

Glan Llyn
Phase 4B & 5D
Remediation Strategy

Glan Llyn, Newport Phase 4B & 5D

Remediation Strategy

For

Revantage Real Estate

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1.0 Introduction

1.1. Terms of Reference

Phase 4B & 5D of the Glan Llyn development in Newport (hereafter referred to as the 'Site') is situated within the ongoing redevelopment of the former Llanwern Steelworks. The site location plan is included in **Appendix A**.

The eastern part of Phase 4B & 5D formed part of a separate contract managed by Vertase FLI and was approved under planning application references 23/1127 (PC27) and 24/0468 (PC28). This area is not included in this Remediation Strategy.

In July 2024 the Client, St Modwen Developments were rebranded to be called Revantage Real Estate. Any reference to the previous company name in this report should be referred to accordingly.

A contractor shall be employed by Revantage Real Estate to undertake the ground preparation and remediation works, to include the requirements of this strategy. A monitoring engineer will oversee the works to monitor that the requirements of this strategy are achieved.

1.2. Purpose

This report has been prepared pursuant to the discharge of Planning Condition 27 of the Outline Planning Permission Reference 06/0471 for the proposed development of residential development Phase 4B & 5D as part of a wider mixed-use development at Llanwern, Newport.

Planning Condition 27 states the following:

“(27) Prior to the commencement of each phase of development as defined by Condition 03 (or at such other date or stage in development or for such specified activities or works as may be agreed in writing with the Local Planning Authority), the following components of a scheme to deal with the risks associated with contamination relating to that phase or activity shall each be submitted to and approved, in writing, by the Local Planning Authority:

- (1) A preliminary risk assessment which has identified:*
 - (a) all previous uses;*
 - (b) potential contaminants associated with those uses;*
 - (c) a conceptual model of the site indicating sources, pathways and receptors;*
 - (d) potentially unacceptable risks arising from contamination at the site.*

(2) A site investigation scheme, based on (1) to provide information for a detailed assessment of the risk to all receptors that may be affected, including those off site.

(3) The site investigation results and the detailed risk assessment (2) and, based on these, an options appraisal and remediation strategy giving full details of the remediation measures required and how they are to be undertaken.

(4) A verification plan providing details of the data that will be collected in order to demonstrate that the works set out in (3) are complete and identifying any requirements for longer term monitoring of pollutant linkages, maintenance and arrangements for contingency action. Any changes to these components require the express consent of the Local Planning Authority.

Reason: To ensure that the proposed development will not cause pollution of the environment or harm to human health."

The scope of this report is detailed in Section 1.3 below. It is considered that this report addresses the requirements of Condition 27 part 3 and part 4. Part 1 and part 2 has been addressed in the Phase 4B & 5D Desk Study & Ground Investigation Report (document reference 18669-RLL-22-XX-RP-O-0328-P03, dated June 2025).

1.3. Objectives

The objective of this document is to specify both the remediation and validation works required to facilitate the proposed development and mitigate identified potential risks to human health. The remediation works will also seek to mitigate previously unidentified risks to human health, should they be encountered.

The potential risks associated with controlled waters shall be managed in accordance with the Soils Validation Strategy for Protection of Controlled Waters and validated in a forthcoming Controlled Waters Validation report by H F Consulting Ltd (HFCL). The primary focus of the remediation works is decreasing the infiltration through Made Ground by way of the re-engineering limiting mobilisation of leachable contaminants to the surface waters. The remediation will comprise the excavation of buried obstructions and removal of contamination identified from previous phases of ground investigation and during the remedial turnover. Material is to be turned over and placed with an onward verification sampling programme to assess compliance with the remediation criteria established within this document for the Site.

Remedial requirements for the onward developer are detailed in Section 6.8.

1.4. Reference Reports

The following documents and data sources have been reviewed in preparation of this document and should be read in conjunction with this report:

- RLL, Phase 4B & 5D Desk Study and Ground Investigation Report, ref. 18669-RLE-22-XX-RP-O-0328-P03, dated June 2025.
- RLL, Updated Controlled Waters Detailed Quantitative Risk Assessment, Glan Llyn, ref. 18669-RLE-19-RP-O-0006, dated June 2022.
- RLL, Phase 4B & 5D Controlled Waters Detailed Quantitative Risk Assessment Addendum ref. 18669-RLL-24-XX-RP-O-0591-P02, dated June 2025.
- H Fraser Consulting (HFCL), Glan Llyn: Soils Validation Strategy for Protection of Controlled Waters December 2024.

1.5. Limitations and Confidentiality

All conclusions and recommendations made within this report are based on and limited to the factual information. No responsibility can be taken by RLL for information obtained by third parties and it has been assumed that all third-party information provided is true and correct.

No liability can be accepted for conditions not revealed within the exploratory holes or pits undertaken. The exploratory points cover only a small portion of the total Site area. RLL has, where necessary, undertaken extrapolation between locations and no responsibility can be taken for different conditions which may occur between locations.

RLL has undertaken the work in accordance with our understanding of current best practice at the time of undertaking the report. Further assessment and revision of the report may be required should new information come to light or legislation/ changes to best practice be introduced after the date of issue of the report. RLL has prepared the report for the sole use and reliance of the Client. The report may not be used or relied upon by any unauthorised third party without the explicit written agreement of RLL.

The work undertaken within this report remains the intellectual property of RLL and must not be divulged to any commercial third party without the prior written agreement of RLL.

2.0 Background Information

2.1. Proposed Development

It is understood that the Site is proposed to be redeveloped for a residential end-use. An illustrative masterplan (ref. 8111-08-A011, dated April 2019) is available in **Appendix A**.

The development will form part of the wider Glan Llyn development.

2.2. Site Description

The Site is located within the Glan Llyn development at the former Llanwern Steelworks, approximately 4km to the east of Newport City Centre at approximate National Grid Reference 335990E, 186950N. The wider Glan Llyn development covers approximately 250 hectares and is proposed to be redeveloped for residential, commercial, and public open space use.

The Site is irregular in shape, covers an area of approximately 3.10ha, and is located in the approximate centre of the wider Glan Llyn development. The Site historically housed a bag filter plant, conveyors, hoppers and a travelling boom.

The Site boundary is shown on drawing 18669-RLL-22-XX-DR-O-0323-P02, **Appendix A**.

2.3. Site History

A detailed assessment of historical maps is provided within the RLL Desk Study & Ground Investigation Report (18669-RLE-22-XX-RP-O-0328-P03), with a brief summary provided below.

Historically, the Site is shown to comprise agricultural land with approximately three structures associated with Decoypool Farm in the north and part of Decoy Pool (marshy pond) which was surrounded by deciduous woodland and an orchard in the north east.

Previous infrastructure was demolished by 1967 when the Site formed part of Llanwern Steelworks, and comprised a conveyor network with associated travelling boom and hoppers and a bag filter plant. The Site was partially demolished by 2006 and completely demolished to slab level by 2009.

2.4. Geology

Information pertaining to underlying ground conditions has been obtained via the British Geological Survey's (BGS) Onshore Geoindex¹.

The published geological information shows the Site to be void of Made Ground. However, due to the Site's history, Made Ground is likely to be present associated with the previous development and subsequent demolition.

Superficial deposits are shown to comprise Tidal Flat Deposits.

Tidal Flat Deposits are described by the BGS as *'unconsolidated sediment, mainly mud and/ or sand. They may form the top surface of a deltaic deposit. Normally a consolidated soft silty clay, with layers of sand, gravel and peat.'*

The underlying bedrock is shown to be the Mercia Mudstone Group.

The Mercia Mudstone Group is described by the BGS as comprising *'predominantly red, less commonly green-grey, mudstones and subordinate siltstones with thick halite bearing units in some basinal areas. Thin beds of gypsum/anhydrite are widespread; sandstones are also present'*.

There is a fault approximately 500m north-east of the Site which trends roughly north to south and extends northwards away from Site.

2.5. Hydrogeology

The Mercia Mudstone Group strata is defined as a Secondary B Aquifer and the superficial Tidal Flat Deposits are defined as Unproductive Strata.

Secondary B Aquifers are classified as comprising *'predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifer'*.

Unproductive Strata classification has been given to cases where *'rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow'*.

¹ <http://mapapps2.bgs.ac.uk/geoindex/home.html>

2.6. Hydrology and Flooding

	Summary
Surface Water features	On-Site: No records of surface water features within Phase 4B & 5D. Off-Site: The Site is located within a privately drained system. The nearest surface watercourse, within the private system, on completion of the development is proposed to be a lake adjacent to the south and Ellen's Reen, approximately 100m northwest. Monk's Ditch is located approximately 500m east of the Site, it is a primary inland river of the Usk and Llwyd catchment. Monks Ditch is canalised in a concrete channel and flows south beneath the Queensway, it is proposed that the future surface water network of reens and lakes in Glan Llyn will discharge via a pumping system into Monk's Ditch. The River Usk is located approximately 3.4km to the west and the Severn Estuary is located approximately 5.0km to the south.
Surface Water Abstractions	No active water abstraction records within 500m.
Flood Risk	The Site lies within an area shown as having a Low Flood Risk from Sea according to Natural Wales Flood Risk mapping from Natural Resources Wales.

2.7. Radon

A Radon Risk Address Search was undertaken and issued by the British Geological Survey, dated November 2022 (Report ID: BGS_329111/39194), which stated that the Site does not lie within a radon affected area and 'no radon protective measures are required for the report area'. A radon affected area is defined as: 'where less than 1% of homes are estimated to be at or above the action level'.

As such, the probability of the Site being above the Action Level for radon is 0-1%.

3.0 Ground Investigations and Surveys

3.1. Existing Reports

One phase of ground investigation has been undertaken within the current Site boundary, as summarised in the following table.

Summary of Historical Exploratory Holes within the Site Boundary	
Report	Exploratory Holes
RLL (2021)	35 Trial Pits (U14, U12, T14, S15, S14, R18, R15, R14, Q17, Q14, P16, P15, P14, V21, V20, V19, V18, V17, V16, V14, V13, V12, V11, V10, U19, U16, U15, U11, U10, T18, T15, T13, T12, T10 and S16)

Drawing 18669-RLL-22-XX-DR-O-0327-P02 presented in Appendix A shows the location of the exploratory holes.

3.2. Geological Summary

The Site was found to be underlain by Made Ground overlying superficial deposits, comprising Tidal Flat Deposits and bedrock strata of the Mercia Mudstone Group.

3.3. Made Ground – Reworked Topsoil

Made Ground of reworked topsoil was encountered overlying general Made Ground in three locations (TP-Q14, TP-R15 and TP-U11), from ground level to depths of between 0.10-0.50m, comprising brown to dark brown occasionally loamy CLAY or soft brown sandy gravelly TOPSOIL with rootlets.

3.4. Made Ground – Surfacing

Surfacing of asphalt was encountered in one location (TP-V18) from ground level to 0.20m.

3.5. Made Ground - General

Made Ground was encountered in all 35 exploratory holes from ground level or underlying the surfacing/ reworked topsoil at thicknesses of between 0.50m to 3.10m and was generally described as:

- Reddish brown to brown sandy gravelly CLAY, with occasional cobbles;
- Brown sandy GRAVEL, with occasional cobbles;
- Orangish brown, reddish brown, black to grey, or white (occasionally clayey and sandy) GRAVEL of slag or fused slag;
- Black, grey or white SAND of slag, (occasionally gravelly or cobbly);
- Bluish grey or greyish black FUSED SLAG;

- Brownish green clayey SAND; and
- Black SAND of slag and/ or coal.

Gravel and cobble constituents typically comprised sandstone, mudstone, shale, concrete, brick, and slag, as well as occasional fragments of plastic, timber, iron ore and metal.

Visual and olfactory evidence of contamination are discussed in Section 3.9.

Buried obstructions and services are discussed in Section 3.10.

3.6. Superficial Deposits

Tidal Flat Deposits were encountered beneath the Made Ground in 14 locations (TP-P14, TP-P15, TP-Q14, TP-R18, TP-S14, TP-S15, TP-S16, TP-T13, TP-T14, TP-T15, TP-U11, TP-U12, TP-U16 and TP-V16). The top of the strata was encountered underlying the Made Ground at depths of 1.20 - 2.30m. The base of the formation was not encountered but the strata was recorded to a maximum depth of 2.60m. It generally comprised very soft to firm bluish grey to occasionally grey mottled black occasionally peaty CLAY.

3.7. Bedrock

The Mercia Mudstone Group bedrock was not encountered during the intrusive investigation of Phase 4B & 5D.

3.8. Encountered Groundwater

During the intrusive investigation, perched water was encountered in 24 locations, typically perched within the Made Ground, or towards the base of the Made Ground perched on top of the natural clay. The depth below ground level was recorded from 0.60m to 2.10m.

3.9. Visual and Olfactory Evidence from Previous Ground Investigations

During the intrusive investigation, visual or olfactory evidence of contamination was encountered in nine locations as detailed in the following table.

Visual / Olfactory Evidence of Contamination			
Exploratory Hole	Depth (m)	Strata*	Remarks
TP-T13	0.60-0.70	MG	Sulphur odour
TP-T14	0.20-0.30	MG	Sulphur odour
TP-U12	1.80-2.00	MG	Sulphurous odour and slight hydrocarbon stain
TP-U14	0.75-0.90	MG	Water had sulphurous odour
TP-U16	0.75-0.90	MG	Water had hydrocarbon sheen and odour
	1.20-1.80	MG	Slight hydrocarbon staining

Visual / Olfactory Evidence of Contamination			
Exploratory Hole	Depth (m)	Strata*	Remarks
TP-V10	1.40-1.50	MG	Water has slight biofilm and slight hydrocarbon sheen
TP-V11	0.50-1.90	MG	Sulphurous odour
TP-V12	1.30-1.60	MG	Hydrocarbon odour
TP-V16	1.40-1.50	MG	Water has slight hydrocarbon sheen

Notes: *MG= Made Ground

3.10. Buried Obstructions

Buried obstructions or services were encountered in eleven exploratory locations as detailed in the following table.

Encountered Buried Obstructions			
Borehole	Depth (m)	Strata*	Remarks
TP-R15	1.40-1.50**	MG	Fused slag
TP-R18	0.60-2.50**	MG/TFD	Pile in west of pit
TP-T10	3.00-3.10**	MG	Concrete obstructions
TP-T12	0.50-0.60**	MG	Hard fused slag
TP-U10	1.70-1.90**	MG	Concrete structure and hard fused slag
TP-U15	1.10**	MG	Concrete slab
TP-V13	1.00-1.20**	MG	Rebar, fused slag and potential concrete slab
TP-V14	1.10-1.20**	MG	Fused slag
TP-V17	0.20-0.30	MG	Asphalt
TP-V19	0.30-0.40	MG	Asphalt
TP-V20	0.50-0.60	MG	Asphalt

Notes: *MG= Made Ground, TFD= Tidal Flat Deposits; **base of obstruction not encountered.

3.11. Perched Water

During the intrusive investigation, perched water was encountered in 24 locations, typically within the Made Ground, or towards the base of the Made Ground on top of the natural clay. The depth below ground level was recorded from 0.60m to 2.10m.

3.12. Ground Gas Monitoring

No gas monitoring was undertaken during the RLL 2021 ground investigation. A programme of shallow gas monitoring is recommended following any turnover and earthworks reengineering.

The classification of the Site will depend on the competency of the upper clay of the Tidal Flat Deposits. A site-specific ground gas assessment is recommended following the completion of the earthworks.

3.13. Contamination Summary

During the 2021 RLL ground investigation, 60 samples were tested for heavy metals, polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbons (TPH), gasoline range organics (GROs), BTEX, pH, soil organic matter (SOM), cyanide, phenols, ammoniacal nitrogen and select samples were also tested for asbestos.

The samples collected were conservatively assessed against LQM/ CIEH 2015 S4ULs (Suitable for Use Levels) for a residential end use with plant uptake (1% SOM). A summary of exceedances is presented in the following table, and the chemical analysis results are presented in full in the Desk Study and Phase 2 Report (18669-RLL-22-XX-RP-O-0328-P03).

Summary of Exceedances of S4ULs Residential with Plant Uptake Criteria.				
Contaminant	No. of Exceedances	Location of Exceedances (Depth in m)	Concentration Range (mg/kg)	Screening Value (mg/kg)
Arsenic	1 of 60	P16-1 (0.30)	78.6	37
Lead	2 of 60	V11-1 (0.50), V16-2 (1.80)	400 - 408	200
Mercury	1 of 60	Q14-1	2.13	1.2
Vanadium	8 of 60	P14-2 (1.80), P15-1 (0.30), P15-2 (2.20), P16-1 (0.30), P16-2 (1.30), Q17-1 (0.30), Q17-2 (1.50), V11-1 (0.50)	413 - 680	410
Aromatics > EC12-EC16	1 of 60	T10-3 (2.90)	151	140
Aromatics > EC16-EC21	1 of 60	T10-3 (2.90)	265	260
Naphthalene	2 of 60	Q14-1 (0.50), Q17-1 (0.30)	20.5 – 24.1	15
Benz(a)anthracene	3 of 60	Q14-1 (0.50), Q17-2 (1.50), T10-1 (0.30)	14.9 – 20.3	7.2
Chrysene	1 of 60	Q17-2	16.9	15
Benzo(b)fluoranthene	10 of 60	P15-2 (2.20), Q14-1 (0.50), Q17-2 (1.50), R15-2 (1.20), T10-1 (0.30), T10-2 (1.00), U10-1 (1.00), U16-1 (1.00), U16-2 (2.00), V10-1 (0.30)	2.62 – 20.8	2.6
Benzo(a)pyrene	8 of 60	P15-2 (2.20), Q14-1 (0.50), Q17-1 (0.30), Q17-2 (1.50), R15-2 (1.20), T10-1 (0.30), T10-2 (1.00), V10-1 (0.30)	2.28 - 15.3	2.2
Dibenzo(a,h)anthracene	15 of 60	P15-2 (2.20), Q14-1 (0.50), Q17-1 (0.30), Q17-2 (1.50), R15-2 (1.20), T10-1 (0.30), T10-2 (1.00), U10-1 (1.00), U12-1 (0.60), U16-1 (1.00), U16-2 (2.00), V10-1 (0.30), V10-2 (0.30), V11-1 (0.50), V11-2 (1.60)	0.25 – 2.12	0.24
Benzene	60 of 60	All Samples	<0.18 - <1.80	0.087

60 of 60 samples were shown to exceed the screening criteria for benzene. It should be noted that only one sample (S16-1 0.90m) had a concentration above the limit of detection for benzene. The detection limit for benzene tested listed by the

laboratory was between 0.18mg/kg (53 samples) or 1.8mg/kg (7 samples), these are greater than the screening value of 0.087mg/kg and causes a significant skew in the results. Where samples are reported at the detection limit, for screening purposes, it has been conservatively assumed that the value is 0.18mg/kg or 1.8mg/kg. The true concentration is likely to be significantly lower than this value.

The samples collected were also assessed against the agreed soil re-use values (SRVs) presented Hannah Fraser Consulting Soils Validation Strategy (30937 R2, **Appendix E**). A summary of exceedances is presented in the following table, full screening is presented in **Appendix B**.

Summary of Exceedances of HFC Soil Re-Use Values:				
Contaminant	No. of Exceedances	Location of Exceedances (Depth in m)	Concentration Range (mg/kg)	Screening Value (mg/kg)
Cyanide (total)	7 of 60	P14-2 (1.80), Q14-1 (0.50), Q17-1 (0.30), U16-1 (1.00), V12-2 (1.60), V18-1 (0.50)	2.35 – 20.90	2.02
Manganese	2 of 60	P15-2 (2.20), P16-1 (0.30)	34.40 – 93.90	33.30
Phenanthrene	2 of 60	Q17-2 (1.50), T10-1 (0.30)	44.3 – 60.80	27.00
Fluoranthene	6 of 60	P15-2 (2.20), Q14-1 (0.50), Q17-2 (1.50), R15-2 (1.20), T10-1 (0.30), T10-3 (2.90)	7.75 – 58.30	6.64
Benzo(b)fluoranthene	7 of 60	P15-2 (2.20), Q14-1 (0.50), Q17-2 (1.50), R15-2 (1.20), T10-1 (0.30), T10-2 (1.00), U16-1 (1.00)	3.44 – 208.00	3.42
Benzo(k)fluoranthene	3 of 60	Q14-1 (0.50), Q17-2 (1.50), T10-1 (0.30)	5.66 – 7.62	5.05

More detailed information including the calculated reuse criteria is available in the Hannah Fraser Consulting Soils Validation Strategy (30937 R2, **Appendix E**).

Asbestos was identified in five samples from the 30 analysed; a summary of the asbestos identified is given in the below table.

Summary of Asbestos Identified within the Site		
Location (Depth in m)	Asbestos Type	Quantification (%)
P15-1 (0.30)	Amosite (Brown) Asbestos	<0.001
R14-1 (0.10)	Chrysotile (White) Asbestos	<0.001
S14-1 (0.50)	Chrysotile (White) Asbestos	<0.001
T10-1 (0.30)	Chrysotile (White) Asbestos	<0.001
U15-1 (1.00)	Chrysotile (White) Asbestos	0.0039

Asbestos was identified in five samples of the 30 tested; all positive samples were tested to ascertain the amount of asbestos tested and returned results of <0.001% to 0.0039%. The Institute of Occupational Medicine (IOM) risk assessment report

for the reuse of soils containing asbestos at Llanwern (Ref. 401134-IOM-14-XX-RP-Z-0001) states that a minimum of 0.6m of clean soil (asbestos content <0.001%) will be placed across the Llanwern site. Soil will be screened and, if asbestos contamination is less than 0.02% (200PPM) in the soil, that soil may be used in residential areas.

No groundwater samples have been taken from within the Site, however, samples taken from the wider development as part of previous investigations have identified elevated concentrations of contamination in line with the historical site usage. Elevated concentrations of contamination within on-Site soils also have the potential to leach and migrated into groundwater. A potential risk to Controlled Waters may therefore exist.

4.0 Conceptual Site Model

4.1. Potential Pollutant Linkages

This section provides a qualitative assessment of the risks posed from on-Site contamination sources identified from the information presented in the previous sections. The Conceptual Site Model (CSM) considers the findings of both the ground investigations/ surveys that have been undertaken at the Site and the Site's history. The CSM is based on current conditions at the Site and makes recommendations for likely remediation and mitigation measures that may be required.

The assessment carried out assumes that the Site will operate as a residential development comprising houses with gardens, therefore a 'residential end use with plant uptake' scenario has been used as the most conservative approach. Should the end-use be altered, potential pathways and receptors should be re-assessed.

The CSM below has been developed based on the commonly adopted source-pathway-receptor model as recommended within the Environment Agency's Land Contamination Risk Management (LCRM, updated from CLR11 'Model Procedures for the Management of Land Contamination') guidance.

4.2. Source

The Site makes up part of the former Llanwern Steelworks; the Site historically comprised a conveyor network with associated travelling boom and hoppers and a bag filter plant.

60 soil samples were collected during the RLL 2021 ground investigation for contamination testing, all of which were taken from the Made Ground.

Chemical analysis of soil samples has identified concentrations higher than Residential with Plant Uptake S4ULs for arsenic, lead, vanadium, mercury, aromatics >EC12-EC16, aromatics >EC16-EC21, benzene and a number of PAHs.

Chemical analysis of soil samples has identified concentrations higher than the agreed soil re-use values (SRVs) for cyanide, manganese, phenanthrene, fluoranthene, benzo(b)fluoranthene, and benzo(k)fluoranthene.

Asbestos was identified within five of the 30 soil samples tested in the form of debris to loose fibres at concentrations of <0.001% to 0.0039%.

Potential contaminant sources are summarised in the following table.

Summary of Identified On Site Sources of Contamination		
Source	Site Area	Key Contaminants
Deep Made Ground, including slag material	Whole Site	Heavy metals, PAHs, cyanide
Historical Steelworks infrastructure	Whole Site	Heavy metals, PAHs, cyanide
Made Ground	Isolated locations across the Site	Low concentrations of asbestos.
Natural Strata	Whole Site	Potential for ground gas from organic materials in the Tidal Flat Deposits

4.3. Potential Pathways

Human Health

There is potential for exposure of Site users (future and proposed) to contaminants in soils via the following pathways, assuming a residential end use (based on the Environment Agency's *Updated Technical Background to the CLEA Model - SR3*):

- Direct soil and dust ingestion;
- Dermal contact with soil directly and indoor dust;
- Plant uptake followed by consumption of homegrown produce;
- Inhalation of vapours;
- Inhalation of dust; and
- Inhalation of gases.

The presence of contamination within the Site presents a potential risk to construction workers within the Site boundary, as such appropriate risk assessments and safety measures (use of PPE/ hygiene rules) will need to be enforced in order to provide adequate protection.

Controlled Waters

Currently Monk's Ditch crosses the wider development within a concrete channel and no connection with the private drainage system presently exists. It is proposed that the future surface water network of reens and lakes will discharge via a pumping system into Monk's Ditch. This on-site surface water system will discharge, via a permit, into Monk's Ditch once the specified quality criteria are met and the application to connect the system is approved.

As such, Monk's Ditch currently isn't a Receptor (it is understood to be hydraulically isolated as it flows between the Glan Llyn development and commercial land to the east within a concrete channel) although it could potentially be a future Receptor when the surface water discharge permit into the Monks Ditch is approved and then enacted.

Site monitoring of areas of site where earthworks have been undertaken show that the re-engineered Made Ground will be unlikely to enable a continuous groundwater

horizon to exist. It is therefore considered unlikely that any significant groundwater flow will develop within the Made Ground.

With regard to controlled waters, the following pathways are considered applicable to the Site, following completion of the development and once relevant approvals have been granted to allow discharge into Monks Ditch:

- Leaching of soil-borne contamination in Made Ground and subsequent lateral migration through permeable pathways in Made Ground to Monks' Ditch via onsite reens.

No effective pathway was identified between the shallow perched water in the Made Ground and the deep groundwater within the Mercia Mudstone Secondary B Aquifer due to the low permeability of the clay-rich Tidal Flat Deposits.

Details relating to the Controlled Waters Risk Assessment are summarised in Section 5.0.

Structures

Concrete classification testing has not been undertaken. A Design Sulphate (DS) class and Aggressive Chemical Environment for Concrete (ACEC) class should be derived for the Site in accordance with the recommendations given within BRE SD1 and based on pH and sulphate testing.

Dependent on finished levels, it is considered likely that chemical resistant barrier pipes will be required.

A site-specific ground gas assessment is recommended following the earthworks. The classification of the Site will depend on the competency of the upper clay of the Tidal Flat Deposits.

4.4. Potential Receptors

The following receptors (current and proposed) have been identified at the Site. Given the absence of significant ecological designations in the vicinity of the Site, ecological receptors are not considered below.

Humans:

- Construction workers and maintenance workers; and
- Residents on and off-site (current and future).

Controlled Waters:

- Mercia Mudstone Group (Secondary B Aquifer) and Tidal Flat Deposits (Secondary [Undifferentiated] Aquifer); and

- Monk's Ditch (once relevant approvals have been granted to allow discharge into Monk's Ditch).

Private Drainage System:

- The nearest proposed water feature comprises the private drainage reens located 50m to the northwest (Ellens Reen) and lake adjacent to the south of the Site.

Property:

- Existing and proposed buildings and services on and immediately surrounding the Site; and
- Proposed infrastructure on the Site.

4.5. Conceptual Site Model and Risk Assessment

Based on the information currently available, plausible pollutant linkages have been identified and a risk assessment has been undertaken for the Site. The estimation of the potential significance of each linkage is based on the proposed Site redevelopment, the mobility and the predicted magnitude of potential contaminants, and the nature of the identified migration/exposure pathways.

4.6. Summary of Conceptual Site Model

The following table presents what are considered to be potential receptors for contamination both pre- and post- remediation. Should the end-use be altered, potential pathways and receptors should be re-assessed.

Summary of Pre-Remediation and Post Remediation Conceptual Site Model (CSM) for Phase 4B & 5D										
Sources	Key Contaminants	Receptor	Pathway	Pre-Remediation			Post-Remediation			
				Probability	Consequence	Risk Level	Mitigation	Probability	Consequence	Risk Level
Made Ground Contaminants within soil and generation of gases.	Inorganic substances (heavy metals/ asbestos)	Human Health:	Direct Contact – dermal contact, absorption through skin, ingestion. Inhalation of vapours (VOCs) from soil derived gas via Made Ground.				During construction, appropriate PPE should be worn when coming into contact with arisings.			
		Construction Workers End Users (on and off site)	Potential migration and build-up of carbon dioxide from soils derived gas via Made Ground (risk of asphyxiation). Inhalation of contaminants in soils/dust/fibres.	Moderate	Medium	Moderate	With the installation of a clean cover system the pathway of contaminants within the underlying soil to reach human health receptors is essentially severed. Additional post-remedial ground gas/ vapour assessment is required.	Low	Medium	Low
	Organic substances (ammoniacal nitrogen, petroleum hydrocarbons, PAHs, VOCs, SVOCs)	Property: Future on Site Buildings Future on Site Infrastructure	Direct contact – contaminants in soils, soil derived dust, perched water and groundwater.	Moderate	Medium	Moderate	Additional post-remedial ground gas/ vapour assessment is required. Design of concrete in accordance with BRE Special Digest 1.	Low	Medium	Low
			Concrete in contact with aggressive ground.				Dependent on finished levels, it is likely that chemical resistant barrier pipes will be required.			
			Potential migration and build-up of methane from soil derived gas via Made Ground (risk of explosion).	Moderate	Medium	Moderate	Additional post-remedial ground gas/ vapour assessment is required to further assess the Site.	Low	Medium	Moderate
		Controlled Waters:	Potential migration of leachable contaminants	Moderate	Medium	Moderate	Analysis of the groundwater data to validate the conclusions of the Controlled Waters	Low	Medium	Low to Moderate

Summary of Pre-Remediation and Post Remediation Conceptual Site Model (CSM) for Phase 4B & 5D										
Sources	Key Contaminants	Receptor	Pathway	Pre-Remediation			Post-Remediation			
				Probability	Consequence	Risk Level	Mitigation	Probability	Consequence	Risk Level
		Secondary B Aquifer Private Drainage System: Ellen Reen	through shallow groundwater.				Risk Assessment which has shown the leachable effect of the Made Ground on the controlled waters receptors is acceptable. The proposed remediation and onward redevelopment will reduce infiltration in an overall betterment of the Site.			
		Flora and Fauna	Uptake through roots of contaminants in soils.	Low	Medium	Low	Importation of suitable topsoil material for use within garden areas and landscaped areas.	Unlikely	Medium	Low
Residual contaminants in groundwater	Inorganic substances (heavy metals) Organic substances (ammoniacal nitrogen, petroleum hydrocarbons, PAHs, VOCs, SVOCs)	Human health: Construction Workers End Users	Direct contact – dermal contact, absorption through skin, ingestion. Inhalation of vapours (VOCs) from soil derived gas via Made Ground.	Moderate	Medium	Moderate	Appropriate PPE should be worn when coming into contact with perched water. Should potentially contaminated perched water be encountered during site works, it should be contained and disposed of off-site at a suitably permitted facility. Due to the depth of the groundwater and with the installation of clean cover, it is unlikely that residential end users will come into contact with it, therefore no viable pathway is present. Vapour resistant membranes may be required following a	Low	Medium	Low to Moderate

Summary of Pre-Remediation and Post Remediation Conceptual Site Model (CSM) for Phase 4B & 5D										
Sources	Key Contaminants	Receptor	Pathway	Pre-Remediation			Post-Remediation			
				Probability	Consequence	Risk Level	Mitigation	Probability	Consequence	Risk Level
							detailed site investigation and risk assessment.			
		Property: Future on Site Buildings Future on Site Infrastructure	Potential migration and build-up of soil/ water-derived vapours via Made Ground.	Low	Medium	Moderate	Additional post-remedial ground gas/ vapour assessment is required to further assess and zone the Site.	Unlikely	Medium	Low
		Controlled Waters: Secondary B Aquifer Private Drainage System: Ellen Reen	Potential migration of contaminants through shallow groundwater.	Moderate	High	Moderate	Remedial works to remove free product/ grossly contaminated soils and treatment of soils/ dissolved phase will significantly reduce the sources onsite reducing the risk to receptors. Low permeability of Tidal Flat Deposits means a viable pathway for downward migration is unlikely.	Low	Medium	Low to Moderate

5.0 Controlled Waters Detailed Quantitative Risk Assessment

5.1. RLL CWDQRA Summary

In 2019, RLL prepared a Controlled Waters Detailed Quantitative Risk Assessment (CWDQRA) for the wider Glan Llyn development site (**Appendix C**). This assessment incorporated a comprehensive dataset of concentrations of contamination recorded in soils across the development, and included data taken from the 2018 investigations within the Site. Screening analysis of soil, soil leachate, groundwater and surface water data revealed potential moderate to low levels of inorganic and organic contamination present onsite in line with contaminants associated with former steelworks sites. Made Ground comprising clayey sandy gravels with local slag, burnt shale, tarmac, concrete, brick and mudstone was found to be a potential source of contamination. Calculation of representative re-use criteria for a commercial end use was undertaken using a dilution assessment methodology based on the site-wide water balance, incorporating site specific permeability and infiltration parameters. No allowance was made for dilution of discharged waters within Monks' Ditch itself as part of this calculation as, this being the receptor, it is proposed that the water quality in this Controlled Water be maintained (as far as possible) at EQS values.

Comparison of re-use criteria against available soil chemical testing established that the much of the Made Ground was likely to be suitable for re-use onsite, however, localised source materials existed containing higher concentrations of contamination (particularly elevated concentrations of iron, manganese and vanadium), and ammoniacal and cyanide components, may require remediation, or offsite disposal.

Further modelling of these contaminants was undertaken using Remedial Target Methodology (RTM) to assess the potential extent of attenuation of these specific determinands within the ground where these soils may be placed, with the receiving surface waters being assumed to be existing blueways (reens), which were considered as the Compliance Points. The compliance point for the Business Park is at the pumping station and will require an enacted permit for discharge to occur.

Initial modelling was carried out by Atkins (Glan Llyn, Llanwern Controlled Waters Detailed Quantitative Risk Assessment dated February 2017), with this approach being adopted within later revisions of this Report in the Rodgers Leask, Controlled Waters Detailed Quantitative Risk Assessment, Glan Llyn (sitewide) Update (2019), using the Equation presented in the EA Table 5.2 – soil-water partitioning of the EA Remedial Targets Methodology Guidance (2006) where a pore-water concentration (C_p) was determined from soil concentration analyses to derive soil reuse criteria at the site as a whole. Subsequently, and purely to gauge the potential distance that re-engineered Made Ground could be placed from the respective Compliance

Point(s), further modelling was carried out for specific determinands using the EA RT Excel Worksheets, based on maximum and average soils concentrations determined within samples of re-engineered Made Ground and available site derived data.

Further modelling was carried out for specific determinands (including specific PAHs) using the EA Remedial Target Excel Worksheets, based on maximum and average soils concentrations did indicate that there was little attenuation of the initial porewater PAH concentrations on migration within the re-engineered Made Ground toward the nearest re-en Receptors. However, the presence of elevated porewater PAH concentrations were only theoretical and based on calculated values derived using the Equation presented in the EA Table 5.2 – soil-water partitioning of the EA Remedial Targets Methodology Guidance (2006). Actual PAH concentrations determined more recently in groundwater samples recovered (where sufficient groundwater was available for sampling purposes), were generally lower, and potentially significantly lower, than the calculated values which were derived using soils analyses data. Additionally, as previously mentioned, there was little evidence obtained of hydraulically continuous groundwater horizon(s) within the re-engineered Made Ground beneath areas proposed for residential and commercial development. Therefore, there have been no proven PAH (or other contaminant) migration pathways towards the reens.

As the data used within the CWDQRA has utilised ground investigation data taken from within the Site, it is therefore considered that the findings of this assessment are representative of the Site and therefore adoption of the calculated re-use criteria and recommendations presented within the CWQRA are appropriate. To confirm this RLL have prepared an addendum CWDQRA for Phase 4B & 5D, this is presented within **Appendix D**.

5.2. HFCL Glan Llyn: Soils Validation Strategy for Protection of Controlled Waters

Following queries from Natural Resources Wales (NRW), H F Consulting Limited (HFCL) were commissioned by RLL to assist with NRW liaison and reporting pursuant to the discharge of PC28. Following discussion with NRW, RLL and the developer, HFCL prepared a revised methodology for the validation of soils in relation to the protection of controlled waters.

The assessment included distance specific remedial targets that model the attenuation of contaminants in the saturated zone allowing for advection, dispersion, retardation and decay during transport. In addition to the inclusion of distance specific remedial targets, further statistical and spatial analysis was carried out on contaminants of concern.

More detail is provided in the HFCL Glan Llyn: Soils Validation Strategy for the Protection of Controlled Waters (30937 R2) (**Appendix E**).

6.0 Remediation Strategy

6.1. Remediation Approach

Based on the results of the previous ground investigations and CWDQRA, the key driver for the remediation of the Site is considered to be the removal of significant sources of contamination, below ground obstructions and re-engineering of near-surface Made Ground to reduce infiltration for the protection of surface waters and installation of a clean cover system for the protection of human health.

Encountered chemical exceedances of S4ULs Residential with Plant Uptake Criteria are shown on RLL Drawing 18669-RLL-25-XX-DR-O-0754-P01, exceedances of relevant SRVs are shown on RLL Drawing 18669-RLL-25-XX-DR-O-0751-P01, both in **Appendix A**.

The potential risks to controlled waters when a future connection exists have been assessed in an CWDQRA report included as **Appendix F** (18669-RLE-19-XX-RP-O-0006, dated August 2019), the methodology for assessing these risks has been presented in the Hannah Fraser Soils Validation Strategy for Protection of Controlled Waters (**Appendix E**).

Protection of human health will be achieved by breaking the potential pathway with the provision of suitable clean cover or construction of hardstanding. Gas protection may be required.

6.2. Remediation Specification

6.3. Proposed Sequence of Deliverables

The sequence of deliverables listed below is proposed:

- Materials Management Plan to enable the movement and re-use of excavated and stockpiled materials in accordance with the limitations set out in this document.
- Removal of vegetation.
- Excavation and turnover of Made Ground to natural clay and removal of unsuitable material and buried obstructions.
- Treatment or offsite disposal of impacted soils (where required).
- Chemical and geotechnical validation of the placement of material following turnover.
- Post remediation ground gas and vapour assessment.
- Preparation of a Remediation Validation Report.
- Regulator liaison and submission pursuant to the discharge of relevant planning conditions; and
- Onward housebuilder obligations to include.
 - a. Placement and validation of a clean cover system (where required).

- b. Provision and validation of appropriate gas / vapour membranes in buildings (where required).
- c. Designing of appropriate concrete for aggressive ground.
- d. Installation of appropriate chemical resistant water pipes.

6.4. Removal of Obstructions

A Materials Management Plan (MMP) will be prepared to allow the on-site reuse of materials in accordance with the CL:AIRE Definition of Waste, Development Industry Code of Practice.

The recommended approach involves excavation of Made Ground to a depth where the natural underlying Tidal Flat Deposits are exposed. Obstructions, where they are unsuitable for retention, shall be removed leaving only the supporting piles. Supporting piles shall be cropped at the level of the underlying natural geology.

The recyclable materials generated (i.e. concrete removed from floor slabs, foundations and buried structures) are to be moved to a material processing area where they will be screened, crushed and validated for re-use within the onward development, in accordance with the MMP. Appropriate revisions will be made to the approved MMP as required.

Asbestos has previously been encountered as free fibres in the Made Ground. Concrete shall therefore be assessed prior to crushing in order to limit the risk of asbestos contamination of crushed concrete stockpiles and care shall be taken to ensure it is not cross contaminated with Made Ground.

Drawing 18669-RLL-25-XX-DR-O-0752-P01 presented in **Appendix A** shows the location of buried obstruction encountered during the Phase 4B & 5D ground investigations. However, other unencountered buried obstructions may be present across the Site.

6.5. Visual Evidence of Contamination

As part of previous investigations, some visual and olfactory evidence of contamination has been identified (see Section 3.9) within the Site. Additional caution and supervision should be taken when undertaking turnover within these areas. Any gross contamination of soils or groundwater encountered in these areas should either be treated or removed from Site in accordance with procedures outlined in Section 7.0.

Where visual or olfactory evidence of contamination is encountered during the turnover works it will be excavated with a watching brief to chase out and stockpiled separately. Subsequent suitability testing and assessment will be undertaken to determine if the material can be reused.

During remediation, if any material exhibits previously unencountered significant evidence of contamination (i.e. free product or grossly impacted soils) the contractor should inform the Client's Engineer on and propose a method for its treatment that will allow re-use (at the supervising engineers discretion) or, options for off-site disposal.

6.6. Protection of Human Health

The remedial criteria adopted for the clean cover system at the Site are based on S4ULs (suitable for use levels) and C4SLs (category 4 screening levels) for a residential end use with plant uptake.

It is likely that human exposure to contaminants during the operational phase of the development will be restricted to inhalation of dust and dermal contact/ ingestion of contaminants within gardens, public open spaces and soil adhering to home grown produce. Risks to human health may be mitigated through either excavation of the contaminants, provision of clean cover, or construction of hardstanding (or a combination of these); this is intended to prevent exposure to these contaminants and thus break the pollutant linkages.

The overall philosophy for remediation of the Site with regards to protection of human health is therefore severance of linkage pathways, by means of the removal of significant sources of contamination from the sub-surface and installation of a clean cover system or hardstanding in order to provide a safe development platform. This includes a turnover strategy as part of the earthworks. Additional measures, such as the provision of clean cover, soil-gas protection, water pipe protection etc, are then to be provided by the future housebuilder.

6.7. Protection of Controlled Waters

The CWDQRA has assessed that once remediation has been undertaken and the removal of any free product and highly contaminated soils has been completed in accordance with the remedial targets set out in the Hannah Fraser Soils Validation Strategy (**Appendix E**) the Site is unlikely to pose a risk to controlled waters.

RLL Drawing 18669-RLL-25-XX-DR-O-0751-P01 (**Appendix A**) shows the locations where exceedances of the HFC reuse screening criteria were recorded during the 2018 trial pitting, the re-use of materials exceeding the specified criteria should be done so in accordance with the Hannah Fraser Soils Validation Strategy (**Appendix E**)

Grids that are lacking trial pitting data were not investigated due to the presence of onsite obstructions, specifically stockpiles. These locations will be subject to further investigation and the findings will be documented in a separate validation report.

In accordance with the Hannah Fraser Soils Validation Strategy a controlled waters validation report shall be prepared on completion of the earthworks to present the

verification information relating to the remediation works undertaken on the Site relating to controlled waters.

6.8. Re-Use of Arisings

Trial pitting has been undertaken across the Site to assess and characterise the Made Ground for suitability for reuse as detailed in Section 3. The results were compared to S4ULs (suitable for use levels) and C4SLs (category 4 screening levels) for a residential end use with plant uptake presented in **Table 1** and **Table 2** included to the rear of this report.

Material present within the Site shall be reused where suitable, in accordance with an approved Materials Management Plan prepared in accordance with the CL:AIRE Definition of Waste, Development Industry Code of Practice.

Where material present within the Site is not considered suitable for retention, it shall be transferred and re-used in the commercial phase of the development, in accordance with an approved Materials Management Plan prepared in accordance with the CL:AIRE Definition of Waste, Development Industry Code of Practice.

Where material is not suitable for either a residential or commercial end use, or during remediation, if any material exhibits previously unencountered significant evidence of contamination (i.e. free product or grossly impacted soils) the contractor should inform the Client's Engineer on and propose a method for its treatment that will allow re-use (at the supervising engineers discretion) or, options for off-site disposal.

The re-use of treated materials will be subject to regulatory approval and an approved Materials Management Plan prepared in accordance with the CL:AIRE Definition of Waste, Development Industry Code of Practice. On-site treatment and processing will be undertaken where possible to reduce contaminant concentrations so the arisings will be either:

- Suitable for shallow residential garden use (part of the clean cover layer);
- Suitable for re-use at depth (e.g. below the clean cover or within POS landscaped areas).

If treatment is required, then testing shall be undertaken at a frequency of 1 sample per 100m³ and compared against the re-use screening criteria for the various potential end-uses detailed in **Table 1** and **Table 2** included to the rear of this report.

6.9. Materials Management Plan

In the interest of sustainability and in order to avoid the unnecessary transport of material from the Site to landfill, it is proposed to re-use the Made Ground and any recycled aggregates generated as part of the works. Re-use of material will be in accordance with the CL:AIRE's Definition of Waste, Development Industry Code of

Practice (DoW:CoP). A compliant Materials Management Plan (MMP) will be prepared, or an existing one updated to include the requirements of this strategy.

Material movements shall be tracked by the Contractor on daily or weekly material tracking sheets, to include:

- Survey plans of material sources and destinations.
- Summaries of volumes and composition of materials moved.
- Associated chemical testing to demonstrate suitability.
- Locations and ongoing volumes of temporary stockpiles.

Material movement records shall be maintained by the Contractor on-Site for inclusion in the Validation Report.

6.10. Clean Cover System

To reasonably prevent contact between Site end users and contaminants within the Made Ground, a clean cover system shall be placed in gardens and areas of public open space. Following completion of the remediation works, the Site shall be left 750mm below from Finished Floor Levels (FFL). This is to incorporate drainage arisings (150mm) and facilitate the installation of the clean cover system for residential gardens, which will comprise a minimum of 600mm of suitable material (or 300mm in areas of public open space). Material is considered suitable after being assessed against the criteria detailed in **Table 1** and **Table 2** at the rear of this document. Material proposed for reuse within residential gardens is to be assessed in accordance with **Table 1**. Material to be reused within public open space near residential areas (i.e. landscaping for an apartment block) is to be assessed in accordance with **Table 2**.

The cover system will comprise suitable subsoil and topsoil and is to be placed by the onward developer. A Validation Report is required for the cover system and this shall be submitted to the regulators to satisfy planning conditions. It is advised that the onward developer also share details of the clean cover system with their chosen housing insurer (NHBC, LABC or equivalent) for approval in accordance with their guidance. The clean cover requirements for areas of public open space are anticipated to be 300mm of suitable material in accordance with **Table 2**.

6.11. Ground Gas Protection Measures

The assessment of ground gas protection measures is to be updated following the remedial works. The classification of the Site will depend on the competency of the upper clay of the Tidal Flat Deposits. A site-specific ground gas assessment is recommended following the earthworks. In accordance with BS8485:2015+A1:2019.

Risks from vapours has not been assessed as part of the 2021 ground investigation and will be assessed as part of the post remediation ground gas and vapour assessment detailed within this Remediation Strategy.

6.12. Risks to Construction Workers

Site workers are advised to follow normal health and safety procedures, including the use of suitable PPE (e.g. gloves and overalls) and following hygiene rules, particularly when handling the Made Ground. Contamination is present within the Made Ground (including asbestos), therefore specific contractor RAMS (with reference to guidelines presented in Control of Asbestos Regulations 2012) may need to be produced to mitigate the risks.

A watching brief should be maintained during excavation works as part of the development to check for the presence of previously unexpected contamination.

6.13. Onward Developer Actions

The following actions are deferred to the onward developer:

- Placement of a clean cover system (600mm), construction materials (including piling mat), soils in residential gardens and areas of public open space as part of the overall development;
- Validation of the thickness and chemical composition of soils placed in gardens (as part of the clean cover system) in accordance with NHBC (or equivalent housing insurer) recommendations;
- Provision of appropriate gas/ vapour membranes in buildings and validation in accordance with BS: 8485:2015+A1:2019 and CIRIA C735, if necessary;
- Designing concrete in accordance with BRE Special Digest 1 will prevent significant risks from concrete degrading if in contact with aggressive ground; and
- Installation of appropriate chemical resistant water pipes (if required).

6.14. Environmental Monitoring

The Construction Environmental Management Plan (Atkins, April 2014) should be read in conjunction with this section for the environmental monitoring requirements.

6.15. Surface Water Monitoring

Phase 4B & 5D is 50m south of Ellen's Reen and bound to the south by Central Lake of the site drainage system, however, no connection between the site private drainage system and Monks Ditch currently exists. Surface water monitoring shall be undertaken from the wider private drainage system and from Monks Ditch at numerous appropriate locations across the site, shown on Drawing 18669-RLL-24-XX-DR-O-0544-P04 (**Appendix A**). Visual monitoring of the surface waters will be undertaken on a daily basis and chemical samples will be taken on a fortnightly basis.

The results of chemical analysis shall be compared against the EQS determinands detailed in **Table 4** at the end of this document.

6.16. Dust and Air Quality

Dust monitoring is required throughout the works as residential and commercial receptors are located near to the Site boundary on all sides. Monitoring locations are detailed in the Construction Environmental Management Plan (CEMP); however the locations shall be reviewed and adapted based on working areas and actual conditions encountered on Site.

6.17. Noise and Vibration

The Contractor will ensure that operations are undertaken in a manner considerate to sensitive receptors, including adjacent residential properties. This includes limiting noise and vibration as far as is reasonably practicable. Details of required monitoring are included in the CEMP.

7.0 Contingency for Unexpected Contaminated Soil

Should the Contractor or Employer's Environmental Engineer identify suspected areas of gross contamination, the suspected contaminated soils shall be excavated and stockpiled separately on polythene sheeting with appropriate bunding and suitably identified.

Contaminated soils shall be defined as soils exhibiting visual evidence of contamination (e.g. soils with hydrocarbon content above the saturation limit) or olfactory indications of contamination (e.g. organic odour indicative of hydrocarbons). Initial vapour screening of the impacted Made Ground/ natural deposits may be undertaken using a photoionization detector (PID), where visual or olfactory evidence of organic contamination is recorded.

Representative samples of affected soils shall be tested for the suspected contaminants of concern. The minimum number of samples will be five i.e. one from each side and one from the base. As a minimum and dependent on contamination type, one sample shall be taken for every 10m along the side per contaminated horizon and one sample per 100m² base area. If the thickness of the contaminated zone is greater than 1.0m, one sample shall be taken per 1.5m of vertical face. Results shall be compared against the criteria detailed in the tables at the rear of this document, which will determine a suitable end-use and the material will be re-used accordingly (in accordance with the MMP). Should samples exceed the criteria, soils will be deemed unsuitable for re-use without liaison with the regulator and further risk assessment and/or treatment. Any material deemed unsuitable following further risk assessment shall require treatment or disposal from the Site.

Should soils require disposal from the Site, the soil's chemical results shall be used to begin the assessment of the material as non-hazardous or hazardous waste. Waste Acceptance Criteria (WAC) testing may be required prior to off-site disposal. Material sent to landfill must be hauled by a registered waste carrier in accordance with the Waste Duty of Care: Code of Practice. The Contractor shall be responsible for keeping all records including waste transfer notes.

Validation testing of the sides and base of the resultant excavation shall be carried out by the appropriate monitoring Engineer, in accordance with Section 9 of this document. The contaminated soils will be deemed to have been successfully removed once the validation samples of the sides and base meet the respective criteria for re-use.

The extent and location of contaminated soils removed shall be surveyed and recorded by the Contractor.

8.0 Re-use of Site Won Material

8.1. Re-use of Site Generated Materials

In the interest of sustainability and in order to avoid the unnecessary transport of material from the Site to landfill, it is proposed to re-use the Made Ground and any recycled aggregates generated as part of the works. Re-use of material will be in accordance with the CL:AIRE Definition of Waste, Development Industry Code of Practice. A compliant Materials Management Plan has previously been prepared for the wider site.

Material movements shall be tracked by the Contractor on daily or weekly material tracking sheets, to include:

- Survey plans of material sources and destinations.
- Summaries of volumes and composition of materials moved.
- Associated chemical testing to demonstrate suitability.
- Locations and ongoing volumes of temporary stockpiles.

Material movement records shall be maintained by the Contractor on Site for inclusion in the Validation Report.

8.2. Soil for Formation of Clean Cover

The placement of clean cover will be the responsibility of the onward developer.

Subsoil and topsoil proposed for formation of capping layers shall be tested prior to import and/ or placement and compared to screening criteria in **Tables 1 and 2** included at the rear of this document. Soils shall be tested at a frequency of one sample per 250m³ and a minimum of three samples per source.

8.3. General Site Fill Beneath Clean Cover

Suitable site won materials and existing validated stockpiled material may be used as general fill below formation level (i.e. below the clean cover), providing they are chemically suitable when compared with the criteria in **Table 3**. Soils that are impacted with free product or grossly contaminated will not be acceptable for re-use without further treatment/ assessment. Screened materials will be tested at a frequency of 1 sample per 500m³ and compared against the screening criteria detailed at the rear of this document.

If asbestos is identified, dependent upon the concentration, it shall be re-used in accordance with the depths detailed in the Institute of Occupational Medicine: Llanwern, Assessment of Asbestos Contamination at Former Llanwern Steelworks Site. The report concludes that a minimum of 600mm of clean soil (the clean cover system) will be placed across the Site. Beneath the clean soils, Made Ground may

be used in residential areas if asbestos contamination is less than 0.02% (200ppm) and used in commercial areas if asbestos contamination is less than 0.03% (300ppm).

Should material be found to contain contaminants above the re-use criteria, then the upper 95th percentile value (US⁹⁵) and upper confidence limit of the mean value may be used to assess the material for suitability for re-use subject to agreement with the Local Authority.

8.4. Offsite Disposal

Material sent to landfill must be hauled by a registered waster carrier in accordance with the Waste Duty of Care: Code of Practice. The Contractor shall be responsible for surveying the source areas of all off site material, recording volumes, relevant compliance and classification testing results and the keeping of records including waste transfer notes, consignment notes and material tracking sheets for inclusion in the Validation Report.

9.0 Validation

9.1. General

The remediation and/ or earthworks activities described in this strategy will be supervised full-time by the suitably qualified Monitoring Engineer. As an addendum to the sitewide remediation strategy, following consultation with Newport City Council and Natural Resources Wales, technical notes have been prepared to capture additional relevant phase specific information as part of the validation exercise. The technical notes prepared as an addendum to the remediation strategy are presented in **Appendix F**. Technical Note 0192, ref. 18669-RLL-22-XX-RP-O-0192 (**Appendix F**) presents additional information relating to the remediation strategy and the setting out the process to collect additional validation information to assess the contamination status of the formation surface. Technical Note 260, ref. 18669-RLL-22-XX-RP-O-0260 (**Appendix F**) presents a validation plan to assess the hydraulic conductivity of the reengineered Made Ground and to assess the sampled perched water samples against the pore water concentrations assumed within the CWDQRA.

Remediation shall be confirmed using the methodology presented in the Validation of Remediation of Land Contamination - Science Report SC030114/R1 (Environment Agency, 2010).

A Validation Report shall be prepared on completion of the works. The Validation Report will be submitted to the Local Planning Authority pursuant to the discharge of relevant planning conditions.

Post-remediation ground gas/ vapour monitoring will be required to further zone the Site with regard to the required gas/ vapour protection measures.

9.2. Validation of Turnover

Turnover works will be undertaken under a full-time watching brief by the Monitoring Engineer. Material exhibiting visual or olfactory evidence of contamination will be segregated and further assessed. Records of wider material movements will also be kept and detailed within the MMP.

Non-targeted grid validation sampling shall be undertaken at a frequency of 1 sample per 500m³ of placed material. Formation level is to be left up to 600mm below final floor level (FFL) to account for the placement of clean cover (300mm in areas of POS). Soil samples shall be compared to the following criteria.

- Made Ground used within residential gardens as part of the clean cover system (i.e. above formation level) shall be compared with the criteria detailed in **Table 1**;

- Made Ground used within public open space as part of the clean cover system (i.e. above formation level) within or near a residential area shall be compared with the criteria detailed in **Table 2**;
- Made Ground used underlying residential areas at depth (i.e. below formation level) shall be compared with the criteria detailed in **Table 3**; and
- A 600mm clean cover system will be placed across the Site. Beneath the clean soils, Made Ground may be used in residential areas if asbestos contamination is less than 0.02% (200ppm).

Validation will generally comprise the following procedure:

I. Delineation of Unexpected Contamination (if encountered)

Material exhibiting evidence of visual or olfactory gross contamination will be removed. A photo ionization detector (PID) should be used on-site to determine the extent of the contamination. Soil sampling and testing shall be undertaken until the results meet the respective re-use criteria detailed in **Table 1** and **Table 2** and the material is not grossly impacted, at which point the extent of the potential hot spot will be regarded as having been delineated.

II. Excavation of Contaminated Material

Material which does not meet the re-use criteria detailed in the tables at the rear of this document or is visually impacted with free product/ grossly impacted will be removed by the Contractor and stockpiled on-site for further assessment/treatment; if necessary the material will be removed from Site. The extent of the excavation may be increased should it be deemed necessary, for example, if further visual or olfactory evidence of significant contamination is present.

III. Hot-Spot Validation Sampling (if required)

Soil samples will be obtained for validation testing on the sides and base of the hot-spot excavation following soil removal. Samples will be tested for the contaminants that did not meet the respective criteria at that particular hot-spot location.

The minimum number of samples will be five i.e. one from each side and one from the base. As a minimum, and dependent on contamination type, one sample shall be taken for every 10m along the side per contaminated horizon and one sample per 100m² base area. If the thickness of the contaminated zone is greater than 1m, one sample shall be taken per 1.5m of vertical face.

If validation samples do not meet the criteria, further soil will be excavated horizontally and vertically and additional validation samples taken. The procedure will be repeated until samples meet the remedial targets. Any deviation from the above methods will require liaison and approval from the regulator.

IV. Survey

The extent of the excavation will be surveyed to Ordnance Datum (coordinates and levels) and a plan produced showing the location of relevant samples taken. Obstructions left in-situ will also be recorded on the survey.

An as dug survey will also be completed for the whole area of the earthworks across the Site showing depth of excavation / turnover per 5m grid and increased survey points array for any deeper excavations.

V. Sampling, Sample Transfer and Analytical Laboratories

Soils for chemical testing shall be sampled in accordance with the following British and Eurocode Standards, BS 10175:2011+A2 2017 – ‘Investigation of potentially contaminated Sites – Code of practice’, Eurocode 7, and the BS 5930:2015 – ‘Code of Practice for Site investigations – Incorporating Amendment No.2’ for contamination testing and for geotechnical testing.

Sample containers required for soils shall include vials for volatile organic compound (VOC) testing, amber jars for hydrocarbon testing and a 1kg sized plastic containers for testing of metals and asbestos screening.

Soil, groundwater and surface water samples are to be stored in a cool box, maintained at a temperature between 2°C and 4°C in darkness and shall be transported under these conditions to the accredited laboratory.

Internal and external laboratories shall be UKAS/MCERTS (or equivalent) accredited or it shall be demonstrated that appropriate quality systems have been implemented in lieu of accreditation for non-accredited tests.

9.3. Validation of Clean Cover

It is proposed that clean cover in residential areas shall be placed as part of the construction of each plot. The clean cover shall be 600mm thick and comprise suitable construction materials, subsoil and topsoil. Clean cover will also be required in areas of public open space within the residential and commercial development of 600mm thickness.

Placement and validation of the clean cover layer, either construction materials or soils in residential gardens, shall be undertaken by the housebuilder in accordance with requirements of the regulators and NHBC.

9.4. Geotechnical Validation

Excavated material will be placed, compacted and tested for compliance with a phase specific Earthworks Specifications. Areas of deeper Made Ground, fill and remnant structures will be surveyed and recorded on a drawing.

10.0 Supervision and Reporting

The post-demolition and remediation works described in this report shall be supervised by the suitably qualified Monitoring Engineer.

Survey plans and test results shall be presented within the Validation Report.

The Contractor shall be responsible for obtaining the necessary licences, permits and consents for the works (correspondence shall be forwarded to the Employer's Environmental Engineer) with the exception of the Materials Management Plan and associated Declaration to CL:AIRE, which shall be updated by the Employer's Environmental Engineer upon regulatory approval of this Remediation Strategy.

The Contractor shall maintain records of:

- Survey plans and material tracking of the movements of material from source to final destination.
- Base of excavation and obstruction survey.
- Type and volumes of any materials removed from the Site for disposal, together with the Duty of Care documentation / waste transfer notes.
- Geochemical and geotechnical sampling locations,
- Records of the works including Daily Records Sheets.
- Health and Safety documentation.
- Noise and dust monitoring carried out.
- Records of the complaints received regarding noise and dust.

The Contractor's Environmental Engineer will prepare a Validation Report for the remedial works undertaken under their supervision. The Validation Report shall be compliant with the Environment Agency's Land Contamination Risk Management (LCRM) guidance and 'Verification of remediation of land contamination (SC030114/R1)', providing the following:

- Details of the earthworks and material movements completed.
- Details of hot-spots/ contaminated material removal (if required),
- Details of the validation and verification analytical testing.

The Validation Report shall be submitted to the regulatory authorities to satisfy the requirements of the planning permission with respect to contamination issues. The report will also contain all earthworks testing data, proof of compliance with the targets and all survey data.

Tables

Table 1: Assessment Criteria for Clean Cover in Residential Gardens (600mm): Residential End Use with Homegrown Produce

Category	Determinand	Criteria mg/kg			Source
	Arsenic	37			a
	Boron	290			b
	Cadmium	26			a
	Chromium VI	6			b
	Chromium III	910			b
	Lead	200			a
	Elemental Mercury	1.2			b
	Inorganic Mercury	40			b
	Methyl Mercury	11			b
	Nickel	130			b
	Selenium	250			b
	Beryllium	1.7			b
	Copper	2400			b
	Vanadium	410			b
	Zinc	3700			b
Soil Organic Matter Content (SOM) dependent		SOM 1%	SOM 2.5%	SOM 6%	
Phenols	Phenol	120	200	380	b
Petroleum Hydrocarbons	Aliphatic EC 5-6	42	78	160	b
	Aliphatic EC>6-8	100	230	530	b
	Aliphatic EC>8-10	27	65	150	b
	Aliphatic EC>10-12	130 (48) ^{vap}	330 (118) ^{vap}	760 (283) ^{vap}	b
	Aliphatic EC>12-16	1100 (24) ^{sol}	2400 (59) ^{sol}	4300 (142) ^{sol}	b
	Aliphatic EC>16-35	65000 (8.48) ^{sol}	92000 (21) ^{sol}	110000	b
	Aliphatic EC>35-44	65000 (8.48) ^{sol}	92000 (21) ^{sol}	110000	b
	Aromatic EC 5-7 (Benzene)	70	140	300	b
	Aromatic EC>7-8 (Toluene)	130	290	660	b
	Aromatic EC>8-10	34	83	190	b
	Aromatic EC>10-12	74	180	380	b
	Aromatic EC>12-16	140	330	660	b
	Aromatic EC>16-21	260	540	930	b
	Aromatic EC>21-35	1100	1500	1700	b
	Aromatic EC>35-44	1100	1500	1700	b
	Aliphatic + Aromatic EC>44-70	1600	1800	1900	b
Polycyclic Aromatic Hydrocarbons	Acenaphthene	210	510	1100	b
	Acenaphthylene	170	420	920	b
	Anthracene	2400	5400	11000	b
	Benz(a)anthracene	7.2	11	13	b
	Benzo(a)pyrene	2.2	2.7	3.0	b
	Benzo(b)fluoranthene	2.6	3.3	3.7	b
	Benzo(ghi)perylene	320	340	350	b
	Benzo(k)fluoranthene	77	93	100	b
	Chrysene	15	22	27	b

Category	Determinand	Criteria mg/kg			Source
	Dibenzo(a,h)anthracene	0.24	0.28	0.3	b
	Fluoranthene	280	560	890	b
	Fluorene	170	400	860	b
	Indeno(1,2,3cd)pyrene	27	36	41	b
	Naphthalene	2.3	5.6	13	b
	Phenanthrene	95	220	440	b
	Pyrene	620	1200	2000	b
Chloroalkanes & alkenes	1,2-Dichloroethane	0.0071	0.011	0.019	b
	1,1,1-trichloroethane	8.8	18	39	b
	1,1,2,2-Tetrachloroethanes (PCA)	1.6	3.4	7.5	b
	1,1,1,2-Tetrachloroethanes (PCA)	1.2	2.8	6.4	b
	Tetrachloroethene (PCE)	0.18	0.39	0.90	b
	Tetrachloromethane (Carbon Tetrachloride)	0.026	0.056	0.13	b
	Trichloroethene (TCE)	0.016	0.034	0.075	b
	Vinyl Chloride (chloroethene)	0.00064	0.00087	0.0014	b
BTEX	o-xylene	60	140	330	b
	m-xylene	59	140	320	b
	p-xylene	56	130	310	b
	Toluene	130	290	660	b
	Ethylbenzene	47	110	260	b
	Benzene	0.087	0.17	0.37	b
	Asbestos	Zero fibres			

Source of Criteria

Category 4 Screening Level (C4SL)
LQM/CIEH Suitable for Use Level (S4UL)

Notes

Organic matter content does not affect assessment criteria for metals

Arsenic S4UL is based on a comparison of oral and dermal soil exposure with oral Index Dose.

Cadmium C4SL is based on lifetime exposure

Beryllium S4UL is based on comparison of inhalation exposure with inhalation TDI

Chromium VI S4UL are based on localised effects comparing inhalation exposure with inhalation ID only

Values for total xylene should be compared with the most protective S4UL for xylene

Methyl mercury is not a routine contaminant but a S4UL has been generated for Sites where this may be present due to past industrial use. Unless methyl and elemental mercury is suspected to be present, a total mercury concentration can be compared with the GAC for inorganic mercury.

^{vap} S4UL presented exceeds the vapour saturation limit, which is presented in brackets.

^{sol} S4UL presented exceeds the solubility limit, which is presented in brackets.

All assessment criteria assume no free phase contamination is present.

Table 2: Assessment Criteria for Clean Cover in POS Near Residential Houses (300mm): Residential End Use without Homegrown Produce

Category	Determinand	Criteria mg/kg			Source
Metals*	Arsenic	79			a
	Boron	21000			b
	Cadmium	220			a
	Chromium VI	7.7			b
	Chromium III	1500			b
	Lead	630			a
	Inorganic Mercury	120			b
	Nickel	230			b
	Selenium	1100			b
	Beryllium	2.2			b
	Copper	12000			b
	Vanadium	2000			b
	Zinc	81000			b
Soil Organic Matter Content (SOM) dependent		SOM 1%	SOM 2.5%	SOM 6%	
Phenols	Phenol	440dir (10000)	690dir (10000)	1300dir (10000)	b
Petroleum Hydrocarbons	Aliphatic EC 5-6	570000 (304) sol	590000	600000	b
	Aliphatic EC>6-8	600000	610000	620000	b
	Aliphatic EC>8-10	13000	13000	13000	b
	Aliphatic EC>10-12	13000	13000	13000	b
	Aliphatic EC>12-16	13000	13000	13000	b
	Aliphatic EC>16-35	250000	250000	250000	b
	Aliphatic EC>35-44	250000	250000	250000	b
	Aromatic EC 5-7 (Benzene)	56000	56000	56000	b
	Aromatic EC>7-8 (Toluene)	56000	56000	56000	b
	Aromatic EC>8-10	5000	5000	5000	b
	Aromatic EC>10-12	5000	5000	5000	b
	Aromatic EC>12-16	5100	5100	5000	b
	Aromatic EC>16-21	3800	3800	3800	b
	Aromatic EC>21-35	3800	3800	3800	b
	Aromatic EC>35-44	3800	3800	3800	b
	Aliphatic + Aromatic EC>44-70	3800	3800	3800	b
Polycyclic Aromatic Hydrocarbons	Acenaphthene	15000	15000	15000	b
	Acenaphthylene	15000	15000	15000	b
	Anthracene	74000	74000	74000	b
	Benz(a)anthracene	29	29	29	b
	Benzo(a)pyrene	5.7	5.7	5.7	b
	Benzo(b)fluoranthene	7.1	7.2	7.2	b
	Benzo(ghi)perylene	640	640	640	b
Polycyclic Aromatic Hydrocarbons	Benzo(k)fluoranthene	190	190	190	b
	Chrysene	57	57	57	b
	Dibenzo(a,h) anthracene	0.57	0.57	0.58	b

Category	Determinand	Criteria mg/kg			Source
	Fluoranthene	3100	3100	3100	b
	Fluorene	9900	9900	9900	b
	Indeno(1,2,3cd)pyrene	82	82	82	b
	Naphthalene	4900	4900	4900	b
	Phenanthrene	3100	3100	3100	b
	Pyrene	7400	7400	7400	b
Chloroalkanes & alkenes	1,2-Dichloroethane	29	29	29	b
	Trichloroethene (TCE)	120	120	120	b
	Vinyl Chloride (chloroethene)	3.5	3.5	3.5	b
BTEX	o-xylene	41000	42000	43000	b
	m-xylene	41000	42000	43000	b
	p-xylene	41000	42000	43000	b
	Toluene	56000	56000	56000	b
	Ethylbenzene	24000	24000	25000	b
	Benzene	72	72	73	b

Source of Criteria

- a Category 4 Screening Level (C4SL)
- b LQM/CIEH Suitable for Use Level (S4UL)

Notes

- Organic matter content does not affect assessment criteria for metals
- Arsenic S4UL is based on a comparison of oral and dermal soil exposure with oral Index Dose.
- Cadmium C4SL is based on lifetime exposure
- Beryllium S4UL is based on comparison of inhalation exposure with inhalation TDI
- Chromium VI S4UL are based on localised effects comparing inhalation exposure with inhalation ID only
- Values for total xylene should be compared with the most protective S4UL for xylene
- Methyl mercury is not a routine contaminant but a S4UL has been generated for Sites where this may be present due to past industrial use. Unless methyl and elemental mercury is suspected to be present, a total mercury concentration can be compared with the GAC for inorganic mercury.
- ^{vap} S4UL presented exceeds the vapour saturation limit, which is presented in brackets.
- ^{sol} S4UL presented exceeds the solubility limit, which is presented in brackets.
- All assessment criteria assume no free phase contamination is present.

Table 3: Hannah Fraser Consulting Soils Validation Strategy for Protection of Controlled Waters – Agreed Soil Re-use Values (SRVs)

Determinand	Residential Area
	Soil re-use values (mg/kg)
Inorganic Metals and Metalloids	
Arsenic	2533
Cadmium	73
Chromium	9431
Copper	451
Iron	3.05E+5
Lead	1.57E+4
Manganese	3.33E+4
Mercury	132
Nickel	1.15E+4
Selenium	702
Vanadium	1606
Zinc	1.38E+5
Other Inorganics	
Ammoniacal Nitrogen	154
Cyanide	2.02
Organics	
Benzene	3.80
Toluene	128
Ethylbenzene	80
Xylene	74
Phenol	3.05
TPH Criteria Working Group	
Aliphatics >C5-C6	73
Aliphatics >C6-C8	359
Aliphatics >C8-C10	2841
Aliphatics >C10-C12	2.25E+4
Aliphatics >C12-C16	4.50E+5
Aliphatics >C16-C21	5.66E+7
Aliphatics >C21-C35	5.66E+7
Aliphatics >C35-C44	5.66E+7
Aromatics >EC5-EC7	8.51
Aromatics >EC7-EC8	177
Aromatics >EC8-EC10	144
Aromatics >EC10-EC12	227
Aromatics >EC12-EC16	451
Aromatics >EC16-EC21	1424
Aromatics >EC21-EC35	1.13E+4
Aromatics >EC35-EC44	1.13E+4
Aromatics >EC40-EC44	1.13E+4
Polyaromatic Hydrocarbons	
Acenaphthylene	16.7
Acenaphthene	30
Anthracene	34
Benz(a)anthracene	607
Benzo(a)pyrene	34
Benzo(b)fluoranthene	3.42
Benzo(k)fluoranthene	5.05
Benzo(g,h,i)perylene	13
Chrysene	621
Dibenzo(a,h)anthracene	838
Indeno(1,2,3-cd)pyrene	25
Fluoranthene	6.64
Fluorene	27
Naphthalene	27
Phenanthrene	27
Pyrene	76

Table 4: Surface Water Testing Suite and Relevant Critical Criteria

Contaminant	Unit	Freshwater EQS*/Gwent Levels SSSI WQS**
pH	-	6-9*
Cyanide, total	mg/l	0.001*
Ammonia	mg/l	0.2*
Ammoniacal Nitrogen as NH4	mg/l	1.1**
Nitrate as NO3	mg/l	-
Sulphate	mg/l	300**
Arsenic	mg/l	0.05*
Barium	mg/l	-
Beryllium	mg/l	-
Boron, Water Soluble	mg/l	2*
Cadmium	mg/l	0.00015*
Chromium	mg/l	0.0034*
Copper	mg/l	0.001*
Iron	mg/l	1*
Lead	mg/l	0.0012*
Mercury	mg/l	0.00007*
Nickel	mg/l	0.004*
Selenium	mg/l	-
Vanadium	mg/l	0.02*
Zinc	mg/l	0.0109*
Manganese	mg/l	0.123*
TPH-CWG split banding	mg/l	0.01*
Naphthalene	mg/l	0.002*
Acenaphthylene	mg/l	0.00000017*
Acenaphthene	mg/l	0.00000017*
Chrysene	mg/l	0.00000017*
Benzo(b)fluoranthene	mg/l	0.000017*
Benzo(k)fluoranthene	mg/l	0.000017*
Benzo(a)pyrene	mg/l	0.00000017*
Indeno(1,2,3-c,d)pyrene	mg/l	-
Dibenzo(a,h)anthracene	mg/l	-
Fluorene	mg/l	-
Phenanthrene	mg/l	0.00000017*
Anthracene	mg/l	0.0001*
Fluoranthene	mg/l	0.0000063*
Pyrene	mg/l	-
Benzo(a)anthracene	mg/l	0.000017*
Benzo(g,h,i)perylene	mg/l	0.0000082*
PAH 4, Total	mg/l	-
Benzene	mg/l	0.01*
Toluene	mg/l	0.074*
Phenol	mg/l	0.0077*

Notes: Assuming CaCO3 100-200mg/l where relevant.

Appendices

Appendix A – Drawings and Plans



GENERAL NOTES

NO DIMENSIONS TO BE SCALED OFF THIS DRAWING.

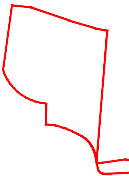
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ALL LEVELS ARE IN METRES UNLESS NOTED OTHERWISE.

ANY DISCREPANCIES NOTED ON SITE ARE TO BE REPORTED TO THE ENGINEER IMMEDIATELY.

KEY:

 Approximate Site Boundary

P02	10/09/2024	Update to site boundary, excluding Vertase Area	AMS	CW
Rev	Date	Amendments	By	Chk



Client

St Modwen Developments

Project

P18-669 Llanwern Reclamation

Drawing Title

Phase 4b & 5d
Site Location Plan

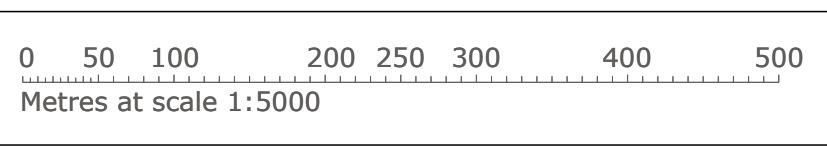
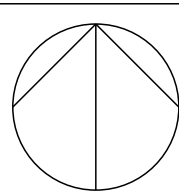
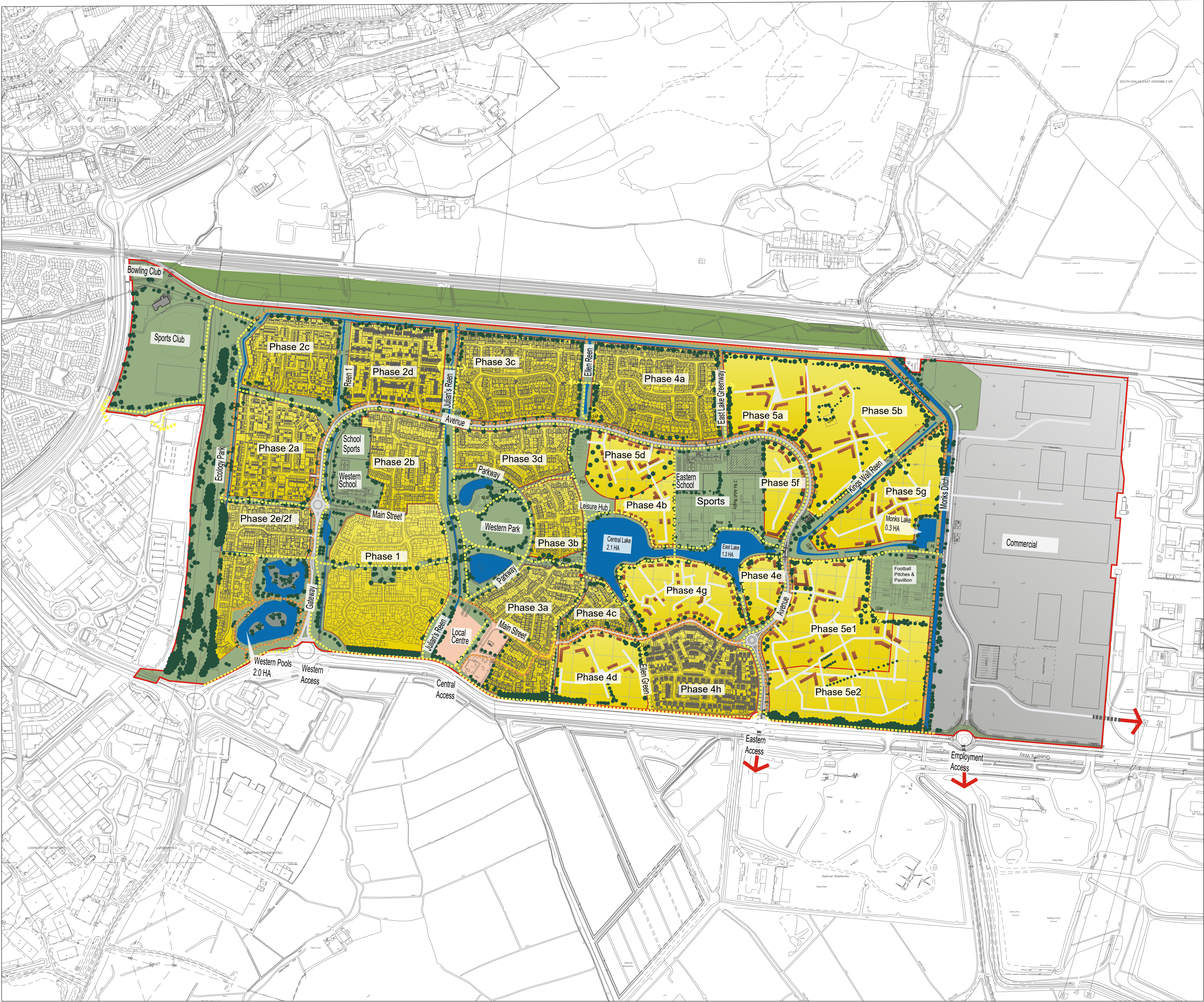
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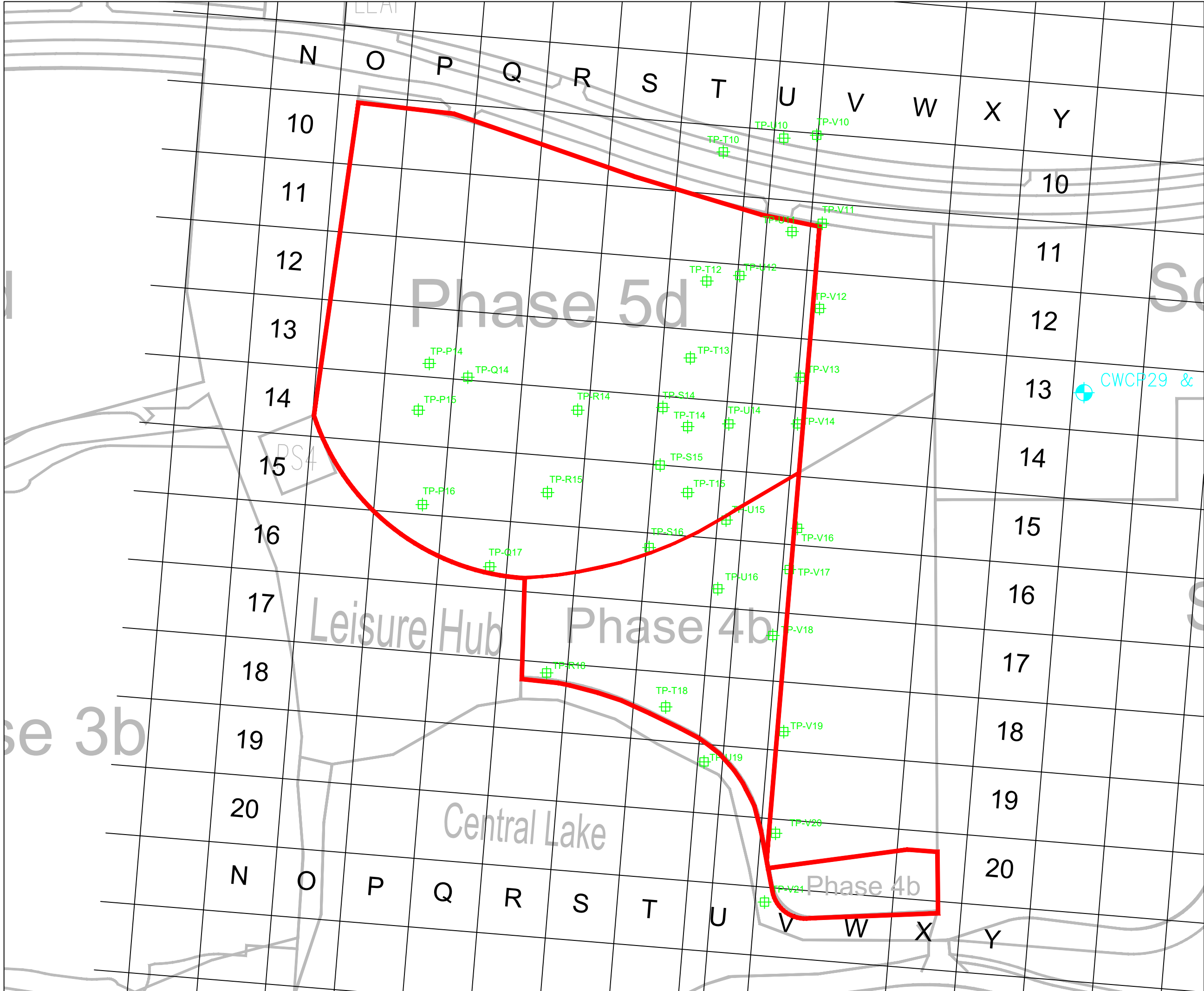
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Drawing No.	Rev.
18669-RLL-22-XX-DR-O-0323	P02

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Glan Llyn -ESAMP Indicative Masterplan





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KEY:

- [Red Outline] SITE BOUNDARY
- [Green Crosshair] COMPLETED TRIAL PIT

P03	10/06/2025	Updated TP Position	AMS	CW
P02	11/09/2024	Updated Site Boundary	AMS	CW
Rev	Date	Amendments	By	Chk



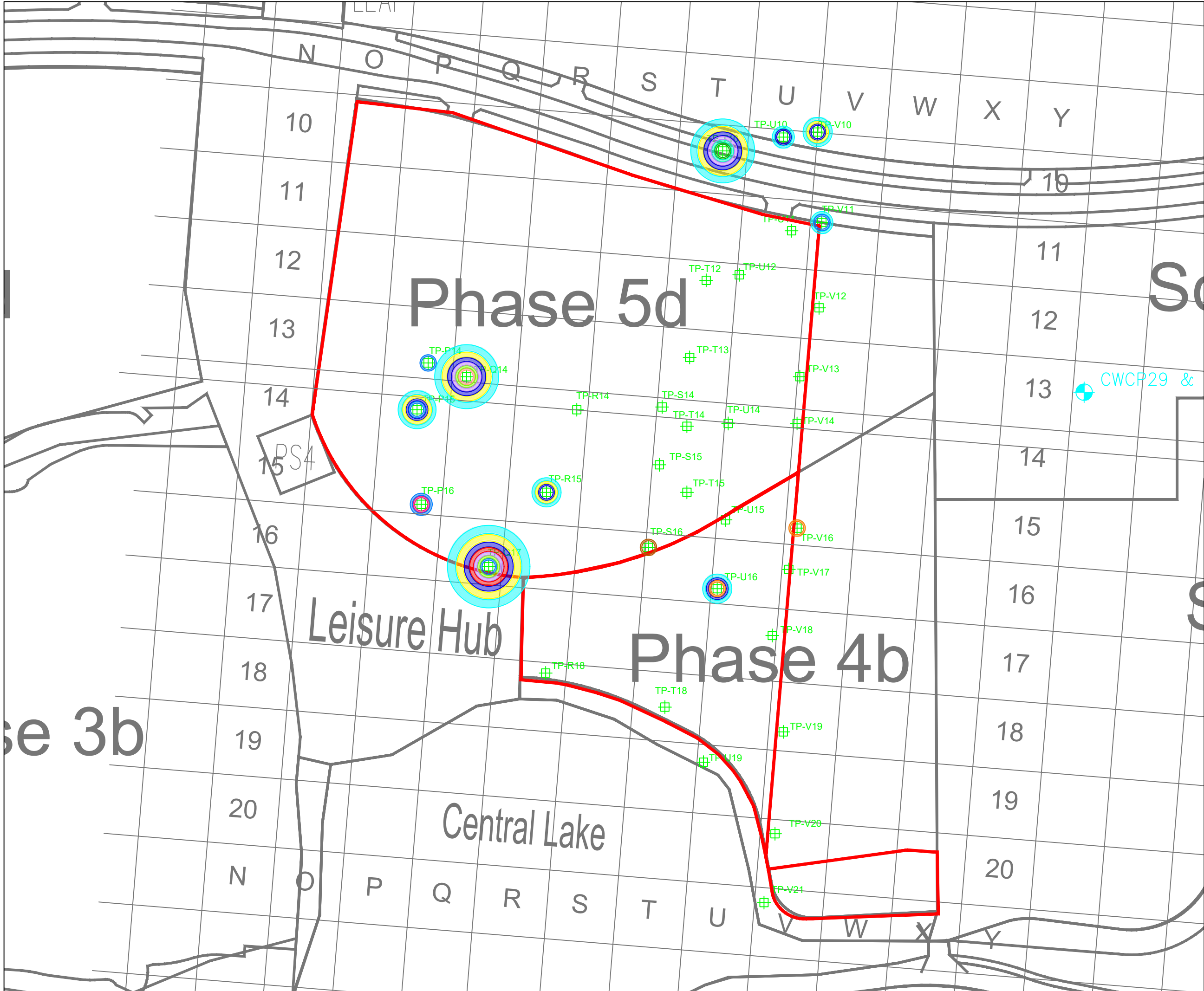
Client
St Modwen Developments

Project
P18-669 Llanwern Reclamation

Drawing Title
Phase 4b & 5d
Exploratory Hole Location Plan

INFORMATION

	Drawn	Checked	Date
NTS	SR	CW	07.06.22
Drawing No.	Rev.		
18669-RLL-22-XX-DR-O-0327	P03		



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ANY DISCREPANCIES NOTED ON SITE ARE TO BE REPORTED TO THE ENGINEER IMMEDIATELY.
SAMPLES BELOW LIMIT OF DETECTION BUT ABOVE SCREENING CRITERIA HAVE BEEN EXCLUDED FROM THIS DRAWING.

KEY:

- Site Boundary
- Rodgers Leask GI 2020/21
- CWRA Borehole
- Vanadium Exceedance Location
- Benzo(b)fluoranthene Exceedance Location
- Lead Exceedance Location
- Benzo(a)pyrene Exceedance Location
- Dibenzo(a,h)anthracene Exceedance Location
- Arsenic Exceedance Location
- Mercury Exceedance Location
- Napthalene Exceedance Location
- Benz(a)anthracene Exceedance Location
- Chrysene Exceedance Location
- Benzene Exceedance Location
- Aromatics > EC12-EC16 Exceedance Location
- Aromatics > EC16-EC21 Exceedance Location

P01	09/06/2025	First Issue	AMS	CW
Rev	Date	Amendments	By	Chk



Client
Revantage Real Estate

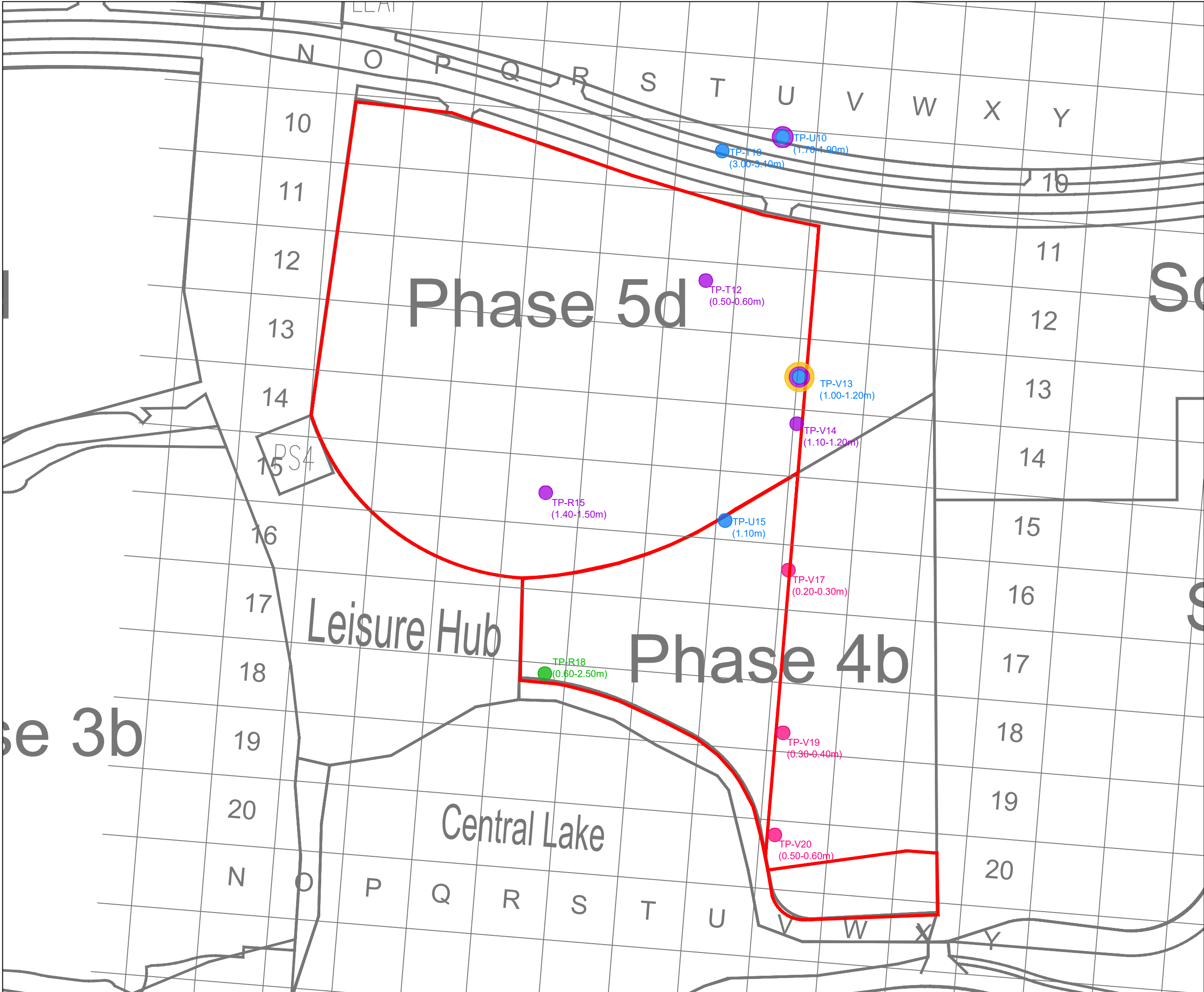
Project
P18-669 Llanwern Reclamation Phase 4B & 5D

Drawing Title
Exceedance Location Plan
S4UL Soil Re-Use Values

INFORMATION

	Drawn	Checked	Date
NTS	ET	CW	20/06/25
Drawing No.	Rev.		
18669-RLL-25-XX-DR-O-0754	P01		

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ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
ALL LEVELS ARE IN METRES UNLESS NOTED OTHERWISE.
ANY DISCREPANCIES NOTED ON SITE ARE TO BE REPORTED TO THE ENGINEER IMMEDIATELY.

KEY:

- SITE BOUNDARY
- FUSED SLAG OBSTRUCTION
- CONCRETE OBSTRUCTION
- PILE OBSTRUCTION
- REBAR OBSTRUCTION
- ASPHALT OBSTRUCTION

P01	10/06/2025	First Issue	AMS	CW
Rev	Date	Amendments	By	Chk



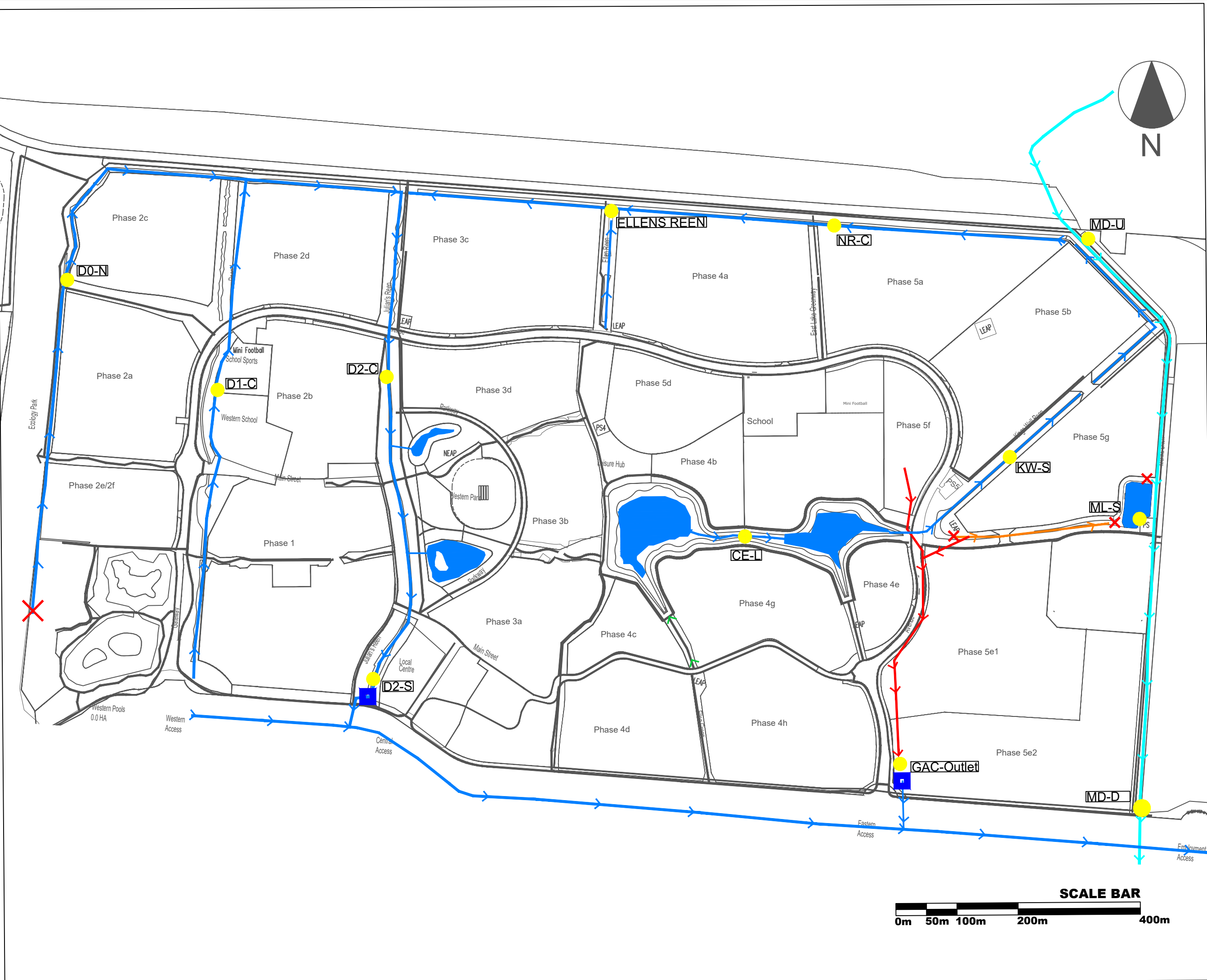
Client
Revantage Real Estate

Project
P18-669 Llanwern Reclamation
Phase 4B & 5D

Drawing Title
Phase 4B & 5D
Obstruction Location Plan

INFORMATION

	Drawn	Checked	Date
NTS	AMS	CW	10/06/25
Drawing No.			Rev.
18669-RLL-25-XX-DR-O-0752			P01
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- KEY:**
- Monks Ditch
 - Clean discharge
 - Construction Water
 - Site discharge through Englobe treatment works
 - ML-S
 - Sampling Location
 - Blocked off drain
 - Discharge Control Point

P04	10/02/2025	2025 System Wide Update	DM	CW
P03	07/11/2024	Dust Positions Amended	AMS	CW
P02	28/10/2024	Sampling Positions Amended & Added	AMS	CW
P01	17/01/2023	Sampling Positions Added	SR	CW
Rev	Date	Amendments	By	Chk



Client
St Modwen Developments

Project
P18-669 Llanwern Reclamation

Drawing Title
Residential Site Surface Water Monitoring Location Plan

INFORMATION

	Drawn	Checked	Date
NTS	DM	CW	12.01.24
Drawing No.	Rev.		
18669-RLL-24-XX-DR-O-0544 P04			
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Appendix B – Phase 4B & 5D Chemical Screening

Client: Rodgers Leak Environmental		Customer Sample ID	Depth	P14-1	P14-2	P15-1	P15-2	P16-1	P16-2	Q14-1	Q14-2	Q17-1	Q17-2	R14-1	R14-2	R15-1	R15-2	R18-1	R18-2	S14-1	S14-2	S15-1	S15-2	S18-1	S18-2	T10-1	T10-2	T10-3	T12-1	T13-1	T13-2	T14-1	T14-2	T15-1	U10-1	U10-2	U11-1																		
Sample Type		Sample Date	Sample Received Date	Final Instruction Date	Report Completed Date	SDG	Sample Temperature																																																
Residential Soil Use Value (Table 2.1)		Number of Exceedances																																																					
Lab Sample Number		Sample Temperature																																																					
Units		LOD																																																					
Determinand	Method	Units	LOD																																																				
Colour	PM204	No units		Dark Brown	Dark Brown	Dark Brown	Black	Grey	Grey	Black	Black	Dark Brown	Grey	Dark Brown	Dark Brown	Dark Brown	Black	Dark Brown	Dark Brown	Black	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Black	Black	Dark Brown	Black	Dark Brown	Black	Dark Brown	Grey	Grey	Dark Brown	Dark Brown	Dark Brown	Dark Brown																
Description	PM204	No units		Loamy Sand	Loamy Sand	Loamy Sand	Sand	Sand	Sand	Sand	Sand	Sandy Loam	Sandy Loam	Sandy Loam	Loamy Sand	Loamy Sand	Sand	Sand	Loamy Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand															
Inclusion 1)	PM204	No units		Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones															
Inclusion 2)	PM204	No units		None	None	None	None	None	None	N/A	Stones	Stones	Stones	N/A	Vegetation	None	Vegetation	Stones	Brick	Stones	Vegetation	None	Vegetation	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	Stones	N/A	None	None	Vegetation	Crushed Brick	Vegetation	Vegetation																
Moisture Content Ratio (% of as received sample)	PM204	%		16.00	11.00	11.00	8.50	8.60	10.00	8.10	13.00	9.80	14.00	13.00	14.00	6.30	11.00	7.70	17.00	13.00	14.00	9.90	32.00	11.00	19.00	1.10	11.00	35.00	3.00	9.70	14.00	12.00	32.00	4.10	10.00	14.00	1.60																		
Asbestos Quantification - Gravimetric - %	TM304	%	0.001																																																				
Date of Analysis	TM304	No units		08/02/2021	-	06/02/2021	-	03/02/2021	-	08/02/2021	-	03/02/2021	-	05/02/2021	-	05/02/2021	-	05/02/2021	-	05/02/2021	-	11/02/2021	-	11/02/2021	-	15/02/2021	-	10/02/2021	-	10/02/2021	-	10/02/2021	-	11/02/2021	-	11/02/2021	-	10/02/2021	-	08/02/2021															
Analysed By	TM304	No units		Marcin Magdziarek	-	Paul Poynton	-	Paul Poynton	-	Marcin Magdziarek	-	Paul Poynton	-	James Richards	-	Paul Poynton	-	James Richards	-	Paul Poynton	-	Marcin Magdziarek	-	Paul Poynton	-	Marcin Magdziarek	-	Christian Hallam	-	Christian Hallam	-	Christian Hallam	-	Paul Poynton	-	Christian Hallam	-	Christian Hallam	-	James Richards															
Asbestos Quantification - PCOM Evaluation - %	TM304	%	0.001																																																				
Additional Asbestos Components (Using TM304)	TM304	No units																																																					
Analysed Comments	TM304	No units																																																					
Asbestos Quantification - Total - %	TM304	%	0.001																																																				
Chrysotile (White) Asbestos	TM304	No units		Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected															
Amosite (Brown) Asbestos	TM304	No units		Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected															
Crocidolite (Blue) Asbestos	TM304	No units		Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected															
Fibrous Anthophyllite	TM304	No units		Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected															
Fibrous Tremolite	TM304	No units		Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected															
Fibrous Actinolite	TM304	No units		Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected															
Non-Asbestos Fibre	TM304	No units		Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected	-	Not Detected															
Comments	TM304	No units																																																					
Soil Organic Matter (SOM)	TM132	%	0.35	49.50	6.36	3.19	1.59	18.80	2.16	-	22.80	21.90	5.97	22.60	12.40	20.50	7.29	8.69	71.20	29.30	17.10	65.90	61.70	32.10	34.80	35.00	-	2.17	24.30	7.57	36.50	84.00	55.70	13.10	28.10	6.24																			
pH	TM133	pH Units	1	11.40	11.90	12.80	12.70	12.60	8.88	8.94	12.50	12.10	8.97	11.10	10.80	11.30	11.10	10.90	9.10	10.60	10.60	8.33	11.10	8.96	10.80	11.80	11.70	10.70	10.00	8.67	9.03	9.22	8.93	9.58	10.20	10.50																			
Exchangeable Ammonia as N	TM153	mg/kg	1	2.02E+00	7	1.06	6.23	<1	<1	<1	6.24	<1	2.35	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1																	
Cyanide, Total	TM204	mg/kg	12	154	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12																		
Arsenic	TM181	mg/kg	0.6	2533.00	0	-6	6.85	-6	76.60	-6	-6	8.89	-6	-6	13.40	-6	10.60	-6	5.32	42.10	5.83	-6	6.45	-6	6.47	5.87	-6	-6	6.47	6.48	-6	6.53	3.72	6.33	7.37	3.37																			
Cadmium	TM181	mg/kg	0.02	73.00	0	0.91	1.56	1.71	0.34	1.71	0.34	1.71	0.34	1.71	0.34	1.71	0.34	1.71	0.34	1.71	0.34	1.71	0.34	1.71	0.34	1.71	0.34	1.71	0.34	1.71	0.34	1.71	0.34	1.71	0.34	1.71	0.34																		
Chromium	TM181	mg/kg	0.9	9431.00	0	284	421.00	741.00	783.00	549.00	62.30	17.50	522.00	426.00	106.00	235.00	300.00	27.40	89.90	11.90	83.60	11.70	214.00	59.90	-6	-6	-6	-6	24.00	42.90	10.30	12.40	22.70	42.90	95.30	144.00																			
Copper																																																							

Appendix C – RLL CWDQRA

Glan Llyn Llanwern
Controlled Water DQRA 2019

Controlled Waters Detailed Quantitative Risk

Assessment

Glan Llyn Llanwern (Sitewide)

2019 Update

For

St. Modwen Developments

DATE: August 2019

REV: A

18669-RLE-19-RP-O-0006

Document Reference & Control

Project Name: Glan Llyn Llanwern Sitewide

Project Reference: P18-669

Report Title: Controlled Waters DQRA 2019 Update

Client: St. Modwen Developments

Document Reference: 18669-RLE-19-RP-O-0006

Report Status: Draft for Issue

Approval Status	Name & Position
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Reviewed by:	Howel Morris BSc MSc CGeol Principal Consultant

Revision Status	Date	Summary of Revision	Revision by:

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Appendix B: Atkins Permeability Technical Note

Appendix C: Groundwater Levels Monitoring

Appendix D: Glan Llyn Diagrammatic CSM

Appendix E: Soils Analysis

Appendix F: Sampling Location Plans

Appendix G: Soil Leachate Analysis

Appendix H: Surface Waters Analysis

Appendix I: Chemical Input Parameters and Justifications

Appendix J: Table 5-4 CWDQRA Reuse Criteria for 5% & 40% Infiltration

Appendix K: Level 3 Groundwater Excel Worksheets

Drawings

Drawing 186669-RLE-19-XX-DR-O-0004 – Site Location Plan

Drawing 8111-008-A011 – Showing Proposed Site Redevelopment

Drawing 5111373-LLA-DWG-EG-0295 – CWRA Borehole Location Plan

Drawing 5111373-LLA-DWG-EG-0408 - Current Surface Water Drainage and Sampling Locations

Drawing D12-084-512 – Post-development Surface Water Drainage Plan

1.0 Introduction

Rodgers Leask Environmental Ltd (RLE) has been commissioned by St Modwen Developments Ltd (St Modwen) to update and further develop a Controlled Waters Detailed Quantitative Risk Assessment (CWDQRA) of the potential risk to Controlled Waters for the Glan Llyn development at Llanwern, Newport (herein referred to as the site). The previous version of this CWDQRA was prepared by Atkins Limited (Atkins), the latest version of which was identified as: Document Reference: 5111373-LLA-OUT-0257, Version: 3 and dated February 2017. It is recommended that reference be made to the aforementioned Atkins Report, in order to obtain greater detail on the known/documented Reporting background to this site.

The principal objectives of the current exercise is to provide, as practicably possible, future surface water flow contributions from the site are compliant upon entry in to the Monks' Ditch, surface water course, which bisects the site, following the redevelopment of the Glan Llyn site for mixed residential and commercial redevelopment and further limiting the amount of material which require off-site removal by virtue of its contaminative potential towards local Controlled Waters.

These introductory comments provide a narrative and rationale for the assumptions made within this updated model, and also provide considerations relating to the temporary management of the water whilst redevelopment is being undertaken, and sustainability of the brownfield project.

As alluded above, an interim state will exist where the site has been reclaimed, but full residential and commercial development is under construction. The reclamation, in terms of surface water quality, will be at its most effective when it is fully developed. The underlying natural clay currently provides a barrier to downward migration of water and the reens (surface water ditches) which are cut into the natural clay and/or peat, drain the water within the Made Ground.

1.1. Atkins Controlled Waters Detailed Quantitative Risk Assessment of 2016

The initial DQCWRA prepared by Atkins (Version: 3 and dated February 2017), was issued with the intention that, as site specific information was collected, the assessment would be reviewed and updated. It was described as the starting point and that the criteria were understood to be conservative. The CWDQRA modelled two site conditions for the mixed use development comprising; residential and commercial end usage.

The residential end use was assumed to have a rainwater interception/ infiltration ratio of 60:40. The commercial end use was assumed to have a rainwater interception/ infiltration ratio of 95:5. The interception is where roofs, roads and hard paving take the rain water and transfer it directly into the surface water reens. The infiltration is where rainwater lands

on grassed or landscaped areas and is able to percolate into the construction material (soils, piling mat, sub base etc) and underlying post-development Made Ground. The current evapotranspiration rate for grassed areas is estimated as 600mm/a against an annual rainfall rate of 953mm/a. The earlier Atkins value utilised, (applicable to permeable areas) was; 416mm/annually.

The Atkins CWDQRA, that generated the initial criteria, assumed that 100% of the infiltrated rainwater (12.85mm per year or 1.3% of total rainfall) mm/a) percolated through the construction material and in to the Made Ground.

Upon derivation of their soil re-use criteria (calculated to be expressed as mg/kg for direct comparison against actual soil analytical data obtained), it was previously noted by Atkins in their 2017 CWDQRA Report and demonstrated in their associated Table 5.5, that the maximum and average soil sample concentrations exhibit some exceedances for inorganic compounds, copper and vanadium. It was also noted that there were exceedances in surface water analyses for iron, manganese, cyanide, and ammoniacal nitrogen. Although these had not been previously analysed by Atkins in soil samples, subsequent analyses has included these determinands.

Exceedances were also noted in soil samples analysed for organic compounds, especially C₁₂-C₃₅ species aromatic TPH (total petroleum hydrocarbons), and a number of PAH (polynuclear aromatic hydrocarbon) species as compared to the derived soil re-use criteria. Concentrations of PAHs present in actual soil analytical data obtained were, in some cases, over one order of magnitude in excess of the calculated re-use criteria, suggesting that attenuation, particularly of heavy fraction TPH and PAHs is likely to be an issue on this site requiring further consideration as part of the proposed remedial and redevelopment works. Although previous analyses of soil samples undertaken by Atkins did not include phenols, recent analyses has included this determined.

1.2. Rationale for Updated Model

The principal rationales for reviewing the model that generated the initial criteria have been:

1. The amount of additional field, site specific, data collected since preparation of the earlier Atkins CWDQRA;
2. The remedial benefits of the currently proposed pre-development turnover and reengineering process were not included in the earlier Atkins CWDQRA. Further details of this proposed Made Ground re-engineering strategy to be employed are provided by Rodgers Leask Environmental Ltd in their Reclamation Performance Specification A – Turnover – Technical Note, dated 14/12/18, Ref: 17480-RLE-18-XX-RP-O-1016). A copy of this Technical Note is provided in **Appendix A** to the current Report.

The large and increasing amount of site specific field data for soils and surface waters has provided further confirmation that the criteria, which is based on theoretical values, is conservative. This is indicated where chemical results for soil placed do not appear to deliver the modelled concentrations to the surface water. The undeveloped site is currently at a worst case scenario where rainfall is free to percolate through material that has not been reengineered. Reengineering and redevelopment will only reduce infiltration and mobilisation serving to improve the currently monitored conditions.

In 2016, geotechnical information relating to the permeability of the Made Ground was assessed (Atkins Ltd Permeability Infiltration Technical Note Ref: 5111373-LLA-OUT-0256, dated 15th December 2016), but this was not used in the model for the Atkins 2017 CWDQRA. A copy of this Technical Note is provided in **Appendix B** of the current Report. The Atkins Ltd Technical Note presented information on the characteristics of the reengineered ground. The earthworks specification for the placement of material (following the turnover to natural clay), requires particle size distribution (PSD) tests, density tests, compaction tests and air void tests on each layer to validate the material has been compacted sufficiently. The particle size distribution within the Made Ground is known to be well graded and when compacted, the permeability is assessed as having a low permeability/poor drainage potential. A number of falling head tests were undertaken within a reengineered plot, which returned failed test results. The reengineering therefore has a remediation/stabilising benefit, by creating a low permeability material and this can be validated by the geotechnical information already collected.

In contrast to the reengineered ground, the construction materials (6F2 piling mat & clean soils) placed above the Made Ground are likely to be of good drainage potential (if they are not, then they will only serve to further limit the downward migration of rainwater).

The low permeability reengineered material inhibits the downward migration of infiltrated rainwater as the pore water in the construction material does not readily flow into the material with much reduced pore spaces (air voids <10%). Lowering the permeability of this material also greatly increases time taken by the perched water to travel within the material.

The engineered characteristics have two distinct remedial benefits as follows:

1. The volume of infiltrated water entering the body of reengineered Made Ground is reduced, therefore the volume of water exposed to mobile contaminants is also reduced;
2. The time taken for migration of the perched water within the reengineered ground is greatly increased and therefore, the volume of perched water reaching the surface water via this route is reduced, increasing the ratio of clean rainwater in the surface water reens. Where this passage is also through areas of cleaner reengineered Made Ground, there are likely to be benefits associated with increased contamination attenuation prior to reens discharge. These are the areas of the site where some retardation (degradation and/or sorption) of contaminants within the Made Ground is

considered possible. On this basis it is proposed to place 'cleaner' Made Ground closer to the reens which are known to be the surface water receptors for the perched waters.

The Atkins CWDQRA, that generated the initial criteria, assumed that in areas of soft landscaping, 100% of the infiltrated rainwater (12.85mm per year or 1.3% of total rainfall) percolated through the construction material (imported top soils) and in to the Made Ground. This value takes account of estimated surface-water run-off (55% of total rainfall) and evapotranspiration (43.7% of total rainfall). It is considered likely that the lowest achievable, permeability of the post-development Made Ground is like to be in the region of (1×10^{-7} m/s).

It was also apparent in the Atkins CWDQRA and Conceptual Site Model that although lateral drainage within the capping layer was anticipated, this wasn't accounted for in the calculations, where it assumed that essentially all (1.3% of the total rainwater) passed into the underlying post-development Made Ground. It is therefore reasonable to assume that a reduction in infiltration into post-development Made Ground will be enabled by the placement of higher permeability ground surface construction materials (imported soils) and any possible introduced gradient within this layer which will encourage an element of lateral flow.

In order to gauge potential impacts on the existing calculated soil reuse criteria, a process of sensitivity analyses was therefore proposed using possible scenarios where 40% of the 12.85mm per year (5.14mm/year) or 5% (0.64mm/year) penetrates into the underlying post-development Made Ground. It is recognised that this modelling is of a further potential reduction in what is already, apparently, a low rate of rainwater infiltration (1.3% of total rainfall). Reuse criteria would then be derived for the range of determinands previously selected by Atkins, and it was proposed that these criteria now also include iron, manganese, cyanide, ammoniacal nitrogen and phenol, which would be modelled in current revision to the Report.

It was considered that the very low 5% (0.64mm/year) infiltration rate may not necessarily be achievable, but was introduced as a mechanism to reflect distance from the surface water receptors (existing reens), and effectively represent a greater travel of infiltrated water. It was proposed that the findings should be superseded by modelled travel time parameters, when appropriate, and from this would be derived what would be considered to be realistic achievable soil reuse criteria.

1.3 Natural Attenuation from Site Features

It is also considered that there is a potential for natural attenuation benefits from further improving and expanding the existing surface water features on the site, which mainly comprise reens and ponds/small lakes. This is anticipated particularly through:

1. Further establishing the vegetation within the reens which will help reduce the concentrations of organic contaminants and particularly nutrients such as ammoniacal

nitrogen. The reens are known to vegetate rapidly and require regular maintenance to remove surplus growth;

2. Undertaking organic matter enrichment of soils along margins of the reens and ponds/lakes into which water penetrating the Made Ground are likely to discharge. This could be undertaken by placement of locally excavated peat (obtained from Alluvial and underlying Tidal Flat Deposits) and other soils containing high concentrations of organic matter. This should enable a further stripping out of low concentrations of PAHs and TPH within these discharge waters. Amendment of these soils with other materials will also be considered, taking into consideration further knowledge of the residual contaminant profile, in order to provide a passive sustainable solution to the long-term remediation of this site.

2.0 Site History and Environmental Setting

2.1 Site Setting

The Glan Llyn development site is located south of Llanwern, immediately east of Newport at National Grid Reference (NGR) ST 36101 86848. The site covers an area of approximately 243 ha which comprises previously developed land (Section 2.2). The site is bound to the north by a railway line and to the south by Queen's Way (A4810). The operational Tata steelworks is located adjacent to the eastern boundary and a north-south drainage ditch borders the western boundary, beyond which lies Newport Retail Park. A plan showing the site's location is presented on Drawing 18669-RLE-19-XX-DR-O-0004. The site is proposed to be redeveloped as a mixed residential and commercial development (Drawing 8111-008-A0111). Residential development is proposed for the majority of the site, whilst commercial development is limited to the Celtic Business Park area in the east of the site (Drawing 8111-008-A0111). A copy of this Drawing is provided to the rear of this Report.

2.2 Site History

Details of the documented site history are provided in the above-noted Atkins CWDQRA Report dated February 2017. However, in summary, the site was extensively developed as a steelworks by Richard Thomas and Baldwins Ltd in the 1960s. Prior to construction, marshland and arable farmland within the site boundary was subject to significant land raise and engineering to bring ground level to current levels. Within the confines of the development site, steelworks ancillaries included but were not limited to; mineral stockyards, blast furnaces, offices, railway sidings, a 'Bit Mac' plant and coking works. Steel making operations ceased in the western half of the steelworks site in 2001, with the majority of infrastructure demolished in 2004, following land transfer to St. Modwen Developments Ltd.

It is much of the material used as part of this pre-development land raise, together with demolished former steelworks buildings and structures that comprise the existing Made Ground across the site, which will be subject to the proposed reengineering and compaction works associated with this redevelopment.

Approximately 20% of the development has been completed up to August 2019, including near completion of two residential phases (Phase 1 & Phase 2), the construction of two commercial units (Amazon & CAF), the park and a pub within the Western Sub Area.

2.3 Geology

2.3.1. Published Geology

The BGS GeoIndex (BGS, 2016a) indicates that Superficial Tidal Flat Deposits comprising clays and silts underlie the areas of interest. The BGS Lexicon of Named Rock Units (BGS, 2016b)

describes these deposits as: *‘normally a consolidated soft silty clay, with layers of sand, gravel and peat. Characteristically low relief; from the tidal zone’* Bedrock geology underlying the areas of interest comprises mudstones of the Mercia Mudstone Group (BGS, 2016a); the BGS Lexicon of Named Rock Units (BGS, 2016b) describes the Mercia Mudstone as: *‘dominantly red, less commonly green-grey, mudstones and subordinate siltstones with thick halite-bearing units in some basinal areas. Thin beds of gypsum/anhydrite [are] widespread, sandstones are also present.’* Given the history of development within the areas of interest, it is anticipated that a layer of Made Ground will be present across the proposed developments.

2.3.2. Local Geology

The Glan Llyn development site benefits from several phases of GI and the ground model for the site is well constrained. For ease of discussion and brevity, a summary of local geology underlying the site is presented in Atkins Table 2-1 below (reproduced from their February 2017 Report). However, a full discussion of local geology within each development phase is presented in the respective “Ground Investigation and Ground Conditions” section of the geo environmental reports (Atkins; 2015b, 2015c, 2015d). Boreholes drilled as part of the 2016 CWRA Ground Investigation (IFA, 2016) confirm the presence of Made Ground, Tidal Flat Deposits and Bedrock across the site, as outlined in Table2-1 below.

Table 2-1 Summary of Local Geology (Atkins, 2015 a)

Geological Unit		Indicative Geological Composition	Approximate Thickness
Topsoil		Soft brown slightly sandy clay.	Nominal thickness, only locally
Made Ground	Made Ground 1	Grey occasionally clayey, sandy gravel of and angular to sub-angular fine to coarse slag with occasional tarmac, concrete, brick, limestone and ceramic / fused slag.	0.02 2.6 m
	Made Ground 2	Red brown / brown clayey sandy gravel (locally gravelly sand) with cobbles and boulders	
	Made Ground 3	Red brown / brown soft to firm sandy gravelly clay with cobbles and boulders. Gravel includes sub-rounded to angular fine to coarse burnt shale, brick, slag, sandstone, mudstone, shale and occasional coal.	
Tidal Flat Deposits	Upper Tidal Clay	Generally very soft to firm blue grey slightly gravelly silty clay with rare localised pockets of peat.	7 – 10 m (IFA, 2016)
	Upper Peat	Generally a spongy dark brown occasionally clayey pseudo-fibrous to fibrous peat.	

Geological Unit		Indicative Geological Composition	Approximate Thickness
	Lower Peat	Generally a spongy to plastic dark brown occasionally clayey occasionally sandy pseudo-fibrous to amorphous peat.	
	Lower Tidal Clay	Generally described as a soft to firm bluish grey slightly sandy slightly gravelly clay gravel is of angular to sub-angular fine to medium sandstone.	
	Red Clay	Generally described as a firm to stiff red brown mottled grey slight gravelly clay, gravel is angular to sub-angular fine to coarse mudstone.	
	Basal Sand	Generally a medium dense light brown slightly silty slightly gravelly fine grained sand the gravel is of sub-rounded to sub-angular fine siltstone and quartzite.	
Bedrock	Mercia Mudstone Group	Weathered Mercia Mudstone being described as stiff to very stiff reddish brown slightly gravelly clay and extremely weak to weak occasionally laminated red brown mudstone.	Encountered, thickness not proven

2.3.3 Post-development Ground Conditions

The post-development ground conditions on site are as detailed in Table 2-2 below. Existing Made Ground is to be excavated and re-compacted to comply with the Atkins geotechnical specification for the development (Atkins, 2016b). In addition, it was proposed that a 1 in 100 gradient (0.01) be applied to the surface of the Made Ground to prevent ponding and promote lateral drainage within the construction materials.

Potential further mitigation to promote lateral flow that may be considered is the provision of a drainage blanket to cap the reengineered material and increasing the fall from the centre of a plot to periphery.

Table 2-2 Post-Development Ground Conditions

Unit	Approximate Thickness	Description
Impermeable Construction Materials/ Housing Sub-base/Permeable Topsoil	0.6 m	Imported clean topsoil/construction materials
Piling Mat*	0.5 m	Imported 6F2 (*may be included within 600mm of construction materials)
Made Ground	1.5 – 2.0 m	Excavated and re-compacted Made Ground
Tidal Flat Deposits	7.0 – 10.0 m	No change from current conditions
Bedrock (Mercia Mudstone Group)	>1,350m	No change from current conditions

2.4 Hydrogeology

The following details are based upon information presented in the Atkins 2017 Report, and reviewed again prior to preparation of the current update.

2.4.1. Published Hydrogeology

Groundwater maps previously available on the Environment Agency website (Atkins, 2015a) show that the Mercia Mudstone bedrock deposits below the proposed developments are classified as a Secondary B Aquifer. The Environment Agency define a Secondary B Aquifer as being: *‘predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.’*

The Tidal Flat Deposits are classified as non-productive strata which are defined by the Environment Agency as being: *‘deposits with low permeability that have negligible significance for water supply or river base flow’.*

It is understood from investigations carried out by Atkins that the Environment Agency website indicated that there were no groundwater abstractions within 1 km of the proposed developments. Information presented on the GroundSure Enviro Data Viewer website (<http://groundsurre.io/>), accessed August 2019, indicates that the Site is not located within a Groundwater Source Protection Zone (SPZ).

2.4.2. Local Hydrogeology

A site-wide programme of monthly groundwater level monitoring was undertaken from May to November 2016 in the shallow and deep wells installed during the CWRA GI (Drawing 5111373-LLA-DWG-EG-0295) to inform the hydrogeological conceptual site model. A copy of this Drawing is provided in the Appendices to the current Report.

This monthly monitoring was subsequently continued until 2017.

A summary of groundwater levels recorded in the deep and shallow wells were presented in Appendix A of the Atkins 2017 CWDQRA Report and are reproduced in the current Report (**Appendix C**). It is indicated that groundwater level monitoring and water strike data recorded during the Ground Investigations (GI) of each site development phase, were presented in the “Ground Investigation and Ground Conditions” section of the relevant geo-environmental Report (Atkins; 2015b, 2015c, 2015d); and are summarised in the CWRA Position Statement (Atkins, 2015a).

It was considered that groundwater levels recorded during the CWRA GI and subsequent monitoring suggested that the groundwater is present beneath the proposed development as follows (Atkins, 2015a):

- Shallow / perched groundwater within the Made Ground (shallow boreholes); and
- Groundwater within the Tidal Flat Deposits (confined to the basal sand layers) and Mercia Mudstone (deep boreholes).

Groundwater monitored within the deep boreholes was considered to be primarily derived from the bedrock geology, and hydraulic continuity between the upper perched shallow groundwater and ‘regional’ groundwater was considered likely to be limited. Post-development, the excavation and re-compaction of the Made Ground was recognised as likely to reduce its permeability, lowering still further, the hydraulic continuity.

The permeability of the reengineered material based on the compaction necessary to attain the requirements of the specification is likely to consistently achieve low permeability or poor drainage characteristics. This is likely to be a permeability of 10^{-7} m/s.

Downward percolation of water through the Tidal Flat Deposits was considered to be limited due to the low permeability of the clay-rich strata. This is likely to cause water to accumulate within the overlying Made Ground. Regional groundwater within the Basal Sands of the Tidal Flat Deposits and Mercia Mudstone bedrock is confined by the overlying clay within the Tidal Flat Deposits and is under sub-artesian pressure (Atkins, 2015a). These conditions are further confirmed by the presence of water strikes consistent with the top of the Mudstone/Basal Sands which rose several metres within a short time period (IFA, 2016).

Where the piezometric level in the regional aquifer is higher than shallow perched water then the shallow perched water system is likely to be hydraulically contained with limited downward leakage permitted. However, it is unknown how groundwater conditions will change throughout the hydraulic year within the post-development site. As outlined by Atkins (2015a), during hydraulic conditions where the piezometric level is below the level of the shallow perched water, slow downward migration of this water through the Tidal Flat

Deposits is to be expected. Table 2-4 of the Atkins 2017 CWDQRA Report, below (reproduced from their February 2017 Report), presents deep – shallow groundwater levels (mAOD) for the available groundwater level data across the site. It was indicated by Atkins that based on a review of the water levels in the deep and shallow borehole pairs, there are examples of both conditions being present at the proposed development site during all 2016 monitoring rounds. It was indicated that the majority of differences between piezometric levels are less than half a metre across the site, with only four occurrences where shallow piezometric levels are at or greater than 1.00m than deep levels (BH05 03/11/16, BH06 03/11/16, BH21 05/10/16 and 07/07/16, BH30 05/10/16).

Table 2-4 Deep and Shallow Groundwater Level Comparison

Deep Borehole	Shallow Borehole	Deep Groundwater Level (mAOD) – Shallow Groundwater Level (mAOD)*						
		10/05/2016	06/06/2016	07/07/2016	02/08/2016	01/09/2016	05/10/2016	03/11/2016
CWCP-03	CWWS-03	0.195	0.005	-0.145	0.035	-0.025	n/a	-0.305
CWCP-04	CWWS-04	-0.264	-0.764	-0.664	-0.584	-0.544	n/a	-0.774
CWCP-05	CWWS-05	0.181	-0.819	n/a	-0.429	-0.659	-0.769	-1.069
CWCP-06	CWWS-06	n/a	n/a	n/a	-0.336	n/a	n/a	-1.186
CWCP-07	CWWS-07	n/a	n/a	n/a	n/a	n/a	n/a	n/a
CWCP-08	CWWS-08	n/a	n/a	n/a	n/a	n/a	n/a	n/a
CWCP-09	CWWS-09	0.018	-0.682	-0.982	0.068	-0.162	-0.122	-0.432
CWCP-10	CWWS-10	-0.089	n/a	n/a	-0.279	-0.389	-0.399	-0.419
CWCP-11	CWWS-11	0.048	0.018	-0.012	-0.092	0.018	-0.032	-0.012
CWCP-12	CWWS-12	n/a	n/a	n/a	n/a	n/a	n/a	n/a
CWCP-13	CWWS-13	-0.904	-0.834	-0.984	-0.844	-0.894	-0.774	-0.864
CWCP-14	CWWS-14	0.008	0.078	-0.022	-0.112	-0.002	-0.212	-0.132
CWCP-15	CWWS-15	0.078	0.118	0.668	-0.032	0.178	-0.242	0.108
CWCP-18	CWWS-18	n/a	n/a	n/a	n/a	n/a	n/a	n/a
CWCP-19	CWWS-19	-0.112	-0.072	-0.232	-0.082	-0.182	-0.252	-0.112
CWCP-20	CWWS-20	n/a	n/a	n/a	n/a	n/a	n/a	n/a
CWCP-21	CWWS-21	-0.93	-0.77	-1.06	0.34	-0.82	-1.18	n/a
CWCP-22	CWWS-22	-0.818	0.152	0.002	0.682	0.232	-0.088	-0.048
CWCP-23	CWWS-23	0.526	0.596	0.856	0.146	0.036	0.036	0.026
CWCP-24	CWWS-24	0.607	0.127	0.117	-0.013	0.127	n/a	-0.253
CWCP-25	CWWS-25	-0.617	-0.257	-0.247	-0.397	-0.337	0.553	-0.637
CWCP-26-e	CWWS-26-e	-0.006	0.014	-0.196	-0.116	-0.156	-1.196	-0.206
CWCP-26-w	CWWS-26-w	0.525	0.365	0.345	0.325	0.155	0.675	-0.305
CWCP-27	CWWS-27	n/a	-0.09	-0.1	-0.17	-0.15	-0.31	-0.36
CWCP-28	CWWS-28	0.189	0.069	0.039	-0.021	0.179	0.069	0.219
CWCP-29	CWWS-29	-0.193	-0.363	-0.413	-0.263	-0.383	0.487	-0.553
CWCP-30	CWWS-30	0.38	0.17	0.15	0.2	-1	0	0.13
CWCP-31	CWWS-31	-0.298	-0.328	-0.398	n/a	-1.088	-0.388	-0.508
CWCP-32	CWWS-32	-0.562	-0.452	-0.552	-0.702	-0.702	-0.562	-0.552
CWCP-34	CWWS-34	n/a	n/a	n/a	n/a	n/a	-5.468	n/a
CWCP-35	CWWS-35	-0.27	-0.47	-0.47	-0.36	0.6	-0.51	-0.44
CWCP-36	CWWS-36	n/a	-0.165	-0.295	n/a	-0.385	n/a	n/a

*n/a indicates no two corresponding samples available for comparison (i.e. dry borehole/no data), where value is negative deep groundwater levels are lower than shallow, positive values indicate deep groundwater levels above shallow.

Further analysis of regional groundwater data (13/10/2015) from the boreholes installed into the bedrock geology was undertaken in the CWRA Position Statement (Atkins, 2015a). Deep groundwater contours produced suggest a regional groundwater flow direction towards the south and south east towards the estuary of the River Severn, which is broadly expected. This is confirmed by analysis of recent groundwater level monitoring data.

Review of the shallow perched water system indicates that it is likely to be extremely complex with no discernible single flow direction (Atkins, 2015a). The Made Ground is known to be highly heterogeneous (Table 2-1), resultant flow of perched water is likely to be discontinuous and tortuous through permeable and connected pathways only. In addition, flow within the Made Ground is fragmented across the site by the extensive network of surface water drainage ditches (reens) across the site (Section 2.5.1); it is anticipated that flow converges towards these surface water features where permeable pathways exist within the Made Ground. As a result of natural clay lining of the reens around the periphery of the site (Section 2.5.1), no lateral hydraulic connection exists between the Made Ground onsite and surrounding superficial deposits.

2.4.2.1. Hydrogeological Properties

Capping Drainage Layer

The gravels of the capping drainage layer are expected to have a permeability of approximately 1×10^{-3} m/s (Freeze and Cherry, 1979), assuming the material to have good drainage characteristics consistent with a clean gravel/sand (Atkins, 2016b).

Made Ground

It was indicated by Atkins, that soakaway tests undertaken within the re-engineered Made Ground onsite (in accordance with BRE 365 (BRE, 2007)) produced very little seepage and therefore analysis of results was not possible. It was noted that composition of the Made Ground as indicated by Particle Size Distribution (PSD) laboratory tests approximate the hydraulic conductivity of the post-development Made Ground at 1×10^{-7} m/s (Atkins, 2016b). It was therefore indicated that the assigned hydraulic conductivity of the re-engineered Made Ground be based on the values included within Barnes (2010) for a material with poor drainage characteristics as indicated by the soakaway tests. It was noted that this value is consistent with previous analysis undertaken by Atkins. The results of these tests are presented in Table 2-5, as reproduced below.

Table 2.5: Properties of the Re-engineered Made Ground

Made Ground	PSD No./ Average	BRE Soakaway Test Result	Adopted Permeability(k)
Test 1	102 No./ 11% fines, 22% sand, 62% gravel, 5% cobbles	Fell 4mm in 3hrs	1×10^{-7} m/s
Test 2		Fell 20mm in 2hrs	1×10^{-7} m/s

2.5. Hydrology

2.5.1. Surface Water Features

It was previously indicated by Atkins that, the surface water drainage onsite comprises several man-made surface water drainage ditches (reens) cut into the natural clay which divide the site north to south, receiving water from the land to the north in addition to onsite drainage and baseflow. A maximum channel flow of 10.64 l/s was previously recorded at sampling location D5N. The reens are connected to east-west drains which run the length of the site along the A4810 (Queen's Way Road) within 50 m from the southern boundary and the northern carrier drain within the site adjacent to the northern boundary (Drawing 5111373-LLA-DWG-EG-0408); ultimately discharging to the water treatment works at the operational Tata steelworks to the east. Drawing 5111373-LLA-DWG-EG-0408 depicts the current surface water drainage onsite and indicates sampling locations.

Monks' Ditch, a main river (Waterbody ID GB109056026850) crosses the site flowing north to south. The river flows across the site in a fully contained deep piled concrete channel approximately 7 m wide and 3 m deep (Rodgers Leask, 2016) before crossing the Gwent Levels to the south as a natural channel (Section 2.5.3) and discharging to the Severn Estuary via a tidal exclusion gate. A number of reens and watercourses controlled and maintained by Cyfoeth Naturiol Cymru / Natural Resources Wales (CNC/NRW) surround the site and are described in the surface water drainage strategy (Rodgers Leask, 2016).

A comprehensive surface water drainage strategy for the site has been developed by Rodgers Leask (2016), considering areas already developed (Western Sub Area and parts of the Celtic Business Park) and those yet to be developed. The strategy outlines the sustainable surface water management planned for the finished development. Approximately 399,000 m³ of storage is planned within the site, taking the form of an extensive network of blueways/reens, lakes and Sustainable Drainage Systems (SuDS), receiving all surface water runoff from the site. A post-development surface water drainage plan is presented in Drawing D12- 084-512 and summarised below:

- Blueways (Reen 1, Reen 2, Julian's Reen, Ellen Reen, East Lake Reen, King's Wall Reen and Celtic Business Park Reens) – primary surface water channels comprising existing and newly created reens which will be engineered to flow south to north across the site, culminating in a west-east channel adjacent to the northern boundary of the site, from which water will be discharged to Monk's Ditch. Reens within the site boundary will be unlined (other than being cut into the underlying clay to achieve the required invert level therefore the base and deeper parts of banks will be formed in the natural clay);
- Greenways – high level dry, shallow ditches intended to channel overland surface water from the development plots into the blueways;
- Lakes – a number of lakes and ponds are anticipated to be connected to the blueway system to provide amenity with some additional storage for surface water runoff; and
- Monks' Ditch – surface water from the site is proposed to be pumped to the Main River at a maximum flow rate of 750 l/s as specified by CNC/NRW.

The strategy as submitted (Rodgers Leask, 2016), states that discharges to Monks' Ditch will be allowed once the specified quality criteria and quality control systems have been

established and are met, until that point discharges to the Tata system will continue from the development site.

2.5.2. Rainfall

In the absence of an onsite rain gauge, rainfall data used within the Atkins 2017 CWDQRA assessment was taken from MAFF (1976) for the area surrounding Newport. Literature values for annual total rainfall, (953 mm, MAFF, 1976) are comparable to available data from nearby CNC/NRW rain gauge at Newport for the year 2015 (945 mm).

2.5.3. Designated Areas

Gwent Levels (Nash and Gold Cliff) Site of Special Scientific Interest (SSSI) encompasses the area between the southern site boundary and the Severn Estuary and comprises a large area of ancient grazing marshes, farmed wetland, and reens. The area is part of a series of adjoining SSSI designated for their wildlife and archaeology; specifically water beetles and dragonflies found in the reens, farmland birds, and brown hare, otter and water vole.

3.0 Conceptual Site Model

3.1 Introduction

A Conceptual Site Model (CSM) was previously prepared by Atkins for the Glan Llyn site, as a whole, and presented in their 2017 CWDQRA Report. It was indicated that the CSM, which was considered to be representative of the site in an un-remediated, undeveloped scenario, considered all available geological and hydrogeological information relating to the proposed development to produce a CSM upon which a detailed assessment of the risk to Controlled Waters could be assessed. Risks to Human health via inhalation, direct ingestion or dermal contact of soils did not form part of the CSM. Again, it is recommended that the relevant chapter of the Atkins Report is read in conjunction with this section of the current Report. However, much of the earlier Atkins CSM is presented again below for convenience.

3.2 Potential Sources of Contamination

The following potential sources of contamination were identified with respect to Controlled Waters considering the available historical and recent data for the site:

The Made Ground, which was historically used to build up the level of the site was known to include imported waste products (slag, concrete, brick, burnt shale) from other steelworks in addition to natural deposits (Table 2-1).

Chemical compounds which have the potential to contaminate the ground outlined by the Department of Environment (DoE, 1995) as being associated with metal production industry are: metals and metalloids, inorganic compounds, acids and alkalis. Contaminants, particularly related to coke-making include; PAHs, cyanides, ammoniacal liquors, sulphur and sulphates, BTEX VOCs and also include petroleum-based fuels and oils. Contaminants of Concern (CoC) are presented in Section 5.1.1.

It was noted by Atkins that groundwater within the bedrock has previously been impacted by contaminants associated with the former steel producing industry formerly located on this site. However given the direction of the groundwater flow and the location of elevated concentrations a link between the steelworks as a source and regional groundwater could not be confirmed.

3.3 Potential Receptors

Receptors relating to Controlled Waters are identified to comprise:

- Monks' Ditch (into which surface water from the development site is pumped);
- Engineered surface water reens onsite;
- Perched groundwater within the Made Ground;
- Groundwater within the Tidal Flat Deposits Unproductive Strata; and
- Mercia Mudstone Secondary B Aquifer.

It was indicated that the Made Ground and Tidal Flat Deposits (unproductive strata) are not considered to be a Controlled Waters receptor in the context of the assessment due to their anticipated low resource potential. The post-development surface water reens within the site were not considered to be Controlled Waters given the artificial nature of their origin and the fact that discharge from this system will always be entirely managed by on site pumping stations. The reens are therefore treated as part of the engineered water management system in the same way that SuDS features are on many developments.

Monks' Ditch, as a Main River, was considered to be the principal receptor for any Controlled Waters impact at the site.

3.4 Potential Pathways

Potential Controlled Waters pathways were identified as follows:

Leaching of soil-borne contamination in Made Ground and subsequent lateral migration through permeable pathways in Made Ground to Monks' Ditch via onsite reens.

No effective pathway was identified between the shallow groundwater in the Made Ground and the deep groundwater within the Mercia Mudstone Secondary B Aquifer, due to the low permeability of the clay-rich Tidal Flat Deposits.

3.5 Potential Pollutant Linkages

It was assessed that contamination present within the Made Ground onsite is anticipated to directly leach into the underlying perched shallow groundwater via infiltration and diffusion. The degree of leaching from the source materials present within the Made Ground is a function of partitioning to the soil matrix and volatilisation potential to the gaseous phase. Little dilution was anticipated to occur within the Made Ground as the site was considered to be hydraulically isolated from the surrounding superficial deposits by reens formed in the natural clay, preventing inflow of uncontaminated groundwater. The base of the reens are also known to be excavated into the clay-rich Tidal Flat Deposits.

The prevailing flow of perched groundwater was anticipated to be separated along the central north-south divide of each sub-area, flowing laterally to the adjacent reen following the slope of the Made Ground (Section 2.3.3). Groundwater flow was considered to be able to move laterally within the Made Ground without impedance. However, it is recognised that areas of low hydraulic conductivity are likely to exist in the Made Ground (i.e. due to the presence of silts and clays), which will baffle flow locally and prevent bulk advection of contaminants.

It was assumed that no dilution occurs within the shallow groundwater in the Made Ground and that concentrations of contaminants reach equilibrium. Substantial dilution will occur within the reens as groundwater mixes with surface water runoff from the site.

Water in the reens is proposed to be physically pumped into the Controlled Waters receptor, Monks' Ditch; details of which are outlined in the Surface Water Drainage Strategy (Rodgers

Leask, 2016). Currently it is understood that the surface water discharge from site flows into the Tata surface water system and is controlled and discharged as part of their industrial discharge consent.

As previously outlined, due to the low resource potential and low permeability nature of the Made Ground, Tidal Flat Deposits and Mercia Mudstone, in addition to the restricted pathway between shallow and deep groundwater, no credible groundwater receptors were realised. A diagrammatic CSM was prepared, which has been reproduced by RLE (dated 05/07/19) and is provided in **Appendix D**.

4.0 Contamination Data Assessment

4.1. Water Quality Standards

The Atkins CSM identified Monks' Ditch as a Controlled Waters receptor for the site. Therefore, the annual average Inland Surface Waters EQS applicable under the Water Framework Directive was adopted as the primary WQS (DEFRA/Welsh Ministers, 2015). Where a value was not available for a particular element or compound, then the following standards were used in order of preference:

- EU Statutory EQS (Protection of Surface Water Quality) (Council Directive 2000/60/EC);
- UK Statutory EQS (Protection of Aquatic Life) (Council Directive 76/464/EEC);
- UK Non-statutory EQSs (Protection of Aquatic Life) (Council Directive 76/464/EEC) and;
- UK Drinking Water Standard (DWS) (Water Supply (Water Quality) Regulations, 2000).

There are no current UK WQS for TPH; however, a concentration of 0.01 mg/l was used, which is based on the UK DWS in the former 1989 regulations (Water Supply (Water Quality) Regulations, 1989).

It is considered upon further review that the EQS Values for Controlled Water as applied in the earlier Atkins 2017 CWDQRA, still remain appropriate for this site, and therefore have remained unchanged in the current Revision.

4.2 Soil Quality Assessment Methodology

In order to determine the potential impacts through leachability of the existing insitu Made Ground, derivation of Screening Values (expressed as mg/kg) was previously undertaken by Atkins for a range of determinands using the Environment Agency calculation provided in their Remedial Target Worksheet (Level 1 Soils), using, where possible, site specific data. These previously derived Screening Values have been retained and utilised as part of the current revised assessment. Details as to the methodology utilised are provided in the earlier Atkins 2017 CWDQRA Report, and it is recommended that this methodology employed be read in conjunction with the current Report.

4.3 Atkins Earlier Findings from July 2015 to September 2016

For greater detail of these findings, reference should be made here to the earlier Atkins 2017 CWDQRA Report. However, in brief summary:

4.3.1 Soils

From analyses of 243 (No.) samples of Made Ground recovered from unremediated stockpiles across the site, it was noted, upon comparison, that total concentrations of determinands (which included metals, petroleum hydrocarbons and PAHs), were found in many of these samples, to exceed their respective calculated Level 1 Soils Screening Values,

based upon application of the proposed site specific EQS Values for Controlled Waters. The full results are presented in Appendix B of the earlier Atkins 2017 CWDQRA Report.

4.3.2 Soil Leachates

114 (No.) soil leachates were also generated from samples of Made Ground recovered. It was noted that upon analyses for an appropriate suite of inorganic determinands (mainly metals), and upon comparison with the proposed site specific EQS values, that a number of these (particularly chromium, copper and vanadium), were also found in many of these samples to exceed the respective EQS values. The full results are presented in Appendix B of the earlier Atkins 2017 CWDQRA Report.

4.3.3 Groundwater Samples

Concentrations of a range of metal determinands, consistent with the former usage of the site in the metal production industry, were also analysed in shallow and deep groundwater samples recovered from boreholes installed across the site. The full results are presented in Appendix C of the earlier Atkins 2017 CWSQRA Report. In view of the relative degree of hydraulic isolation of the shallow and deep groundwater horizons present across the site, these findings were considered separately.

4.3.3.1 Shallow Groundwater Horizon Samples

These samples were considered to be representative of groundwater in contact with existing Made Ground present on the site.

A total of 68 (No.) samples were recovered from the shallow groundwater within the Made Ground across 24 locations during May, June and July 2016 based upon a specification presented in an earlier monitoring strategy (Atkins, 2016a). The WQS standards adopted for groundwater quality screening are as outlined in Section 4.1 of the Atkins 2017 CWDQRA Report, and a summary of exceedances is presented in Table 4-3 of the same Report as it was determined that the LoD (limit of detection) was greater than or equal to the WQS for many of the determinands, for screening purposes exceedances were only considered for samples where analytical results were found to be above the LoD.

It was noted that, as expected, the determinands in exceedance of the WQS in the soil samples (consistent with those associated with the metal production industry (DOE, 1995)) are also reflected in the results of analyses of the shallow groundwater samples.

A review and discussion of the results of analyses of shallow groundwater samples is presented below, together with consideration of the results of more recent (post 2017) monitoring and analyses.

4.3.3.2 Deep Groundwater Horizon Samples

A total of 138 (No.) samples were recovered from the deep groundwater within the Tidal Flat Deposits and underlying Mudstone across 47 locations during May, June and July 2016 based upon a specification presented in an earlier monitoring strategy (Atkins, 2016a). Again, as the LoD was greater than or equal to the WQS for many of the determinands, for screening purposes exceedances were only considered for samples above the LoD. A summary of WQS exceedances is presented in Table 4-4 of the Atkins 2017 CWDQRA Report.

4.3.4 Surface Water Quality

It was indicated that surface water quality data was collected monthly from the reens and ponds onsite based upon a specification presented in an earlier monitoring strategy (Atkins, 2016a). A total of 104 (no.) samples were collected from June to November 2016 and were screened as outlined in Section 4.1 of the Atkins 2017 CWDQRA Report. Again, as the LoD was greater than or equal to the WQS for many of the determinands, for screening purposes exceedances were only considered for samples above the LoD.

4.3.4.1 Onsite Surface Water Quality

Of the 104 (No.) samples, 94 (No.) were from onsite. The determinands detected above the WQS within the onsite surface water samples were considered to be broadly consistent with those identified within the soil samples (Table 4-1 of the Atkins 2017 CWDQRA Report). Cyanide, iron, manganese, SVOC and VOCs were in exceedance of the WQS in the surface water, however they were not tested for in the soil samples, so a comparison may not be made.

Upon further review of the results obtained, it may be noted that:

- 67% exceeded the ammoniacal nitrogen WQS;
- 6% exceeded the total cyanide WQS;
- 4.3% samples exceeded the copper WQS, where bioavailable copper is considered only;
- 5.4% exceeded the vanadium WQS;
- 6.5% exceeded the nickel WQS.

4.3.4.2. Monks' Ditch Surface Water Quality

Of the 104 (No.) samples recovered, 10 (No.) were from the Monks' Ditch monitoring locations (MD-N and MD-S). The exceedances of the WQS present within Monks' Ditch were presented in Table 4-6 of the Atkins 2017 CWDQRA Report. It was indicated that the exceedances reported were spread across all samples and collection dates. As the Monks' Ditch is understood to be hydraulically isolated as it flows through the Glan Llyn Llanwern Site, then assuming that this is the case, then it may be inferred that where elevated concentrations of contaminant determinands are recorded, then these are likely to have originated from an offsite up-gradient/up-flow source.

4.4 Assessment of Data from 2017 Onwards

4.4.1 Soils

Subsequent soils analyses have been undertaken on samples recovered from across the site, over a period from 01/05/17 to 03/04/19, with a total number of 1806 (No.) samples being analysed. The results of analyses are provided in **Appendix E** of the current Report. Details of specific areas of the site where these samples have been recovered are presented in **Appendix F** of the current Report. From analyses of 1806 (No.) samples of Made Ground recovered from unremediated ground across the site, it may be noted again, upon comparison, that total concentrations of determinands (which included metals, petroleum hydrocarbons and PAHs), may be found in many of these samples, to exceed their respective calculated Level 1 Soils Screening Values, based upon application of the proposed site specific WQS Values for Controlled Waters.

4.4.2 Soil Leachates

Subsequent soil leachate analyses have been undertaken on samples recovered from across the site, over a period from 01/06/18 to 11/04/19, with a total number of 1121 (No.) samples being analysed for metals. The results of analyses are provided in **Appendix G** of the current Report. Details of specific areas of the site where these samples have been recovered are presented in **Appendix F**. It was noted that upon comparison of metals results with the proposed site specific WQS values, that a number of these, again, particularly; arsenic, chromium, copper, vanadium and to a lesser extent; lead and zinc, were also found in a significant number of these samples to exceed their respective WQS values. It should be recognised, however, that the laboratory preparation of leachate samples produces results which will tend to be conservative and of limited relevance where shallow surface water quality results are available (as in the case of this site), for comparison purposes.

However, it is noted that of the samples analysed:

- 83% exceeded the arsenic WQS;
- 54% exceeded the chromium WQS;
- 86% exceeded the copper WQS;
- 66% exceeded the nickel WQS;
- 76% exceeded the selenium WQS;
- 92% exceeded the vanadium WQS;
- 42% exceeded the lead WQS;
- 66% exceeded the zinc WQS;
- A low to very low number of exceedances for BTEX VOCs were recorded;
- No samples exceeded the respective WQS values for PAHs;
- No samples exceeded the respective WQS values for TPHs.

4.4.3 Groundwater

No additional groundwater monitoring samples have been recovered.

4.4.4 Surface Water Quality

4.4.4.1 Onsite Surface Water Quality

A further significant volume of additional data has been obtained from monitoring of the quality of surface waters across the site, with a total number of 998 samples being recovered over a period from 06/03/2018 to 30/04/19. The results of analyses are provided in **Appendix H** of the current Report. It is noted that of the samples analysed:

- 63% exceeded the ammoniacal nitrogen WQS;
- 3.4% exceed the free cyanide WQS;
- No samples exceeded the copper WQS where bioavailable copper is considered only;
- 25.5% exceeded the vanadium WQS
- No samples exceeded the nickel WQS where bioavailable nickel is considered only;
- 4.3% of samples exceeded the TPH WQS;
- 90% of samples exceeded their WQS for a range of PAHs.

4.4.4.2 Monks' Ditch Surface Water Quality

Of the 104 (No.) samples taken, 48 (No.) were from the Monks' Ditch monitoring locations (MD-N and MD-S). The flow direction is from MD-N to MD-S, in a southerly direction.

It may be noted that for the MD-N location:

- 16% exceeded the ammoniacal nitrogen WQS;
- 4% exceeded the aliphatic TPH (C₂₁-C₃₅ aliphatic carbon chain) WQS;
- 88% of samples exceeded their WQS for a range of PAHs;
- Exceedances were noted for a range of metals in unfiltered samples, but did not exceed their respective WQS in filtered samples and corrected for bioavailability;
- pH values recorded ranged between 7.80 and 8.24 and were within the proposed WQS range.

It may be noted that for the MD-S location:

- 39% exceeded the ammoniacal nitrogen WQS;
- 83% of samples exceeded their WQS for a range of PAHs;
- Exceedances were noted for a range of metals in unfiltered samples, but did not exceed their respective WQS in filtered samples and corrected for bioavailability;
- 22% of samples exceeded the proposed WQS range for pH. Values recorded ranged between 7.54 and 9.68.

4.5. Discussion of Results

4.5.1 Surface Waters

4.5.1.1 Inorganics

Compared to earlier data, there appears to be a significant increase in the number of surface water samples analysed which exceed the vanadium WQS concentration. It is known that

vanadium becomes concentrated (between 2-3% mass) in BOF- (basic oxygen furnace slag). This is considered likely to be the vanadium source (particularly vanadium dicalcium silicate phases), with vanadium leaching out into surface waters, as the slag weathers. Vanadium concentrations were noted to be particularly elevated in surface water samples recovered from position R4C, and to extent in R1C. Vanadium concentrations appear to become more diluted/attenuated as surface water drains towards Surface Water Pumping Station No. 2. However it appears that the vanadium precipitates out, as pH values tend to lower (become more neutral) and some incorporation with iron oxyhydroxides (particularly goethite) which are another slag weathering by-product takes place.

There appears to be no obvious increase or decrease in recorded concentrations of metal determinands within upstream reens and positions downstream within the Kings Wall Reen. However, cyanide concentrations appear to increase downstream within the reen system, possibly as leached contributions are made from deposited wastes associated with the former coking works located within the northern central section of the site. However, there is evidence for decrease again in cyanide concentrations, further downstream, potentially due to complexation with metals such as iron and nickel, particularly in the higher pH conditions which are likely to prevail. There is also noted to be evidence of a possible contribution here from ammoniacal liquors associated with the former coking works.

When iron concentrations are compared, it may be noted that in post 2017 samples analysed, only 0.5% of the samples exceeded WQS values for filtered samples whilst 22% exceeded the WQS in unfiltered samples. This suggests that iron is flocculating/precipitating out as the leached solution becomes more oxygenated. Within the reens, this iron precipitation as an oxi-hydroxide is likely to take place contemporaneously with the dissolved vanadium.

When compared with earlier results obtained by Atkins prior to 2017, the number of WQS exceedance for concentrations of ammoniacal nitrogen remain largely unchanged (63% exceeding WQS) in post-2017 data, although some concentration values were found to be more elevated in recently obtained surface water samples.

The number of WQS exceedances for cyanide in post-2017 data appear comparable to those obtained by Atkins pre-2017.

4.5.1.2 Organics

Although there are a slightly higher proportion of surface water samples recovered from across the site, more generally, that exceed the WQS for PAH concentration (over 90.58% exceed the WQS for fluoranthene), it is also noted that for water samples recovered from the Monks' Ditch, which is understood to be hydraulically isolated from the Glan Llyn Llanwern site, PAH (again; fluoranthene) exceedance of the WQS in up to 88.0% of the samples (Monks' Ditch North MD-N) and 82.6% of samples (Monks' Ditch South MD-S) was noted. The source of these slightly elevated PAH concentrations determined in the Monks' Ditch is unclear, although again, it suggests the presence of an upstream off-site contributing source.

There appears to be no discernible reduction in PAH concentrations generally when comparing the earlier and post-2017 surface water analytical results.

TPH concentrations were exceeded in 4.3% of surface water samples recovered from across the site. These findings are considered to be consistent with TPH impact from isolated hotspots within the Made Ground.

4.5.2 Groundwaters

4.5.2.1 Inorganics

The following discussion is largely taken from the Atkins 2017 CWDQRA Report and updated, as considered appropriate. Consistent with soil leachate samples, elevations of pH are greatest in the shallow groundwater, with an average of 9.6, and 49% of samples greater than the WQS range of 6-9. In comparison pH values in the deep groundwater are lower; the reported average is 8, and less than 9% of samples are in exceedance. The elevated pH in shallow groundwater samples as compared to deep groundwater samples is likely to be attributable to impacts from weathering of BOF slag, whilst the pH of deeper groundwater samples can be influenced by oxidation of sulphidic minerals which will lower the pH of groundwater in contact with these minerals. However, in this case where an average pH of 8 is reported, the findings would suggest an absence of evidence for impact from weathering BOF slag or significant impact from sulphide oxidation.

Copper, lead, nickel and selenium are present at higher concentrations and produce more exceedances of the WQS within the shallow groundwater. Concentrations of vanadium are also found to be much greater in shallow groundwater; the maximum shallow groundwater value is 485 mg/l (WQS exceedance in 28% of samples) in comparison to the deep groundwater maximum of 157 mg/l (WQS exceedance in 7% of samples). Again, the elevated vanadium concentrations are likely to be attributable to weathering of the BOF slag, which may also be impacting on concentrations of copper, lead, nickel and selenium in shallow groundwater, as compared to the deeper groundwater samples recovered where slag weathering by-products are less likely to impact.

Concentrations of ammoniacal nitrogen are reduced by half in the shallow groundwater in comparison to the deep. Atkins (2015a) suggested that the lower ammoniacal nitrogen concentrations present in the shallow groundwater are the result of upward leakage and that the direction of the groundwater flow from the north west indicates that the elevated concentrations of ammoniacal nitrogen are more likely to be from an off-site diffuse source, such as from infiltrated runoff from agricultural activities.

Maximum and average concentrations of dissolved arsenic are considerably higher in the deep groundwater (220 µg/l and 32.1 µg/l respectively) than in the shallow (40.5 µg/l and 9.2 µg/l respectively). Similarly for total arsenic, 13% of the deep samples but only 3% of shallow samples are in exceedance of the WQS (50 µg/l). Concentrations of iron, cadmium, chromium, manganese are also elevated within the deep groundwater in comparison to the

shallow. The lower concentrations of these metals determined in surface water samples as compared to deeper samples may be due in part to greater dilution of the surface groundwaters, as the results of soil leachate analyses suggests that Made Ground across the site are likely to contain significant leachable concentrations of these metals.

4.5.2.2 Organics

The majority of TPH samples in both shallow and deep groundwater are reported below the LoD, however a few boreholes are proven to be hot spots for TPH contamination. Maximum concentrations of TPH are up to two orders of magnitude greater in shallow groundwater in comparison to deep groundwater. In shallow groundwater, TPH in exceedance of the WQS are limited to less than 15% of the total sample population for each exceeding contaminant. The samples reported in exceedance during the May 2016 sampling round are distributed across nine locations, however samples in the June and July rounds exceeding for three or more contaminants are limited to locations CWS-04, CWS-19 and CWS-11.

In deep groundwater, TPH in exceedance of the WQS are limited to less than 5% of the total sample population for each exceeding contaminant with the exception of aromatic >EC21-EC35 (16.7%). Sample locations with exceedances of two or more TPH in a single sample are locations CBBH04, CBBH05, CWCP- 04, CWCP-19 and CWCP-11.

PAHs are present in both the shallow and deep groundwater; concentrations of contaminants and frequency of exceedances are greater in the shallow groundwater. As for TPH, maximum concentrations within the shallow groundwater are up to two orders of magnitude larger than in the deep. Exceedances are widespread within the shallow groundwater, with a percentage of samples exceeding up to 69%; within deep groundwater exceedances are limited to 14%, with the exception of fluoranthene (29%) and benzo(a)pyrene (28%).

Exceedances of SVOCs and VOCs above the LoD are limited, and remain below 9% of the shallow groundwater and 2.2% of the deep groundwater total sample population for each contaminant.

A wide range of contaminants are found to exceed the WQS in both the shallow and deep groundwater. However, the chemical signatures of each aquifer unit are distinct and the greatest concentrations and percentages of exceedances are not simply attributed to the shallow groundwater. It is possible that due to the fluctuating upwards and downwards gradients across the site as presented in Section 2.4.2 (Table 2-4) groundwater from either unit may be influencing the other. For example, where deep groundwater levels are lower than shallow, downward migration of water into the Tidal Flat Deposits is possible. Atkins (2015a) calculated that the un-retarded breakthrough of shallow groundwater through the Tidal Flat Deposits is likely to be 9 years. Taking into account conservative partition coefficients for naphthalene (a mobile PAH) and cadmium, the retarded breakthrough of naphthalene and cadmium is likely to be 644 and 1,435 years, respectively. Considering this,

it is unlikely that the contamination identified within the deep groundwater originated within the made ground.

5.0 Detailed Quantitative Risk Assessment and Re-use Assessment

5.1. Overview

It was indicated in the earlier Atkins 2017 CWDQRA Report, that the purpose of this assessment was to define, for a set of potential contaminants, the maximum concentration in the soil that does not pose a risk to the Controlled Waters receptor (re-use criteria). Where site soil concentrations, for one or more contaminants are greater than the re-use criteria, then in the absence of soil remediation or water treatment prior to discharge, a risk to Controlled Waters may exist.

5.1.1. Contaminants of Concern

Based on the site contamination status and known contaminants associated with steelworks (DoE, 1995), calculation of re-use criteria are to be undertaken for the Contaminants of Concern (CoCs) outlined in below. The current contamination status of the site is outlined above in Section 4; the assessment highlighted several metals, TPH and PAH that exceed the appropriate criteria. This essentially remains unchanged for the updated assessment.

Table 5-1: Contaminants of Concern (COCs)

Compound Type	Compounds
Heavy Metals/Metalloids	Arsenic, cadmium, chromium, copper, iron, lead, vanadium, manganese, mercury, nickel, selenium, zinc.
Other Inorganics	Ammoniacal nitrogen, cyanide.
Organics	Ethylbenzene, xylene, PCB, phenol.
TPH Bands	TPH aliphatic >C5-C6, TPH aliphatic >C6-C8, TPH aliphatic >C8-C10, TPH aliphatic >C10-C12, TPH aliphatic >C12-C16, TPH aliphatic >C16-C21, TPH aliphatic >C21-C35, TPH aliphatic >C35-C44, TPH aromatic >C5-C7 (Benzene), TPH aromatic >C7-C8 (Toluene), TPH aromatic >C8-C10, TPH aromatic >C10-C12, TPH aromatic >C12-C16, TPH aromatic >C16-C21, TPH aromatic >C21-C35, TPH aromatic >C35-C44, TPH Aromatic >C40-C44.
PAHs	Acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, di-benz(a,h)anthracene, indeno(1,2,3-cd)pyrene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene.

5.1.2. Compliance Point

In order to be protective of the Controlled Waters receptor outlined in Section 4.5, determination of the site specific compliance point has been undertaken in general accordance with the RTM (Environment Agency, 2006). The compliance point has been assigned to the point of discharge into the receptor (Monks' Ditch). Consistent with the contamination data assessment (Section 4), the WQS (Water Quality Standards) have been

set at the EQS in order to be protective of the principal Controlled Waters receptor (Section 4.1).

5.2. Dilution Assessment

5.2.1. Rationale

It was previously indicated that in order to maintain discharge of EQS compliant waters into the Controlled Waters receptor (Monks' Ditch), concentrations within the reens must be retained at or below the EQS. Due to the anthropogenic controls on discharges of water from the on-site reens to Monks' Ditch, in order to calculate the maximum concentration allowable for each contaminant within the excavated and re-compacted Made Ground (re-use criteria) the average annual water balance for the entire site is applied. This is considered appropriate given that EQS values are in relation to the annual average concentration.

Shallow groundwater is known to originate from infiltrating precipitation only, as the Made Ground of the site is hydraulically contained (Section 2.4.2). The remainder of the precipitation is either lost to evapotranspiration/evaporation or constitutes surface water runoff, and is diverted directly to the onsite drainage reens by SuDS (Section 2.5.1). Therefore, contaminant concentrations present in the shallow groundwater within the Made Ground are subject to dilution within the reens by clean SuDS drainage. As outlined in Section 2.3.3, the proportion of proposed impermeable to permeable surface area differs between the residential area and the Celtic Business Park commercial area. Resultantly, individual re-use criteria values were previously produced for each contaminant (Table 5-4 of Atkins 2017 CWDQRA Report), within each development area due to the differing volumes of water available for dilution.

As indicated in the current Introduction, the earlier CWDQRA prepared by Atkins (Version: 3 and dated February 2017), was issued with the intention that, as further site specific information was collected, the assessment would be reviewed and updated. It was described as the starting point and that the re-use criteria generated were understood to be conservative. An assumption was also made that 100% of the infiltrated rainwater percolated through the construction material and in to the Made Ground.

Since preparation of the Atkins 2017 CWDQRA Report, further consideration has been given (Rodgers Leask Environmental Ltd - Reclamation Performance Specification A – Turnover – Technical Note, dated 14/12/18, Ref: 17480-RLE-18-XX-RP-O-1016), to the pre-construction reclamation methodology to be employed across the site. The particle size distribution of the Made Ground is known to be well graded, and when compacted, the permeability is assessed as having poor drainage potential, with when appropriately placed, expected values in the region of 10^{-7} m/s.

Consideration has also been given to the application of differing standards of compaction of the Made Ground, and as a result, alteration of the rates of incident water infiltration. In order to consider the impacts of reducing infiltration rates into the Made Ground (impacts of which are likely to be greatest in areas of the site proposed for residential reusage where greater areas of soft landscaping will be present), two modelling scenarios have been considered in comparison with the Atkins previously assumed 100% infiltration into the underlying Made Ground. These models assume a greater proportion of incident rainwater

being directed laterally within the clean surface soils and 6F2 granular blanket, towards the reens. On this basis, the assumption is made that these redirected waters remain uncontaminated and provide further dilution of the waters passing through the Made Ground and ultimately discharging into the reens. In order to provide values which are likely to be 'typical' and 'potentially achievable', the following scenarios (details of which are outlined in Section 1.2 above), have been considered:

1. A 40% infiltration rate into underlying Made Ground which should be easily achievable;
2. A 5% infiltration rate into underlying Made Ground which, it is considered may be potentially achievable.

5.2.2. Methodology

The methodology employed in the current updated CWDQRA is that utilised previously by Atkins in their 2017 CWDQRA. The maximum (annual average) contaminant concentration possible within the perched groundwater in the Made Ground is calculated using dilution within the reens onsite as per Equations 3 to 7 below, whilst retaining concentrations at the EQS. Again, no allowance has been made for dilution of discharged water within Monks' Ditch as part of this calculation, as this being the receptor, it is proposed that the WSQ in this Controlled Water be maintained (as far as possible) at EQS values.

A summary of the methodology is provided below:

$$EQS = (C_{gw} + Q_{gw})/Q_r \quad \text{Equation 3}$$

$$C_{gw} = (EQS \times Q_r)/Q_{gw} \quad \text{Equation 4}$$

- Where:
 - EQS (mg/l) = Environmental Quality Standard
 - C_{gw} (mg/l) = annual average groundwater contaminant concentration
 - Q_{gw} (m³/a) = groundwater flow
 - Q_r (m³/a) = reen flow

$$Q_r = Q_{gw} + Q_{ol} + (RO \times \text{permeable surface area}) \quad \text{Equation 5}$$

$$Q_{gw} = (R - ET - RO) \times \text{permeable surface area} \quad \text{Equation 6}$$

$$Q_{ol} = (R - E) \times \text{impermeable surface area} \quad \text{Equation 7}$$

- Where:
 - R (mm/a) = total annual rainfall
 - E (mm/a) = evaporation
 - RO (mm/a) = runoff

The calculated annual average groundwater contaminant concentration C_{gw} (mg/l) values have been converted to Made Ground solid C_{mg} (mg/kg) values using Equation 8.

$$C_{mg} = C_{gw} \times ((K_d + (\theta_w + \theta_a \times H))/P_c) \quad \text{Equation 8}$$

- Where:
 - C_{mg} (mg/kg) = annual average Made Ground (solid) concentration
 - K_d (l/kg) = contaminant partition coefficient
 - θ_w (-) = water filled porosity
 - θ_a (-) = air filled porosity
 - H (-) = Henry's law constant
 - P_c (g/cm³) = soil bulk density

5.2.3. Parameterisation

A summary of key input parameters is presented in Table 5-2 and Table 5-3 below. The full chemical input parameters and justifications are included in **Appendix I** of the current Report.

Table 5-2: Physical Parameters

Parameter	Unit	Value	Comment/Justification/Source
Average Annual Rainfall	mm/a	953	MAFF, 1976
Evapotranspiration	mm/a	416	MAFF, 1976. Applicable to permeable areas
Evaporation	%	10	Grimmond & Oke, 1999. Evaporation from impermeable surface area as a percentage of total rainfall.
Runoff coefficient	%	55	National Coal Board, 1982 (See Figure E-1)
Residential Permeable Area	m ²	676,000	Rodgers Leask, 2016
Residential Impermeable Area	m ²	1,014,000	Rodgers Leask, 2016
Commercial Permeable Area	m ²	45,000	Rodgers Leask, 2016
Commercial Impermeable Area	m ²	405,000	Rodgers Leask, 2016

Table 5-3 Chemical Parameters

Parameter	Abbreviation	Unit	Value	Comment/Justification/Source
Fraction of Organic Carbon	foc	fraction	0.024	Site specific value - average foc from 243 samples of Made Ground
Air Filled Porosity	θ _a	fraction	0.0037	Site specific value – average θ _a from 3 samples of Made Ground
Water Filled Porosity	θ _w	fraction	0.5	Site specific value – average θ _w from 3 samples of Made Ground
Dry Bulk Density	P _c	g/cm ³	1.36	Site specific value – average P _c from 3 samples of Made Ground

5.2.4. Assumptions and Limitations

The following assumptions and limitations are inherent within the modelling undertaken:

- Dilution calculations produce maximum likely average concentrations of contaminants (re-use criteria) within the Made Ground;
- Dilution methodology does not account for any dilution within Monks' Ditch at the point of discharge;
- Incident infiltrating rainwater is considered to flow laterally through the capping drainage layer, with varying proportions entering the underlying Made Ground. A 5% infiltration and a 40% infiltration rate into the underlying Made Ground have been modelled;
- No infiltration is assumed to occur within the impermeable area;
- Limited retardation (degradation and/or sorption) of contaminants within the Made Ground is considered given the extensive area of potential source materials across the site;
- Dilution calculations assume simultaneous discharge of the annual volume of surface water runoff and infiltrated water, providing a worst case volume of potentially contaminated shallow groundwater;

- No allowance has been made for additional dilution as a result of inflows to the reengineered system from the land to the north, as it is understood that these flows are minimal;
- The site geology and hydrogeology are assumed to be homogeneous, and parameter values and contaminant concentrations used are based on site-specific data, where available;
- Where no site-specific data are available, literature sources have been used to develop suitable parameters considered likely to reflect site conditions;
- Made Ground geology by its very nature is likely to be both laterally and vertically variable following finalisation of site development;
- Data presented by third parties has been incorporated into this report. These data have been assumed to be correct for the purposes of this assessment; and
- This assessment has been made considerate of the proposed post-development ground conditions and cover. Should this change, then the site may require re-assessment.
- It should be noted that the assessment undertaken herein and re-use criteria is for protection of Controlled Waters only. The re-use criteria derived are not necessarily protective of risk to Human Health. Re-used materials must also be geotechnically suitable, however this has not been considered as part of this assessment.

5.2.5. Material Re-use Criteria

The calculated maximum concentration of each PCOC (Re-use Criteria) in Made Ground (mg/kg) based upon the two scenarios of a 40% infiltration rate into underlying Made Ground and a 5% infiltration rate into underlying Made Ground are presented in Table 5.4 (**Appendix J**) of the current Report.

The updated results have been formatted to allow direct comparison with the earlier derived Atkins re-use criteria where 100% infiltration rate into underlying Made Ground has been assumed.

The calculated re-use criteria specified are intended to be protective of the Controlled Waters receptor with regard to the post-development site, and will, compared to earlier derived values, facilitate the greater re-use of existing on-site Made Ground in general accordance with a Remediation Strategy (Section 6.2). As previously indicated, it should be noted that re-use criteria do not apply where there is evidence of contamination in soil or Made Ground in excess of solubility (i.e. free phase product)

5.3 Contaminant Attenuation Assessment

It may be noted from Table 5.4 (**Appendix J**) that assuming only a 5% infiltration of incident rainwater into reengineered Made Ground, there remain exceedances of the respective re-use criteria in both residential and commercial redevelopment scenarios, for manganese (within a residential area reusage only) but particularly for a number of PAH species within both commercial and residential reusage areas.

Given that it is proposed within the reengineered Made Ground, to achieve a permeability of approximately 1×10^{-7} m/s, then it is considered that, particularly where organic CoC are considered (such as PAHs), that there is a potential for consideration of attenuation through processes of degradation/biodegradation of these leached species within the Made Ground

in view of their likely significant residence time prior to discharge into a local surface water reën.

However, given that the extent of these residual contaminant sources are likely to be of widespread (albeit variable contribution) presence within the reengineered Made Ground, then the potential for attenuation of these contaminants within the Made Ground between their source and the designated receptor (surface water reën) will be compromised. This needs to be appreciated within the further assessment undertaken, as outlined below:

5.3.1 EA Remedial Target Worksheet (Level 3 Groundwater) Assessment

In order to further consider the potential for attenuation of the residual contaminants within the Made Ground, this has been undertaken using the Environment Agency calculations provided in their Remedial Target Worksheet (Level 3 Groundwater) using, where possible, site specific data, as indicated below:

Table 5.3.1: Site Specific Data Sources Utilised in RT Worksheet Level 3 Groundwater Assessment

Variable	Value Utilised	Data Source
Width of aquifer at source	500m	Site measurements and likely width of each separate redevelopment perpendicular to directed perched groundwater flow towards appropriate reën.
Plume thickness at source	2.0m	Based upon proposed thickness of reengineered Made Ground and assumption that full thickness of Made Ground represents potential contaminant source
Saturated aquifer thickness	1.5m	Based upon typical likely groundwater levels in reengineered Made Ground.
Bulk Density of aquifer materials	1.36g/cm ³	Site specific test data
Effective Porosity of aquifer	0.08	Site specific test data
Hydraulic Gradient	0.0133	Estimation - also based upon earlier estimation used by Atkins
Hydraulic Conductivity of aquifer	8.64E-03m/d (1.0E-7m/s)	Based upon proposed permeability to be achieved following turning and reengineering of Made Ground
Distance to Compliance Point	20m	Assumed to be typical distance to surface water reën. However further dilution of contaminants will take place in reëns from uncontaminated runoff from redevelopment

Using site-derived soil analyses concentration data for a range of determinands taken from 2017 onwards, maximum derived concentrations (mg/kg) in each case were then utilised for the modelled determinands. These data were then input into the equation presented in the EA Table 5.2 – soil-water partitioning of the EA Remedial Targets Methodology Guidance (2006) and a pore-water concentration C_p was determined. Soil/water partition coefficient (K_d) values utilised were site specific, and derived from those generated by Atkins (Table E4 of the Llanwern Controlled Waters Detailed Quantitative Risk Assessment Version 3.0 (February 2017)).

Consideration has also been given as to the application in the Level 3 Groundwater Remedial Target Calculation of applying ‘degradation of organics in all phases’ or whether a ‘dissolved

pollutants only' variable should be applied. It is considered that there are likely to be different degradation rates for dissolved phase and free product. Evidence for choosing an 'all phases' variable was based upon:

- Site observations made on 09/05/19, where it was noted that hydrocarbon free-product was also present on water surface within some of the recent excavations, albeit mainly as surface iridescence, (together with probable dissolved phase). Therefore, there was considered to be evidence for the presence in site soils of hydrocarbons in both dissolved (laboratory evidence) and free-phase (site observations).
- Given in this instance that the scenario being considered is near surface degradation and biodegradation, then oxidation and volatilisation are likely to be fairly important means of loss of both free-product and dissolved phase, and will probably encourage a faster rate of degradation than would be likely at greater depth within a more anaerobic/less oxygenated environment. However, it has been noted that 'applying degradation rate to dissolved pollutants only' appears to add more conservativity to the model, so it has been proposed to utilise this variable.

The calculated pore-water value was then considered to be representative of the initial contaminant concentration in groundwater at the plume core, and utilised in the Level 3 Groundwater Remedial Target Calculation, as provided in the Excel Worksheets accompanying the current CWDQRA Report revision Draft.

The selected determinands chosen for modelling were from within (but not all) of those where soil concentrations were found from chemical analyses carried out to continue to exceed the calculated 5% and 40% infiltration scenarios reuse criteria. These determinands included metals: iron, manganese and vanadium and PAHs, benzo(a)pyrene, benzo(b)fluoranthene and naphthalene.

In the case of the Remedial Target modelling carried out to date, no specific consideration of 5% and 40% infiltration scenarios has taken place, and the assessment was carried out essentially to gauge the potential extent of attenuation of these specific determinands within the ground where these soils may be placed, with receiving surface waters being assumed to be existing reens, which have been taken as the Compliance Points. For initial calculation purposes, it has been assumed that compliant material proposed to be reused, would be placed no nearer than 20m from these reens.

It is proposed that the calculations may be revisited and updated, should it be considered appropriate, as more detailed information becomes available on the proposed site redevelopment layout.

Calculated values for Contaminants of Concern (CoC), as derived using the Level 3 Groundwater Excel Worksheets, are provided in **Appendix K** to the current Report. Where determined maximum soil concentrations exceed the calculated 40% and 5% infiltration reuse criteria, the initial contaminant porewater concentration in groundwater is

calculated based upon the maximum soil concentration recorded for each determinand, utilising the Equation provided in Table 5.2 of the EA Remedial Targets Methodology Guidance. In order to consider the impact of different concentrations of the above determinands, these scenarios have also been modelled using average porewater concentrations (calculated from average soil concentrations) utilising the Equation provided in Table 5.2 of the EA Remedial Targets Methodology Guidance. Copies of the associated Excel spreadsheets modelled for these same determinands and based upon average porewater concentrations are also provided in **Appendix K**.

As indicated above, in selecting the specific determinands for modelling, Level 3 Groundwater calculations have been carried out for a representative range of PAHs and metals, as actual concentrations of these have been found from analyses of site soils to exceed the calculated 40% and 5% infiltration reuse criteria, rather than only considering contaminants currently determined in the reens which are found to exceed the proposed EQS Values. The reasoning for this is based upon the rationale that existing water quality within the reens may not necessarily be representative of the water quality following excavation and replacement of this Made Ground prior to redevelopment. However existing surface water quality has been considered when assessing which determinands to model, and it was not considered appropriate to model ammoniacal nitrogen attenuation, as in a number of cases, exceedances were noted for this determinand in incoming off-site surface waters (as indicated above). It also appeared that cyanide concentrations deplete during flow through the reens, potentially due to complexation with metals such as iron and nickel, particularly in the higher pH conditions which are likely to prevail initially.

For this exercise, the modelling has therefore included the following determinands, with iron, manganese and vanadium being considered representative of metal behaviour and benzo(a)pyrene, benzo(b)fluoranthene and naphthalene of PAHs :

- Benzo(a)pyrene –
- Benzo(b)fluoranthene
- Naphthalene
- Iron
- Manganese
- Vanadium

Discussion of Findings

PAHs

As indicated above, the PAHs modelled have included benzo(a)pyrene, benzo(b)fluoranthene and naphthalene.

Although naphthalene concentrations in some site soils were found to be elevated in concentration, this PAH is readily attenuated, probably mostly through processes of volatilisation and aerobic biodegradation as indicated in the Level 3 Groundwater Excel Worksheets, (**Appendix K**) to the current Report.

It may be noted that the PAHs determined in surface water and shallow groundwater samples recovered, which were found to be most significantly elevated, have included fluoranthene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, Benzo(g,h,i)perylene and Indeno(1,2,3-cd)pyrene, this is consistent with many of the PAH

determinands found to exceed the calculated reuse criteria. This suggests that significant leaching of these PAHs into the perched groundwater and subsequently into the receiving surface water reens is currently taking place across the site, and from consideration of the Level 3 Groundwater Excel Worksheets, is likely to continue from re-engineered Made Ground assuming that all of the PAH concentrations determined in shallow groundwaters are dissolved rather than being present in all phases. Where the Level 3 Groundwater Excel Worksheets are modelled to 'apply the degradation rate to all phases', then there is significant attenuation of these PAHs, thereby suggesting that re-engineered Made Ground containing concentrations of these PAHs in excess (up to the maximum determined) of the soil reuse criteria (**Appendix J**) may be utilised. In reality, it is considered likely (as indicated above) that although attenuation is taking place, and some processes of volatilisation and aerobic oxidation are likely to be experienced, these processes are not significant enough to enable placement of soils with PAH concentrations in excess of the calculated reuse criteria (in 40% and 5% infiltrations scenarios) very close to the surface water reens.

Metals

It may be noted that based upon scenarios where the maximum iron (2390000mg/kg), manganese (408000mg/kg) and vanadium (2880mg/kg) concentrations determined in samples of Made Ground at the site are present, then soils of this concentration and assuming a 5% and more especially a 40% infiltration of surface water following re-engineering and placement of this material show a potential to impact on the quality of a Compliance Point (taken as the nearest reen) located at a distance of approximately 20m away. Where these scenarios have also been modelled using average porewater concentrations (calculated from average soil concentrations for iron, manganese, vanadium), utilising the Equation provided in Table 5.2 of the EA Remedial Targets Methodology Guidance, it is noted that these soils also show, a potential to impact on the quality of a Compliance Point located at a distance of approximately 20m away.

5.4. DQRA Results

The re-use criteria presented in Table 5-4 (**Appendix J**) are compared to maximum and average concentrations of each determinand as recorded from the 1806 (No.) samples of Made Ground..

Earlier Atkins re-use criteria were calculated based upon the assumption that 100% of the rainwater incident upon areas of the site utilised for soft landscaping for both residential and commercial development penetrates into the underlying re-engineered Made Ground. As indicated above, re-use criteria have now been recalculated assuming a 5% and 40% rainwater infiltration into the re-engineering Made Ground. It is considered that these two infiltration values are likely to be more realistic of the redeveloped site following the undertaking of the Made Ground re-engineering works and the incorporation of measures to encourage infiltrating water to move laterally to the reens through a near-surface drainage blanket comprising clean materials.

In comparison with the calculated re-use criteria, the maximum soil sample concentrations continue to exhibit some exceedances (shown as highlighted, cells in Table 5-4 (**Appendix J**)), which are discussed below.

The calculated re-use criteria for the commercial area are greater than for the residential area as a result of the smaller infiltration to runoff ratio.

Inorganics

With reference to the Soil Re-use Criteria presented in Table 5.4, **(Appendix J)** it may be noted that:

Based upon an assumption of a 40% infiltration scenario:

Compared to calculated re-use criteria, exceedances for samples of Made Ground potentially for re-use in a residential scenario were determined for iron, manganese and vanadium, where maximum concentrations of these metals are considered. However, where average concentrations are considered, it may be noted that these values are found to be significantly lower than their respective calculated re-use criteria.

For a commercial re-use scenario, concentration exceedances for iron and manganese were determined. Where average concentrations are considered, it may be noted that all of these values are found to be significantly lower than their respective calculated re-use criteria.

Compared to calculated re-use criteria, significant exceedances were also noted for ammoniacal nitrogen and cyanide for a 40% infiltration in both residential and commercial materials reuse scenarios.

Based upon an assumption of a 5% infiltration scenario:

Compared to calculated re-use criteria, exceedances for samples of Made Ground potentially for re-use in a residential scenario were determined for manganese only, where maximum concentration of this metal are considered. Where average concentrations are considered, it may be noted that the average manganese soil concentration is significantly lower than the calculated re-use criteria for this metal.

For a commercial re-use scenario, with the exception of cyanide, no concentration exceedances were determined.

Compared to calculated re-use criteria, significant exceedances were noted for ammoniacal nitrogen and cyanide for a 5% infiltration in residential and cyanide only in commercial materials reuse scenarios.

Comparison with the more conservative 40% infiltration scenario for ammoniacal nitrogen Cgw for the commercial (510.69.75 mg/l) and residential areas (129.25 mg/l) with the maximum previously reported shallow groundwater concentration (66.1 mg/l) and more recently reported (post 2017) maximum surface water concentration (18.6mg/l) suggests however that these soils represent a low risk to the quality of Controlled Waters in terms of ammoniacal nitrogen contribution. Similarly with 40% infiltration scenario for iron and manganese, the maximum previously reported shallow groundwater concentrations (92 mg/l and 12 mg/l respectively) are lower than the Cgw for the commercial (1702.33mg/l and 209.39mg/l) and residential (430.85 mg/l and 52.99 mg/l) areas, again suggesting that these soils represent a low risk to the quality of Controlled Waters. For cyanide, a comparison (40% infiltration scenario) of the maximum previously reported shallow groundwater concentration (1.4 mg/l) with Cgw for the commercial (1.70.64 mg/l) and residential areas (0.43 mg/l) indicates an exceedance. However, average shallow groundwater concentrations (0.13 mg/l) are lower than the Cgw for both commercial and residential areas. The maximum surface water cyanide concentration recorded post-2017 was 0.28mg/l.

Organics

PAHs:

In the case of the highlighted PAH concentrations a selection of which have been further modelled using the EA RT Level 3 Groundwater Worksheets, it may be noted that the levels of exceedance (based upon maximum determined soil concentrations of these specific PAHs, in both 5% and 40% infiltration scenarios), are likely to impact on the quality of water within the Compliance Point (nearest reen), assuming that this reen is at a distance of 20m from Made Ground. However, this modelling does not take account of processes of volatilisation, which may cause some further depletion in the leached PAH concentrations prior to discharge in surface water reens.

Phenols:

Compared to calculated re-use criteria for both 5% and 40% infiltration scenarios, no exceedances for phenols were determined. In addition, the maximum phenol concentration previously reported in shallow groundwater (0.83 mg/l) is compliant with the 5% and more conservative 40% infiltration scenarios Cgw for the commercial (13.10 mg/l) and residential areas (3.32.25 mg/l). As further comparison, a maximum phenol concentration of 0.04mg/l was determined in surface water samples recovered, post 2017.

Petroleum Hydrocarbons based upon an assumption of 40% infiltration scenario:

Exceedances of the re-use criteria are present for several TPH species with respect to the maximum soil concentration within the aromatic C₁₀-C₂₁ range for residential reusage and C₁₂-C₂₁ range for commercial reusage. However, where average concentrations are considered, it may be noted that these values are all found to be significantly lower than their respective calculated re-use criteria.

Petroleum Hydrocarbons based upon an assumption of 5% infiltration scenario:

No exceedances of the re-use criteria are determined for TPH species under a 5% infiltration scenario.

5.4.1. DQRA Discussion

The previous re-use criteria produced by Atkins and provided in their 2017 CWDQRA Report (Version: 3 and dated February 2017) were purposely presented as conservative values. A principal conservativity was indicated to be the dilution assessment assumption of a simultaneous discharge of the annual volume of surface water runoff and infiltrated water (Section 5.4). It was indicated that in actual fact, the infiltrated water is subject to storage within the Made Ground and travel times are anticipated to be elongated. Applying Darcy's Law ($q = Ki$ where K = hydraulic conductivity (m/s) and i = hydraulic gradient (-) (change in groundwater level/travel distance) and using a hydraulic conductivity 1×10^{-7} m/s, travel distance of 10 m and hydraulic gradient of 0.013 (assuming 2 m thick Made Ground is fully saturated), the un-retarded travel time within the Western Sub-Area is likely to be 238 years (at a flux of 0.04 m/year). With the current CWDQRA Revision, and additional assessment using EA P20 Level 3 Groundwater RT Worksheet modelling, these parameters have been incorporated and the re-engineered Made Ground has been predicted as presenting a hydraulic conductivity of 1×10^{-7} m/s.

The earlier assumption which has been shown to have significant impact on the value of the re-use criteria, has been the degree of infiltration of the incident water into the re-engineered Made Ground. The earlier Atkins assessment assumed that 100% of this water would penetrate into the Made Ground. However, given the proposed hydraulic conductivity (1×10^{-7} m/s) of this re-engineered material, and the introduction of an overlying 6F2 piling mat/drainage blanket (estimated permeability of 1×10^{-3} m/s) beneath clean imported topsoils and subsoils, then a significant proportion of this infiltrating water is considered unlikely to penetrate the re-engineered Made Ground. In order to further encourage lateral movement of this incident water toward the nearest reens prior to penetration into the underlying Made Ground, it has been proposed to create a shallow gradient across the surface of the Made Ground within the development plots sloping downwards towards the reens. On this basis, it has been estimated that water infiltration, rates, provided Made Ground re-engineering works are suitably undertaken, may potentially be reduced to 5% penetration.

It was previously indicated in the Atkins 2017 CWDQRA Report that maximum contaminant soil concentrations were present up to two orders of magnitude larger than the commercial area re-use criteria for several TPH and PAH. In view of this, it was proposed that the poorest quality Made Ground material would be relocated to beneath the commercial area, where infiltration is lowest. It was also indicated that where onsite concentrations are greater than the re-use criteria, remediation or disposal of material offsite may be required. The current revision of the re-use criteria has indicated that provided this material is appropriately re-engineered, then a greater proportion of existing Made Ground may potentially be re-used beneath sections of the site proposed for residential redevelopment. The results of additional EA P20 Level 3 Groundwater RT Worksheet modelling, has also suggested that material which contains concentrations of PAHs in excess of the re-use criteria (Table 5.4 (**Appendix J**)), may also (subject to verification) be suitable for placement across most areas of the site provided that a suitably thick buffer zone of uncontaminated materials is placed between the redeveloped plots and the surface water receptors (reens and ponds). Based upon EA P20 Level 3 Groundwater RT Worksheet modelling, it would appear necessary that the width of this buffer zone between this material and existing surface water reens, will need to be in excess of 20m and potentially closer to 200m. The nature of materials utilised in these buffer zones will need further consideration, in order to optimise the potential for biodegradation of organic contaminants, attenuation of dissolved metals and lowering of pH values prior to discharge of these waters into the reens, within which it is proposed to further encourage fauna and flora colonisation.

It was previously considered by Atkins that reported exceedances of the EQS in the onsite surface water samples are a reflection of the current site condition. This is considered to remain an important point with post-development conditions significantly reducing surface water infiltration by reducing the permeability of the Made Ground and increasing the impermeable surface area across the site, causing increased surface water runoff and subsequently, dilution within the reens. Concentrations of ammoniacal nitrogen released from Made Ground are considered likely to deplete over time in surface waters across the site as this component is leached from the residual sources associated with the former coking works. However, there are known to be other potential off-site sources (mainly agriculturally related), which will continue to impact on the quality particularly of the Monks' Ditch. However, surface water reens across the site which are hydraulically isolated from the main river Monk's Ditch but receive inflow from upstream off-site, surface waters

including agricultural land, may also be impacted by atmospheric contribution of ammoniacal nitrogen, again largely from agriculturally related sources.

As indicated above, fluids passing through the weathering BOF (basic oxygen furnace slag) which will be incorporated within the re-engineered Made Ground will potentially provide an ongoing source of dissolved metals and high pH discharge into the surface water reens. However, reducing the permeability of this Made Ground by reengineering, and placement of a greater proportion of impermeable surface cover following redevelopment should reduce contributions from the present (likely) worst case levels.

6. Conclusions and Recommendations

6.1. Conclusions

Rodgers Leask Environmental Ltd (RLE) has been commissioned by St Modwen Developments Ltd (St Modwen) to update and further develop a Controlled Waters Detailed Quantitative Risk Assessment (CWDQRA) of the potential risk to Controlled Waters for the Glan Llyn development at Llanwern, Newport. A Conceptual Site Model (CSM) for the site has been further developed and updated based on the contamination data assessment. Screening analysis of recent soil, soil leachate, groundwater and surface water data (revealed potential moderate to low levels of inorganic and organic contamination present onsite in line with contaminants associated with former steelworks sites (DoE, 1995). Made Ground constituting clayey sandy gravels with local slag, burnt shale, tarmac, concrete, brick and mudstone was found to be a potential source of contamination. Contaminants in the unsaturated zone and shallow groundwater attenuate along the transport pathway, including within the onsite drainage ditches (reens), where groundwater seepage combines with onsite water from the SuDS system before being discharged to the Controlled Waters receptor (Monks' Ditch).

There appears to be no obvious increase or decrease in recorded concentrations of metal determinands within upstream reens and positions downstream within the Kings Wall Reen. However, cyanide concentrations appear to increase downstream within the reen system, possibly as leached contributions are made from deposited wastes associated with the former coking works located within the northern central section of the site. However, there is evidence for decrease again in cyanide concentrations, further downstream, potentially due to complexation with metals such as iron and nickel, particularly in the higher pH (alkaline) conditions which are likely to prevail. There is also noted to be evidence of a possible contribution here from ammoniacal liquors associated with the former coking works, although pervasive slightly elevated concentrations of ammoniacal nitrogen have been recorded in surface waters more widely across the site, and from what appear to be sources upstream of the study site.

It is considered that following the undertaking specific remedial works within the area of the site previously occupied by the coking works, then this should have a positive impact on the reduction of ammoniacal and cyanide leachates which appear to be currently entering the surface water reen drainage system.

Calculation of conservative re-use criteria was undertaken using a dilution assessment methodology based on the site-wide water balance and has now incorporated permeability and infiltration parameters which it is considered are more representative of the redeveloped site. Comparison of re-use criteria against available information regarding the current composition of the Made Ground established that the much of Made Ground is likely to be suitable for re-use onsite, however localised source materials containing high concentration material (particularly elevated concentrations of iron, manganese and vanadium), and ammoniacal and cyanide components, may require remediation, or offsite disposal.

Where materials contain PAH concentrations in excess of the calculated reuse criteria for 40% and 5% infiltrations scenarios are to be used within areas of the site proposed for

residential and commercial reuse, then it concluded that this material should, as a precaution, be placed no closer than 150m-200m from the surface water reens into which infiltrated waters are likely to discharge and materials placed within the 'buffer zone' be engineered to provide a dissolved hydrocarbons and metals (principally iron and manganese), attenuating capability.

6.2. Recommendations

The following recommendations are proposed based on the outcomes of the assessment:

- The current programme of long-term monthly surface water monitoring should be continued at the established current sampling locations to monitor the quality of the reen system during and post-development until it is established that water quality is stable and compliant;
- Discharges into Monks' Ditch from the reens onsite are not to occur until specified quality criteria and quality control systems have been established and are met; and
- The sitewide MMP sets out the overall approach to materials management within the development and is a live document to be updated as the development progresses. In order to appropriately mitigate the risk to Controlled Waters, it is proposed that a remediation strategy be produced in conjunction with updates to the Materials Management Plan (MMP), as required, on a phase by phase basis, to regulate the application of the re-use criteria and establish remediation requirements for any localised source zones.

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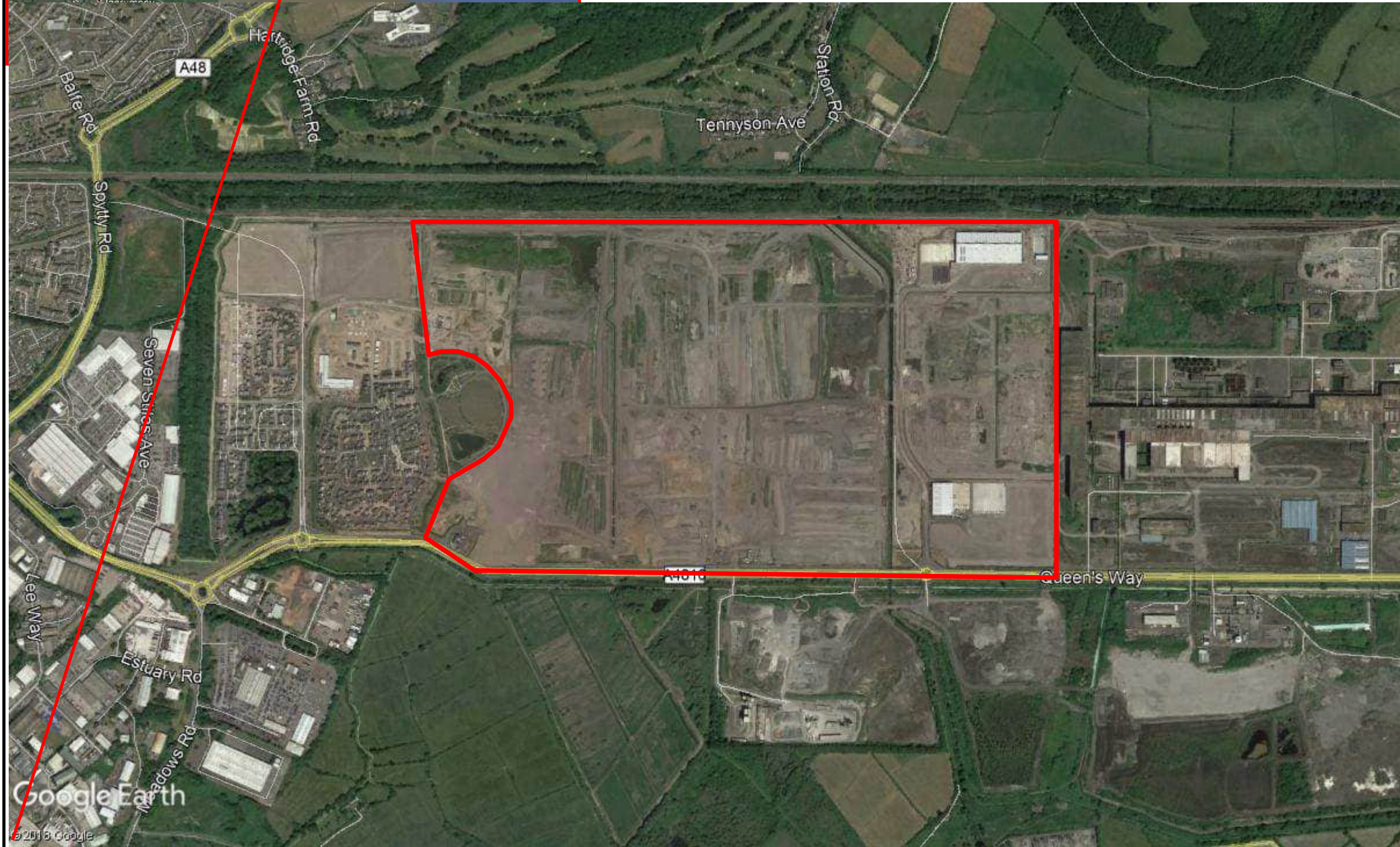
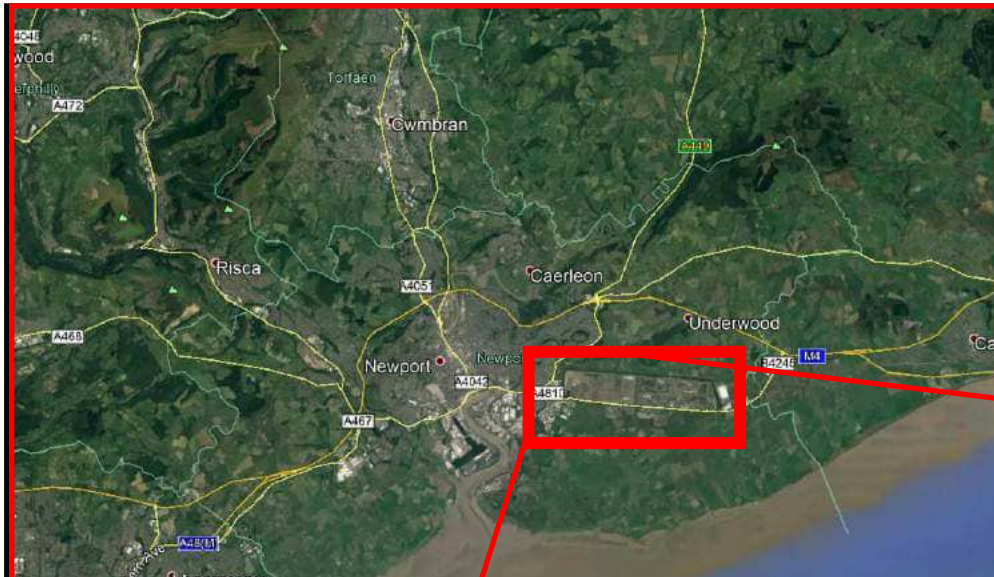
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GENERAL NOTES

NO DIMENSIONS TO BE SCALED OFF THIS DRAWING

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTS AND ENGINEER'S DRAWINGS

ANY DISCREPANCIES NOTED ON SITE ARE TO BE REPORTED TO THE ENGINEER IMMEDIATELY

Key

Redline boundary



CLIENT

ST. MODWEN DEVELOPMENTS

PROJECT

LLANWERN SITE LOCATION PLAN

STATUS

FOR INFORMATION

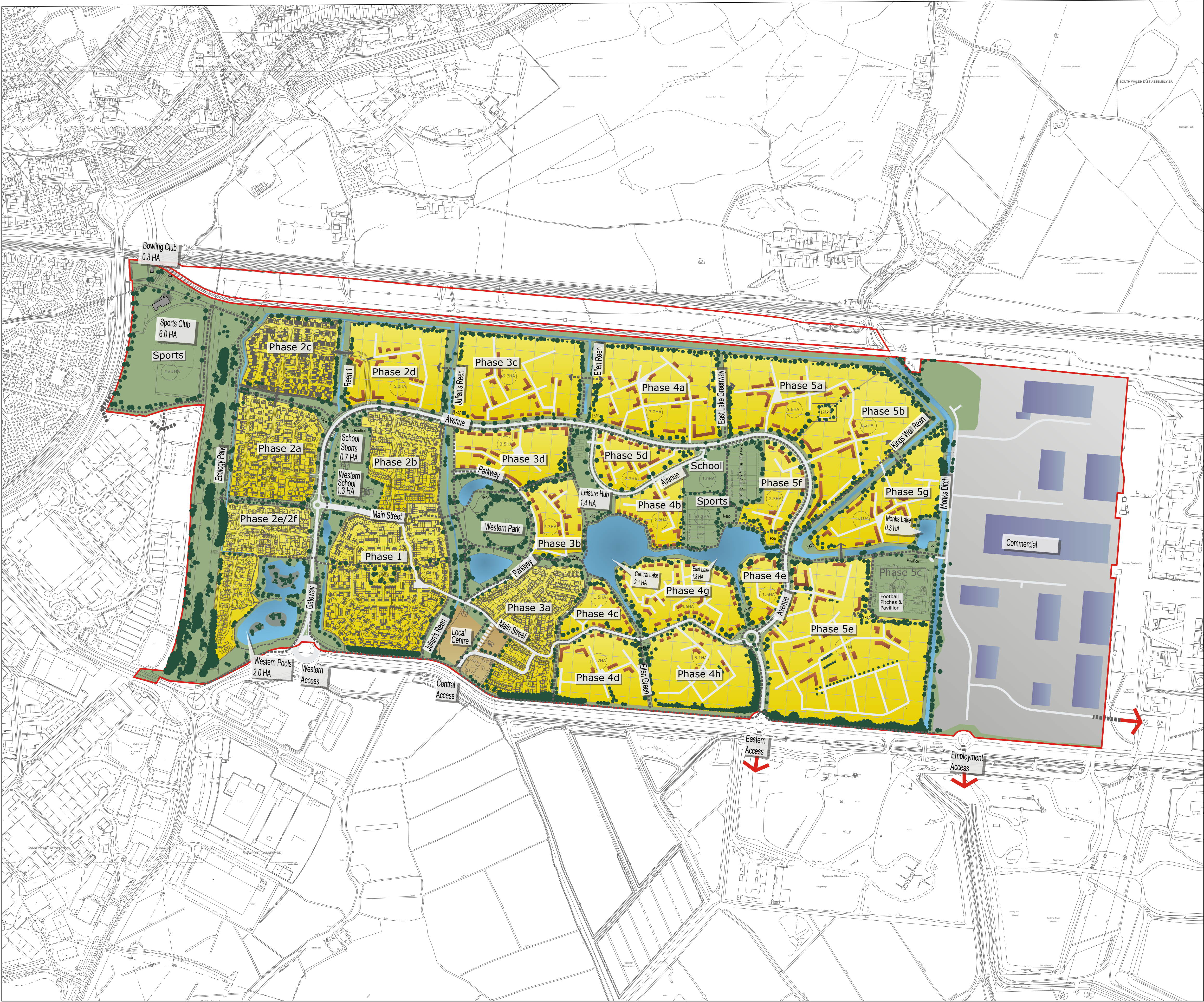
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ET CW 19/08/2019

PROJECT NUMBER DRAWING NUMBER REV.

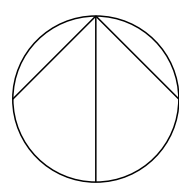
P18-669 18669-RLE-19-XX-DR-O-0004

Glan Llyn -ESAMP Indicative Masterplan



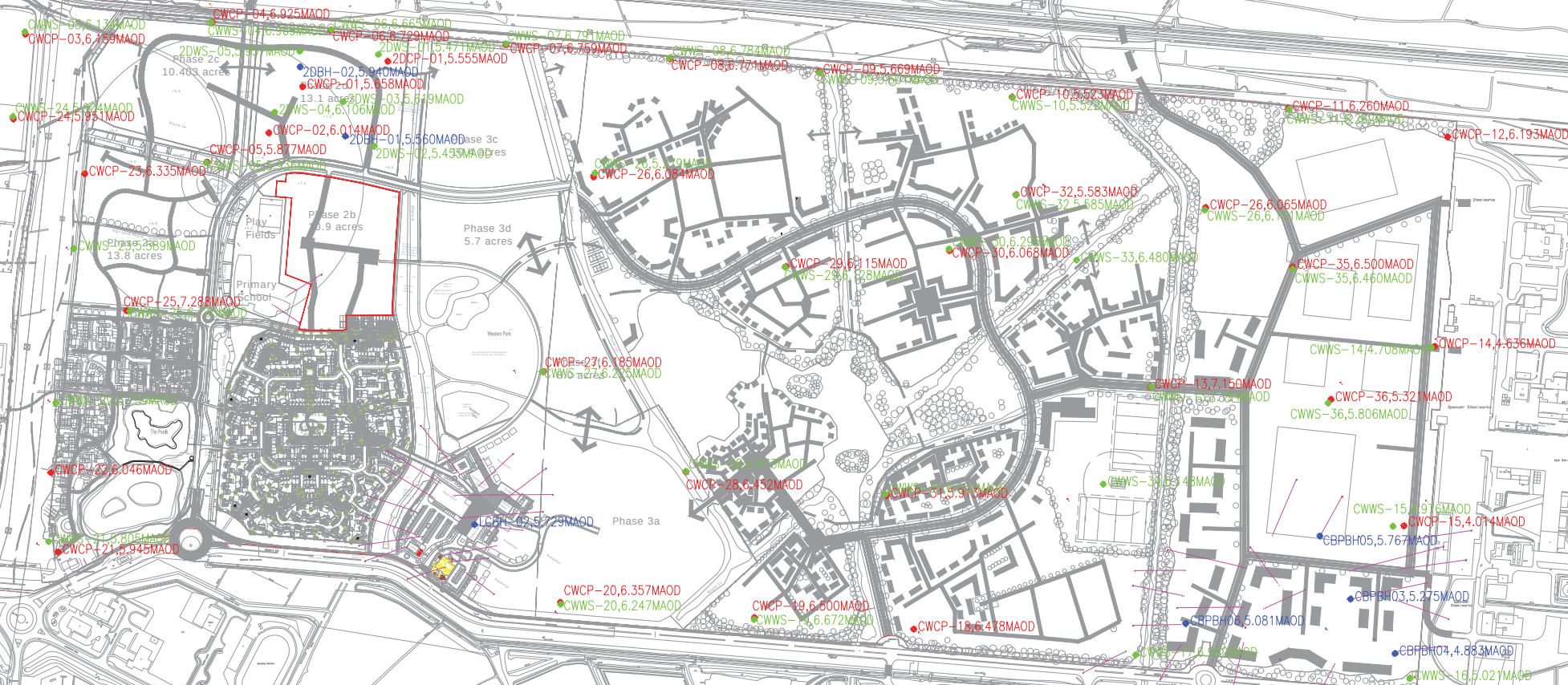
Glan Llyn Residential Numbers (based on existing masterplan)					
Phase/Plot	Outlet	Area (HA)	Area (Acres)	Density (HA)	Total Units
1	Persimmon	9.77	24.15	31.4	307
2/a	Bellway	5.20	12.84	35	182
2/b	SMH	4.06	10.02	35	142
2/c	Bellway	4.30	10.62	35.3	152
2/d	Persimmon	4.98	12.30	35	174
2/e&f	SMH	5.10	12.61	29.8	152
1 and 2/Total		33.40	82.54		1109
3a		5.86	14.49	35	205
3b		2.32	5.74	35	81
3c		6.72	16.60	38.1	256
3d		3.45	8.53	35	121
3 Total		18.36	45.36		663
4a		7.19	17.78	34.8	250
4b		2.04	5.04	35	71
4c		1.53	3.78	35	54
4d		3.65	9.03	35	128
4e		1.49	3.68	35	52
4f		-	-	-	-
4g		4.64	11.46	35	162
4h		5.15	12.73	35	180
5a		5.65	13.95	35	198
5b		6.23	15.41	35	218
5c	Sports	2.67	6.60	35	93
5d		2.24	5.53	35	78
5e		13.72	33.90	35	480
5f		2.49	6.15	35	87
5g		5.06	12.50	35	177
4 and 5/Total		63.75	157.53		2230
1,2,3,4,5 Total		115.51	285.44		4002

NOTE: Areas and housing numbers assume that plot 5c sports is moved to CBP and converted to resi





- KEY
- SHALLOW AND DEEP MONITORING WELL
 - SHALLOW ONLY MONITORING WELL
 - EXISTING BODDLE



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REVISIONS	Drawn By	Checked By	Date
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PURPOSE OF ISSUE	Rev.	Authorised for issue	Date
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THIS DRAWING IS NOT TO BE SCALED

CLIENT
ST.MODWEN

PROJECT
Llanwern

DRAWING TITLE
CWBA BODDLE LCA PL

Scale	1 : 5000	DRAWN KM	CHECKED CW	CO-ORD CHECK ☐
DATE	10/05/2010	DATE	10/05/2010	DATE
SHEET A1			PLOT DATE 02/03/10	

DRAWING NO	5111373-LLA-DWG-EG-0295	REV	B
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