conditions at the reduced level and hence the requirements for Terram determined.
Controlled Waters	Cover thickness on all gardens / soft landscaping is to be independently validated by excavation and photography for inclusion in a Validation Report.
Concrete Specification	Imported soils are to comply with the analysis criteria contained in Appendix G To be discussed in an addendum report
Water Mains	Based on the foregoing assessment, concrete in the ground should be specified to conform to the compositional requirements of Design Chemical Class DC-1, as defined in BRE Special Digest 1: 2005.
	The specification for new water mains at this site was based on the criteria specified in Paper 10/WM/03/21 'Guidance for the selection of Water Supply Pipes to be used in Brownfield Sites' published by UK Water Industry Research (UKWIR) January 2011.
	The findings indicate that the soil concentrations of pertinent hydrocarbon contaminant species are below the threshold concentrations permitted under the UKWIR guidance and hence new water mains may be specified as standard PE pipe construction. Good practice requires that mains be laid in a remediated alignment comprising of clean granular fill extending to 600mm + pipe diameter and to 300mm below pipe underside.
	Pipes should be laid in accordance with BS EN 12201-2 'Plastic piping systems for water supply, and for drainage and sewerage under pressure – Polyethylene (PE) as stated in UKWIR guidance.
Gas Risk Assessment	Notwithstanding the above preliminary assessment, the developer should contact the relevant water supply company (United Utilities) to obtain concurrence with the recommendations given above and may be required to return a completed Risk Assessment.
	After 1nr rounds of monitoring, a preliminary Gas Screening Value (GSV) of 0.0016l/hrs is calculated for CO ₂ .
	Using these GSV values, the risk to the proposed development was assessed in line with Situation A as defined in CIRIA C665, and on this basis the site complies with Characteristic Situation 1 and based on this classification gas protection measures are not required.
Waste Classification	It must be borne in mind that the remaining 5nr monitoring visits will be required to conclude the assessment which will be documented via an addendum report.
	A waste classification exercise was undertaken in relation to potential offsite disposal of excavation arisings. The first stage entailed the assessment of the basic soil contamination data via the Hazwaste online program. The output data from this basic assessment is provided in Appendix J. This program generates the baseline 'Hazardous / Non-Hazardous' classification of soils.
	The appended Hazwaste report classifies all soils analysed as being 'Non-Hazardous Waste'. However, should be noted that the final decision on waste classification is at the discretion of the accepting landfill, and it is recommended that consultation with landfill operators be undertaken during the development of the waste management plan.

Foundations & Ground Floor Slabs	See Section 21.0 for full discussion
Excavations	Excavations in the observed made ground and natural drift soils may be undertaken by light hydraulic excavators. Excavations more than 1.2mbgl in loose sands will require side support.
Groundwater Management	Slight seepages were reported at some exploratory sampling positions during the ground investigation with monitored standing water levels being in the order of 0.67mbgl > 0.97mbgl during the ongoing gas – groundwater monitoring programme. These levels are not considered indicative of a water table, but more likely to indicate perched rainwater infiltration resting on the natural clay deposits. In these conditions where perched water accumulations are likely, a prudent contractor would allow for some minor pumping to maintain dry working conditions during foundation / service installations during periods of heavy and/or prolonged periods of precipitation.
Further Work	• Complete the ongoing gas – groundwater monitoring programme • Update gas risk assessment • Prepare Phase III Remediation Strategy Report • Prepare Phase IV Validation Report