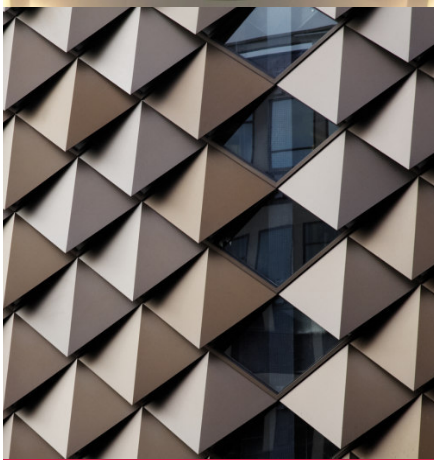


Former CHUBB Factory Site, Ferndale

Remediation Strategy & Verification Plan

Curtins Ref: LYF-CUR-A1-XX-SP-G-00004-Remediation_Strategy

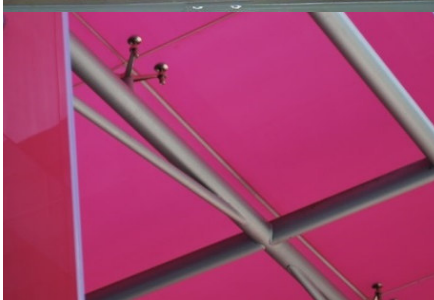
Revision: P04

Issue Date: 06 January 2023

Client Name: Rhondda Cynon Taff CBC c/o Wynne Construction Ltd

Client Address: Charles House, Kinmel Park, Bodelwyddan, Denbighshire, LL18 5TY.

Site Address: Land off Ferndale Industrial Estate, CF43 4TP.



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01	First Issue	KH	JS	Oct 2022
02	Update text following regulator comment	KH	JS	Oct 2022
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Appendices

1.0 Introduction

This Remediation Strategy & Verification Plan has been prepared by Curtins for Wynne Construction Ltd on behalf of Rhondda Cynon Taff County Borough Council to provide guidance with respect to the required remediation works at the proposed new Ysgol Gynradd Gymraeg Lyn Y Forwyn and associated works including a new pedestrian access, landscaping, sustainable drainage, car and cycle parking in Ferndale. In addition, guidance with respect to the disposal of soils and imported soils specification for the proposed development. The remediation strategy and verification plan in this document relates specifically to the currently known geo-environmental aspects that pose a risk to the end users of the site or other receptors in the surrounding environment.

The approximate site area of the development site (in which this Remediation Strategy pertains to) is presented in Figure 1. The remediation work is aimed at addressing contamination within the red line boundary shown below with the site containing the proposed school development (boundary in blue) and future development area. The former land use has resulted in contamination existing across the full red line boundary area with the need to remediation the full site in order to facilitate the initial school development.

Figure 1 – Site Location Plan.

Approximate centre of site located at National Grid Reference: 298680, 197593

1.1 Requirements of the Remediation Strategy

The Remediation Strategy is to account for the following:

- A description of the materials likely to be encountered by the developer and their appointed sub-contractors;
- Proposals for excavations with respect to the materials likely to be encountered;
- Advice with respect to classification of unsuitable materials for disposal to a suitably licensed facility;
- Advice with respect to the provision of an engineered cover layer in the proposed soft landscaping areas;
- Advice with respect to groundwater contamination;
- Advice on the gas/vapour protection measures required for the development;
- Advice on the installation of upgraded barrier water supply pipes;
- Advice on the validation of imported topsoil and subsoil materials to the proposed soft landscaping areas as suitable for the intended end use; and,
- Guidance on any unexpected contamination encountered as part of the development works.

1.2 Definitions

In this document the following definitions apply:

Contractor Refers to the appointed contractor responsible for undertaking the remediation works.

Site Manager Refers to a representative of the appointed principal contractor resident on site.

Engineer Refers to a suitably qualified representative from Curtins, who would not normally be resident on site.

1.3 References

The Remediation Strategy has been prepared with reference to the following reports:

- Earth Science Partnership (March 2020) YGG Llyn Y Forwen, Ferndale Proposed School Development Desk Study. Report number ESP.7422d.3311
- Earth Science Partnership (June 2021) Former CHUBB Factory, Ferndale Proposed School Development Main Ground Investigation Report. Report number ESP.7422d.03.3434
- Curtins (January 2023) Former CHUBB Factory Site, Ferndale - Phase 2 Ground Investigation Report number LYF-CUR-A1-XX-RP-G-00001-P04-Phase_2 Ground_Investigation_Report.

- Curtins (September 2022) Former CHUBB Factory Site, Ferndale – Controlled Waters Detailed Quantitative Risk Assessment report number LYF-CUR-XX-XX-RP-GE-00002-P02.
- Curtins (January 2023) Former CHUBB Factory Site, Ferndale – Soil Vapour Risk Assessment report LYF-CUR-XX-XX-T-GE-00003-P02.

It is envisaged that the recipients of this Remediation Strategy and Verification Plan will have been issued with the above reports and, therefore, further copies are not incorporated herein.

2.0 Encountered Ground Conditions

Ground conditions for the site have been summarised below, based on the findings of historical Ground Investigation reports produced for the proposed development area as referenced in Section 1.3.

A review of the available historical mapping information for the Phase 1 development site, as presented in ESP Desk Study report (Ref. 1) reveals that the site was undeveloped until the early 1950s when factories were constructed on an earthworks development plateau. We understand this factory was the Pyrene Company, which later expanded and became the Chubb Fire and Security Factory in the 1970s, which was a fire extinguisher manufacturing and testing facility that included numerous buildings, tanks and electrical sub stations. Most of the buildings were demolished between 2006 and 2015 and the rubble remains stockpiled on-site. Previous investigations, by others, reveal that the site is likely underlain by a covering of Made Ground which increases in thickness to the east to a maximum thickness of around 7m, due to earthworks to create a level development platform. The Made Ground is anticipated to include the former floor slab and historic foundations in the areas of former buildings.

The following information has been reproduced from the ESP and Curtins ground investigation information (Ref. 2 and 3). A drawing showing the combined ESP and Curtins exploratory hole location is provided in Appendix A1. It should be noted that in compilation of this Remediation Strategy, data quality issues have been identified in the ESP survey data presented on some of their borehole logs. This error has been corrected on the exploratory hole location plan by Curtins for the purposes of this document as well as being amended in Curtins Phase 2 ground investigation report and re-issued as version P03 .

2.1 ESP 2021 Ground Investigation (Ref. 2)

As part of the previous ground investigation works, ESP completed a ground investigation in June 2021 with groundwater and ground gas monitoring also completed. The ground investigation consisted of cable percussive boreholes, machine excavated trial pits, windowless sampling boreholes, rotary dynamic sampling, rotary open hole boreholes and a range of in-situ testing.

Several superficial deposits were recorded to be present on site and found to underlay the Made Ground deposits. A summary of the superficial deposits encountered are described in Table 2.1 below.

Table 2.1 – Summary of the Deposits Encountered during ESP 2021 Ground Investigation

Strata	Maximum Depth (m bgl)	Upper Surface (mOD)	Description
Made Ground	4.70	262.20 to 274.84	Generally encountered as light to dark brown and grey sand with carrying portions of clay and gravel, a greyish brown sandy clay and a clayey sandy gravel with typically a low cobble content. Relict topsoil (between 3.30m and 5.00m bgl) and reworked Glacial Diamicton (maximum depth 3.20m bgl) were also encountered

Strata	Maximum Depth (m bgl)	Upper Surface (mOD)	Description
Glacial Diamicton – Fine Grained	18.90	261.57 to 273.95	Generally comprised brown, grey and orange clay with varying portions of silt, sand and gravel. Gravel was generally sub-angular to rounded fine to coarse sandstone and rare fine coal. Low cobble content of sub-angular sandstone.
Glacial Diamicton – Coarse Grained	26.50	263.27 to 274.40	Generally comprised grey, brown and orangish brown gravelly clayey fine to coarse sand and clayey gravel. The gravel weas recorded as fine to coarse and sub-angular to sub-rounded sandstone and mudstone with a low cobble content.,
Coal Measures Bedrock	50.00	246.36 to 264.45	Encountered in rotary open holes only as interbedded sandstone and mudstone with no evidence of workings or thick coal seams. Traces of coal were encountered in some boreholes.

Several groundwater strikes were observed during the 2021 ground investigation within the Made Ground, natural superficial deposits and the underlying bedrock. Groundwater strikes during the investigation were encountered between 0.45 m and 45.00 m below ground level (bgl) as well as localised seepages within some trial pit locations.

Post-investigative groundwater monitoring showed groundwater levels ranged between 0.00 m bgl and 37.70 m bgl. Based on the groundwater data presented in the ESP report there are three groundwater bodies present within the subsurface of the area to include:

- A discontinuous perched groundwater body within the Made Ground
- Groundwater within the Glacial Diamicton
- Groundwater within the Coal Measures Bedrock

Several instances of visual and/or olfactory evidence of possible contamination were observed during the ground investigation. Visual evidence included blue/green staining (possible but not proven blue billy (cyanide and sulphate)), landfill type odours and hydrocarbon odours as well as hydrocarbon sheens on groundwater in some trial pits. In addition, one occurrence of an Aniseed odour and <5mm layer of LNAPLs were encountered as well as a strong bitumen odour.

2.2 Curtins 2022 Ground Investigation (Ref. 3)

A summary of the ground conditions encountered during the Curtins 2022 ground investigation works are presented below, with a detailed summary of each strata also presented below.

Table 2.2 - Summary of Ground Conditions Encountered

Stratum	Depth to top of strata (m AOD)	Thickness (m)	Description
Made Ground	269.32 – 274.69	0.20 – 5.90*	Greyish brown and brown clayey sandy angular to sub-angular fine to coarse GRAVEL of sandstone, mudstone and occasional brick and metal fragments, with low cobble content. Cobbles are angular of sandstone. Locally grey brown slightly silty/clayey gravelly SAND with low cobble content as well as soft to firm brown to mottled grey gravelly SILT with medium cobble content. TP218 encountered a re-worked firm dark brown amorphous PEAT (300mm thick) at the base of Made Ground prior to entering granular Glacial Diamicton
Glacial Diamicton – Cohesive	264.32 – 274.32	0.40 – 18.30*	Typically, firm to locally very stiff light brown to grey sandy gravelly to very gravelly CLAY with some sandstone cobbles. Locally, soft becoming stiff grey sandy, gravelly clayey SILT. A distinct layer of firm dark brown slightly gravely amorphous PEAT was encountered in BH203 (northeastern most corner of the site).
Glacial Diamicton – Granular	244.52 – 273.00	0.45 – 16.60*	Predominantly brown to mottled grey clayey, sandy fine to coarse sandstone GRAVEL with some to many sandstone cobbles. Locally grey to mottled brown silty, gravelly fine to coarse SAND with some sandstone cobbles.
Upper Coal Measures	229.32 – 261.65	18.00* - 34.20*	Predominantly MUDSTONE with some interbedded SANDSTONE and SILTSTONE. Where cored, recovered as weak to medium strong light grey to dark grey partially weathered MUDSTONE with occasional traces of coal. Where cored, recovered as medium strong light grey locally orange stained medium grained SANDSTONE. Where cored, recovered as weak to medium strong dark grey SILTOSNE.

2.3 Made Ground

Made Ground was encountered across most boreholes as either light brown clayey sandy angular to sub-angular fine to coarse GRAVEL of sandstone, concrete, brick and some metal rebar with some sandstone, concrete and brick cobbles. Locally, the predominantly granular Made Ground was interspersed with a stiff greyish brown to dark grey brown sandy gravelly CLAY. The gravel constituent typically comprised angular to sub-angular fine to coarse sandstone, brick and concrete.

A reworked firm dark brown amorphous PEAT was encountered in BH202 and was classed as Made Ground. It was located directly beneath the cohesive Made Ground in this location and above the cohesive Glacial Diamicton. It should also be noted that reworked PEAT was also located in TP218 and TP228 as well as a naturally occurring PEAT located within BH203. All four of these occurrences were located within the eastern most section of site and not within the school development area.

Asphalt was present in some areas, underlain by sub-base in the areas of the access roads that cross the site. Reinforced concrete was located at the surface of TP208, located within the central southernmost section of the site. A strong hydrocarbon odour was detected in TP213 with the underlaying cohesive Glacial Diamicton holding water with an oily sheen. A hydrocarbon odour was also detected in TP214 with both of these locations close to the location of a known (unspecified) above ground storage tank.

A number of redundant ceramic and metal pipes were located during the trial pitting work along with some intact sections of brickwork, former roadways overlain by relict topsoil/granular Made Ground, buried concrete, geotextile membranes and occasional concrete walls.

2.4 Glacial Diamicton - Cohesive

Not encountered in every exploratory hole location, this deposit typically comprised firm to locally very stiff light brown to grey sandy, gravelly to very gravelly CLAY with some sandstone cobbles. Locally encountered as soft becoming stiff grey sandy, gravelly clayey SITL as well as a dark brown slight gravelly amorphous PEAT within the eastern most section of the site as discussed above.

Some central and eastern sections of the site did not encounter cohesive Glacial Diamicton with some northern sections of the site encountering cohesive Glacial Diamicton beneath the typically deeper granular Glacial Diamicton.

2.5 Glacial Diamicton - Granular

Encountered far more widespread than the cohesive Glacial Diamicton, this granular deposit was predominantly brown to mottled grey clayey, sandy fine to coarse sandstone GRAVEL with some to many sandstone cobbles. It was also locally encountered as grey to mottled brown silty, gravelly fine to coarse SAND with some sandstone cobbles.

2.6 Upper Coal Measures Bedrock

Encountered in the rotary open hole and rotary cored boreholes only from depths typically greater than 20 m bgl (~250 m AOD) in the western (school site) section to 25 m bgl (~245 m AOD) in the eastern (future development) section. The noticeable drop in ground elevation from west to east appears to be mirrored in the depth to bedrock.

The bedrock was encountered predominantly as a MUDSTONE with some interbedded SANDSTONE and SILTSTONE and when mudstone was cored it was recovered as weak to medium strong light grey to dark grey partially weathered MUDSTONE with occasional traces of coal and where cored, the sandstone was recovered as medium strong light grey locally orange stained medium grained SANDSTONE.

2.7 Human Health Soil Assessment

The Human Health soil assessment presented in Curtins Phase 2 Ground Investigation report (Ref. 3) was based on a Public Open Space near residential housing (*POSIresi)* end use scenario. Soil organic matter (SOM) values for the Made Ground site soils ranged from 0.3% to 24.5%. The underlying superficial deposits recorded SOM values ranging between 0.4% to 13.2%. The higher organic content encountered in some of the Made Ground samples are considered to be isolated areas of higher organic matter than are not representative of the wide Made Ground.

With consideration for a calculated geometric average, Made Ground features determine a SOM of 5.23%, whereas the underlying superficial deposits determines a SOM of 3.83%. As such, a comparison against Tier 1 thresholds for a conservative SOM of 2.5% for ‘Public Open Space near residential housing (*POSresi)* end use has been adopted for both Made Ground and natural soil features, where applicable.

Many of the exposure pathways considered in the CLEA model assume that the adult or child is in contact with the contaminated ground or that such contamination is easily mobilised from the surface. However, plant uptake of chemicals and the release of soil vapour may occur from greater depths. Although, the highest density of roots occurs in the top 80 cm, many crop plant root depths are between one and two metres. Based on the ‘POSresi end use scenario, this pathway has been discounted. Although the transport potential decreases, vapours have the potential of migrating to the surface over distances of tens of metres (Updated technical background to the CLEA model - SC050021/SR3).

The adopted GACs are listed in Appendix A2.

2.7.1 Generic Assessment Criteria Screening of Soil Laboratory Results

With respect to the proposed end use of the site, the results of the contamination testing recorded a number of exceedances when compared with ‘*Public Open Space near residential housing (POSresi)’* GACs. Details of the positive Asbestos identifications, contaminant exceedances recorded in the Curtins ground investigation, and their locations are detailed below.

The ESP ground investigation recorded exceednaceds of PAH compounds as well as localised exceedances of Barium and Nickel.

Table 2.7.1 - Soil Tier 1 Exceedances for a POSlresi end use with a SOM of 2.5%.

Exploratory Hole ID	Depth (m bgl)	Stratum	Determinant	Quantification (%) or Concentration (mg/kg)	GAC (mg/kg)
TP242	1.00	Made Ground	Asbestos - Amosite loose fibres	<0.001	-
TP214	0.40	Made Ground	Asbestos - Chrysotile loose fibres	<0.001	-
TP227	1.00	Made Ground	Asbestos – Amosite loose fibres	<0.001	-
BH205	1.40	Made Ground	Asbestos – Chrysotile loose fibres	0.037	-
BH205	3.70	Glacial Diamicton	Asbestos – Chrysotile loose fibres	<0.001	-
TP234	0.40	Made Ground	Asbestos – Chrysotile & Amosite loose fibres	<0.001	-
BH206	4.00	Made Ground	Asbestos – Chrysotile loose fibres	1130	640
TP247	0.60	Made Ground	Benzo(a)anthracene	160	29
		Made Ground	Benzo(a)pyrene	75.6	5.7
		Made Ground	Benzo(b)fluoranthene	115	7.2
		Made Ground	Chrysene	251	57
		Made Ground	Dibenzo(ah)anthracene	19.2	0.58

Exploratory Hole ID	Depth (m bgl)	Stratum	Determinant	Quantification (%) or Concentration (mg/kg)	GAC (mg/kg)
BH206	1.00	Made Ground	Benzo(a)pyrene	14.3	5.7
		Made Ground	Benzo(b)fluoranthene	21.2	7.2
		Made Ground	Dibenzo(ah)anthracene	3.12	0.58
BH206	2.00	Made Ground	Benzo(b)fluoranthene	7.34	7.2

2.8 Controlled Waters GQRA

Historically the site has been recorded as being the site of the former CHUBB Fire Factory where firefighting equipment and foams were manufactured. This land use is susceptible to a bespoke contaminant fingerprint with chlorinated solvents and Perfluoroalkyl Surfactants (PFAS) synonymous with this manufacturing industry. The site is recorded to be underlain by superficial deposits of glacial diamicton (Secondary Undifferentiated aquifer), which are underlain by residual soils and bedrock of the Coal Measures (Secondary A aquifer).

The closest surface water feature is located on site recorded to be the Afon Rhondda Fach at the bottom of the valley to the northeast of the development site. As noted above, historically there are several potential sources of contamination that pose a risk to contaminating the surface water receptor.

Whilst the site is directly underlain by Secondary (undifferentiated) and Secondary A aquifers, the primary controlled waters receptor is the Afon Rhondda Fach due to it being unlikely that the groundwater below the site would be utilised as a resource for potable water abstraction before it discharges to the Afon Rhondda Fach, which the groundwater within the glacial diamicton is assumed to be in hydraulic connectivity with.

2.8.1 Adopted Controlled Waters Tier 1 Screening Values & Methodology

A generic quantitative risk assessment (GQRA) was undertaken as part of the preliminary risk assessment to determine contaminants of potential concern (COPC). The following hierarchy of water quality standards (WQS) were adopted for the assessment of groundwater and soil leachate results:

1. Environmental quality standards (EQS)
2. UK Drinking Water Standards (UK DWS)
3. World Health Organisation Drinking Water Guidelines (WHO DWG)

2.8.2 Tier 1 Screening of Groundwater Laboratory Results

Both groundwater and surface water samples (Afon Rhondda Fach Upstream & Downstream) samples were laboratory tested. The results from the groundwater environmental testing were compared against the EQS and DWS groundwater thresholds revealing a number of contaminants of concern requiring further assessment via a Detailed Quantitative Risk Assessment (DQRA).

2.9 Controlled Waters DQRA

Curtins carried out a Controlled Waters Detailed Quantitative Risk Assessment (DQRA) (Ref. 4) with the following Contaminants of Potential Concern (COPC) identified in the GQRA. The following COPC have been determined not to present a significant risk for the reasons described with Curtins DQRA (Ref. 4), and have accordingly not been taken forward into the DQRA:

- Heavy metals[Error! Bookmark not defined.] – Widespread exceedances of heavy metals are likely to be associated with a natural source.
- Phenol – Only two minor exceedances were detected in soil leachate and no exceedances were detected in groundwater.
- TPHs[Error! Bookmark not defined.] (inc. benzene) – Only limited localised and minor exceedances were detected in soil leachate and groundwater.
- PAHs[Error! Bookmark not defined.] – Given the distance to the Afon Rhondda Fach and the low mobility of PAHs, risks are unlikely.
- Chlorinated hydrocarbons[1] – Exceedances in groundwater were widespread and numerous for several chlorinated hydrocarbons, however, their presence was coincident and considerably less severe than TCE, which is considered a conservative surrogate marker for the assessment risks from all detected chlorinated hydrocarbons.

Based on the above discussion, the PFOS and TCE were taken forward into the DQRA. Further details of maximum contaminant concentrations are provided below in Table 2.9 overleaf.

[1] Carbon tetrachloride, chloroform, cis-1,2-DCE, dichloromethane, 1,1,1-trichloroethane and VC.

Table 2.9 – *Selected COPC for Detailed Quantitative Risk Assessment*

COPC	Determination 2006/118/EC Classification and JAGDAG	Water Quality Standard (mg/l)	Max. GW Conc. (mg/l)	Max. Leacahte Conc. (mg/l)
PFOS	Hazardous	0.00000065	**0.0081**	**0.0105**
TCE	Hazardous	0.01	**28.0**	**0.047**

NOTES: **Bold text** indicates concentration exceeds the screening criteria

2.10 Controlled Waters DQRA Results

Soil leachate results from the unsaturated zone were screened against the Level 3 soil leachate SSAC.

PFOS

Exceedances of the soil leachate site specific assessment criteria (SSAC) (0.00142 µg/l) for PFOS were detected in samples from TP137 (0.4 m), TP138 (0.5 m) and BH-M (0.8 m). All samples were recovered from the Made Ground and the locations were within the vicinity of the former fire test area in the south of the site. The exceedances were four orders of magnitude above the derived SSAC. However, it should be noted that the soil leachate results from these samples are only slightly above the PFOS concentrations detected in up gradient monitoring wells and so whilst a potentially unacceptable risk to the Afon Rhondda Fach has been identified, the additional impact to the groundwater caused by leaching from shallow soils is relatively limited.

TCE

Only one marginal exceedance of the soil leachate SSAC (45.1 µg/l) for TCE was detected in the soil leachate sample from TP133 (2.5 m). However, as detailed in Section **Error! Reference source not found.**, there were only limited numbers of soil and soil leachate samples tested for investigation locations where the most severe groundwater impact had been observed. Given the magnitude and distribution of the TCE groundwater concentrations in the source area, the historical tanks and/or degreasers are likely to be the primary TCE (and other chlorinated hydrocarbons) sources though it is possible that the precise location(s) of the shallow soil source(s) may not been identified by the soil sample analysis undertaken to date. Therefore, whilst there was an absence of significant exceedances of the TCE soil leachate SSAC, this should not be interpreted as there being no shallow soil source, which is unlikely given the elevated groundwater results and the above ground nature of the historical tanks and degreasers.

Groundwater

Groundwater results were screened against the Level 3 groundwater SSAC.

PFOS

Exceedances of the groundwater SSAC (0.000865 µg/l) for PFOS were detected in 30 samples, with the largest exceedance being at BH-M (8.1 µg/l) near the former fire test area. The numerous and widespread nature of the SSAC exceedances reaffirms the likely existence of an elevated background flowing on to site from the southwest within the shallow aquifer. Whilst the highest PFOS concentrations are in monitoring wells located near the former fire test area in the south of the site, these results are typically no more than one order of magnitude higher than the observed background. So, as per the soil leachate assessment, it appears likely that although an unacceptable risk to the Afon Rhondda Fach from groundwater is potentially present, the additional impact from a site derived source is relatively limited.

In addition to the above, upstream and downstream sampling of the Afon Rhondda Fach has indicated the presence of low but detectable concentrations (0.03 µg/l) of PFOS within the watercourse. However, there is no increase in the PFOS concentration from the upstream to downstream sampling points. Based upon this, two points can be concluded:

- PFOS contamination derived from the site source is not currently resulting in a detectable impact to the Afon Rhondda Fach.
- An alternative upstream source is already having a detectable impact upon the water quality of the Afon Rhondda Fach.

Whilst the groundwater modelling indicates that PFOS contamination derived from the site source would take 312 years to reach the Afon Rhondda Fach, it is likely that the adopted hydraulic conductivity (0.0516 m/day) may be an underestimate when considering the values that may typically be expected for the general granular nature of the diamicton and that the site derived value was based on testing from only one location. For example, hydraulic conductivities one to two orders of magnitude higher than the site derived value may be typically expected for the encountered geology, which would result in travel times to the Afon Rhondda Fach of 31.2 years and 3.12 years. Given PFAS compounds were only manufactured from the middle of the 20th Century onwards, the site wide distribution of PFOS in groundwater would be appear unlikely to occur if the hydraulic conductivity of the glacial diamicton was as low as the adopted value. Based on the more likely travel times to the Afon Rhondda Fach, it is likely that adverse impact to the Afon Rhondda Fach resulting from the site source would be detectable in the upstream and downstream samples. However, as stated previously, this is not the case.

In light of the above, the adopted hydraulic conductivity value used for modelling may appear insufficiently conservative, however, it is noted that the model has still identified a potentially unacceptable risk to the receptor and is, therefore, considered adequately conservative for the purposes of this assessment.

TCE

Exceedances of the groundwater SSAC (547 µg/l) for TCE were detected in samples from eight locations, with the largest exceedance being at BH-G (28,000 µg/l) in the centre of the site, which was 48.8 times higher than the SSAC. The larger SSAC exceedances were generally located within the identified source area in the centre of the site, though there were some more marginal exceedances further towards the northern site boundary at BH-B (D) (though only during one of the two sampling rounds) and BH-C (S). Consistently elevated TCE results were detected across two monitoring rounds at BH-F, BH-G, BH-N (S) and BH-N (D), with only one exceedance at WS113 (sampled twice) and BH206 (sampled once). Based on the results of the modelling, an unacceptable risk to the Afon Rhondda Fach exists from a TCE groundwater source.

Whilst a potentially unacceptable risk has been identified, upstream and downstream sampling of the Afon Rhondda Fach does not indicate any detectable impact to the water quality from TCE as both results are below detection. As per the discussion for PFOS, the hydraulic conductivity may be an underestimate of the true site conditions and so the estimated travel time of 68.3 years is likely to be an overestimate.

A hydraulic conductivity one or two orders of magnitude higher than that used for the modelling would result in travel times to the Afon Rhondda Fach of 6.83 years and 0.683 years. Based on these timescales and that the chlorinated hydrocarbon contamination is likely to have occurred at least 15 – 20 years ago, given the site closure in 2005, it is anticipated that if a detectable impact to the Afon Rhondda Fach was occurring it would have been identified in changes in upstream and downstream sampling. It is also noted that there is no detectable impact to the upstream and downstream samples from the other chlorinated hydrocarbons that are present in groundwater below the site.

Based on the findings of this assessment, it is considered likely that unacceptable risks to controlled water receptors exist at the site. However, the magnitude of these impacts and certainty of their occurrence remain uncertain to a degree. Nonetheless, it is recommended that remedial intervention is undertaken to address the most significant contamination that has been identified.

2.11 Asbestos

A total of 125 No. soil samples across all ground investigation work carried out on the site were collected and analysed for asbestos recovered from exploratory holes advanced as part of the ground investigation works. All 125 No. soil samples taken were screened for asbestos as part of the environmental testing suite and 18 No. samples recording positive presence of Asbestos.

Asbestos was not reported in any of the remaining 107 No. laboratory screening tests carried out on samples obtained from the ground investigation.

The presence of proposed hardstanding as part of the development works would remove the source-pathway-receptor (SPR) link between the source and receptor.

Within soft landscaping areas, a suitable cover system is likely to be required. Considering the age of the structures historically, and stages of demolition historically, the presence of ACMs and / or asbestos fibres on this site is likely to be present. An asbestos action plan may be established prior to any construction work.

The treatment of asbestos must be undertaken by a specialist who will need to provide a method statement for the works. However, it is anticipated that mitigation works will include, subject to local authority approval, the following;

a) Asbestos containing soils to be left undisturbed in-situ if currently provided with sufficient cover of non-asbestos impacted soils and otherwise clean and inert soil is to be provided;

b) Asbestos containing soils are excavated and re-used to be placed in a less sensitive area of the development works were building structures and or hardstanding can provide an appropriate break to the source-pathway-receptor linkage to site users;

c) Excavate and remove to a suitably licensed disposal facility;

d) Specialist monitoring of excavations in areas of recorded asbestos.

Note that for excavation and re-use option b) the groundworks will have to be undertaken in accordance with The Definition of Waste: Development Industry Code of Practice Version 2 March 2011 (CL:AIRE).

2.12 Ground Gas

Curtins carried out a programme of six gas monitoring visits over three months. The barometric pressure was recorded between 970 and 993 Mb during the rounds, which were undertaken during varying barometric pressure trends. The results log sheets are summarised in Table 2.10. Where the flow has been recorded as a dashed line, it represents that the GA5000 was below the limit of detection of the flow of 0.1 litres per hour.

Where the flow has been recorded as a dashed line, it represents that the GA5000 was below the limit of detection of flow of 0.1 litres per hour.

Table 2.10 - Results of The Ground Gas Monitoring Visits

Location	Maximum Methane Concentration (%)	Maximum Carbon Dioxide Concentration (%)	Minimum Oxygen Steady Reading (%)	Maximum Gas Flow (l/hr)
BH201A	0.1	5.5	12.9	-
BH203 Shallow	6.2	4.3	5.5	-

BH203 Deep	0.1	1.9	2.8	-
BH204 Shallow (35mm)	1.0	0.1	20.4	0.2
Location	Maximum Methane Concentration (%)	Maximum Carbon Dioxide Concentration (%)	Minimum Oxygen Steady Reading (%)	Maximum Gas Flow (l/hr)
BH204 Deep (35mm)	0.1	1.0	20.4	-
BH205	0.1	2.0	19.9	-
BH206	0.1	1.0	19.8	-
BH208	0.1	2.2	18.3	0.5
BH209A	0.1	2.0	18.5	-
BH211A	0.1	0.5	20.4	6.0
BH212A	0.1	0.5	18.3	0.20
BH213	0.3	5.8	4.4	0.1
BH214	0.1	1.3	18.2	0.5
BH215	0.1	2.1	12.4	0.1
BH216	0.1	1.5	16.4	-
BH217	0.1	6.0	12.7	7.3
BH-C Shallow	0.7	5.7	10.6	-
BH-C Deep	4.7	5.9	1.7	-
BH-C(R) Shallow	0.1	0.3	19.9	0.5
BH-C(R) Deep	0.1	0.3	19.9	-
BH-D Shallow	0.0	6.7	15.2	-
BH-E (R) Shallow	0.0	0.0	20.2	-
BH-G	0.2	2.8	18.5	0.11
BH-K Shallow	0.0	1.7	17.7	-
BH-N Shallow	0.2	8.9	10.4	-
BH-N Deep	0.1	0.2	20.5	-
BH-F	0.3	7.6	0.2	0.2
BH-F(R) Shallow	1.1	1.9	0.4	-
BH-F(R) Deep	1.2	1.9	0.2	-

Gas and groundwater monitoring work carried out recorded maximum methane readings of 6.2% and maximum carbon dioxide readings of 8.9% with a maximum flow rate of 7.3l/hr recorded in boreholes within the site.

The Conceptual Site Model presented within the ESP Geotechnical & Geo-environmental interpretative Report (Ref. 2) identified Made Ground deposits as a potential source of ground gas generation both on-site and off-site resulting from historical developments and land uses. The report notes organic rich drift deposits (e.g., peat) may also be present within the superficial deposits. Coal deposits are not recorded to underlie the site within the Coal Measures bedrock. Noxious and asphyxiate gases were attributed to include, but not limited to, carbon dioxide, carbon monoxide, methane, and hydrogen sulphide.

Made Ground was recorded to be present across the site. This was underlain by several superficial deposits comprising of generally sandy, silty gravels, sands and clays with localised peat bands. This was further underlain by the bedrock deposits of the Upper Coal Measures comprising of mudstones with interbeds of siltstones and sandstones. The position of TP238 recorded soil organic matter of 24.5% within the Made Ground at 1.00m bgl. This location is not within the main school development area.

Consideration of the recorded soil gas flow rates, presented above, enables hazardous gas flow rates to be evaluated. Q_{hg} can be derived for both 'worst credible' and 'worst possible' scenarios and a comparison made in support of an appropriate assessment of ground gas risk. For a 'worst credible' scenario steady state flow rates are adopted, whilst for a 'worst possible' scenario peak flow are adopted.

Evaluation of the 'worst credible scenario' (highest hazardous gas flow rate that is realistically possible, i.e., in a single borehole), records a maximum Q_{hg} of 0.0062 l/hr for methane.

Evaluation of the 'worst possible scenario' (highest Q_{hg} across the entire dataset irrespective of location and discrete monitoring events), records a maximum Q_{hg} of 0.45l/hr for methane.

Evaluation of the 'worst credible scenario' (highest hazardous gas flow rate that is realistically possible, i.e. in a single borehole) records a maximum Q_{hg} of 0.0089 l/hr for carbon dioxide.

Evaluation of the 'worst possible scenario' (highest Q_{hg} across the entire dataset irrespective of location and discrete monitoring events) again records a maximum Q_{hg} of 0.65 l/hr for carbon dioxide.

Gas flow was recorded on-site and in boreholes where the flow has been shown to have variable gas concentrations. Therefore, the site's Gas Screening Value (GSV) has adopted the worst credible scenario. Following an assessment by CIRIA C665, the GSV indicates a Characteristic Situation 2 (CS2) gas regime which will require special ground gas protection measures. Notwithstanding the soil vapour assessment.

Based on BS8485:2015+A1:2019, the proposed school end use can represent a medium sensitivity "Type B" building in some areas, with a minimum gas protection score of 3.5.

A combination of at least two types of protection measures is required based on the following types of measures:

- Structural barrier of the floor slab
- Passively ventilated underfloor subspace
- Gas-resistant membrane

As per guidance in BS8485, whenever possible, all gas protection measures should incorporate a pressure relief pathway as a minimum. All works should be installed to a reasonable level of workmanship/ in line with current good practice under CQA with integrity testing and independent validation by CIRIA C735.

2.13 Vapour Risk

A preliminary assessment of vapour risks presented by volatile contamination in groundwater beneath the site has been undertaken against SoBRA groundwater vapour generic assessment criteria (GAC_{gwvap}). The results of volatile groundwater contamination from the ESP and Curtins ground investigations have been assessed. Based upon the proposed construction of a school on the site, residential land-use GAC_{gwvap} were adopted for the assessment since commercial land-use GAC_{gwvap} is not considered sufficiently conservative.

A summary of the exceedances is included below in Table 2.11a.

Table 2.11a – Summary of SoBRA GAC_{gwvap} exceedances in groundwater

Contaminant	SoBRA GAC_{gwvap} (µg/l)	Max. result from ESP Investigation (µg/l)	Max.Result from Curtins Investigation (µg/l)	No. Locations Exceeding GAC_{gwvap}
Aromatic Hydrocarbons - Aliphatic C5-C6	1,900	2,100	-	1
1,1,1-Trichloroethane	3,000	8,800	<	1
1,1-Dichloroethylene	160	600	<	3
1,2-Dichloroethane	8.9	9	-	1
Carbon tetrachloride	5.3	260	9	9
cis-1,2-Dichloroethylene	130	5,000	161	5
Trichloroethylene	5.7	28,000	9,006	31

Vinyl Chloride	0.62	220	10	8

- Denotes that the contaminant was not detected during this phase of monitoring.

< Denotes that the contaminant was above the limit of detection but was below the SoBRA GAC_{gwvap}.

The preliminary groundwater vapour risk assessment results indicate the existence of potentially unacceptable risks to human health receptors via the inhalation of volatile vapours. Except for one result, all exceedances were associated with chlorinated hydrocarbons, with the majority being for trichloroethylene (TCE), indicating widespread impact from this compound. Exceedances of cis-1,2-dichloroethylene, vinyl chloride and carbon tetrachloride were detected at five or more locations. Cis-1,2-dichloroethylene, 1,1-dichloroethylene, and vinyl chloride are known daughter products of TCE, so their coincidence with TCE contamination is expected.

Based upon the outcome of the preliminary groundwater vapour assessment, a soil vapour assessment was carried out to further inform the risk.

A series of 6no vapour monitoring wells were installed in and around the proposed school building footprint and chlorinated solvent source area following an assessment of source location and migration routes. The well response zones for the shallow vapour wells (VP101 – VP106) were installed to intersect the shallow groundwater levels, where possible, to provide representative worst-case vapour concentrations. The selected existing wells (WS113, BH204 and BH-E (R)-S) were chosen as the monitoring well screens have typically intersected the resting shallow groundwater levels and thus provide representative worst-case vapour concentrations.

The soil vapour results have been compared to generic assessment criteria (GAC) derived from SoBRA GAC_{gwvap} . Alongside the publication of GAC_{gwvap} for groundwater, the SoBRA report (2017) provided the modelling output sheets that include the calculated equilibrium soil vapour concentrations which can be utilised as vapour phase GAC (herein referred to as GAC_{vap}). A summary of the exceedances detected following the soil vapour sampling are summarised in Table 2.11b.

Table 2.11b: SoBRA Vapour GAC Exceedances

Hole ID	Analyte	GAC_{vap} ($\mu g/m^3$)	Result ($\mu g/m^3$)	Exceedance Factor
VP104	cis-1,2-Dichloroethene	9,340	18,955	x 2.0
	Trichloroethene	1,060	12,007.7	x 11.3
VP106	Carbon Tetrachloride	3,070	39,217.4	x 12.8

Based on the results and a conservative residential land-use scenario, only two locations have exceedances of the GAC_{vap}. The cis-1,2-DCE result at VP104 was only slightly above the GAC_{vap} and is of the same order of magnitude. The TCE and carbon tetrachloride results at VP104 and VP106 respectively were approximately one order of magnitude above their GAC_{vap}. VP104 and VP106 are both located near historical tanks, with VP106 also being adjacent to BH-G where the highest groundwater concentrations of VOCs were detected. Given the distribution of the elevated vapour concentrations, it is likely that both tanks were contamination point sources.

Furthermore, whilst there were no GAC_{vap} exceedances at WS113, elevated concentrations of several VOCs in the vapour phase were detected, which suggests that the historical tank near this location was also likely to be a contamination point source. Elevated VOC concentrations in groundwater were also previously detected at WS113.

The presence of the GAC_{vap} exceedance at VP106 is unlikely to present an unacceptable risk to the proposed school building due to it being approximately 60 m to the southeast. This is further supported by the absence of GAC_{vap} exceedances and much reduced VOC vapour concentrations at VP105, located between V106 and the proposed school building.

The GAC_{vap} exceedances at VP104 are the only ones within the footprint of the proposed school building, further indicating the historical tank near this location to be a likely point source. Whilst the VP104 GAC_{vap} exceedances are localised and the adopted GAC_{vap} are potentially overly conservative due to being based on a residential land-use scenario, a potential risk to the occupants of the proposed school building is cannot be discounted.

Whilst further detailed risk quantitative assessment (DQRA) of the potential risks from vapour inhalation to occupants of the proposed school building could be undertaken, it is noted that there is an existing requirement for gas protection measures, including a membrane, to be incorporated within the building's construction. Therefore, it is considered more cost-efficient to upgrade the existing gas membrane requirement to a proprietary VOC vapour membrane.

3.0 Conceptual Site Model

A Conceptual Site Model (CSM) for the site has been developed using the historical ground investigations that have been completed at the site and considers the likely enabling works proposed. The CSM details several pollutant linkages at the site; however, based on the risk assessments undertaken, the potential pollutant linkages (PPLs) listed in Table 3.0 were identified as requiring remediation to enable the safe re-development of the site.

Table 3.0 – Potential Pollutant Linkages (Existing)

PPL	Sources	Receptor	Potential Pathway	Remediation Recommended
1	Exceedances of PAH contamination has been recorded. Comparison against POSResi GACs. The presence of Asbestos has been identified within Made Ground soils. However, some organic and inorganic compounds including PCB and PFOS are present, all others are not above GACs	Site end users – staff, visitors, etc	Direct Contact, inhalation, ingestion	Specification for an appropriate engineered cover system minimum 300mm thickness and installation of demarcation membrane should be provided in areas of all proposed soft landscaping to protect end users. To be upgraded to minimum 600mm in areas of planned 'school Planting activities'.
2	Groundwater – dissolved phase PFOS and chlorinated solvents have been identified at levels that potentially present a risk to controlled waters	Controlled Waters – Primarily Afon Rhondda Fach as well as underlying superficial and bedrock aquifers	Lateral migration through existing soils on site. Leaching/Dissolution from soil/NAPL	Implementation of appropriate in-situ remediation technologies to reduce dissolved phase contaminant concentrations
3	Ground Gas – from soils on site and vapours resulting from chlorinated solvents on site	Site end users	Vertical and horizontal migration through existing Made Ground deposits followed by inhalation	Specification for the installation and verification of the gas protection measures in line with a CS2 requirement rating and propriety VOC vapour membrane.
4	Concentrations of PAHs, PCB, and TPHs, and predominantly alkaline conditions in areas of the Made Ground soils.	Water Supply Pipes	Leaching through water pipes followed by ingestion	Installation of Barrier Pipes.

PPL	Sources	Receptor	Potential Pathway	Remediation Recommended
5	Possibility of 'unexpected contamination'	Site end users – staff, visitors, etc	Direct Contact, Inhalation of Dust/Fibres and Vapours	Watching brief and procedures installed to deal with any occurrences.

Under current health and safety legislation, employers are required to carry out their own appropriate risk assessments and mitigation to protect themselves and their employees, other human receptors, and the environment from potential contamination sources.

Such risks must be mitigated by law, specifically the Construction Design Management (CDM) Regulations, 2015 which require that potential risks to human health and the environment from construction activities are appropriately identified and all necessary steps taken to eliminate / manage that risk.

Agreed. Yes, assumed sample contamination due to the drilling process. We have included the following section within 7.4.

4.0 Overview of Remedial Actions

With reference to the Conceptual Site Model and the potential pollutant linkages detailed in Table 3.0, five remedial actions are recommended for the site to be brought up to a condition that is deemed 'suitable for use'.

Remedial Action 1: Provision of a specification for minimum 300mm engineered cover layer with high visibility demarcation membrane to serve as a physical barrier between the Made Ground deposits and the end users of the site within all the proposed soft landscaping areas. This cover layer thickness to be increased to a minimum of 600mm in areas of planned 'school Planting activities'.

Remedial Action 2: Provision of in-situ treatment via approved technology/methodology to reduce rick to controlled waters from the presence of PFOS and TCE contamination observed on site.

Remedial Action 3: Provision of a specification for the required gas and ground vapour protection measures to be incorporated into the new school development.

Remedial Action 4: Provision of upgraded water supply pipes to Barrier (PE-AI-PE) pipe.

Remedial Action 5: Preparation of Unexpected Contamination procedure and action plan.

4.1 Remedial Action 1 – Engineered Cover Layer

This PPL relates to the dermal contact and ingestion of contaminants and inhalation of asbestos fibres in the existing Made Ground materials. The potential for exposure of contaminated Made Ground to take place is greatest in areas of proposed soft landscaping where receptors (end users, maintenance workers and visitors) at the site are mostly likely to be exposed and where soils are unprotected from the elements and not developed over. Remedial measures in areas of soft landscaping should therefore be adopted at the site and remedial measures for this area are discussed in Table 4.1. The hardstanding areas do not require a cover layer as the SPR linkage will be broken by constructing over the unsuitable soils. This is based on the contaminants identified not presenting a vapour risk (risk considered further in Remedial Action 4). Therefore, it is recommended that current development plans within areas of identified unsuitable materials remain as planned to ensure that the SPR linkage is broken.

Table 4.1 – Engineered Cover Details for Proposed Soft Landscaping

Proposed Development Area	Further Remedial Measures Required (1)	Rationale
Soft Landscaping	Provision of a minimum **300mm** 'clean and inert' cover layer comprising minimum 150mm topsoil over remaining 150mm depth of subsoil (topsoil should not exceed 300mm). A 100mm thick capillary break layer is recommended. Placement of cap sequence above a demarcation membrane.	Remove potential exposure of receptors via contact with contaminants in Made Ground.
Planting Areas	Thickness to be increased to a minimum **600mm** in areas of planned school Planting activities. These areas will be in self-contained isolated raised beds independent of landscaping.	

(1) Note – The recommended remedial measures assume that any excavations for formation for remedial action will not encounter the base of the Made Ground.

Most of, if not all, soils used to form the soft landscaping engineered cover are likely to be imported soils. Chemical testing requirements of these imported soils are outlined in Section 5.4. A high visibility geotextile marker membrane is considered to be required based on the contaminant concentrations identified and should further contaminants or increased concentrations be identified, the cover system should be reassessed.

The above remedial action should be reassessed where site levels are altered. Where site levels are proposed to be reduced, Made Ground materials may be removed as part of these works. Subject to the depth of removal, this may remove some of the potential source. In addition, where levels are to be raised using site-won Made Ground materials, the engineered cover requirements should be incorporated as part of the final surface level.

It is recommended that the reuse of any site won soils is declared, managed and recorded by compliance with the Definition of Waste – Development Industry Code of Practice by way of a Materials Management Plan.

4.2 Remedial Action 2 – Controlled Waters Protection Measures

PFAS and chlorinated solvent contaminated groundwater has been identified via the Curtins Controlled Waters DQRA report Ref. 4)). The CWDQRA found the following;

- The Level 3 RTM (Environment Agency Remedial Target Methodology) modelling results for soil leachate indicate a theoretical risk to controlled waters from PFOS with the exceedances being four orders of magnitude above the derived site specific assessment criteria (SSAC). However, it should be noted that the soil leachate results were only slightly above the PFOS concentrations detected in upgradient monitoring wells, which indicate the potential existence of an offsite source, and so whilst a potentially unacceptable risk to the Afon Rhondda Fach has been identified, the additional impact to the groundwater caused by leaching from shallow soils is relatively limited.

- The Level 3 RTM modelling results for soil leachate indicate a theoretical risk to controlled waters from TCE is unlikely as only one marginal exceedance of the soil leachate SSAC was detected. However, there were only limited numbers of soil and soil leachate samples tested for investigation locations where the most severe groundwater impact had been observed. Given the magnitude and distribution of the TCE groundwater concentrations in the source area, the historical tanks and/or degreasers are likely to be the primary TCE (and other chlorinated hydrocarbons) sources though it is possible that the precise location(s) of the shallow soil source(s) have not been identified by the soil sample analysis undertaken to date. Therefore, whilst there was an absence of significant exceedances of the TCE soil leachate SSAC, the presence of a potential shallow soil source cannot be discounted.

- The Level 3 RTM modelling results for groundwater indicates a theoretical risk to controlled waters from PFOS. However, the numerous and widespread nature of the SSAC exceedances indicates the potential existence of elevated background concentrations flowing on to site from the southwest within the shallow aquifer. Whilst the highest PFOS concentrations are in monitoring wells located near the former fire test area in the south of the site, these results are typically no more than one order of magnitude higher than the observed background. So, as per the soil leachate assessment, it appears likely that although a potentially unacceptable risk to the Afon Rhondda Fach from groundwater has been identified, the additional impact from a site derived sources is relatively limited. In addition, upstream and downstream sampling of the Afon Rhondda Fach has indicated the presence of low but detectable concentrations (0.03 µg/l) of PFOS within the watercourse. However, there is no increase in the PFOS concentration from the upstream to downstream sampling points, which suggests that PFOS contamination derived from the site source is not currently resulting in a detectable impact to the Afon Rhondda Fach. An alternative upstream source is seemingly potentially already having a detectable impact upon the water quality of the Afon Rhondda Fach.

- The Level 3 RTM modelling results for groundwater indicates a theoretical risk to controlled waters from TCE. Exceedances of the groundwater SSAC for TCE were detected in samples from eight locations, with the largest exceedance being at BH-G (28,000 µg/l) in the centre of the site, which was 48.8 times higher than the derived SSAC. The larger SSAC exceedances were generally located within the identified source area in the centre of the site, though there were some more marginal exceedances further towards the northern site boundary. Whilst a potentially unacceptable risk has been identified, upstream and downstream sampling of the

Afon Rhondda Fach does not indicate any detectable impact to the water quality from TCE as both results are below detection. It is also noted that there is no detectable impact to the upstream and downstream samples from the other chlorinated hydrocarbons that are present in groundwater below the site.

Based on the findings of this assessment, it is considered likely that unacceptable risks to controlled water receptors exist at the site. However, the magnitude of these impacts and certainty of their occurrence remain uncertain to a degree. Nonetheless, it is recommended that remedial intervention is undertaken to address the most significant contamination that has been identified.

4.3 Remedial Action 3 – Gas/Vapour Protection Measures

Another Potential Pollutant Linkage (PPL) identified at the site relates to the acute risk of explosion and/or asphyxiation of property and end-users through the vertical and horizontal migration of hazardous gases (asphyxiating) from soil gas sources as identified in Table 3.0 into proposed buildings on site. In this case, methane and carbon dioxide were identified as the primary hazardous gases and therefore, gas protection measures are to be implemented during the development of the site to mitigate the risk to the property and end-users. Due to the nature of the development, it is recommended that the building types are classified as Type B Commercial buildings, in accordance with BS8485 (Ref. 6).

As previously detailed in Section 2.8, a Ground Gas Characteristic Situation 2 (CS2) is considered for this site.

In light of a Type B development and CS2 classification, **a ground gas point protection score of 3.5 is required**. Points should be obtained via a combination of gas membrane as per Table 7 and other measures detailed within Table 6 within BS8485:2015+A1 2019. In addition, radon protective measures are also required. Where a gas resistant membrane is adopted, it must meet all the following criteria:

1. Sufficiently impervious to the levels of methane and carbon dioxide recorded during the gas monitoring;
2. Capable after installation of providing a complete barrier to the entry of the relevant gas;
3. Sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions;
4. Sufficiently strong to withstand in service stresses (e.g. due to ground settlement if placed below a floor slab);
5. Sufficiently strong to withstand the installation process and following construction activities until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, and dropping tools);
6. Chemically resistant to degradation by other contaminants that might be present; and

7. Verified in accordance with CIRIA C735 (Ref.8).

It is recommended that an appropriately experienced and qualified workforce is employed to install gas protection systems to be verified under CIRIA C735 (Ref. 8). The installed gas protection measures should be independently validated by a third party.

A combined ground gas and VOC vapour membrane should be specified by installer in collaboration with the manufacturer, in accordance with CIRIA C748. The membrane installation should be undertaken by a qualified and experienced installer in line with current good practise, and be integrity tested to ensure the system is sealed, particularly around service entries.

Validation of the installed system should be undertaken by an independent company in accordance with CIRIA C735 and should be warranted and certified.

The guidance document CIRIA (C716) '*Remediating and mitigating risks from volatile organic compound (VOC) vapours from land affected by contamination'* (2012) provides details and considerations for the various aspects needing consideration.

4.4 Remedial Action 4 – Water Supply Pipes

With reference to the UKWIR publication 'Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites' document reference 10/WM/03/21 advice is given on the appropriate materials for these ground conditions.

Due to concentrations of PAHs and TPHs observed within the site shallow soils, it is recommended that Barrier (PE-AI-PE) pipe would be suitable materials for the water supply pipes.

The exact requirements are to be confirmed with the relevant utility supplier.

It is recommended that a verification report of the installation of the water supply pipes be provided, which should be included within a Remediation Verification Report on completion of the project.

4.5 Remedial Action 5 – Unexpected Contamination

Ground investigation works have been completed by Curtins in 2022 (Ref. 3). Further occurrences of encountered contamination may occur during the development works and an 'Unexpected Contamination' procedure should be adopted and implemented to deal with any such incidents.

It is recommended that the procedure presented in Appendix A4 should be integrated into the development plans and actioned where necessary.

5.0 Engineered Cover Specification

Materials are to be placed within proposed soft landscaping areas as part of the development works. At the time of writing the remediation strategy, no cut and fill drawings or landscape specification have been produced. The following sub-sections provide guidance with respect to the sourcing of both on-site and imported soils on a chemically suitable basis. This is not a geotechnical specification for general fill materials. It is envisaged that, if this is necessary, this will be covered in a standalone earthworks specification.

5.1 Sourcing of Materials

5.1.1 Off-Site Sources

It is anticipated that materials are to be imported to the site for use in constructing the engineered cover soft landscaping areas as it is unlikely that there is sufficient topsoil present on site for re-use. It is strongly recommended that should additional materials be required, they are sourced from reputable suppliers and comprise materials that have been suitably processed to produce standardised materials.

It is not recommended that materials are imported directly from 'donor' development sites. Imported material will also require verification testing to ensure suitability for reuse, and it is strongly advised that the Contractor undertake their own independent verification testing if accepting material from a third party, rather than relying on supplier reports.

5.1.2 On-site Sources

Based on the findings of the site investigation, and the subsequent review the Made Ground soils are considered as being 'contaminated'. Consequently, this material is only suitable beneath an engineered cover layer. It is recommended that material for use within the engineered cover soft landscaping areas as described in Table 4.1 should be imported 'clean inert'.

In proposed soft landscaped areas where Made Ground cannot be placed prior to the 'clean and inert' cover system, it should be placed beneath hard standing areas or scheduled for off site disposal in line with current waste guidance.

It is recommended that the reuse of any site won soils is declared, managed and recorded by compliance with the Definition of Waste – Development Industry Code of Practice by way of a Materials Management Plan.

5.2 Imported Topsoil

Imported topsoil may be required and should be supplied and placed in accordance with the Architects' specification but generally, all topsoil will be a minimum of 150mm thick in areas of soft landscaping (as part of the overall cover layer thickness detailed in Table 4.1).

Where topsoil is imported it is to be 'Multipurpose' in accordance with BS 3882:2015 'Specification for Topsoil and Requirements for Use'. The topsoil should also be confirmed to be 'suitable for use' with regards to human health assessment as per the analysis outlined in Section 5.4.

No anthropogenic fragments should be present in the imported topsoil materials.

In general, the topsoil should not be placed during inclement weather and should be free draining and not over-compacted to prevent waterlogging and excessive damage to the soil structure.

5.3 Imported Subsoil

Imported subsoil may also be required as part of proposed soft landscaping areas and placed in accordance with the landscape architects' specification. This can be cohesive or granular but should be free-draining. The subsoil material should be confirmed to be 'suitable for use' with regards to human health assessment as per the analysis outlined in Section 5.4. No anthropogenic fragments should be present within the subsoil material.

In general, the subsoils should not be placed during inclement weather and should be free draining and not over-compacted to prevent waterlogging.

5.4 Suitability of Imported and Site Won Soils

Imported topsoil and subsoil should not contain concentrations of contaminants that present an unacceptable risk to the health of future site occupants or to controlled waters. The Contractor shall be responsible for demonstrating that imported material is 'clean' and therefore suitable for use as part of the engineered cover layer in soft landscaping areas.

This will include the recovery of samples for laboratory testing from both the material source and verification testing of material following delivery to site.

The required testing frequencies for materials source types are detailed below. Other sources may be applicable, however, testing frequencies shall be confirmed with the Engineer prior to acceptance.

Table 5.4a Environmental chemistry testing frequency

Source	Testing Frequency
Imported Topsoil Greenfield/ manufactured)	**At Source:** One sample for every 250m^3 imported is to be tested by the supplier in accordance with Clause 5 of BS 3882:2015. **On-site Validation:** Four samples every 250m^3 used (or a minimum of 4 No. samples, whichever is greater).
Imported Subsoil (Greenfield/ manufactured)	**On-site Validation:** Four samples every 250m^3 (or a minimum of 4 No. samples whichever is greater). One sample to be taken from the base of each validation position.
Re-used/ Site Won Inert constituents of Topsoil/Reworked Material	**On-site Validation:** one sample every 50m^3 used (or a minimum of 6 No. samples whichever is greater).
Re-used/ Site Won Natural Soils/Site Won Made Ground	**On-site Validation:** one sample every 100m^3 used (or a minimum of 6 No. samples whichever is greater).

The environmental chemistry testing requirements for Re-Used Site Won materials (including Made Ground) need to be assessed against '*POSresi* GACs for a 2.5% SOM. Where multiple values are given for individual GACs, the lowest value should be taken as the required criteria. All movement of Site Won soils to be carried out under an approved Materials Management Plan (MMP) with any occurrence of bulk asbestos handpicked by an approved Asbestos Contractor.

The environmental chemistry testing requirements are detailed in Table 5.4b below. The importation of soils for this site should be managed in accordance with guidance contained in WLGA '*Requirements for the Chemical Testing of Imported Soils for Various End Uses and Validation of Cover Systems'* presented in Appendix A3.

If the Topsoil is not naturally sourced, e.g., recycled soil, further chemical determinants may be added to the chemical analysis suite at the discretion of the Engineer. In these instances, chemical analysis of the topsoil is to be undertaken at a frequency of one sample every 50m^3 used.

Table 5.4b Environmental chemistry analysis suite for site won and imported soils.

Suite Reference	Environmental Chemistry Analysis
Greenfield or Manufactured Soils Imported to Site for use as Engineered Cover	Total metals: Arsenic, cadmium, chromium, chromium VI, lead, mercury, selenium, copper, nickel, zinc, water soluble boron; pH Soil Organic Matter Asbestos Screening Polycyclic Aromatic Hydrocarbons (PAHs) by GC-MS (Detection Limit 0.1mg/kg for each compound - 16 USEPA speciation)

Suite Reference	Environmental Chemistry Analysis
	Total Petroleum Hydrocarbons CWG (TPHs) Aromatic and Aliphatic split. Inc. BTEX & MTBE.

Assessment criteria: Concentrations of the above determinants shall not exceed the '*Public Open Space near residential housing (POSresi)* in specific areas; end use screening criteria. This screening criteria can be observed in Appendix A2.

Definition of 'clean': Where ALL concentrations are less than the screening values the soils shall be defined as 'clean'. Any imported soils found to record a positive asbestos identification will **not** be used as a part of the engineered cover layer detailed in Table 4.1.

Soil organic matter (SOM): A review of the thresholds in the ground investigation reports may be made for specific soil sources whereby the Soil Organic Matter is proving to be at or above 2.5%.

Asbestos content: Limit for asbestos in site won soils will be set at 0.001% with the recommendation that regular dust suppression, management and monitoring (to be determined by specialist Asbestos Contractor) and a trace detect level as defined by HSG248 '*Asbestos: The Analysts' Guide'* (second edition 2021) set for imported materials. Site Won Soils to be placed beneath hardstanding areas or subject to clean capping requirements set out in Remedial Action 1 (Section 4.1).

Assessment reasoning: Potential for contamination hotpots exist on site and the requirement for sampling and testing above is assigned to ensure any potential hotspots are identified and the material dealt with accordingly and not re-used on site.

5.5 Validation of Engineered Cover

Evidence of the 300mm (or 600mm where required) cover layer and demarcation membrane should be in the form of comparative photographic records (before and after deposits) and should ideally include either hand excavated trial pits systematically advanced in areas where material has been placed or survey drawings for a comparison of levels before and after placement. It is recommended that visits are made to the site by the Engineer to verify the cover thickness and the hand excavated trial pits undertaken following completion of landscaping areas (prior to seeding). Generally, a minimum of three holes per landscaping areas will be required. A photographic record and record drawing should be produced to document this work, detailed in a verification report. Chemical testing to confirm the source materials and materials placed should be included in the verification report.

6.0 Controlled Waters Protection Measures

The CSM outlined in Section 3 conclude that potentially significant pollutant linkages exist at this site. The ground investigation work and subsequent Controlled Waters DQRA carried out by Curtins concludes that protection of controlled waters is a key requirement of this remediation strategy. This is subject to approval by NRW but aims to mitigate risks to controlled waters receptors from the contamination within the groundwater that has been identified by the DQRA as follows:

- Reducing Controlled Waters risk from TCE and other chlorinated solvents to an acceptable level in line with the derived remedial target from the Curtins Controlled Waters DQRA (Ref. 4).
- Betterment of groundwater conditions with respect to PFOS contamination.

6.1 Remedial Options Appraisal

A number of remedial treatment options are available for consideration, and these can be split into two2 main categories. The categories and definitions are presented as follows

5.5.1 Ex situ Treatments

Extraction and Disposal - Physical extraction by pumping, collection into tankers and off-site disposal. Can be cost effective but time consuming

Pumping and Treatment – Physical pumping of contaminated groundwater through a specialist water treatment system (designed to treat the contamination type), then either returning the treated water to the ground or into the drainage system (subject to permissions).

5.5.2 In situ Treatments

Chemical Oxidation – Introduction of chemicals to reduce the levels of contamination within the groundwater through chemical oxidation. Can be expensive, time consuming and depending on contamination type, effectiveness may not be to the required level. Whilst effective against chlorinated solvents, this would not address PFOS contamination. Furthermore, it is an aggressive remediation technology that may further mobilise presently sorbed contamination.

Air Sparging – More suited to fuel, oil or hydrocarbon contamination, this method introduces oxygen into the groundwater which increases the bacterial action to breakdown contamination present. Will not be suitable for this site given the nature of the contamination present.

Soil Vapour Extraction –The removal of fuel odours from groundwater with the extracted vapour passed through carbon filters until it is safe to exhaust to the air. Will not be suitable for this site given the nature of the contamination present.

Injection Treatment – Injection of substances, such as activated carbon particles, to provide fixation points for contamination. This fixes the contamination within the groundwater preventing migration of-site to controlled waters. Considered the most suitable option for the PFOS contamination. Chlorinated solvent contamination may be more effectively addressed through the injection of alternative remediation products, such as zero valent iron (ZVI) and/or biological stimulants.

It is envisaged that in-situ injection treatment is best suited to this site and consultation with specialist contractors is recommended. All existing ground investigation and assessment work is to be provided to specialist contractors to obtain recommendations and costings for the remedial treatment of the groundwater on site.

Given the complexity of the chlorinated solvent and PFOS contamination targeted for remedial treatment, a combined approach may not be feasible but it is considered that a targeted reduction in TCE alongside a betterment to PFOS contamination is the best outcome for this site.

6.2 Remediation Design

A formal remediation tender exercise was carried out citing the requirement for each specialist contractor to provide their recommendations and program for this site with the preferred bidder engaged. The appointed contractor was then required to liaise with the Curtins to agree and confirm the detailed design and application in order to achieve the desired remediation.

The treatment areas are as follows and shown on drawing 080397.300-CUR-XX-XX-DR-GE-0003-V01 In Appendix A1;

- Treatment off TCE plume – 2,400m^2 to achieve SSAC of 574μg/l.
- Treatment of PFOS plume – 150m^2 to achieve betterment from existing conditions.

TCE - BH-G encountered maximum concentrations of 28,000μg/l within the Glacial Diamicton aquifer and should be the focus point for treatment and validation.

PFOS – Exceedances for PFOS contamination were situated around the fire test area in the southern section of the site. This location should the focus for POS remedial treatment.

Though TCE and PFOS have been specified as the primary COPCs, the proposed remedial actions will likely improve the groundwater conditions within the treatment area for other associated chlorinated hydrocarbons and PFAS that have been detected in groundwater.

Further consultation with NRW has been undertaken to gain their approval to the remediation approach taking on board any specific requirements, changes or targets they required. These discussions have been concluded resulting in the production of the completed Remediation Strategy with the appointed Remediation Contractors detailed methodology and cost benefit exercise presented in Appendix A5.

6.3 Remediation Monitoring And Validation Plan

6.3.1 Establishment of Baseline Conditions

Establishment of baseline groundwater conditions should be carried out. Given the development time constraint, it is recommended that one round of sampling and laboratory testing is carried out on with the results used alongside the existing ESP and Curtins data to establish the baseline conditions. Sampling should be carried out within the recommended borehole locations listed below as well as upstream and downstream of the site in the Afon Rhondda Fach watercourse.

6.3.2 Monitoring & Validation Boreholes

The following boreholes on site will require sampling and testing to establish the baseline and will also be used for remediation validation.

Table 6.3.2a – Existing Monitoring Wells to be Sampled - TCE

Borehole	Monitoring Well Response Zone	Coordinates	Strata
BH-G	1.00m to 7.10m (273.84m AOD to 267.74m AOD)	E-298775 N-197540	Glacial Diamicton
BH-N (shallow)	1.00m to 5.20m bgl (269.27m AOD to 265.07m AOD)	E-298775 N-197522	Glacial Diamicton
BH-F	1.00m to 5.20m bgl (269.34m AOD to 265.15m AOD)	E-298745 N-197541	Glacial Diamicton
BH-F(R)	6.00m to 8.60m bgl (264.31 AOD to 261.71m AOD)	E-298741 N-197539	Glacial Diamicton
BH-K	1.20m to 7.00m bgl (268.83m AOD to 263.23m AOD)	E-298802 N-197502	Glacial Diamicton
BH206	10.00m to 20.00m bgl (263.75m AOD to 253.75m AOD)	E- 298762.22 N-197586.23	Glacial Diamicton
BH-B (Deep)	6.00m to 8.50m bgl (263.57m AOD to 261.07m AOD)	E-298765 N-197609	Glacial Diamicton

These borehole locations are presented on a drawing in Appendix A1.

Table 6.3.2b – Existing Monitoring Wells to be Sampled - PFOS

Borehole	Monitoring Well Response Zone	Coordinates	Strata
BH-M	1.00m to 6.50m bgl (269.85m AOD to 264.35m AOD)	E-298765 N-197498	Glacial Diamicton
BH-N (shallow)	1.00m to 5.20m bgl (269.27m AOD to 265.07m AOD)	E-298775 N-197522	Glacial Diamicton
BH-F	1.00m to 5.20m bgl (269.34m AOD to 265.15m AOD)	E-298745 N-197541	Glacial Diamicton
BH-F(R)	6.00m to 8.60m bgl (264.31 AOD to 261.71m AOD)	E-298741 N-197539	Glacial Diamicton
BH-K	1.20m to 7.00m bgl (268.83m AOD to 263.23m AOD)	E-298802 N-197502	Glacial Diamicton
BH206	10.00m to 20.00m bgl (263.75m AOD to 253.75m AOD)	E- 298762.22 N-197586.23	Glacial Diamicton
BH-B (Deep)	6.00m to 8.50m bgl (263.57m AOD to 261.07m AOD)	E-298765 N-197609	Glacial Diamicton

These borehole locations are presented on a drawing in Appendix A1.

6.3.3 Laboratory Testing Requirements

Groundwater monitoring from the wells lists above as well as upstream and downstream river samples will require testing for the following contaminants.

- For TCE Assessment – Suite of Volatile and Semi Volatile Organic Compounds (VOC and SVOC) with suite testing details sent to Curtins for approval prior to initial baseline sampling.
- For PFOS Assessment – Suite of PFAS compounds with suite details sent to Curtins for approval prior to initial baseline sampling

Given the potential for cross-contamination and bespoke requirements, PFAS-specific sampling and laboratory testing procedures are to be employed that are consistent with industry best practice guidance.

6.3.4 Post Remediation Monitoring

Following completion of the groundwater remediation works, a groundwater and surface water (upstream and downstream Afon Rhondda Fach) monitoring program will be implemented monthly for 6 months and then quarterly for a further 6 months.

6.3.5 Production of a Verification Report

The results of the groundwater will be presented in the verification report, including presenting all groundwater monitoring results and trends in data graphically, with a view to demonstrating that the remediation has been completed successfully.

The Verification Report should also document decommissioning of the long-term monitoring wells.

6.3.6 Borehole Decommissioning

On completion of the remediation and monitoring work outlined within the Remediation Strategy, all boreholes will need to be decommissioned by the Contractor in line with guidance contained within the Environment Agency '*Good Practice for Decommissioning Redundant Boreholes and Wells'* October 2012.

7.0 Earthworks

The following section provides general guidance with respect to infrastructure works specifically, excavations and the materials arising from them. It has already been noted in Section 5.0 that this Remediation Strategy and Verification Plan is not a geotechnical earthworks specification. The following earthworks section relates to the geo-environmental impact of the site and the impacts to human health, groundwater, and surface water receptors.

7.1 General

Method statements and risk assessments: Before excavation work commences all relevant sub-contractors are to make available method statements and risk assessments to the Principal Designer with respect to sub-surface excavations.

Personal protective equipment and site sanitary facilities: Should be provided to a standard that adequately accounts for the nature of the materials likely to be encountered during excavations. Reference is to be made to HSE document HS (G) 66 'PROTECTION OF WORKERS AND THE GENERAL PUBLIC DURING THE DEVELOPMENT OF CONTAMINATED LAND'.

7.2 Excavations

UXO risk: The Contractor is to assess the UXO risk prior to intrusive works and undertake the appropriate mitigation measures.

Identification of excavation areas: The Contractor is to identify the area of the site in which the excavation is to be undertaken and accurately locate and mark out on site the length and the width of the proposed excavation.

Expected ground conditions: The Contractor is to familiarise themselves with the expected ground conditions in order that the type of Made Ground in this location can be correctly identified. A summary of the recorded ground conditions at the site is provided in Section 2.0.

Excavation of Made Ground: Excavate (providing suitable trench support where required) the required depth of underlying existing (historical) Made Ground to excavation formation.

Removal or re-use of excavated Made Ground: Remove from site to a suitably licensed disposal facility all surplus existing (historical) Made Ground unless deemed environmentally and geotechnically suitable. Whereby the soils can be used as selected backfill in the works approved under the granted Planning Permission and in accordance with the CL:AIRE Definition of Waste: Code of Practice. Environmentally suitable is defined as '*POSresi* end use compliant with a SOM of 2.5%.

Excavation of natural soils: If natural soils are likely to be encountered due to the depth of excavation required, the Made Ground is to be excavated taking care not to over excavate to minimise cross contamination of the natural soils.

Re-use of excavated natural soils: If environmentally and geo-technically suitable for reuse as selected backfill, place, and store the excavated 'clean' natural soils in a suitable location on the site on top of the clean natural imported fill. Provide a polythene membrane under the stored natural soils to minimise mixing and facilitate ease of recovery.

Removal of excavated natural soils: If the 'clean' natural soils are not suitable as selected backfill or trench backfill, remove from site to a suitably licensed disposal facility.

Service Trenches: Install / construct foundations, pipes, ductwork, cables etc. and backfill the excavation up to the reclamation level with suitable engineering materials in accordance with the relevant utility / engineer's specification utilising the excavated soils where suitable.

7.3 Waste Classification of Surplus Excavation Arisings for Disposal

Where any site soils are to be disposed of off-site guidance on the disposal of contaminated soils is provided within the following documents published by the Environment Agency.

- Guidance on the Classification and Assessment of Waste Technical Guidance WM3 (Version 1.1.GB 2021). (Ref. 7).

Further advice has been given by the Environment Agency in regarding the classification of 'oily waste and wastes containing oil'. This guidance has now been incorporated within the Hazardous Waste Technical Guidance WM3 Version 1.2GB (October 2021).

Guidance states that the principal contractor (or any other sub-contractor undertaking excavations) should, in conjunction with the proposed disposal facility, use where possible the relevant environmental chemistry analyses results to classify any surplus material identified for off-site disposal. However, it should be noted that this information is for guidance only and material identified for disposal will have to be tested and assessed in accordance with WM3 to enable classification during the works.

Landfill operators are not obliged to accept waste and, if they were to do so, may have specific requirements beyond those outlined above prior to acceptance.

8.0 Strategy for Handling Potentially Contaminated Soil on Site

Surplus soils to be removed from site which have been identified as contaminated should be loaded onto a lorry, covered securely, and transported to the landfill facility immediately.

Where stockpiling is unavoidable the stockpile should be located on an impermeable membrane with a bunded perimeter and be covered also with a low permeability membrane at the end of each working day. Where soils are wet when excavated, measures should be taken to ensure there is no runoff from the soils onto the surrounding soils.

Duty of Care: Under his duty of care, the Principal Contractor shall ensure the proper and safe disposal of waste from each site after it has been passed on to another party. In this respect, details of the landfill facility to be used and the company disposing of the waste regarding hazardous (special) and non-hazardous waste shall be provided to the Site Manager. Copies of **all** Consignment Notices for special waste and Waste Transfer Notes for hazardous and non-hazardous waste shall be kept on site for review by Curtins and inclusion within the Remediation Verification Report on completion of the project.

If material is revealed on the site of a nature that does not accord with the previously observed and recorded descriptions within the ground investigation reports (Ref. 2 & 3) the following procedure is to be complied with:

a) Cease and make safe all excavations in this location and report observations to the Site Manager.

b) The Site Manager is to notify the Engineer.

c) Under guidance of the Engineer take representative samples of the suspect materials and forward to a suitably accredited laboratory for analysis.

d) Await Engineers instructions with respect to re-commencement of the works and or removal from of suspect material to a suitably licensed disposal facility (following guidance outlined in Section 6 and 8 above).

e) The Local Authority and if relevant, Natural Resources Wales are to be kept fully informed of any site such occurrences.

Advice with respect to Potentially Contaminative Incidents is presented in Section 10.0.

9.0 Strategy for Potentially Contaminative Incidents

Based on the evidence presented within the Ground Investigations including the historical and more recent usage of the site, the presence of unexpected sub-structures and contaminated materials is a moderate risk.

It is possible that some below ground features / structures exist that have not been recorded on plans and have not been encountered during the ground investigation works or else demolition works. Although considered unlikely it is possible that unknown / unrecorded substructures exist which if ruptured may release materials that could contaminate the surrounding soils and groundwater (petroleum hydrocarbons, solvents, for example).

If this occurs an outline strategy is detailed below.

9.1 Outline Strategy

Where such a tank/pipework is damaged during excavation and the contents are released into the surrounding soil, the tank / pipework should be immediately pumped dry into another suitable container and a trench with a low permeability base formed around the tank/pipework to prevent seepage laterally and to collect the contaminant. Where groundwater is encountered in the trench, it should be pumped into a suitable container and tested for the contaminant. All soils affected shall then be tested and removed from site as appropriate.

Where the damage is caused to the underside of a tank and seepage is vertical, the contaminants may present a risk of polluting the groundwater. In this instance and subject to the findings of a risk assessment, boreholes may be required to prove and intercept the contaminant. The contaminant will then be pumped into suitable containers. The Engineer shall approve all proposals for such remediation.

9.2 Environmental Controls

The Principal Contractor must assess the implications of working practices regarding the following environmental issues and ensure that all applicable legislative requirements are met. If any relevant legislation is breached during the works, the Engineer will instruct the Principal Contractor to stop work until mitigation measures are put in place.

- **Dust**; the Principal Contractor shall ensure that levels of airborne dust are kept as low as reasonably practicable during the works and appropriate boundary monitoring shall be undertaken, as agreed with the Engineer. The Contractor shall include in relevant method statements. Methods of dust suppression to be available if required, for approval by the Principal Designer.
- **Mud on roads**; the Principal Contractor shall ensure that mud is not tracked across site roads and public highways. The Principal Contractor shall be responsible for ensuring that any mud

deposited on site roads or public highways is removed and the roads or highways cleaned as soon as is practicable.

- **Odours, gaseous emissions, and airborne particulate emissions**; the Principal Contractor shall ensure that noxious odours, potentially toxic gaseous emissions, and airborne particulate emissions are kept below levels which present a nuisance or a hazard to the health of any site user or the public. The Principal Contractor shall assess in relevant health and safety risk assessments and method statements, the likelihood of such occurrences and the severity of their effects.
- **Groundwater management**; The Contractor should describe in their method statements how they will manage and dispose of water from excavations. Perched water, groundwater or 'contaminated' surface water run-off which has collected in excavations must not be returned to the ground or pumped directly to surface waters once extracted from the ground. Should waters be impacted by free phase hydrocarbons they should be treated with absorbent materials or a surface skimmer pump. If impacts are encountered to be more extensive then alternative methods such as an oil water separator or similar may be preferable. Should disposal to surface water or public sewer be deemed appropriate, The Contractor will be responsible for any pre-treatment, additional sampling and monitoring. Any specific testing requirements will need to be agreed with the EA for discharges to surface water, or if to public sewer, with the local authority and water authority, prior to any discharge taking place

10.0 Validation & Verification Reporting

Validation visits and a watching brief will need to be undertaken by the Engineer throughout the construction phase to ensure that the requirements of the Remediation Strategy have been implemented at the site for inclusion in the Remediation Verification Report. The Remediation Verification Report will provide details on the following:

- Observe the installation and provide verification of the gas and vapour protection measures installed. Verification should be provided by a suitably qualified person in line with guidance contained within CIRIA C735 (Ref. 8);
- Provide details of employed groundwater treatment method with evidence of application along with post application testing to verify targeted reduction of TCE and betterment of PFOS contamination levels;
- Confirm the installation of the Barrier pipe with photographic evidence and details of the specific pipe used;
- Verify the engineered cover thickness in the soft landscaping areas to be minimum 300mm thick (600mm where applicable) and underlain by a demarcation membrane by completing hand excavated trial pits with photographic evidence;
- Collect environmental samples of any imported topsoil and subsoil materials to confirm the suitability for use with regards to human health to be compared against the thresholds in Appendix A2 and guidance contained in WLGA/CLILC Guidance (Ref. 9) presented in Appendix A3 and declared using the enclosed Imported Materials Declaration Form'
- Obtain waste transfer notes or consignment notes for all known and / or unexpected contaminated materials disposed off-site; an
- Details of any unexpected, contaminated materials encountered, or potentially contaminative incidents and what measures were taken. Where no unexpected, contaminated materials were encountered, confirmation will be provided that no unexpected, contaminated materials were encountered.
- Confirmation that the Remediation Strategy has been followed and that no potential pollutant linkages remain at the site
- Details of the quantities of material leaving and/or entering site. This includes details of any chemical testing carried out
- Plans showing locations of any additional samples obtained for testing due to unforeseen contamination along with and delineation of materials and quantities
- Results of any additional chemical and WAC testing undertaken along with method of sample collection and transportation to the laboratory, laboratory quality assurance and accreditation.
- Records of any asbestos management measures employed;
- Details of any areas of unexpected contamination and the actions taken;
- Details of any water removed from excavations and disposed off-site, including chemical testing;
- Details and demonstration of any relevant permits or exemptions required for the works;

- Details on any protection measures installed for contamination and monitoring (if applicable) of such measures – in particular records will be required to confirm whether protection measures were required for contaminants present in excavations or water supply pipes; and
- Details of regular dialogue and any additional liaison and agreements with regulators.

The frequency and number of visits shall be determined following confirmation of the enabling works and construction phase programme.

This Remediation Strategy and Verification Plan should be reviewed and updated, as necessary, following engagement with the relevant regulators.

11.0 References

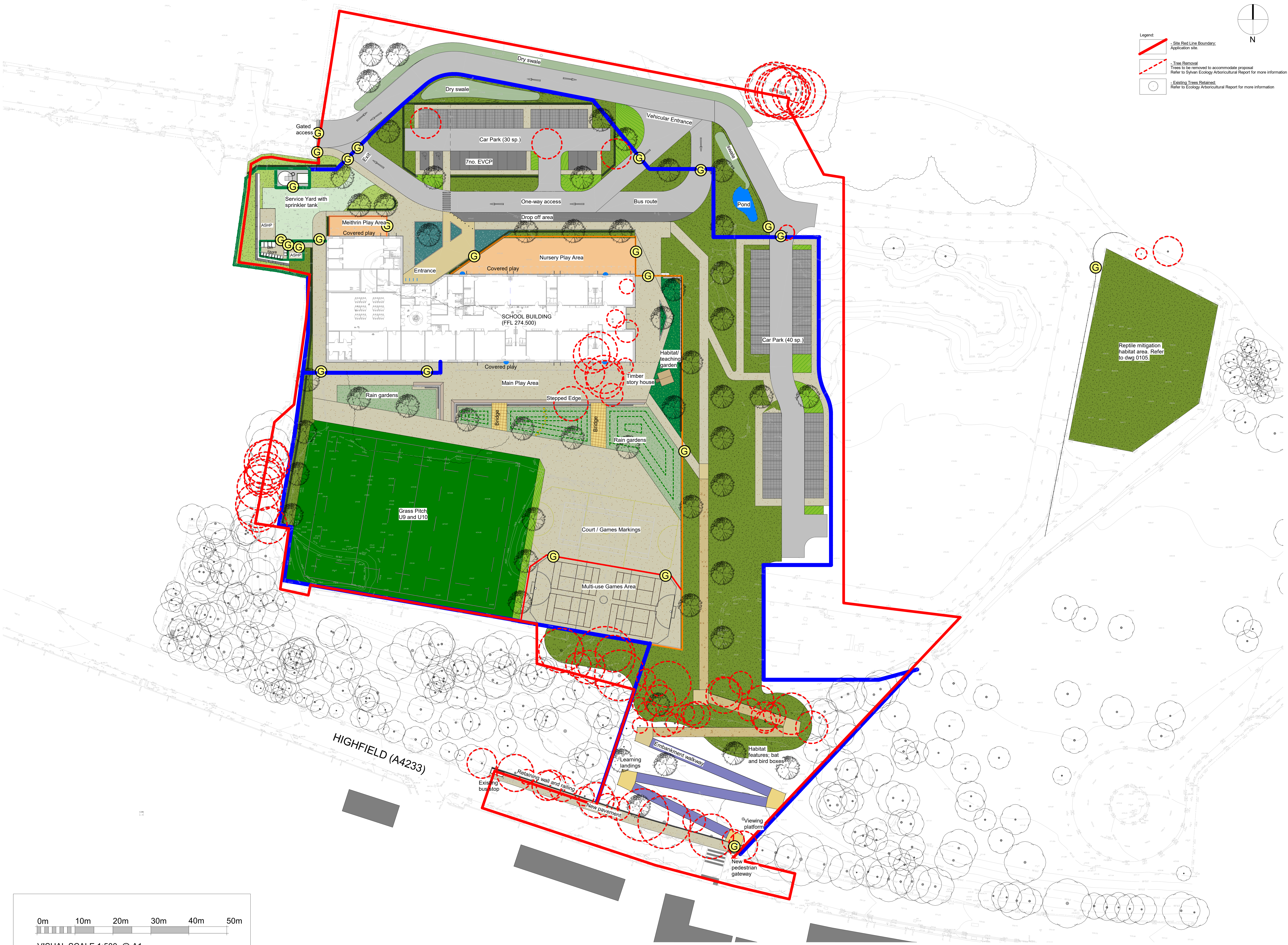
1. Earth Science Partnership (March 2020) YGG Llyn Y Forwen Ferndale Proposed School Development Desk Study. Report number ESP.7422d.3311.
2. Earth Science Partnership (June 2021) Former CHUBB factory, Ferndale Proposed School Development Main Ground Investigation Report. Report number ESP.7422d.03.3434.
3. Curtins (September 2022) Former CHUBB Factory Site, Ferndale - Phase 2 Ground Investigation Report number LYF-CUR-A1-XX-RP-G-00001-P03-Phase_2 Ground_Investigation_Report.
4. Curtins (September 2022) Former CHUBB Factory Site, Ferndale – Controlled Waters Detailed Quantitative Risk Assessment report number LYF-CUR-XX-XX-RP-GE-00002-P02.
5. Curtins (September 2022) Former CHUBB Factory Site, Ferndale – Soil Vapour Risk Assessment report LYF-CUR-XX-XX-T-GE-00003-P02.
6. BS8485:2015+A1:2019 – *Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings.*
7. Environment Agency (2015) *Guidance on the Classification and Assessment of Waste Technical Guidance WM3* (Version 1.1.GB 2021).
8. CIRIA C735 (2014) *Good practice on the testing and verification of protection system for buildings against ground gases.*
9. Welsh Land Contamination Working Group (WLGA) (2013) *Requirements for the Chemical Testing of Imported Materials for Various End Uses and Validation of Cover Systems.*

Appendix A1 – Drawings

- Combined ESP & Curtins Exploratory Hole Location Plan (Curtins corrected)
- Proposed Development Layout Plan
- CPOC Plume Location Plan

1 LYF-LANDSCAPE PLAN

1 : 500



0m 10m 20m 30m 40m 50m

VISUAL SCALE 1:500 @ A1

Legend:

- Site Red Line Boundary:
Application site.

- Tree Removal
Trees to be removed to accommodate proposal
Refer to Sylvan Ecology Arboricultural Report for more information

- Existing Trees Retained:
Refer to Ecology Arboricultural Report for more information

Notes

- This drawing is the copyright of Land Studio. It must not be copied or reproduced without written consent.
- This drawing is to be read as part of a full Landscape Drawing Package in conjunction with all the relevant surveys alongside the Architectural and Engineers drawings
- Only figured dimensions are to be taken from this drawing. Dimensions should not be scaled from this drawing, as scaling of this drawing cannot be assured.
- All dimensions are to millimetres unless specified otherwise
- All contractors must visit the site and be responsible for taking and checking all dimensions, services and setting out related to the works shown on this drawing
- All coordinates are set to dimensional points to enable easy cross referencing on site
- All setting out points are to be verified on site and any discrepancies should be clarified by the Landscape Architect
- Hatching is not a technical representation of surface patterns, contractors are to follow the line of direction specified on drawings . Where no line of direction is given contractor to contact Landscape Architect before laying.

All levels should be checked on site and conflicts reported to the design office.

…If in doubt ask

Proposed Hard Works:

Vehicular Tarmac:
New road with vehicular grade tarmac (non-permeable)

Vehicular Permeable Block Paving:
New parking bays with vehicular grade build-up (permeable)

Vehicular Block Paving:
New parking bays with vehicular grade build-up (non-permeable)

Pedestrian Tarmac:
New pavement with pavement grade build-up (non-permeable)

Pedestrian Tarmac:
New embankment path (buff colour) with pavement grade build-up (permeable)

Pedestrian Block Paving:
New entrance paving with pavement grade build-up (non-permeable)

Vehicular Grasscrete:
New service yard with vehicular grade build-up (permeable)

Metal Boardwalk:
Metal safety deck boardwalk (stainless steel or similar) to provide pedestrian access from Ffladau Terrace.

Metal Boardwalk Landings:
Metal safety deck boardwalk learning landings (coloured RAL to tie in with school branding)

Wetpour Rubber Crumb Surface:
Safety surfacing to early years play areas, final design to incorporate play and learning features (permeable)

Proposed Soft Works:

Tree Planting:
Refer to Planting Schedule on Planting Plan

Woodland Groundcover Planting:
Refer to Planting Schedule on Planting Plan

Grass and Wildflower Areas:
Refer to Planting Schedule on Planting Plan

Swale Grass Areas:
Refer to Planting Schedule on Planting Plan

Grass Pitch:
Refer to Planting Schedule on Planting Plan

Heather and Grass Mix:
Refer to Planting Schedule on Planting Plan

Hedge Planting:
Refer to Planting Schedule on Planting Plan

Features and Furniture:

For boundary fencing, gates and railings please refer to dwg 0201 Boundary Treatment Strategy for details

Cycle Hoop:
Stainless steel cycle hoop (4no. total 8 bikes)

Cycle & Scooter Storage:
Half MiniPod Cycle Stores or equal approved located under canopies (4no. total, 16 bikes and 12 scooters)

Multi-use Games Area Goal Ends:
Timber Multi Goal end or similar approved.

Gates:
Refer to dwg 0201 Boundary Treatment Plan for details of gates and fencing types.

Timber Story House:
Timber Forest Story House from Handmade Places or similar approved.

Stepping Stones:
HopOp stepping stones through rain garden from Artform or similar approved.

Rev	Drawn	Checked	Date	Description
P10	MR	RF	20.09.22	Red Line Boundary Amended
P9	RF	RF	14.09.22	Amended Redline
P8	MR	RF	08.08.22	Stage 3 Approval
P7	MR	RF	18.07.2022	Pedestrian entrance moved and guardrail added
P6	MR	SR	21.06.2022	PAC Issue (2)
P5	RF	RF	14.06.2022	PAC Issue
P4	RF	RF	10.06.2022	PAC Draft
P3	RF	RF	03.05.2022	Amended Fencing Strategy
P2	RF	RF	13.04.2022	Stage 2
P1	RF	RF	30.3.2022	Issued for comment

FOR APPROVAL

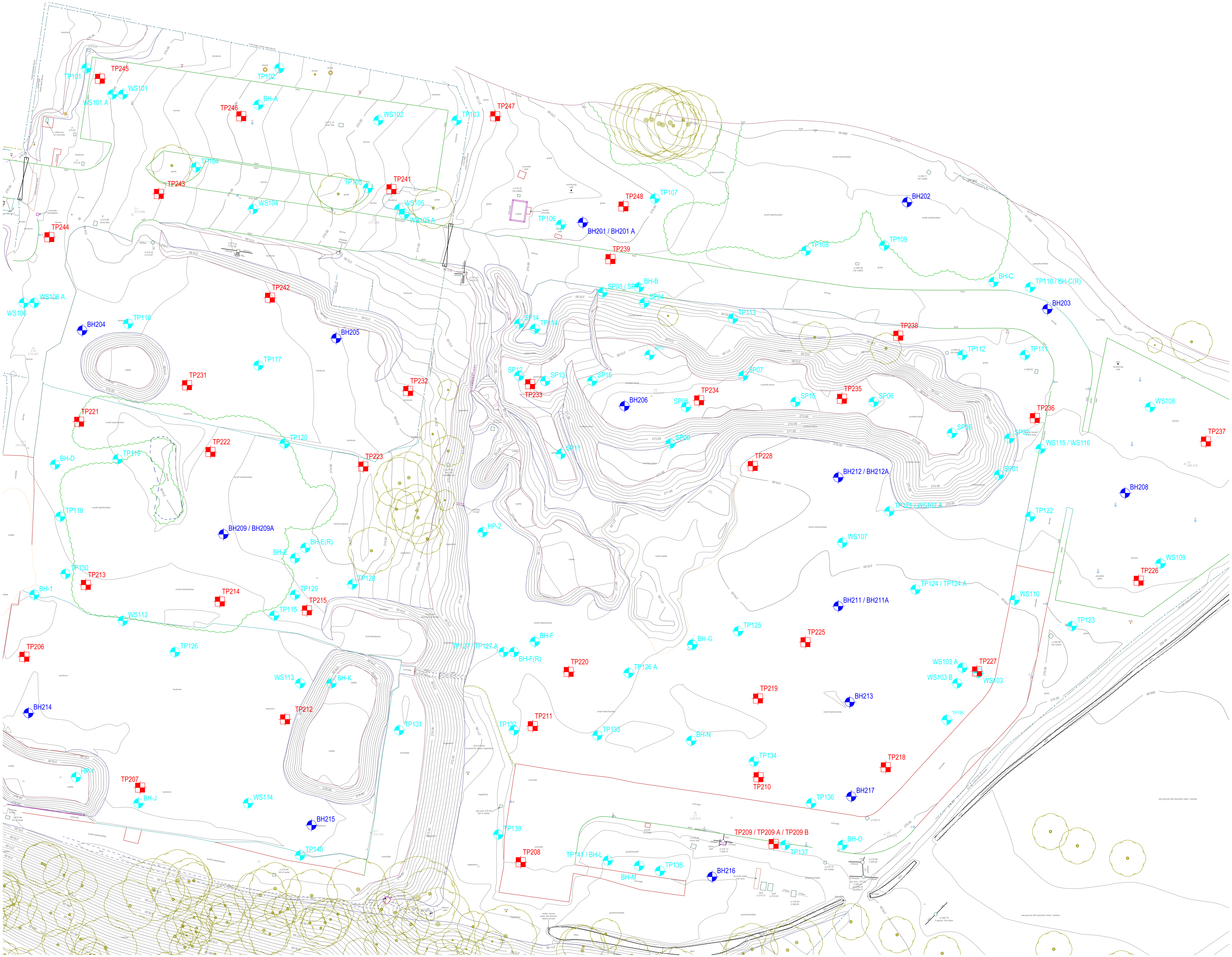
land | studio

Client:
Rhondda Cynon Taff

Project:
Llyn y Forwyn

Drawing Title:
LANDSCAPE
SITE MASTERPLAN

Drawn By: RF — Date: 22.05.13
Checked By: SR/RF — Date: 22.06.14
Drawing Scale: 1 : 500 — Sheet Size: A1
Drawing No: LYF-LST-A1-XX-DR-L-0101 — Status: S4 — Rev.: P10



GENERAL NOTES:

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTS AND ENGINEERS DRAWINGS AND SPECIFICATIONS.
2. DO NOT SCALE THIS DRAWING. ANY AMBIGUITIES, OMISSIONS AND ERRORS ON DRAWINGS SHALL BE BROUGHT TO THE ENGINEERS ATTENTION IMMEDIATELY. ALL DIMENSIONS MUST BE CHECKED / VERIFIED ON SITE.
3. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
4. FOR GENERAL NOTES REFER TO DRAWING.

KEY

BH — DENOTES BOREHOLE LOCATIONS

TP — DENOTES TRIAL PIT LOCATION, UP TO 3.50m BGL

DENOTES 2021 EXPLORATORY HOLES

Rev:	Description:	Date:	By:	Chkd:
P01	ISSUED FOR INFORMATION	13/07/22	NG	IC

curtins
3 Cwrt-y-Parc, Earlswood Road, Cardiff, CF14 5GH
029 2068 0900
cardiff@curtins.com
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Civils & Structures • Transport Planning • Environmental • Infrastructure • Geotechnical • Conservation & Heritage • Principal Designer
Birmingham • Bristol • Cambridge • Cardiff • Douglas • Dublin • Edinburgh • Glasgow • Kendal • Leeds • Liverpool • London • Manchester • Nottingham

Status: SUITABLE FOR INFORMATION S2

Project: YGG LLYN Y FORWYN, FERNDALE

Drg Title: EXPLORATORY HOLE LOCATION PLAN

Size:	Date:	Drawn By:	Designed By:	Checked By:
A0	12/07/22	N. GILL	K. HUGHES	K. HUGHES
Scale: 1:200				

Project No:	Originator:	Volume:	Level:	Type:	Role:	Category / Number:	Rev:
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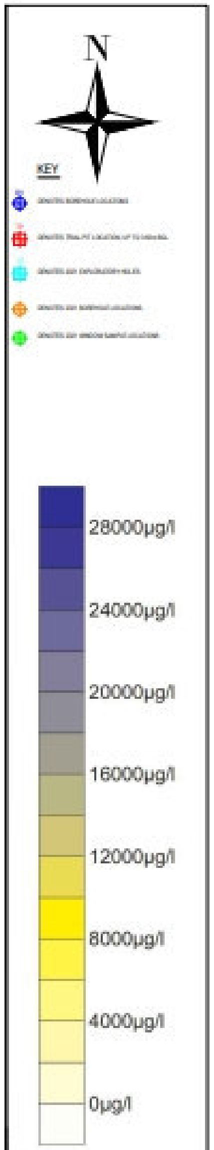

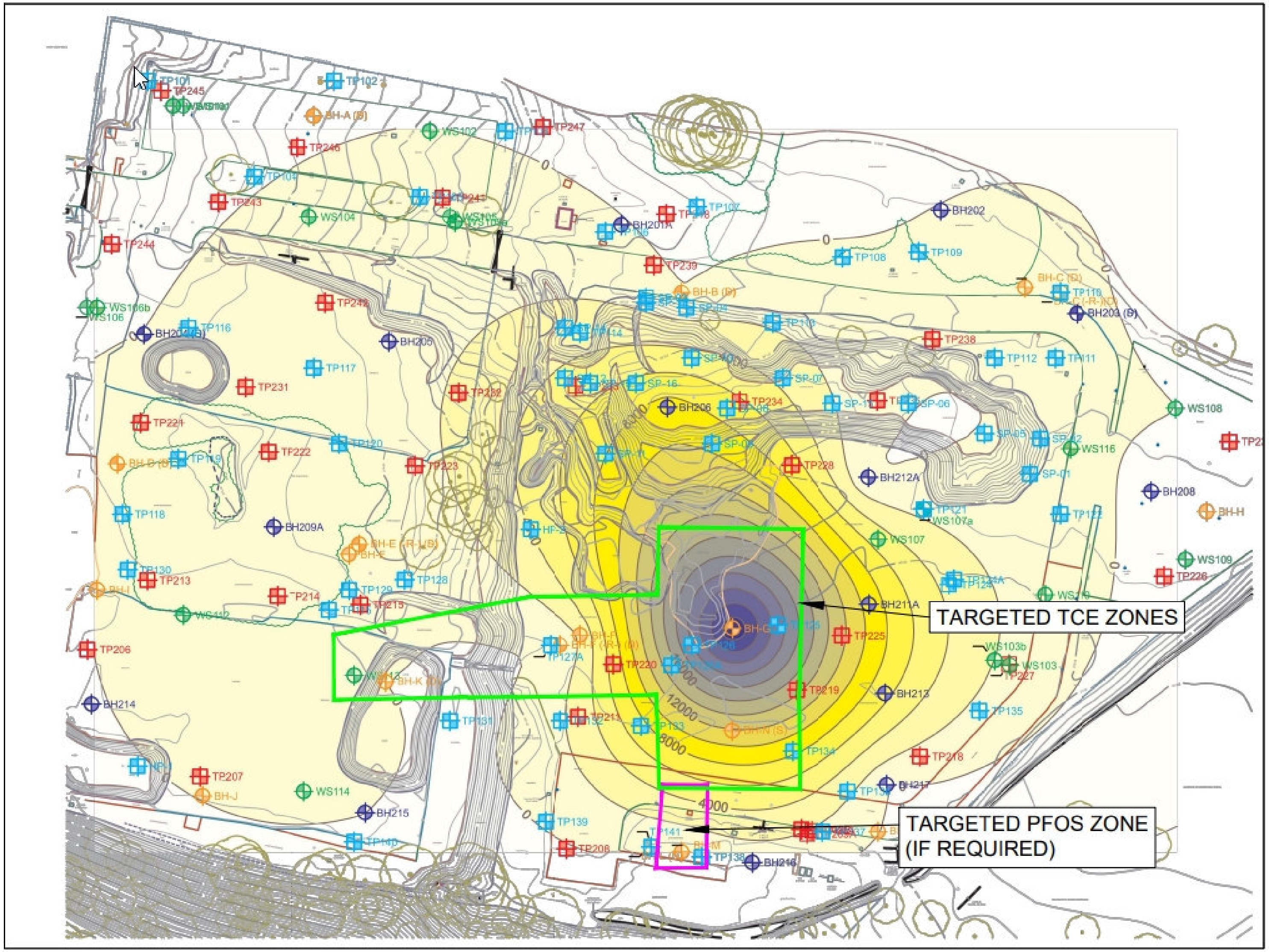

--		17/10/22	KH
Rev:	Description:	Date:	By:

GENERAL NOTES:

curtins

3 Cwrt Y {arc,
Earlswood Road,
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Civils & Structures • Transport Planning • Environmental • Infrastructure • Geotechnical • Conservation & Heritage • Principal Designer
Birmingham • Bristol • Cambridge • Cardiff • Douglas • Dublin • Edinburgh • Glasgow • Kendal • Leeds • Liverpool • London • Manchester • Nottingham

Project: Former CHUBB Factory, Ferndale

Status: For Information

Drg Title: CPOC Plume Location Plan

Drawn By: KH | Checked By: KH

Designed By: KH | Date: 17/10/22

Scale: NTS

Project No: Originator: Zone: Level: Type: Discipline: Category/Number: Rev:

Drg No: 080397.300-CUR-XX-XX-DR-GE-003-V01

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Project: YSGOL LLYN Y FORWYN

Drg Title: BOREHOLE LOCATIONS

STATUS: S2 - SUITABLE FOR INFORMATION

Drawn By: DO Checked By: KH

Date: 12/12/2022

Appendix A2 – Imported Soil Screening Assessment Criteria

- POSIresi end use at 2.5% SOM.
- Groundwater GACs

Adopted Soil Generic Assessment Criteria
Sandy loam with 2.5% SOM

Contaminants	Residential with home grown produce	Residential without home grown produce	Allotments	Commercial	Public open space near residential housing POS_{resi}	Public park POS_{park}
Metals						
Beryllium	*1.7*	*1.7*	*35*	*12*	*2.2*	*63*
Boron	*290*	*11,000*	*45*	*240,000*	*21,000*	*46,000*
Cadmium	**10**[13] 22	**85**[13] 150	**1.8** 3.9	**230** 410	*120* 220	*560* 880
Chromium III	*910*	*910*	*18,000*	*8,600*	*1,500*	*33,000*
Chromium VI	*6* 21	*6* 21	*1.8* 170	*33* 49	*7.7* 21	*220* 250
Lead	200	310	80	2,300	630	1,300
Mercury *(elemental)*	**1**	**1**	**26**	**26**	*16*	**26**[8] [*30*]
Mercury (inorganic)	**170**	**240**	**80**	**3600**	*120*	*240*
Nickel	*130*[10]	*180*[10]	*53*[11]	*980*[10]	*230*	*800*
Vanadium	*410*	*1200*	*91*	*9000*	*2000*	*5000*
Copper	*2400*	*7100*	*520*	*68000*	*12000*	*44000*
Zinc	*3700*	*40000*	*620*	*730000*	*81000*	*170000*
Semi-Metals and non-metals						
Arsenic	**32**[12] 37	**35**[12] 40	**43**[12] 49	**640**[12] 640	*79* 79	*170* 170
Antimony		***550***		***7500***	***1500***	***3300***
Selenium	**350**	**600**	**120**	**13000**	*1100*	*1800*
Inorganic chemicals						
Cyanide	34	34	34	34	34	34
Organic contaminants						
Aliphatic risk banded hydrocarbons - TPHCWG method						
$EC_{>5}$ - EC_6	*78*	*78*	*1700*	*5900*	*590000*	*130000*
$EC_{>6}$ - EC_8	*230*	*230*	*5600*	*17000*	*610000*	*220000*
$EC_{>8}$ - EC_{10}	*65*	*65*	*770*	*4800*	*13000*	*18000*
EC_{10}-EC_{12}	*330*	*330*	*4400*	*23000*	*13000*	*23000*
EC_{12}-EC_{16}	*2400*	*2400*	*13000*	*82000*	*13000*	*25000*
$EC_{>16}$ - EC_{35}	*92000*	*92000*	*270000*	*1700000*	*250000*	*480000*
$EC{>}_{35}$ - EC_{44}	*92000*	*92000*	*270000*	*1700000*	*250000*	*480000*
Aromatic risk banded hydrocarbons - TPHCWG method						
$EC{>}_5$ - EC_7	*140*	*690*	*27*	*46000*	*56000*	*84000*
$EC{>}_7$ - EC_8	*290*	*1800*	*51*	*110000*	*56000*	*95000*
$EC_{>8}$ - EC_{10}	*83*	*110*	*21*	*8100*	*5000*	*8500*
EC_{10} - EC_{12}	*180*	*590*	*31*	*28000*	*5000*	*9700*
EC_{12} - EC_{16}	*330*	*2300*	*57*	*37000*	*5100*	*10000*
$EC_{>16}$ - EC_{21}	*540*	*1900*	*110*	*28000*	*3800*	*7700*
$EC_{>21}$ - EC_{35}	*1500*	*1900*	*820*	*28000*	*3800*	*7800*
$EC{>}_{35}$ - EC_{44}	*1500*	*1900*	*820*	*28000*	*3800*	*7800*
Aliph + Arom EC >44-70	*1800*	*1900*	*2100*	*28000*	3800	7800
Aromatic						
Benzene	**0.16**	**0.49**	**0.035**	**50**	*72*	*100*
Ethyl benzene	**150**	**380**	**39**	**1200**[8] [35000]	**1200**[8] [*24000*]	**1200**[8] [*22000*]
Toluene	**270**	**1300**	**51**	**1900**[8] [110000]	**1900**[8] [*56000*]	**1900**[8] [*95000*]
Xylene[9]	**98**	**120**	**70**	**1200**[8] [14000]	**1200**[8] [*42000*]	**1200**[8] [*23000*]
Phenol	**290**	**420**	**140**	**1500**[14] (35000)	**1500**[14] (*10000*)	**1500**[14] (*8300*)
Polycyclic Aromatic Hydrocarbons (PAH)						
Naphthalene	*5.6*	*5.6*	*10*	*460*	*4900*	*1900*
Acenaphthylene	*420*	*4600*	*69*	*97000*	*15000*	*30000*
Acenaphthene	*510*	*4700*	*85*	*97000*	*15000*	*30000*
Fluorene	*400*	*3800*	*67*	*68000*	*9900*	*20000*
Phenanthrene	*220*	*1500*	*38*	*22000*	*3100*	*6200*
Anthracene	*5400*	*35000*	*950*	*540000*	*74000*	*150000*
Fluoranthene	*560*	*1600*	*130*	*23000*	*3100*	*6300*
Pyrene	*1200*	*3800*	*270*	*54000*	*7400*	*15000*
Benz(a)anthracene	*11*	*14*	*6.5*	*170*	*29*	*56*
Chrysene	*22*	*31*	*9.4*	*350*	*57*	*110*
Benzo(b)fluoranthene	*3.3*	*4.0*	*2.1*	*44*	*7.2*	*15*
Benzo(k)fluoranthene	*93*	*110*	*75*	*1200*	*190*	*410*
Benzo(a)pyrene	*2.7*	*3.2*	*2*	*35*	*5.7*	*12*
Indeno(123cd)pyrene	*36*	*46*	*21*	*510*	*82*	*170*
Dibenzo(ah)anthracene	*0.28*	*0.32*	*0.27*	*3.6*	*0.57*	*1.3*
Benzo(ghi)perylene	*340*	*360*	*470*	*4000*	*640*	*1500*
Chlorinated Aliphatic Hydrocarbons						
Vinyl chloride	*0.00087*	*0.001*	*0.001*	*0.077*	*3.5*	*5*
Trichloroethene (TCE)	*0.034*	*0.036*	*0.091*	*2.6*	*120*	*91*
1,1,1,2 Tetrachlorethane	*2.8*	*3.5*	*1.9*	*250*	*1400*	*1800*
Tetrachlorethene (PCE)	*0.39*	*0.4*	*1.5*	*42*	*1400*	*1100*
1,1,1 Trichlorethane	*18*	*18*	*110*	*1300*	*140000*	*76000*

Notes

1. All values above are in mg/kg
2. **Numbers in bold are SGVs or GAC that are derived based on SGV report input parameters**, *numbers in italics are S4ULs*, ***numbers in bold-italics are based on EIC/AGS/CL:AIRE numbers & input parameters*** and underlined numbers are C4SLs
3. Soil organic matter (SOM) is assumed to be 2.5% - DEFAULT VALUE
4. Soil type is assumed to be sandy loam - DEFAULT SOIL TYPE
5. For residential, the building type is conservatively assumed to be a small terrace house where the development includes bungalows change to more conservative bungalow setting in computer model
6. For commercial, the building type is conservatively assumed to be a pre 1970s office building, where the proposed development comprises houses, flat with living spaces changes setting in model accordingly
7. For classrooms consider increasing the dust loading fator in the 'Soil and Building Data' of the CLEA 1.04 model from 50 to 100μg m^{-3}
8. Based on vapour saturation limt as suggested by EA / [ ] model value
9. Lowest of o-, m- and p-xylene
10. Based on comparison of inhalation exposure with inhalation TDI
11. Based on comparison of oral, dermal, and inhalation exposure with the oral TDI
12. Based on a comparison of oral and dermal soil exposure with oral Index Dose only
13. Averaged over and based on lifetime exposure
14. Based on critical concentration for skin irritation in humans arising from contact with phenol in aqueous solution (number in brackets based on health effects following long term exposure for illustration)
15. NA: Not applicable

V1 Mar 2017

Tier 1 Thresholds

Water Contaminants: Initial Assessment of Risk

Introduction

The Generic Assessment Criteria (GAC) employed as Tier 1 Controlled Water Screening criteria are given in Tables 1 and 2. The more conservative available Drinking Water Standards (DWS) and Environmental Quality Standards (EQS) (Freshwater and Saltwater), applicable in England and Wales have been included in the tables.

The list of determinands is non-industry specific and it should be recognised that additional site specific determinands may need to be taken into account. The applicability of these criteria, with regard to the developed Conceptual Site Model, is discussed within the relevant section of the preceding report. Further details on individual GAC can be obtained in the referenced source legislation.

Generic Assessment Criteria

Table 1 – Inorganic Contaminant Controlled Waters Generic Assessment Criteria

Contaminant	Units	Hardness Banding (mg/l CaCO3)	EQS (Freshwater)	EQS (Saltwater)	EU DWS	WHO
Arsenic	µg/l	-	50	25	10	10
Boron	µg/l	-	2000	7000	1000	0.3
Cadmium	µg/l	<40	0.08	0.2	5	3
		40- <50	0.08			
		50- <100	0.09			
		100- <200	0.15			
		>200	0.25			
Chromium III	µg/l	-	4.7	-	50	50
Chromium VI	µg/l	-	3.4	0.6		
Copper	µg/l	-	1 bioavailable[i]	3.76 Where DOC[ii] ≤ 1mg	2000	2000
				3.76 + (2.677 x ((DOC/2)-0.5)) Where DOC[ii] >1mg/l		
Cyanide (Free)	µg/l	-	1	1		
Cyanide (Total)	µg/l	-	1	1	50	70
Iron	µg/l	-	1000	1000	200	300
Lead	µg/l		1.2	1.3	10	10
Mercury	µg/l	-	0.07[iii]	0.07 [iii]	1	1
Nickel	µg/l	-	4 bioavailable[i]	8.6	20	70

Contaminant	Units	Hardness Banding (mg/l CaCO3)	EQS (Freshwater)	EQS (Saltwater)	EU DWS	WHO
Selenium	µg/l	-	-	-	10	10
Sulphate	mg/l	-	400	-	250	-
Sulphide	µg/l	-	0.25	-	-	-
Zinc	µg/l	-	10.9 bioavailable[ii] + ABC[v]	6.8 dissolved[iV] + ABC	5000	3000

i - fraction likely to have toxic effect as determined using the UKTAG Metal Bioavailability Assessment Tool
ii - concentration of dissolved organic carbon in mg/l of the receiving water (as identified in the Conceptual Site Model)
iii - in absence on Annual Average the Maximum Allowable Concentration Used
iv - total dissolved as reported
V - Average Background Concentration (ABC) as listed in Part 2 Table 2 in Ref. 1.

Table 2 – Organic Contaminant Controlled Waters Generic Assessment Criteria

Contaminant	Units	EQS (Freshwater)	EQS (Saltwater)	EU DWS	WHO
Organics					
Phenol (total)	µg/l	7.7	7.7	0.5	-
MTBE	µg/l	-	-	-	15
Total Petroleum Hydrocarbons (TPH)					
Aliphatic C5-C6	µg/l	-	-	-	15000
Aliphatic C6-C8	µg/l	-	-	-	15000
Aliphatic C8-C10	µg/l	-	-	-	300
Aliphatic C10-C12	µg/l	-	-	-	300
Aliphatic C12-C16	µg/l	-	-	-	300
Aliphatic C16-C21	µg/l	-	-	-	300
Aliphatic C21-C35	µg/l	-	-	-	300
Aromatic C6-C7 (benzene)	µg/l	10	8	1	10
Aromatic C7-C8 (toluene)	µg/l	74	74	-	700
Aromatic C8-C10 (ethylbenzene)	µg/l	20	20	-	300
Aromatic C10-C12	µg/l	-	-	-	100
Aromatic C12-C16	µg/l	-	-	-	100
Aromatic C16-C21	µg/l	-	-	-	90
Aromatic C21-C35	µg/l	-	-	-	90
Total Hydrocarbons (Dissolved / Emulsion)	µg/l	-	-	10 (revoked)	300

Contaminant	Units	EQS (Freshwater)	EQS (Saltwater)	EU DWS	WHO
BTEX Compounds					
Benzene	µg/l	10	8	1	10
Toluene	µg/l	74	74	-	700
Ethyl-benzene	µg/l	20	20	-	300
Xylene (o+p+m)	µg/l	30	30	-	-
Polycyclic Aromatic Hydrocarbons (PAH)					
Anthracene	µg/l	0.1	0.1	-	-
Benzo(a)pyrene	µg/l	0.00017	0.00017	0.01	0.01
Napthalene	µg/l	2	2	-	-
PAHs Sum of four- benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, indeno(1,2,3-c,d)pyrene	µg/l	-	-	0.1	-

References

1 The Water Framework Directive, (Standards and Classification) Directions (England and Wales) [2015]
2 Council Directive 76/464/EEC, Council Directive on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (Dangerous Substances Directive) [1976]
3 Council Directive 98/83/EC on the quality of water intented for human consumption [1998]
4 World Health Organisation (WHO), Guidelines for Drinking Water Quality. Third edition [2004]

Appendix A3 – Soil Importation Guidance

- WLGA – Requirements for the Chemical Testing of Imported Materials for Various End Uses and Validation of Cover Systems.

WLGA • CLILC

Requirements for the Chemical Testing of Imported Materials for Various End Uses and Validation of Cover Systems

Prepared by

Welsh Land Contamination Working Group

V.1 May 2013

This guidance is primarily for property owners, developers, environmental consultants, architects and surveyors who require information to assist their submissions to the Local Planning Authority (LPA)/ Contaminated Land Officer (CLO)/ Environmental Health Officer (EHO) in support of planning conditions applicable to the importation of soils, stones or any other similar materials to a development, for the purposes of garden, landscape or engineering use.

It is strongly recommended that, before importing any material to site, the intended sampling regime for that material is discussed and agreed in advance with the Local Authority LPA/CLO/EHO

The process for ensuring all information is submitted in relation to the relevant planning condition is outlined in **TABLE 1** in a series of step by step actions. Adherence to these will greatly assist the LPA/ CLO/EHO to effectively make final recommendation for discharge and will also ensure that contaminative risks from imported materials are avoided.

STEP 1.

Please use **Table 2,** below as an initial screening tool to use when assessing what testing requirements will be required when considering importing material for use at a development site. The Colour Coding is explained as follows:

Green– Usually no testing required go to **Step 3** –*However this category does not include soils being imported from 'greenfield sites'. Where such sources are identified the developer must initially consult with the CLO/EHO, and as a minimum provide Site Investigation data from the proposed site demonstrating chemical testing of the identified soils. Based on the data the CLO/EHO will agree the requirements for further testing (if deemed necessary) in line with **Step 2.***

Yellow - Chemical Testing Required. **Go to Step 2** for specific requirements.

Amber - Where it is proposed to import waste/ processed waste materials chemical testing is required, **Go Step 2. However, i**n addition to the chemical testing required, please provide exemption reference number/ Environmental Permit Number/ or waste protocol being used, **PRIOR TO THE COMMENCEMENT OF ANY IMPORTATION.**

Red – Importation of such materials prohibited.

Step 2.

Please refer to Table 3. This details the specific sampling frequencies and analytical requirements, which are dependent on the required quantities and the proposed end use of the development

Step 3.

Please complete and sign the attached declaration form with all necessary information in support of the relevant planning condition number. Failure to complete all sections of this form will result in delays when discharging the relevant planning condition

Table 1 – Process for Submitting Relevant Information on Imported Materials

STEP	RESPONSIBILITY	TASK	REQUIREMENT
1	**APPLICANT**	Submit information relating to proposed materials for import	Application needs to complete an Imported Materials Declaration Form, which can be found at the end of this document.
2	**APPLICANT**	Sampling of intended material(s) (topsoil, subsoil, stone, aggregates etc)	Either the supplier or importer must arrange for a suitably competent third party to undertake necessary sampling of intended materials prior to their importation to the development in line with the sampling frequency of **TABLE 3**. Imported Materials Declaration form to be completed and returned to CLO/EHO.
2	**APPLICANT**	Notify intentions to use "Other" Imported Materials (if applicable)	Imported Materials Declaration completed to notify CLO/EHO of the type of materials such as by-products of any chemical manufacturing or processing e.g. furnace slag must be submitted. Such products must be subject to additional laboratory testing to those set out in **TABLE 3** to determine for example a product's chemical stability/leachability etc. Additional testing proposals must be submitted to and agreed with CLO/EHO prior to importation to ensure that potential contaminative risks are avoided.
3	**LABORATORY**	Analysis of submitted samples	Analysis of submitted samples for determinands relevant to the specific development as outlined in **TABLE 3.** All analysis (where applicable) must be subject to MCERTS accreditation(*) at a certified laboratory.
4	**APPLICANT**	Employ a suitably qualified consultant to review analysis	Submission of a report interpreting the laboratory results and a conclusion on the suitability for the sampled material(s) to be used for the intended purpose at the development site.
5	**CLO/EHO**	Review the consultant's comments and raw data	If satisfactory partial discharge to be recommended of relevant planning condition.
6	**APPLICANT**	Notify CLO/EHO following import completion	Confirm the total volume and type(s) of material imported to site to CLO/EHO.
7	**CLO/EHO**	Check receipt of all required information	Consideration to be given to discharge planning condition in full.

[*] Further information is available from Natural Resources Wales at www.naturalresourceswales.gov.uk
Telephone: 0300 065 3000.

TABLE 2. Screening Tool to Assess if Chemical Testing is Required

Nature of Imported Materials	Comments	Chemical Testing required
Bagged or bulk bag quantities of **soils** / **compost and sand**.	**Applicable only to** materials available from retai outlets such as garden centres, DIY Superstores builder's merchants. All other sources will require testing in accordance with TABLE 3 overleaf, unless otherwise agreed with a CLO/EHO.	**TESTING NOT REQUIRED**
Bagged / bulk quantities of **aggregate, gravel and stone**.	**Applicable only to** material available from retai outlets such as garden centres, DIY Superstores builder's merchants. All other sources will require testing in accordance with TABLE 2 overleaf, unless otherwise agreed with a CLO/EHO	
Naturally sourced materials.	Includes quarry products and peat which have accompanying British Standard certification.	
Recycled, sieved, blended or screened soils, stones or aggregates.	Testing required regardless of whether these are from one source or several sources / suppliers.	**TESTING REQUIRED**
By products from industrial processes. Mechanically screened and sorted demolition wastes.	Additional testing to that in **TABLE 3** will be required to determine the suitability of these materials for specific uses prior to CLO/EHO acceptance for import. This is likely to include leachability testing in line with WAC testing or Remedial Targets Methodology Appendix B Leachate testing.	
Any Unprocessed / unsorted demolition wastes.	Where potential waste materials or previously contaminated materials are to be imported and processed for reuse the Developer must ensure that such materials are suitable for use in accordance with the Definition of Waste: Development Industry Code of Practice V2. Prior to **any importation** the developer **MUST** provide details of an exemption reference number/ Environmental Permit Number/ or waste protocol being used. Under no circumstances should such materials be imported without the above documents being provided, and formal written agreement received from the relevant CLO/EHO and or Environment Agency officer. Additional testing to that in **TABLE 3** will be required to determine the suitability of these materials for specific uses prior to CLO/EHO acceptance for import. This is likely to include leachability testing in line with WAC testing or Remedial Targets Methodology Appendix B Leachate testing.	**TESTING REQUIRED**
Any materials originating from a site confirmed as being contaminated or potentially contaminated		
Materials containaing Japanese Knotweed stems, leaves and rhizome infested soils	It is an offence under the Wildlife and Countryside Act 1981 to spread this invasive weed.	**IMPORTATION PROHIBITED**

TABLE 3 – Sampling Frequencies and Analytical Requirements for Imported Materials

<table>
<tr><td rowspan="3"></td><td colspan="5">DEVELOPMENT TYPE</td></tr>
<tr><td rowspan="2">Residential</td><td rowspan="2">Allotments</td><td rowspan="2">Parks, Play Areas, & POSs</td><td colspan="2">Commercial & Industrial</td></tr>
<tr><td>With Landscaping</td><td>Hardstand Only</td></tr>
<tr><td>QUANTITY TO BE IMPORTED</td><td colspan="5">NUMBER OF SAMPLES REQUIRED</td></tr>
<tr><td>Less than 20m^3</td><td colspan="5">Please contact CLO/EHO to agree sampling requirements</td></tr>
<tr><td>Between 20m^3 - 250m^3</td><td>4</td><td>4</td><td>3</td><td>2</td><td>2</td></tr>
<tr><td>More than 250m3</td><td>4 per 250m^3</td><td>4 per 250m^3</td><td>4 per 250m^3</td><td>4 per 250m^3</td><td>4 per 250m^3</td></tr>
<tr><td>>1000m3</td><td colspan="5">Where significant volumes of subsoil/topsoil are required, it is appreciated that laboratory costs for suitable frequency of analysis could be cost prohibitive. As such an appropriate sampling scheme should be agreed with the CLO/EHO.</td></tr>
<tr><td>DETERMINAND</td><td colspan="5">LABORATORY ANALYSIS</td></tr>
<tr><td>Arsenic / Cadmium/ Chromium (Total) / Lead / Mercury and Selenium</td><td rowspan="4">✓</td><td rowspan="4">✓</td><td rowspan="4">✓</td><td>✓</td><td>Optional</td></tr>
<tr><td>Boron / Copper / Nickel and Zinc</td><td>Optional</td><td>Optional</td></tr>
<tr><td>Speciated PAHs</td><td rowspan="2">✓</td><td>Optional</td></tr>
<tr><td>TPH [1] Phenol & Asbestos</td><td>✓</td></tr>
</table>

(1) Further testing will be required for BTEX compounds if significantly elevated concentrations are present in the sample(s) tested.

IMPORTED MATERIALS DECLARATION FORM

1.	Planning Permission Number	2.	Development Address

3.	Proposed use(s) of ALL imported material(s)	4.	Description of material imported	British Standard Certification supplied Yes	No
☐	Engineering use/works (e.g. backfill, sub formation, foundation)	☐	Topsoil	☐	☐
☐	Domestic Garden use (inc. crop growing)	☐	Subsoil	☐	☐
☐	Landscaping (play areas, communal areas, roadside)	☐	Aggregate	☐	☐
☐	Other *Please specify*	☐	Quarry stone	☐	☐
			Other *(Please specify)*____________	☐	☐

5.	Origin of Imported Material(s) ☐
☐	Greenfield Site *(Please specify)*____________________________
☐	Brownfield Site *(Please specify)*____________________________ Recycling / Process supplier (*Please specify)*____________________________
	Other *(Please specify)* ____________________________

6.	Volume(s) of Material to be Imported	7.	No of samples taken (per source)
☐	Less than $20m^3$	☐	2-3
☐	Between $20m^3$ - $100m^3$	☐	4-6
☐	More than $100m^3$	☐	More than 6 *(please specify)* (NB: All analyses (where applicable) must be subject to MCERTS accreditation(◦) at a certified laboratory)

8. Suitability of Use

Confirmation that soil imported does not contain any evidence of Japanese Knotweed stems, leaves and rhizomes. YES☐ NO ☐

Confirmation the imported soil does not contain any unprocessed / unsorted demolition waste YES☐ NO☐

Confirmation that the soil imported does not contain contaminated or potentially contaminated by chemical or radioactive substances YES ☐ NO ☐

Confirmation that the soils imported is suitable for use for the intended purpose on site YES ☐ NO☐

Signed:……………………………………………………………Date:………………

Name:………………………………………………Position:………………………………………

Company Name and Address

Validation of Capping Systems

Capping Systems are an engineered remediation solution frequently used to address contamination issues on development sites. They offer a simplistic and effective method to ensure that the risks from any residual contamination to future site users are adequately managed ensuring minimal long term exposure.

In essence capping systems or clean cover systems, as they are also referred to, involve the placement of a predetermined thickness of certified clean subsoil and/ or topsoil over areas of insitu contamination. They are predominately used when concentrations of contaminants are marginally in excess of SGVs/GACs. Where significantly elevated concentrations are identified or when hydrocarbon and other organic contaminants are present the use of a cover system as a single remediation method is not normally viable, and additional remediation technique(s) are likely to be required. A detailed assessment of the nature and extent of contamination must be undertaken by a suitably qualified consultant or specialist to determine if a capping system in isolation is a sufficient remedial solution.

Whenever capping systems are used the quantity of material to be imported will be dependant on the size of the garden and depth of cover material required. Full design details of the cover system including the proposed depth cover and risk assessment supporting why it is sufficient, must be detailed in a Remediation Strategy for the site and agreed with the LPA/CLO/EHO prior to the commencement of the verification of imported materials. The required depth will be dependant upon the type and concentration of contaminant(s) that will remain in situ and the proposed end use of the site. Whether any additional design measures are required as part of the cover system, such as a warning geomembrane or capillary break layer should also be clearly considered and details provided.

If the purpose of importing materials is for any other reason then the depth of cover may not need to be approved by the LPA/CLO/EHO although you are advised to check.

CIRIA Special Publication 124 'Barriers liners and cover systems for containment and control of land contamination', 1996 and CIRIA Special Publication 106 'Remedial Treatment for contaminated land', 1996 both provide advice on the provision of imported material as a cover/barrier to contaminated ground. The BRE document 'Cover systems for land regeneration - thickness of cover systems for contaminated land', 2004 also provides advice on designing a cover system although this document is heavily caveated and was designed for use in limited scenarios as detailed in the document (which should be read fully).

Verification of Capping Thickness

Capping systems need to be validated to demonstrate that the agreed thickness of clean cover has been achieved and this must be undertaken by a suitably experienced consultant or specialist. There are three main elements that must be verified to prove that the capping system is suitable:

- Details of the origin of the capping material (as detailed earlier in this document)
- Confirmation that the agreed capping thickness has been achieved
- Chemical analysis results which confirm that material used in the cover system are certified clean and free from contamination. (as detailed earlier in this document)

The most common and simplistic way of verifying capping thickness is by the excavation of trial holes (usually hand dug) within completed areas. A verification report should document all trial holes (including a plan showing their location) and the confirmation of thickness should be confirmed through a log which should describe the material encountered in accordance with BS5930. The log descriptions should be supported with photographs of the trial holes with a scale reference (tape measure/ staff) to fully demonstrate the capping thickness.

Alternatively, on some sites it may be convenient to use data from level surveys made before and after cover system placement from which the thickness of cover materials can be calculated.

For housing developments the frequency of thickness verification will be dependant on the number of plots and also whether the capping material came from a variety of sources/locations. Table 4 below provides a **suggested minimum frequency** based on plot numbers. However advice and approval should always be sought from the LPA/CLO/EHO before commencing work.

Table 4. Verification of Capping Thickness

Development Size	Frequency for Verification
1- 5 Plots	1 per plot
5-20 Plots	1 in every 2 plots
20-30 Plots	1 in every 3 plots
> 30 Plots	1 in every 4 plots
Adapted from NHBC Technical Extra Note Issue 8 Nov 2012	

Appendix A4 – Unexpected Contamination Procedure

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Unexpected Contamination & Strategy for Handling Contaminated or Potentially Contaminated Soil on Site

Any gross contamination identified over and above within the previous reporting should be considered unexpected. For the avoidance of doubt, potentially contaminated materials are those soils that, either via visual, olfactory, or in-situ testing (such as by PID – Photoionization Detection), are suspected to be contaminated.

1. Preliminary Actions.

The contractor shall be required to provide a Risk Assessment Method Statement (RAMS) pack relating to unexpected areas of contamination during site works, including earthworks and excavations.

2. Outline Unexpected Contamination Procedure.

If material is revealed on site of a nature that does not accord with the previously observed and recorded descriptions, the following procedure must be complied with.

a) Cease works and make all excavations in this location safe (for both site users and surrounding environs) and report observations to the Site Manager. [1]

b) The Site Manager is to notify the Engineer. [1]

c) The Local Authority and the Environment Agency must be kept fully informed. [2]

d) Excavation of the potentially contaminated material Under the guidance of Engineer [3]

e) Take representative samples of the suspect materials and forward them to a suitably accredited laboratory for analysis. [4]

f) Await the Engineer's instructions regarding re-commencement of the works and/or removal of suspect material to a suitably licensed disposal facility. [5]

Across the site, the Engineer shall regularly inspect excavations to check for the presence of unexpected or gross contamination; where encountered, the Engineer shall proceed as above.

Note 1. During the watching brief, a geo-environmental engineer should be available to assist with preliminary deliberations.

Note 2. The contractor, or if appointed, Curtin's, should liaise with statutory authorities, including the local authority and National Resources Wales, at an early stage and should agree to proposals to remediate this material.

Note 3. The contaminated area should be marked out and surveyed, and a record of the expected volume of material which needs to be removed should be produced.

Note 4. The primary anticipated remediation method for unexpected soil contamination will be excavation. The contaminated soils should be excavated with a minimum of 500mm of over digging to help reduce the likelihood of surrounding soils being contaminated through pre-existing leaching. The extent of the excavation should be undertaken with the oversight of a suitably qualified geo-environmental engineer who can make dynamic decisions about the extent of ground contamination.

Samples of the affected soils should be tested for suspected contaminants. However, the suite and chemical criteria for verification are to be defined in consultation with Curtins, and the regulatory authorises based on the nature of the contamination encountered. Validation testing will need to be carried out on the sides (e.g. 1 sample per 10m) and base (1 sample per 100m^2) of the excavation. Results should be compared against relevant soil guideline values.

Note 5. If the material passes the re-use thresholds (and is geotechnically suitable for re-use), the contractor should work to re-use these soils in the scheme. It will, however, be imperative to retain all records of testing, quantity, depth, and original and final location of the material identified to prove the suitability of the soils.

If the material fails, the screening values then the material should be excluded from the re-use strategy, and alternative uses for re-use should be considered.

Unsuitable material must be assessed for its hazardous waste stream and landfill suitability. If wholly unsuitable, offsite disposal may be required per current waste regulations. A registered waste carrier must ship material bound for landfill disposal following the Duty of Care Regulations 1991. The contractor must keep all records, including waste transfer notes, the volumes of material disposed, and the receiving site.

The contaminated soils will be removed only when validation samples meet relevant soil screening criteria. The final extent and location of contaminated soils must be marked, surveyed, and recorded. The excavation, if required to be backfilled, should be made up with clean inert fill, which will be subject to quality assurance measures mentioned elsewhere in this document.

In the unlikely event that the contamination is a free product, so severe or widespread that additional specialist remediation works will be required (such as removing free products), Curtins should be contacted for preliminary advice. Excavation works should be halted until further advice has been sought. The advice of specialist remediation contractors may be required to offer targeted advice on appropriate remediation techniques.

3. Strategy for Handling Contaminated Soils

Surplus soils to be removed from the site identified as contaminated should be loaded onto a lorry, covered securely, and transported to the landfill facility immediately. The soil stockpile must be appropriately marked as potentially hazardous. Where stockpiling is unavoidable the stockpile should be located on an impermeable membrane and be covered with a low permeability membrane at the end of each working day. Special considerations may be necessary for some types of contaminated materials. Where soils are wet when excavated, measures should be taken to ensure there is no runoff from the soils onto the surrounding soils. Contaminated liquids must be stored in suitable containers and appropriately labelled, and appropriate safety data sheets should be created.

Notes for hazardous and non-hazardous waste shall be kept on site for review by the Engineer. If identified, a specialist asbestos contractor should undertake ACM debris disposal.

The Principal Contractor shall ensure the proper storage and safe disposal of waste from the site after it has been passed on to another party. The contractor will undertake all works in a manner which does not cause an impact from contaminated soils to the wider environment and where asbestos fragments and or soils are being handled; an asbestos management plan should be developed to provide a framework for safe working and handling of spoils. In this respect, the Site Manager shall provide details of the landfill facility to be used and the company disposing of the waste regarding hazardous (particular) and non-hazardous waste.

Appendix A5 – Remediation Contractor Expanded Methodology & Cost Justification

Technical Note

Project:	Former Chubb Fire Site, Ferndale	**Project Number:**	T6667
Subject:	Proposed In-situ Groundwater Remediation Implementation Plan		
Author:	Dr Paul Adams	**Technical Note Ref:**	T6667/001 Issue 2
Date:	12/12/2022		

Circulation:

Matt Llewhellin – Natural Resources Wales

Kieran Hughes - Curtins

Tom Hocknell & Andrew Garner – Wynne Construction

Dear Matt,

1 INTRODUCTION

Keltbray have been engaged by Wynne Construction to undertake the in-situ groundwater remediation of the previously identified chlorinated solvent and perfluorooctanesulfonic acid (PFOS) contamination across the region the former Chubb Fire site which is proposed to be redeveloped into a school.

Keltbray understands that the Remediation Strategy produced by our client's environmental consultant, Curtins has been presented to Natural Resources Wales (NRW) and has been accepted in principle subject to the regulators review and approval of the remediation design.

- Remediation Strategy & Verification Plan. Curtins. Ref: LYF-CUR-A1-XX-SP-G-00004-Remediation_Strategy. Revision: P01. Issue Date: 21 October 2022

This Technical Note aims to present the details of our design along with a discussion of the methodology to be adopted to achieve sign-off.

2 PROJECT UNDERSTANDING

The Site is located off Ferndale Industrial Estate, Tan Y Bryn, Maerdy in South Wales, CF43 4TP. The Site was first developed in the 1950s as a factory operated by the Pyrene Company which was constructed on an earthworks development plateau. The factory expanded and became the Chubb Fire and Security Factory where fire extinguishers were manufactured and tested. Most buildings were demolished to ground level between 2006-2015. Demolition rubble, presumably from this site demolition activity, remains on onsite along with some vegetated areas. The western and central region of the Site is proposed for redevelopment to create a new school. The remainder of the Site is scheduled for future, unspecified development.

Various phases of ground investigation and risk assessment have been undertaken by a number of consultants, most recently by Curtins who undertook a Ground Investigation and controlled waters Detailed Quantitative Risk Assessment (DQRA) in 2022. It was concluded that both chlorinated solvents and PFOS in groundwater presented an unacceptable risk to the principal-controlled waters receptor, the river Rhondda Fach located c. 150m northeast of the Site. The watercourse is located c. 20m below the level of the Site. The Site is underlain by superficial deposits comprising Glacial Diamicton to c. 20m bgl. This stratum is classified as a Secondary (Undifferentiated Aquifer). The bedrock comprises Coal Measures but were logged as comprising primarily Mudstone. The bedrock is classified as a Secondary (A) Aquifer. The Site is not located within a groundwater Source Protection Zone.

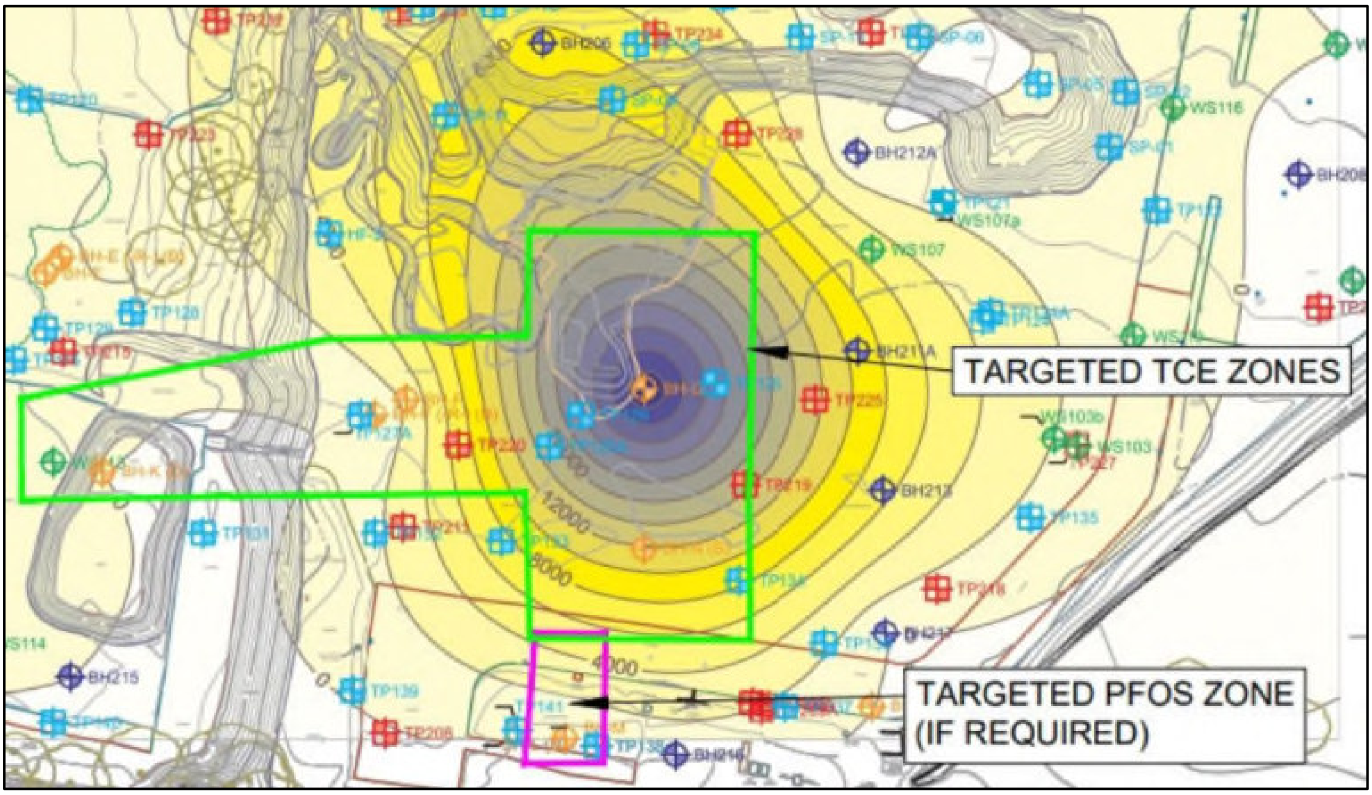
The consultant subsequently produced a Remediation Strategy for the Site which stipulated the following:

1. 300-600mm cover systems in areas of soft landscaping with a geotextile (for the protection of future Site users against asbestos and polycyclic aromatic hydrocarbon (PAH) exceedances);

2. In-situ treatment of dissolved phase PFOS and chlorinated solvent contamination in the south of the Site;

    a. Treatment of a trichloroethylene (TCE) plume across an area of 2,400m^2 to achieve a Site-Specific Action Criteria (SSAC) of 574 ug/l;

    b. Treatment of a PFOS plume across an area of 150m^2 to achieve 'betterment'.



Extract from Remediation Strategy by Curtins. Drawing Ref: 080397.300-CUR-XX-XX-DR-GE-003-V01

3. A single round of pre-remediation groundwater monitoring to establish a baseline. Monthly post-remediation monitoring for 6 months then quarterly monitoring for another 12 months.

4. Gas protection measures to Characteristic Situation 2 in new buildings with a membrane upgraded to offer vapour protection;

5. Barrier pipe for potable water supply;

6. Watching brief for unexpected contamination; and

7. Verification report and borehole decommissioning.

Keltbray have been engaged to complete items 2 and 3 (and 7 for our portion of the works).

3 REMEDIATION PROPOSAL

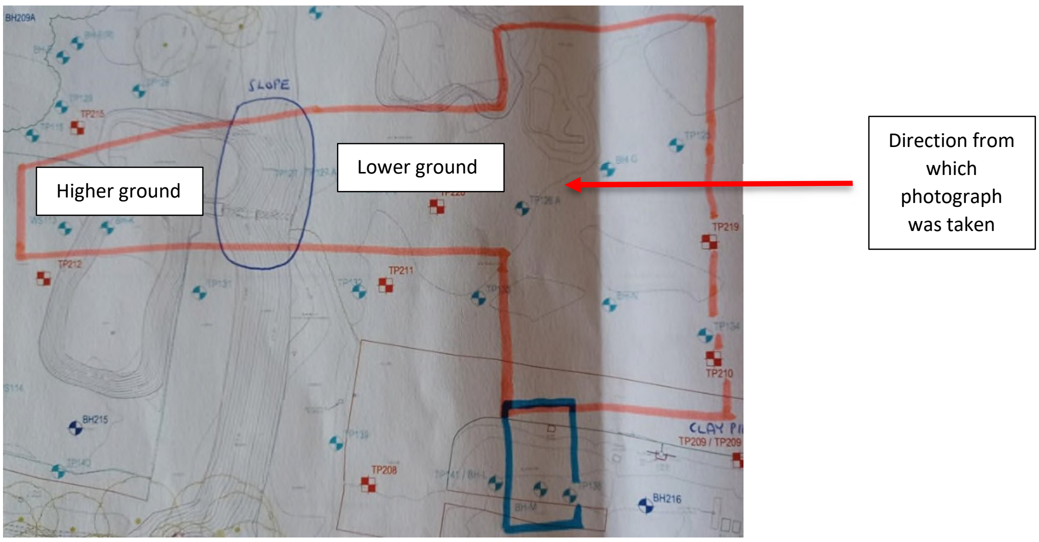
3.1 Treatment of chlorinated solvent contamination

As chlorinated solvents are degraded in the absence of oxygen (reducing conditions) the proposed in-situ groundwater remediation is designed to promote anaerobic conditions and stimulate specific microbial populations capable of metabolising / degrading the previously identified contaminants of concern.

Chemicals will be injected to promote both in-situ chemical reduction and enhanced reductive dechlorination. Products based on a combination of emulsified vegetable oils (EVO) and zero valent iron (ZVI) will be mixed with water and injected into the aquifer as a slurry under our Mobile Treatment Licence (deployment to be applied for via the NRW website). Injection of chemical treatments via a 'direct push' technique on a 4m injection point spacing across the full 2,400m^2 treatment area (c. 150 points) is proposed at a range of depths at 1m increments throughout the saturated zone (starting at c. 1.0m bgl) within the shallow superficial aquifer down to c. 5m below the top of the groundwater table. A direct push technique has the advantage of not needing to drill conventional boreholes. This results in a faster treatment (the injection period is estimated at six to eight weeks) with no soil waste, fewer consumables, the ability to inject at multiple depths and no need to decommission injection wells on completion.

Our current design (prior to the two proposed pre-remediation activities – see below) comprises a 12.5% EVO solution in water being injected at just over 75l per liner metre and a 15% ZVI slurry water solution being injected at just under 150l per linear metre.

There is a significant change of levels across the western region of the proposed TCE injection area (see pink outline on marked-up plan exert and photograph below). This area is considered too steep and inaccessible (even post vegetation clearance) for injection points to be installed. Hence, there will be a small region, estimated at c. 5m lateral meters, which we will not be able to inject into. Injection points will be installed as close as possible to the top and base of the slope.



The available groundwater level data indicates that groundwater levels are highly variable across the site. This is likely to be due to the variable make-up and locally clay-dominated nature of the Diamicton which will result in locally perched horizons of groundwater and limited continuity in some instances. Groundwater is reportedly present at 0.0-1.0m bgl across the lower level of the injection area. Groundwater is reportedly present at c. 1.0-2.0m bgl across the upper level of the injection area (this is despite the presence of the significant bank).

Prior to the injection, the existing monitoring wells present on the upper level of the injection area will be gauged to determine current groundwater levels. Injection depths will then be determined with injection being undertaken only in the saturated zone.

If significant daylighting (breakout to surface) occurs, the injection rate will be reduced to attempt to maximize the volume of chemicals injected. Where daylighting continues, the location will be terminated. The face of the slope will be closely monitored for daylighting.

3.1.1 Vertical delineation of the plume

Both Keltbray and Curtins consider that the site has been well delineated from a lateral standpoint. However, we agreed that there is somewhat less certainty regarding how the plume is vertically distributed (the permeability of the clay-rich Diamicton is likely to be variable). Hence, we are proposing a membrane interface probe (MIP) based investigation. The MIP is capable of providing semi-quantitative results to allow relative solvent concentrations to be recorded with varying depth across the plume area. The probing will be undertaken over a 3-day period, completing as many locations as possible to a target depth of 5-10 m bgl. This will enable the maximum injection depth(s) to be determined across the plume / treatment area. It may also indicate a need to alter the position / extent of the injection area (although significant changes are not anticipated in this regard).

3.1.2 Pilot-scale injection trial

With any in-situ chemical oxidation remediation, there is inherent uncertainty regarding what the ground conditions will allow. There are two main aspects 1) the volume of liquid which the ground will accept before pore pressure prevents further injection and 2) the volume of liquid which can be injected before daylighting occurs. Hence, we are proposing a pilot-scale injection trial whereby either water alone or a small volume of diluted chemicals will be injected at varying depths via c. 6 No. points across the injection area over a period of 3-5 days. This exercise will provide valuable information enabling the design to be adapted where required such that the full-scale works run smoothly (giving the client programme confidence) and we achieve a maximum possible injection volume and the greatest possible (targeted) vertical and lateral coverage.

3.2 Treatment of PFOS contamination

PFOS will be treated via immobilisation. A liquid substrate containing a form of activated carbon will be injected across the 150m^2 injection area on a 3m injection spacing (c. 17 points) using the same methodology as described above for the chlorinated solvent treatment. We estimate that the injection in the PFOS area will take two weeks to complete and would likely be undertaken concurrently with the chlorinated solvent remediation.

3.2.1 *Cost Benefit Assessment*

Our current design (at the time of writing and prior to the proposed pilot trial) comprises a c. 60kg of colloidal carbon suspended in water being injected per location (12kg per linear metre at each injection point). A specialist colloidal carbon supplier stated the following regarding the dosing:

> Based on a preliminary site data analysis, a relatively low dose of 5.4 kg carbon / m3 soil is recommended across the 150m^2 x 5 m deep saturated treatment zone. This is less than the standard dosing rates but provides a theoretical adsorption capacity of approximately ten times the known mass of PFOS in the treatment area. There are several unknowns including leaching flux, soil phase concentrations and extent of competition for adsorption sites, but this application rate is considered acceptable for a betterment design.

The cost to undertake the remediation of the 150m^2 PFOS plume area has been determined to be c. £116k plus VAT. Circa £80k of this is the supply of the colloidal carbon. This leaves c. £36k to carry out the work, much of which is associated with injection of the colloidal carbon.

Therefore, theoretically, if one were to double the dose (which the specialist indicates is not necessary based on the available site data) and add 33% to the injection costs (an extension to programme to inject a more concentrated product), then an increase of c. £92k and an overall cost of c. £208k would be incurred; a substantial increase which the specialist supplier indicated is unnecessary.

3.3 Deeper treatment of chlorinated solvent contamination

An allowance has been made to undertake deeper treatment (down to c. 10m bgl over c. 400m^2) in the immediate vicinity of BH-N(D) in the south of the TCE plume area (lower-level injection region). However, **no** allowance has been made to undertake any treatment beyond this depth for the following reasons:

- Injecting chemicals at greater depth would require the installation of standpipes in boreholes. Some of the proposed treatment chemicals are not designed to be introduced via borehole standpipes (as their solubility is too low). Other options for treating these forms of contamination are largely limited to immobilisation / barriers;
- The bedrock geology whilst mapped as coal measures has been logged as ‘predominately mudstone and some interbedded sandstone and siltstone’. The top of the bedrock has been logged at 229 and 262m AOD with the superficial deposits logged between 245 and 274m AOD (although

the maximum extent of the superficial deposits was not proven in all instances). The level of the river has been recorded as c. 240m AOD (c. 20m below the lowest level of the site). The mudstone is likely to have a very low permeability and hence will act as a natural barrier to the vertical migration of the contamination. This is evidenced in that no TCE has been recorded in surface water samples taken from the river to date. Furthermore, there is little point in attempting to inject into a stratum of this nature.

Thus, the costs of deeper treatment (provisionally calculated to be more than double than that of the proposed works) would far outweigh the additional benefits meaning that deeper treatment is not thought to be practicable or justifiable. It is considered that the proposed approach will target the main sources of the contamination and offer the most practicable, cost-effective solution.

4 GROUNDWATER MONITORING

Groundwater monitoring will be undertaken as per the Remediation Strategy i.e. one round pre-remediation (with the data combined with the existing dataset to create a baseline) followed by monthly rounds for six months and finally, quarterly rounds for twelve months. During each round, samples will be recovered from 7 No. wells (BH-B deep, BH-F, BH-F[R], BH-G, BH-K, BH-N shallow and BH206) for chlorinated solvents (VOC and SVOC suite) and 8 No. wells (BH-B deep, BH-F, BH-F[R], BH-G, BH-M, BH-N shallow, BH-O and BH206) for PFOS plus up and down gradient samples from the river for both contaminants of concern. Groundwater samples will be collected using the low-flow methodology whereby physicochemical water parameters will be monitored and the sample will not be taken until these have sufficiently stabilised.

5 SIGN-OFF

There are a number of factors which require consideration when considering the data review and sign-off process.

For chlorinated solvents, the treatment has been designed to function in two ways: the ZVI degrades the contaminants via an active in-situ chemical reductive process, whilst the EVO modifies redox conditions within the aquifer making them suitable for reductive dechlorination to occur via natural (microbiological) processes. The manufacturers of the products state that the reducing effects of the chemicals can last for up to five years within the aquifer. There is a DQRA-derived site-specific remedial target of 574 ug/l TCE.

Keltbray has provided the above implementation plan based on a single round of injection only at the designed concentration and injection density targeting the shallow groundwater. The injected compounds have up to 5 years subsurface activity over which time the concentrations of contaminants will continue to reduce (subject to no new contaminant inputs) close to and beyond the remediation target values. However, it is unknown whether the target criteria will be achieved within the period specified

The Remediation Strategy specifies an 18-month post remediation monitoring period. Yet, the school development programme requires initial construction activities to commence in April 2023 if the project is to remain in line with the Local Authorities' programme. There is a conflict here which needs to be managed to give our Client the confidence that the development programme will not be adversely affected by the required remediation, whilst ensuring NRW can be confident in achieving the desired outcome from the remediation intervention. Therefore it is not practicable to complete the proposed post remediation groundwater monitoring programme prior to the commencement of construction. This situation is not unique to this site, as where in-situ biologically mediated groundwater remediation is implemented achieving the desired conditions within the aquifer and the subsequent biological degradation can be a lengthy process. However, the remediation technologies applied are well tested and proven for the contamination at the site. We are therefore proposing a site specific and progressive Verification Plan for the project to demonstrate that each aspect of the remediation (design, implementation and aquifer reaction) is completed and monitored to an approved schedule. We propose a lines of evidence approach to verification:

a) Formal written agreement of the in-situ Remediation Implementation Plan (to include details on injection points, concentrations and quantities of remediation compounds);
b) Verification of concentrations and volumes of chemicals injected across the target area (to verify agreed design);
c) Demonstration that the treatment has resulted in reducing conditions required for reductive dechlorination to occur within the target aquifer via the recording of the following physicochemical / chemical parameters over successive groundwater monitoring rounds:
    i. Negative Oxidation Reduction Potential (ORP) (may take time to establish)
    ii. An increase in Total Organic Carbon post injection
    iii. Concentrations of electron acceptors (nitrate, ferric iron, sulphate, elemental sulphur)
    iv. Reduction in TCE concentration below baseline conditions (average across all monitoring wells)
    v. Increasing total chlorine mass removal (calculated from laboratory test data)
    vi. Ongoing trends with respect to concentrations of breakdown products
d) 'Interim' sign-off prior to 17th April 2023 (after an estimated 2 No. monitoring rounds) enabling construction works to commence(demonstration of items A & B will be possible in this timeframe, whereas Item C may be ongoing and take in excessive of 6 months to demonstrate)
e) Completion of the 18-month monitoring programme and production of a Verification Report
f) Full sign-off from the regulator following receipt and review of the Verification Report.

For PFOS, the target is 'betterment' and hence demonstrating of a continuing falling or initial fall followed by a stable trend is considered to be reasonable. [We note that BH-B and BH206 are considerably downgradient of the PFOS injection zone. It may be unrealistic to expect to see evidence of betterment in these wells in the short to mid-term].

6 CLOSING STATEMENT

We consider that the proposed approach represents a practicable, deliverable and cost-effective solution. We would welcome the opportunity to discuss the above proposal with NRW in conjunction with our client's consultant, Curtins thus allowing the Remediation Strategy to be finalised.

Sincerely,

For, and on behalf of, Keltbray Ltd.

Dr Paul Adams

Senior Remediation Advisor

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