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Contaminated Land
and Hydrogeology

Glan Llyn, Llanwern: Soil Quality Verification Report, Phase 4D

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1. INTRODUCTION

Brighton STM Developments Ltd, on behalf of Revantage, has appointed H Fraser Consulting Ltd (HFCL) to assist with validating remediation works undertaken the former Llanwern Steelworks site at Glan Llyn.

The site has undergone remediation, comprising excavation of Made Ground materials, removal of materials unsuitable for re-use in the development platform, and recompaction of suitable Made Ground materials as an engineered fill. The remediation strategy for the site also requires a drainage layer to be installed above the engineered fill layer, to reduce infiltration to the Made Ground.

Two planning conditions (PC) apply to the site remediation work.

- PC 27 requires that, prior to commencement of each phase of development, a risk assessment, remediation strategy and verification plan are submitted to and approved in writing by the Local Authority.
- PC 28 requires that prior to commencement of each phase of development (excluding works required for the remediation strategy) a verification report is submitted to and approved in writing by the Local Authority, to demonstrate completion of the remediation strategy and the effectiveness of the remediation.

The site is being redeveloped in phases, and the current report relates to Phase 4D.

1.1 Remediation verification

Discussion between Revantage (and its predecessor St Modwen Developments), Natural Resources Wales (NRW), the designers of the remediation strategy Rodgers Leask Ltd (RLL) and HFCL resulted in an agreed process for the verification of phase-by-phase remediation of the site. This process is described in HFCL (2024a).

RLL has collected and processed the data relevant to verification of the remediation process and has provided the data used in this report. HFCL has reviewed and agreed RLL's data processing for Phase 4D.

1.2 Objective

The objective of this report is to demonstrate that the remediation criteria relating to controlled waters have been met. (RLL (2025) has separately reviewed the risks to human health.) This verification report is intended to be submitted alongside the human health assessment, to obtain discharge of Part 1 of PC 28 for Phase 4D.¹

1.3 Scope of works

The following work has been undertaken:

- RLL has reviewed and presented the data relevant to Phase 4D;

¹ Part 2 of PC 28 requires presentation of evidence of the placement of a drainage layer at the base of the clean cap. This is the responsibility of the plot developers and will be signed off separately.

- HFCL has confirmed its agreement with the presented data and has checked that the data can be adequately mapped onto the agreed verification process;
- HFCL has produced this report to determine whether controlled waters risks related to Phase 4D have been adequately addressed.

2 BACKGROUND

2.1 Plot location

The location of Phase 4D is shown in the south-central part of Figure 2.1. Grid squares measure 50 m. At its northeast corner, the phase is more than 50 m from the nearest mapped surface water feature (Ellen Reen), which is part of the site reen system (still under development).



Figure 2.1 Plot Location

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2.2 Derivation of remediation criteria

Soil re-use values (SRVs) were derived by Atkins (2017) and amended by RLL (2019-22). A further minor correction for the residential development areas (including Phase 4D) was presented by HFCL (2024b). The derivation of SRVs assumes the following conceptual model.

- 60% of the site surface is impermeable, and 100% of incident rainfall on impermeable areas either evaporates or is routed via the drainage system directly to the reens.
- 40% of the site has soft landscaping, and in these areas infiltration was calculated as 12.85 mm/a, by subtracting evapotranspiration and runoff from the total rainfall figure. Runoff from these areas also passes to the reens.
- 12.85 mm/a infiltrates the drainage layer overlying the engineered fill.
- In the soft landscaping areas, 60% of infiltration drains laterally through the drainage layer into a reen, and does not enter the engineered fill.
- 40% of infiltration drains into the engineered fill and migrates through the fill to a reen, dissolving potential contaminants from the fill materials.

- The infiltration that travels through the fill is diluted on reaching the reens by runoff and infiltration through the drainage layer. The relative fluxes of water passing through the fill to clean runoff provides the dilution factor.
- SRVs are calculated by multiplying the Environmental Quality Standard (EQS) by the dilution factor and converting this water concentration into a soil concentration using a partition co-efficient.

This approach was set out originally by Atkins in 2017, modified by Rogers Leask in their Remediation Strategy report and approved by the Local Authority under discharge of Planning Condition 27.

Soil re-use values (SRVs) are set out HFCL (2024b) and values for selected contaminants of concern are reproduced here in Table 2.1.

Table 2.1 Selected soil re-use values

Determinand	Units	SRV
Cyanide (Total)	mg/kg	2.02
Manganese	mg/kg	33,315
Benzene	mg/kg	3.803
Benzo[b]fluoranthene	mg/kg	3.42

3 REMEDIATION ACTIVITIES AND VERIFICATION DATA

3.1 Remediation process

The remediation and verification work on Phase 4D has included the following:

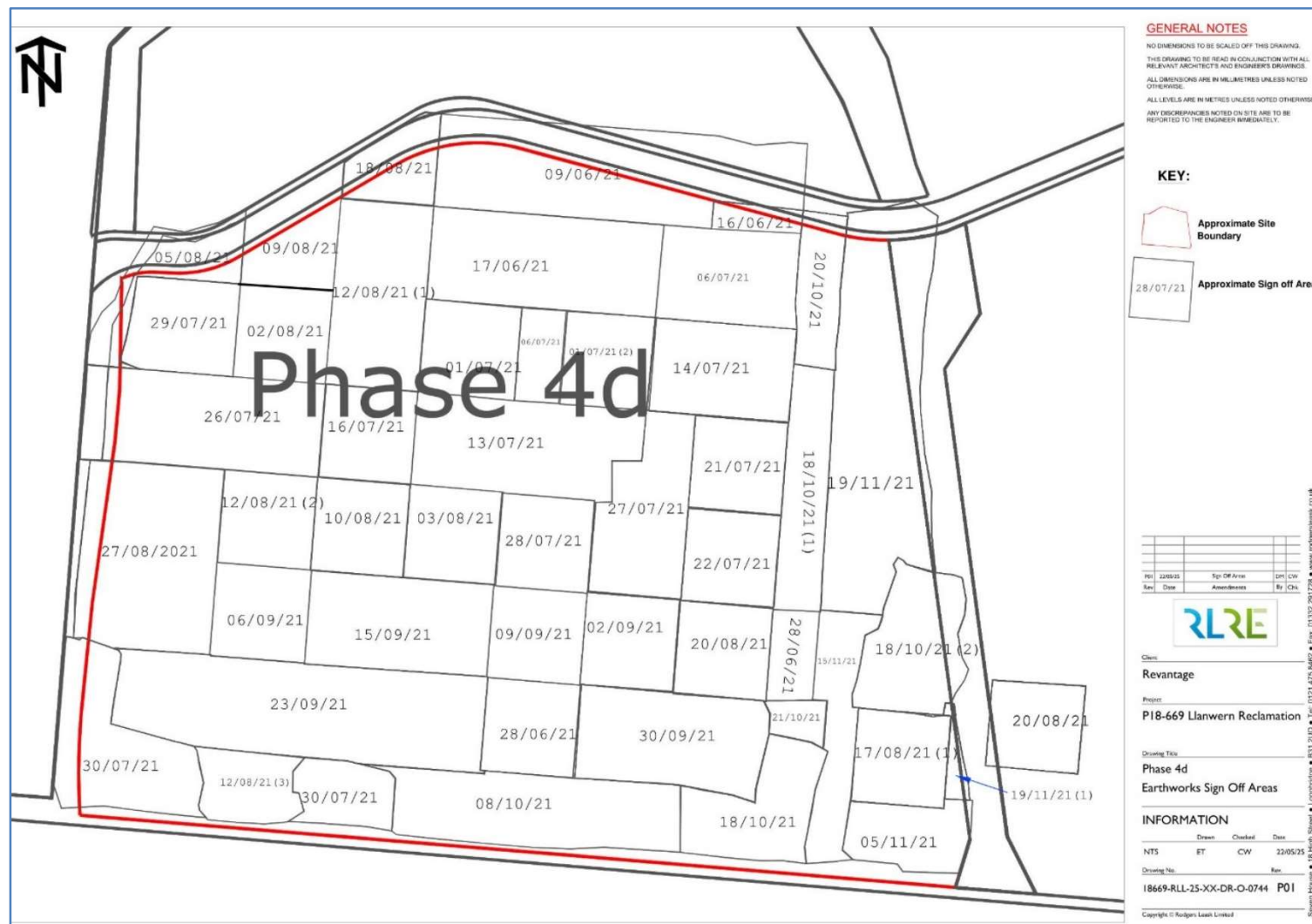
- Complete excavation of Made Ground materials to the underlying Tidal Flat Deposits, screening and stockpiling;
- Sampling of stockpile materials;
- Removal of material unsuitable for use;
- Subdivision of the site into backfill zones;
- Placement of engineered fill in 300 mm layers, zone by zone;
- Sampling of surface materials, post-placement, to provide additional verification data.

3.2 Soil movements

All of the engineered fill used for Phase 4D derived from excavated site soils; various stockpiles of these soils were exploited to provide the required materials. No fill materials were brought from off site.

3.3 Soils validation data

In total 150 samples are available from fill materials for Phase 4D, and an additional 20 samples were taken from the near-surface, post-placement. Figure 3.1 shows the backfill zones for Phase 4D; each zone was backfilled in 300 mm layers, and the date label for each zone is the date that the backfill was completed. A materials management database was maintained so that there is a record of which stockpile was used for each layer in each backfill zone. Appendix A presents a full screening of chemical data. Laboratory certificates are appended to the human health report for the phase (Rodgers Leask, 2025).



4 ASSESSMENT OF CONTAMINANTS OF CONCERN

4.1 Assessment stages

HFCL (2024a) sets out the verification process that has been agreed. This proceeds through three stages, as follows.

4.1.1 Identification of Contaminants of Concern

The verification data for the phase are screened against the SRVs. Contaminants of Concern (CoCs) are defined as determinands for which the 95thile of the analytical results from the fill materials exceeded the SRV. Some CoCs have such slow travel times that they cannot be expected to travel the minimum 12.5 m assessment distance within a 1,000-year assessment period and therefore present no significant risk. Those that have a 95thile exceeding the SRV and that are mobile enough to travel more than 12.5 m in the assessment period are taken forward for further evaluation.

4.1.2 Statistical assessment

At this stage a thorough statistical and spatial analysis is carried out. This includes presentation of the entire data set for each CoC as a box plot, presentation of the same data sets as histograms; and spatial assessment of the data, with an average concentration and UCLmean concentration calculated for each backfill zone in the phase. If the UCLmean concentration for any CoC in any backfill zone exceeds the SRV this is taken to the next stage.

4.1.3 Screening against Reference Values

The average and UCLmean concentrations for the different backfill zones are then compared against the Reference Values that are relevant, considering the distance of each backfill zone from the nearest surface water (the travel distance required for contaminants to move from the backfill zone to the receptor).

Any UCLmean concentration that exceeds the relevant Reference Value requires additional justified mitigation, or fails the validation method.

4.1.4 Review of hydraulic conductivity data for engineered fill

Because the derivation of the SRVs assumes a hydraulic conductivity no higher than 1×10^{-6} m/d for the engineered fill, hydraulic conductivity data need to be presented to show that this has been achieved.

4.2 Stage 1 – Identification of Contaminants of Concern

The verification data for Phase 4D have been screened against the SRVs. Results are summarised in Table 4.1 and detailed in Appendix A. This includes the samples taken from stockpiles prior to backfilling and the surface verification samples taken after placement. In both the table and the appendix any value exceeding the SRV is highlighted in red. (Values below the relevant SRV are highlighted in green in the appendix.)

The analysis shows that most of the assessed determinands were detected in a significant number of soil samples. However, maximum values only exceeded the SRV in six cases, and 95th percentile values are below the SRV for every determinand.

Table 4.1 Summary of soil quality results

Determinand	Units	SRV	N Detects*	Mean	Max	95%ile
Inorganics						
Cyanide (Free)	mg/kg	2.02	25	1.02	11.4	1.46
Ammoniacal Nitrogen	mg/kg	154	31	8.93	20.00	12.00
Iron (Total)	mg/kg	305,000	150	102,623	443,000	248,100
Arsenic	mg/kg	2,533	129	13.8	82.9	35.3
Cadmium	mg/kg	73	98	0.70	10.3	2.51
Chromium	mg/kg	9,431	142	153	1,290	447
Manganese	mg/kg	33,300	150	10,744	67,300	29,475
Copper	mg/kg	451	134	39.4	350	121
Mercury	mg/kg	132	48	0.64	7.90	1.40
Nickel	mg/kg	11,500	150	36.8	386	120
Lead	mg/kg	15,700	144	73.6	727	240
Selenium	mg/kg	702	69	5.08	27.3	10.1
Vanadium	mg/kg	1,606	147	172	831	450
Zinc	mg/kg	138,000	150	356	22,900	735
Speciated TPH						
Aliphatic VPH >C5-C6	mg/kg	73	23	0.32	1.00	1.00
Aliphatic VPH >C6-C8	mg/kg	359	35	0.32	1.00	1.00
Aliphatic VPH >C8-C10	mg/kg	2841	40	0.53	21.0	1.00
Aliphatic EPH >C10-C12	mg/kg	22,500	24	7.63	330	41.52
Aliphatic EPH >C12-C16	mg/kg	450,000	64	45.4	1,500	295
Aliphatic EPH >C16-C21	mg/kg	56,600,000	105	78.8	2,400	435
Aliphatic EPH >C21-C35	mg/kg	56,600,000	124	361	10,000	1439
Aliphatic EPH >C35-C44	mg/kg	56,600,000	90	71.6	2,370	384
Aromatic VPH >C5-C7	mg/kg	8.51	7	0.32	1.00	1.00
Aromatic VPH >C7-C8	mg/kg	177	12	1.30	32.0	1.00
Aromatic VPH >C8-C10	mg/kg	144	35	0.36	1.67	1.00
Aromatic EPH >C10-C12	mg/kg	227	11	2.42	100	4.57
Aromatic EPH >C12-C16	mg/kg	451	37	14.1	950	52.58
Aromatic EPH >C16-C21	mg/kg	1,424	79	16.2	810	52.02
Aromatic EPH >C21-C35	mg/kg	11,300	121	67.1	739	377
Aromatic EPH >C35-C44	mg/kg	11,300	60	5.29	191	10.78
PAH						
Naphthalene	mg/kg	27	108	0.36	7.30	1.86
Acenaphthylene	mg/kg	17	82	0.10	1.70	0.28
Acenaphthene	mg/kg	30	68	0.10	1.98	0.37
Fluorene	mg/kg	27	86	0.13	1.90	0.48
Phenanthrene	mg/kg	27	131	0.78	13.0	2.50
Anthracene	mg/kg	34	101	0.21	4.40	0.49
Fluoranthene	mg/kg	6.64	135	1.21	31.0	3.10
Pyrene	mg/kg	76	136	0.95	20.0	2.48
Benzo[a]anthracene	mg/kg	607	128	0.60	13.0	1.60
Chrysene	mg/kg	621	135	0.59	11.0	1.56

Determinand	Units	SRV	N Detects*	Mean	Max	95%ile
Benzo[b]fluoranthene	mg/kg	3.42	126	0.86	15.0	2.66
Benzo[k]fluoranthene	mg/kg	5.05	114	0.33	4.80	1.31
Benzo[a]pyrene	mg/kg	34	120	0.58	11.0	1.70
Indeno(1,2,3-c,d)Pyrene	mg/kg	25	115	0.50	9.40	1.70
Dibenz[a,h]Anthracene	mg/kg	838	69	0.14	1.90	0.55
Benzo[g,h,i]perylene	mg/kg	13	108	0.45	6.90	1.41
Other organics						
Phenol	mg/kg	3.05	9	0.03	1.70	0.02
Benzene	µg/kg	3,800	17	125	645	180
Toluene	µg/kg	128,000	14	94.7	140	140
Ethylbenzene	µg/kg	80,000	2	54.3	231	80.0
m & p-Xylene	µg/kg	74,000	5	135	554	200
o-Xylene	µg/kg	74,000	4	133	200	200
Phenol	mg/kg	3.05	9	0.03	1.70	0.02

* 150 samples were analysed for all determinands.

As the analysis shows, the backfill in Phase 4D was of good enough chemical quality that none of the potential contaminants was flagged as a CoC. Stages 2 and 3 of the chemical assessment are therefore not required for this phase.

4.3 Stage 2 – Statistical assessment

Not required for Phase 4D (see Section 4.2 above).

4.4 Stage 3 – Screening against Reference Values

Not required for Phase 4D (see Section 4.2 above).

4.5 Hydraulic conductivity data

Rodgers Leask (2025) reports hydraulic conductivity data for Phase 4D and includes detailed appendices showing the derivation of the hydraulic conductivity results. They are summarised here for ease of reference.

Table 4.2 Hydraulic conductivity testing at Phase 4D

Method	N tests	Hydraulic conductivity (m/s)		
		Min	Max	Mean
Falling head test	10	5.5×10^{-7}	9.7×10^{-7}	8.6×10^{-7}
Falling head test	5	5.9×10^{-7}	9.1×10^{-7}	7.4×10^{-7}
Rising head test	6	2.2×10^{-7}	9.8×10^{-7}	6.3×10^{-7}
Aggregate	21	2.2×10^{-7}	9.8×10^{-7}	7.6×10^{-7}

As the table demonstrates, all measured hydraulic conductivity values were smaller than the assumed value of 10^{-6} m/s and the mean value of all tests was 7.6×10^{-7} m/s. The assumption used in the derivation of the SRVs is therefore valid.

5 CONCLUSIONS

Remediation has been undertaken on Phase 4D of the Glan Llyn development site, comprising excavation of Made Ground materials, stockpiling, and placement of suitable materials as a compacted engineered fill. The plot is subdivided into backfill zones, which were sequentially backfilled in layers.

Verification samples comprise stockpile sampling, with materials tracking such that average concentrations of potential contaminants can be calculated for each backfill zone. Surface samples were also taken after the backfill was placed, which enhance the verification sample data set.

The data set was screened against Soil Re-use Values (SRVs) by comparing the 95thile value for each contaminant against the SRV. For Phase 4D, the 95thile concentration was below the SRV for all assessed contaminants.

Further statistical presentation of data and comparison to Reference Values was therefore not required.

The chemical data demonstrate that the engineered fill in Phase 4D meets the SRVs and presents no significant risk to controlled waters. It therefore meets the remediation requirements.

The remediation strategy required that the hydraulic conductivity of the fill be limited to 10^{-6} m/s. In practice all measured values are below this and the requirement is also therefore met.

We conclude that the data presented are sufficient to allow the sign-off of PC28 Part 1 for Phase 4D.

REFERENCES

Atkins, 2017, Glan Llyn, Llanwern: Llanwern Controlled Waters Detailed Quantitative Risk Assessment, report no. 5111373-LLA-OUT-0257.

HFCL, 2024a, Glan Llyn: Soils validation strategy for protection of controlled waters, report no. 30937 R2.

HFCL, 2024b, Glan Llyn, Llanwern: Soil quality verification – Correction to calculated re-use criteria for soils at Glan Llyn (residential), technical note no. 30937 TN1.

Rodgers Leask, 2019-2022: Glan Llyn Llanwern Sitewide: Controlled Waters DQRA 2019 Update, report no. 18669-RLE-19-RP-O-0006.

Rodgers Leask, 2025: Glan Llyn, Phase 4D Chemical Validation Report, report no. 18669-RLL-22-XX-RP-O-0283-REVF.

APPENDIX A

Chemical screening