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environmental water management

HYDROGEOLOGICAL RISK ASSESSMENT

BEAM QUARRY, GREAT TORRINGTON, DEVON

Report Reference: 2908/HRA
Version F1
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Report prepared for:

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GENERAL NOTES

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1 INTRODUCTION

1.1 Report context

Beam Quarry near Great Torrington, Devon, has been worked for aggregate and sandstone since the 1930s. The quarry originally had permission to dispose of imported inert waste and operate a waste transfer station under planning permission 01/40/0330/94, granted in 1995. Quarrying and infilling operations are currently permitted under a section 73 Planning Permission, reference DCC/4223/2021 dated 17th May 2021. This permission allows mineral extraction, inert waste infilling and inert waste recycling until April 2055 for the purposes of:

- Providing safe access to geological features of interest in the quarry
- Improving overall safety at the site via provision of rock traps and face drainage
- Providing detailed restoration and an aftercare scheme
- Providing a range of biodiversity benefits
- Improving landscape and visual aspects of the site

Hafren Water has been commissioned by L J Developments to carry out a Hydrogeological Risk Assessment (HRA) in support of an application for an Environmental Permit for a waste recovery operation. The HRA has been prepared with due regard to the hydrogeological risk assessment guidance (Environment Agency, 2016) and template (Environment Agency, March 2010) provided by the Environment Agency.

As a stand-alone Conceptual Model, Environmental Setting and Site Design (ESSD) report has not been completed, however a Site Condition Report has been prepared by Crestwood Environmental. This HRA report provides further details of the background and baseline conditions that have been used to derive the conceptual model for the site in terms of source, pathways and receptors.

1.2 Data sources

The following data sources were used in this assessment:

L J Developments

- Site plans
- Section 73 Application to vary the approved working and tipping schemes and submission of restoration proposals to discharge Condition 17 of planning permission reference 1/0423/2014/CPZ(DCC/3593/2013)

Ordnance Survey (OS)

- 1:25,000 scale series mapping

British Geological Survey (BGS)

- Geological map Sheet 307 & 308, Bude, solid and drift,1:50,000-scale (England & Wales)
- Web Map Service (WMS)

Environment Agency (EA)

- Information on licensed abstractions, discharge consents and rainfall data

Devon County Council (DCC)

- Devon Minerals Plan 2011 – 2031 - adopted February 2017

Crestwood Environmental Ltd

- Groundsure report dated 22nd July 2021
- Environmental Management System. Bespoke Environmental Permit Application for the Deposit of Inert Waste for Recovery Beam Quarry, Torrington, Devon, EX38 8JF. Report reference CE-BQ-1936-RP04-EMS-Draft v.2. Report Date: 13 October 2021
- Site Condition Report. Bespoke Environmental Permit Application for the Deposit of Inert Waste for Recovery. Beam Quarry, Torrington, Devon, EX38 8JF. Report Reference: CE-BQ-1936-RP02-SCR-Draft v.1.docx. Report Date: 2 December 2021

Quarry Design

- Phasing drawings and volume calculations

2 CONCEPTUAL HYDROGEOLOGICAL SITE MODEL

2.1 Location and topography

Beam Quarry is located approximately 2 km to the northwest of Great Torrington, Devon, centred on National Grid Reference (NGR) SS 46988 20374 (*Drawing 2908/HRA/01*). The quarry has a rural setting with arable fields, woodland and pastures immediately surrounding the site. There are a number of villages nearby, the closest of which is Frithelstock, 0.8 km to the southwest.

The quarry is located on the northern side of a small watercourse, the Mill Leat, which flows to the east into the River Torridge. Natural ground is steeply sloping with elevations immediately north of the quarry void at between 80 m and 110 metres Above Ordnance Datum (mAOD), while next to the stream bank, 125 m to the south of the quarry face, elevations drop below 24 mAOD.

2.2 Hydrological setting

The hydrological characteristics have been derived from Ordnance Survey maps and features of significance are indicated on *Drawing 2908/HRA/02*.

2.2.1 Watercourses

Beam Quarry is situated within the catchment of the Mill Leat, a tributary of the River Torridge. At its confluence with the Torridge, the Mill Leat has a catchment area of 3.6 km^2, which drains a largely rural catchment. The stream receives run-off from two watercourses that join approximately 500 m upstream of the quarry.

The stream's channel is relatively narrow with a gradient of 3% adjacent to the quarry boundary. Its gradient increases dramatically at the eastern end of the quarry before it passes through a road culvert beneath the A386, after which it joins the River Torridge approximately 40 m further east. Elevations vary from 25 mAOD in the west to 16 mAOD in the east, at the A386.

The River Torridge has a catchment of over 660 km^2 upstream of its confluence with Mill Leat. The river flows northwards for approximately 12 km before discharging into Barnstaple Bay.

2.2.2 Waterbodies

No natural waterbodies are present within the quarry or its immediate surroundings.

Small water management sumps/ponds are located towards the western and central eastern ends of the quarry floor. They discharge into the stream across the quarry floor or by means of a pipe outlet.

2.2.3 Springs

The 1:25,000-scale Ordnance Survey Map shows that there is one spring within 1 km of the site boundary. The spring is located 0.98 km to the southwest of the quarry, close to the village of Frithelstock, at an elevation of approximately 105 mAOD.

An additional spring is reported close to the northwestern site boundary. During a site visit on 6th August 2021, this was little more than a wet area of land with no observable flow.

2.2.4 Surface water abstractions

There are no licensed surface water abstractions within 3 km of the site centre.

2.2.5 Water Framework Directive (WFD)

The site lies within the Torridge (Lew to Estuary) surface waterbody (GB108050014660) which has a Moderate WFD (2019) classification.

2.3 Geological setting

2.3.1 Superficial deposits

Superficial deposits are shown on BGS maps to be largely confined to the valley floor of the River Torridge and its tributaries and for short distances upstream of their confluence. The deposits largely comprise alluvium with River Terrace Deposits present in places only within the valley of the River Torrington.

2.3.2 Bedrock

The bedrock comprises the Upper Carboniferous Bude Formation, which, in the vicinity of the quarry is largely comprised of sandstone with subsidiary bands of mudstone and siltstone. The grey, thick-bedded, somewhat argillaceous and silty sandstones, occur in laterally discontinuous internally massive beds, 1-5 m thick and commonly amalgamated into units up to 10 m thick. Grey mudstones occur as interbeds of up to 1 m thick.

The region is folded and faulted, the faults having a predominant northwest/southeast strike.

2.3.3 Conservation

The quarry is a Devon County Geological Site and is registered as a Regionally Important Geological Site (RIGS).

2.4 Hydrogeological setting

2.4.1 Aquifer designation

The superficial alluvium and the River Terrace deposits are designated as Secondary 'A' Aquifers by the Environment Agency. The Bude Formation is also designated as a Secondary 'A' Aquifer. These are generally classed as able to support local water supplies rather than regional scale public water supplies.

The site is not located with a Source Protection Zone, Drinking Water Protected Zone or Drinking Water Safeguarding Zone.

2.4.2 Aquifer properties

Jones *et al* (1997)[1] report that primary porosity is commonly 10 to 15% with permeability varying dependant on the degree of cementation in the sandstone units. Both porosity and permeability tend to decrease with depth. This results in a general "absence of significant intergranular permeability in most Carboniferous strata". Groundwater, where observed, is therefore restricted to secondary permeability resulting from fractures and fissures which mainly occur in the sandstone and grits.

Yields are reportedly very varied with unproductive boreholes being common. According to Jones *et al* (1997), there are only seven sites within the Bude Formation where information is available on aquifer properties. Tests at these sites gave transmissivities in the range 1 to 23 m^2/d and specific capacities between 1.7 and 52 $m^3/d/m$.

The general BGS descriptions indicate that the strata are of low permeability with flow occurring only in discrete fractures. Site observations confirm this to be the case in the quarry, where the strata are heavily folded, resulting in sub-vertical beds with only minor issues occurring in the south facing quarry face, in the east of the site and only after periods of heavy rainfall.

1 Jones H K, Morris B L, Cheney C S, Brewerton L J, Merrin P D, Lewis M A, MacDonald A M, Coleby L M, Talbot J C, McKenzie A A, Bird M J, Cunningham J and Robinson V K. 2000. The physical properties of minor aquifers in England and Wales. BGS Technical report WD/00/4. Environment Agency R&D publication 68

2.4.3 Groundwater quality

No data are available on groundwater quality in the Bude Formation.

2.4.4 Groundwater level

The closest borehole record to the site on the BGS GeoIndex is 2 km to the southeast at Pollards Hill (BGS ref SS41NE2). The borehole is drilled into the Bude Formation to a depth of approximately 36.5 m. Rest groundwater at the time of drilling (1960) was approximately 10 m below ground level (mbgl) and ground elevations at the borehole are approximately 91 mAOD. The approximate rest groundwater level is therefore 81 mAOD. This is above the current quarry floor elevation.

Another borehole, 2.5 km southeast of the site (BGS ref SS42SE4) was drilled to 45.7 m in the Bude Formation and rest water level in 1969 was recorded as 24.4 mbgl. The elevation of the borehole is not given on the borehole log, however it is estimated at approximately 65 mAOD. Based on this, groundwater levels would be approximately 40 mAOD.

No further data are available on groundwater level in the Bude Formation.

2.4.5 Groundwater abstractions

There are no licensed groundwater abstractions within 3 km of the site centre. A number of wells are shown on the 1:25,000 Ordnance Survey map, as indicated on *Drawing 2908/HRA/03*. All are located a significant distance from the quarry and at elevations above that of the quarry. They are not therefore considered to be potential receptors. However, they do indicate that the Bude Formation is capable of supporting small-scale water supplies.

2.4.6 Water Framework Directive

The site lies within the Torridge and Hartland Streams groundwater body (GB40802G800600) which has a WFD classification (2019) of Poor.

2.4.7 Conceptual hydrogeological understanding

It is considered that groundwater in the Bude Formation is limited to fractures and fissures, the main body of the deposit exhibiting very low permeability and low water storage potential. Groundwater in the fissures is likely to be poorly connected, as demonstrated by the wide variation in groundwater elevations between the site, which is dry (base elevations between 22 and 19 mAOD) and the nearest borehole where groundwater elevations around

80 mAOD are indicated and the second borehole where a groundwater level of 40 mAOD is indicated.

Observations in the quarry itself indicate only very limited issues from the quarry face after periods of high rainfall. It is considered that this represents bypass flow of water which infiltrates the upper, more fractured horizon of the sandstone and emerges at high elevations and does not reach the watertable. These issues only occur after periods of rainfall.

The Mill Leat close to the site is underlain by cohesive Alluvial deposits and therefore it is unlikely that groundwater from beneath the site provides significant baseflow.

Run-off collects on the quarry floor at low points, also indicating the low permeability of the current base of the site.

It is considered that groundwater is effectively absent in the vicinity of the site. This assessment of the low sensitivity of the site setting in terms of groundwater is reflected in the recent Planning Application where assessment of impacts on groundwater was not required as part of the Environmental Impact Assessment (EIA) and Environmental Statement (ES)

Surface water run-off is in the direction of the Mill Leat locally and water draining from the site discharges to this stream.

2.5 Proposed development

2.5.1 Quarry layout

The existing quarry plan is shown in *Appendix 2908/HRA/A1* as Quarry Design Drawing 00464-200723-01.

2.5.2 Mineral extraction

It is proposed to extract 88,000 tonnes of stone from the quarry, which will involve removing mineral from the floor of the quarry to create a uniform base across the site at an elevation of 20.5 mAOD. There will be no lateral extension of the existing quarry void. Extraction of these mineral reserves would take place over years 1 to 6 of the proposed scheme (*Table 2908/HRA/T1* below).

2.5.3 Waste importation

The proposed restoration requires the importation over a period of 10 years of 97,000 m^3 (145,500 tonnes) of inert waste, of which 10,000 m^3 comprises soil to be spread over non-filled areas (*Table 2908/HRA/T1*).

2908/HRA/T1: Proposed phasing of mineral extraction and waste import						
Time period	**Mineral extracted (to 20.5 mAOD)**		**Inert waste**	**Inert Waste Tonnages[1]**		
	m³	**Tonnes (@ 2.7t/m³)**	**m³**	**Tonnes tipped (@1.5t/m³)**	**Tonnes recycled (@10%)**	**Total tonnes into site**
Years 1 and 2	13,000[2]	35,100	7,556	11,334	1,133	12,467
Years 3 and 4	11,500	31,050	12,415	18,623	1,862	20,485
Years 5 and 6	8,020	21,654	13,670	20,505	2,051	22,556
Years 7 and 8	End of mineral extraction in quarry floor		26,955	40,433	4,043	44,476
Years 9 and 10	-	-	26,400	39,600	3,960	43,560
Restoration subsoils and topsoils[3]	-	-	10,000	15,000	-	15,000
Totals	**32,520**	**87,804**	**96,996**	**145,494**	**13,049**	**158,543**

1 It is proposed to bring into the site an additional 10% approx of inert waste for processing/recycling
2 There is an additional approx 3,270 m³ mineral extraction from the eastern lagoon excavation
3 Estimated based on 300 mm topsoil on slope areas and 1000 mm on floor areas

2.5.4 Water management

No groundwater lowering/dewatering is undertaken at the site and due to the inert nature of the waste, long-term groundwater control is not required in order to prevent groundwater pollution.

A granular drainage layer will be placed between the waste and the northern and western quarry faces. This will allow any water within the Bude Formation to drain without flowing into the waste. The backwall drainage layer will allow water to passively flow out into the surface water drainage system.

An outlet will be provided to the east of the backwall drainage to allow collected water to drain southward towards the surface water lagoon. The existing surface water lagoon will be lost after Phase 2, at which time a new, bigger lagoon will have been constructed to its south. To control the water emerging from the backwall drainage layer, a drain will be constructed comprising approximately 1 m by 1 m cross-sectional area with a 300 mm, twin wall drainage pipe set within a granular surround. This will link the backwall drainage system with the surface water lagoon (existing and the proposed).

Using a combination of backwall drainage and the eastern drain linking this to the surface water lagoon, any water emerging from the face of the existing quarry will be collected and transferred away from the waste, preventing a build-up of water pressure between the waste and the existing quarry face.

2.5.5 Restoration

The proposed restoration is illustrated on Drawing N° 2889-4-4-4-DR-0001-S5, reproduced in *Appendix 2908/HRA/A2*.

2.6 Source, pathway, receptor model

Source

The proposed materials to be imported to Beam Quarry to create the proposed landform include soils, subsoils and minerals as listed in *Table 2908/HRA/T2* below.

2908/HRA/T2: Permitted waste types

Source	Sub-source	Waste code	Description	Additional restrictions
17: Construction and demolition wastes	17 01: Concrete, bricks, tiles and ceramics	17 01 01	Concrete	
		17 01 02	Bricks	
		17 01 07	Mixtures of concrete, bricks, tiles and ceramics other than those mentioned in 17 01 06	Metal from reinforced concrete must have been removed
	17 05: Soil, stones and dredging spoil	17 05 04	Soil and stones other than those mentioned in 17 05 03	
20: Municipal Wastes (Household waste and similar commercial, industrial and institutional wastes) including separately collected fractions	20 02: garden and park waste (including cemetery waste)	20 02 02	Soil and stones	

All of the above classified wastes are identified in the European Union Council Decision 2003/33/EC regarding criteria and procedures for accepting waste at landfills, as waste that can be accepted without the need for any chemical testing providing that it has low contents of other types of materials (like metals, plastic, soil, organics, wood, rubber, etc) and the origin of the waste must be known.

Only part of the quarry will be subject to imported waste. It is proposed to import 87,000 m^3 of inert waste to bring the site contours from 20.5 mAOD at the quarry floor to between 42 mAOD in the west, and 22 mAOD in the east, to create the final proposed profile and allow safe access to the RIGS. The upper elevations of the quarry will remain unfilled to maintain the RIGS exposures.

Infilling of the site will be undertaken over a period of 10 years with final restoration in the eleventh year. It will commence in the northeast and continue west along the northern quarry face and then southwards. The southeastern part of the site will remain unfilled but will be restored with subsoils and topsoils in accordance with the approved restoration scheme.

All waste will be generated by the operator in the course of their groundworks commissions for development locally. No other waste supplies will be accepted at the site.

As the waste is proposed to form a safe structure to allow access to the RIGS, care will be taken to ensure that the waste is appropriate in terms of physical properties and that it is well compacted in place.

Due to the nature of the very restricted waste stream proposed for the site, the potential for inclusion of Hazardous Substances or Non-hazardous Pollutants is considered extremely small.

Chemicals and fuels required to facilitate mineral extraction and restoration operations will be stored in designated areas with appropriate secondary containment and managed/ handled in strict accordance with the Environmental Management System (EMS), best practice and guidance to prevent contaminant release to the site. In the event of an accidental release, appropriate equipment and suitably trained and experienced personnel will be in place to contain, clean up and document the release and area of impact to limit contaminant migration.

Pathways

As described above the Bude Formation Sandstone appears to exhibit a very low permeability with available groundwater levels data indicating the absence of a local or regional watertable. Some flow appears to occur in the upper horizons of the quarry face after periods of rainfall but the majority of the face remains dry. The quarry floor is dry and above any local watertable. Due to the apparent low permeability of the sandstone locally it is considered that no groundwater pathway exists at the site.

A drainage layer is proposed against the northern quarry face to collect and transfer any run-off or bypass flow from the quarry face to the proposed surface water management system.

The profile of the final landform is sloped from the northern quarry face towards the southern site boundary at a gradient of approximately 20%. This will encourage surface water run-off and little infiltration of the waste is anticipated.

The only plausible pathway is therefore ‘overland’ flow off the waste body and flow within the backwall drainage layer.

Receptors

As stated above, it is considered that a plausible groundwater receptor does not exist locally to the site.

The Mill Leat and thereafter the River Torridge, receive run-off from the site via the designed discharge from the proposed flow balancing lagoon in the south of the site. The Mill Leat is the closest surface water receptor.

The compliance point for the site will be where surface water leaves the site boundary, ie at the consented discharge point.

3 HYDROGEOLOGICAL RISK ASSESSMENT

3.1 Nature of the Hydrogeological Risk Assessment

The Environment Agency does not necessarily require a Hydrogeological Risk Assessment (HRA) in support of a bespoke permit for waste recovery to land. These are only required where the site setting is deemed particularly sensitive. This HRA has been prepared in the absence of an ESSD report and assessment at the planning stage.

Environment Agency guidance proposes a tiered approach to risk assessment such that the degree of effort and complexity reflects the potential risk posed by a particular site or situation, the sensitivity of the site setting and the degree of uncertainty and likelihood of the risk being realised. To meet the requirement, a robust conceptual model for the site has been set out and basic risk screening undertaken. The conceptual model is set out in Sections 2.2 to 2.4 above. A risk screening has been undertaken as summarised in Section 3.2 below.

Risk screening is partially covered by the assessment of the application of the Environment Agency's Landfill Location Policy, the identification of source-pathway-receptor linkages (Sections 2.6 above) and the proposed technical precautions to be put in place to reduce any potential impacts. These are assessed in Section 3.2.5.

3.2 Risk screening

3.2.1 Location

Although an application for a landfill permit is not being made, the location of the site is assessed against the Environment Agency's policy on the location of landfills, which is detailed in 'The Environment Agency's approach to groundwater protection (February 2018), Position Statement E1. Landfill Location'. This states:

> " *The Environment Agency will normally object to any proposed landfill site in groundwater SPZ1.*
>
> *For all other proposed landfill site locations, a risk assessment must be conducted based on the nature and quantity of the wastes and the natural setting and properties of the location.*
>
> *Where this risk assessment demonstrates that active long-term site management is essential to prevent long-term groundwater pollution, the Environment Agency will object to sites:*

- *below the watertable in any strata where the groundwater provides an important contribution to river flow, or other sensitive receptors*
- *within SPZ2 or 3*
- *on or in a Principal Aquifer*"

The site is located within a bedrock, Secondary 'A' Aquifer. There are no data with which to indicate the presence of a regular watertable within the aquifer. What sparse data there is on groundwater elevations indicates a disconnected fracture system with only localised water bearing strata exists in the region. Despite the quarry being 20 m deep at the quarry face, issues are only observed in the upper part in the east of the site and run-off pools at low points in the quarry floor indicating that this is of low permeability. The Mill Leat is assumed to receive little baseflow from this aquifer. The site is not located within a groundwater Source Protection Zone or drinking water protection area.

It is therefore concluded that the site complies with the Environment Agency landfill location policy. The site setting is deemed to be of low sensitivity with respect to groundwater.

3.2.2 Waste types

The site will receive inert wastes generated on-site and a very restricted list of imported waste generated and transported by the operator from local groundworks. Due to the proposed waste codes acceptable at the site, the waste will be truly inert, ie stable and non-reactive, unlikely to contain and/or release mobile contaminants and are not putrescible or biodegradable. Hazardous Substances and Non-hazardous Pollutants are not expected and the proposed waste is not required to be tested in accordance with the relevant EU Council Decision.

3.2.3 Waste Acceptance Procedures

Strict waste acceptance procedures have been prepared and are detailed elsewhere in the permit application. The site will not operate on an "open gate" policy, with all waste to be generated by the operator, from known sites where they are undertaking groundworks. Incoming waste will therefore be from known sources and carefully scrutinised.

3.2.4 Compliance with Environmental Permitting (England and Wales) Regulations (2016)

Environmental Permitting (England and Wales) Regulations (2016), Schedule 22 'Groundwater Activities' apply. These ensure that Hazardous substances must not be present in groundwater beneath the site at concentrations discernible above background and Non-hazardous pollutants must not be present in concentrations such that pollution of nearby groundwater is caused

3.2.5 Proposed technical precautions

As the site will not operate as a landfill and will only receive inert wastes of known origin, leachate collection and management will not be required. In addition, provision of an engineered liner and cap are also not necessary.

As a precaution, it is proposed to provide a foundation layer of approximately 1 m thickness across the base of the site. This layer will be constructed from select clean cohesive soils compacted in place. This will provide a stable base for the waste and also provide attenuation capacity should any contaminant be accidentally included in the waste.

The backwall drainage together with the restoration contours (landform will be sloping at a gradient of approximately 0.2) will result in run-off of rainfall preferentially rather than infiltration to the waste. Therefore, very little water is expected to permeate through the waste mass. The backwall drainage and toe drain will allow surface water to be managed and controlled.

Surface water will be collected in a flow balancing pond in the southeast of the site. A discharge will occur from this pond to the Mill Leat. It will be possible to monitor the quality of the water exiting the site at this location.

3.2.6 Screening assessment

In the context of the hydrogeological conceptual site model used to determine the level of risk posed by a development to the water environment, a source, pathway and receptor are defined as the following:

- A source is a potential contaminant present within imported waste materials used for site restoration that has the potential to cause harm
- Receptors are controlled waters (eg surface waters and aquifers), abstractions and ecology which could be adversely affected by the contaminant
- A pathway is the route or means by which a receptor could be exposed to, or affected by, a contaminant

For a potential risk to exist all three of the above elements must be present, and linked, to form a “pollutant linkage”. The potential risk associated with each pollutant linkage can be assessed by considering the nature of the contaminant, the degree of potential exposure of a receptor to a contaminant and the sensitivity of the receptor.

Based on the assessment of these three elements above:

- sensitivity of the site setting is considered low
- the proposed foundation layer at the base of the waste mass will provide attenuation capacity, if required
- backwall drainage is to be provided which will direct any water emerging from the sandstone face away from the body of waste
- the restored profile will discourage infiltration of rainfall to the waste
- the restricted wastes stream to be accepted at the site
- adherence to the waste acceptance procedures proposed in accordance with the Environment Agency guidance "Waste acceptance procedures for waste recovery on land" available on their website (https://www.gov.uk/guidance/waste-acceptance-procedures-for-waste-recovery-on-land) dated October 2016

It is considered that the proposed waste recovery operation does not pose a risk to groundwater quality or to the quality of nearby watercourses and no quantitative assessment is required.

3.3 Tier 1 risk screening

Environment Agency guidance indicates that "*Your qualitative risk screening should assess whether the potential discharge from your activity is acceptable and so will not require further assessment.*

This could be because:

- *the discharge has acceptably low concentrations of hazardous substances, or in concentrations that are the same as the natural background levels in the groundwater (whichever is the higher concentration)*
- *the discharge has concentrations of non-hazardous pollutants that are within the relevant environmental standards, or in concentrations that are the same as the natural background levels in the groundwater*
- *there's a very low risk to groundwater-fed receptors due to the presence of unproductive drift or unproductive bedrock strata (and there are no aquifers present or near your activity) and remoteness from surface waters*

- *the volume or hydraulic loading rate of the discharge is so small such that only minimal dilution in underlying groundwater will be needed to avoid pollution by non-hazardous pollutants*"[2]

There is no evidence of a water-bearing, connected fracture network in the vicinity of the site. Hence it is considered that, a groundwater receptor and pathway do not exist locally. In light of the restricted proposed waste stream, it is considered that the potential contaminant loading from the proposed waste is also very limited. Therefore the criteria above are met and quantitative assessment is not required.

3.4 Proposed assessment scenarios

3.4.1 Lifecycle phases

Environment Agency guidance states that a Hydrogeological Risk Assessment must be carried out for the whole lifecycle of the landfill, ie from the start of the operational phase until the point at which the landfill is no longer capable of posing an unacceptable environmental risk.

Given the outcome of the risk screening, a quantitative Hydrogeological Risk Assessment of the intended operational and post-closure phases is not deemed necessary.

3.4.2 Failure scenarios and accidents

Failure scenarios

Due to the inert nature of the proposed infill materials and the site setting, there are no engineering management structures at the site to prevent the ingress of groundwater or the egress of leachate. Failure of such systems is, therefore, not possible and failure scenarios will not be considered.

Accidents

Accidents are considered to be unintentional incidents that could reasonably occur, which are unforeseeable at their time of occurrence. An assessment of the potential impacts of accidents, together with the likelihood of their occurrence and magnitude of the consequences (in relation to compliance with the Environmental Permitting (England and Wales) Regulations (2016)) is presented below.

[2] Environment Agency Guidance. Groundwater risk assessment for your environmental permit. 3rd April 2018

Accidents at the site could include the acceptance of contaminated material within the waste imported to the site. Due to the way the site will be managed, ie only using waste generated by the operator, it is considered highly unlikely that 'rogue loads' will be accidentally accepted, however, a 'rogue load' assessment has been undertaken and is summarised below. Details of the modelling are provided in *Appendix 2908/HRA/A3* and this is summarised below.

3.5 Rogue load assessment

It is not possible, with RAM, to model a number of disparate rogue loads deposited throughout the waste body. Therefore, it has been assumed that 5% of the waste body is non-conforming and exhibits concentrations up to two times Inert WAC. The main body of the waste is assumed to have concentrations equivalent to half Inert WAC concentrations. It should be noted that it is NOT intended that site-specific WAC are set at this level. This is considered a conservative scenario.

Results of the modelling indicate that this scenario is acceptable and would not cause a breach of the Environmental Assessment Limits chosen for the site.

3.6 Review of technical precautions

On the basis of the assessment of risk posed by the site, it is considered that the proposed essential and technical precautions detailed below are appropriate and sufficient to prevent any unacceptable discharge from the site:

i) Single supplier of waste from local ground works only from known sites
ii) Strict adherence to Waste Acceptance Procedures
iii) The placement of all waste above the watertable in dry conditions
iv) The placement of clean cohesive soils as a foundation layer
v) Provision of backwall drainage to collect and control any water issuing from the quarry face
vi) Progressive restoration to a sloping profile that will minimise infiltration to the waste by encouraging surface water run-off
vii) Monitoring of the water quality of the consented site discharge, if required

Details of the Waste Acceptance Procedures are considered elsewhere in the application.

3.7 Emissions to groundwater

One of the main purposes of the HRA is to establish whether the predicted discharge from the site complies with the requirements of the Environmental Permitting (England and Wales)

Regulations (EPR 2016) Schedule 22 Groundwater activities. As there is considered to be no pathway to groundwater and no groundwater receptor, emissions to groundwater will not occur.

3.7.1 Hazardous substances

The HRA must consider whether there is likely to be a discernible discharge of Hazardous substances to controlled waters. The compliance point in this case is the off-site discharge prior to dilution in Mill Leat.

The imported fill will be inert and locally derived from groundworks operations; it will generally only contain substances at concentrations naturally occurring in the region. Hazardous substances are not expected to be present in concentrations likely to cause a breach of the EPR (2016). It is therefore considered that the technical precautions discussed above are sufficient to ensure that during normal operation and through to long-term post-closure, there would be no discernible discharge of hazardous substances from the waste into groundwater.

3.7.2 Non-hazardous pollutants

The HRA must also demonstrate that technical precautions will limit the introduction of Non-hazardous pollutants into controlled waters so as to avoid pollution, ie exceed the relevant standards and environmental quality criteria.

A pathway exists for Non-hazardous pollutants to the Mill Leat. However, given the inert nature of the waste and the technical precautions described, it is concluded that, under normal operation and through to long-term post-closure, concentrations of Non-hazardous pollutants would be sufficiently low as to avoid pollution of the Mill Leat.

3.7.3 Surface water management

It is proposed to manage surface water as described in Section 3.2.5 above. On completion of the restoration of the site, surface water discharge will occur from the site passively without the need for active control. This will continue post-restoration.

4 REQUISITE SURVEILLANCE

4.1 Risk-based monitoring scheme

The risk screening and the quantitative rogue load modelling indicate under normal operation and through to post-closure that the proposed waste recovery scheme does not pose a risk to the water environment.

4.2 Surface water monitoring

If deemed necessary, it is proposed that sampling be undertaken from the balancing pond prior to discharge from the site on a quarterly basis for chemical analyses. Samples would be analysed for the proposed suite as shown below in *Table 2908/HRA/T3*.

2908/HRA/T3: Proposed analytical suites for site discharge

Frequency	Analytical suite
Quarterly	pH, conductivity, ammoniacal nitrogen, chloride, Biological Oxygen Demand, Chemical Oxygen Demand, sulphate, arsenic, cadmium and benzene
Annually	As quarterly suite plus: total alkalinity, sodium, magnesium, potassium, nitrate lead, copper, zinc, chromium, iron, manganese, nickel, TPH and polyaromatic hydrocarbons

If hazardous substances are identified above the limit of detection or an increasing trend in non-hazardous pollutants is detected the following actions will be undertaken:

For non-hazardous substances, monitoring results will be assessed on a three-point rolling average to identify trends. This will ensure that EAL levels are not breached by single peaks in substance concentration

If EALs are breached, as described above, the following action will be taken in order as shown:

- Advise site management
- Advise manager of operating company
- Confirm breach by repeat sampling and analysis
- Review existing monitoring information
- Determine degree of risk presented by breach
- Review site management and operation and if necessary, implement actions to prevent future failure
- If appropriate, agree any corrective/remedial action with Environment Agency

5 CONCLUSIONS

5.1 Compliance with the Environmental Permitting (England and Wales) Regulations (2016)

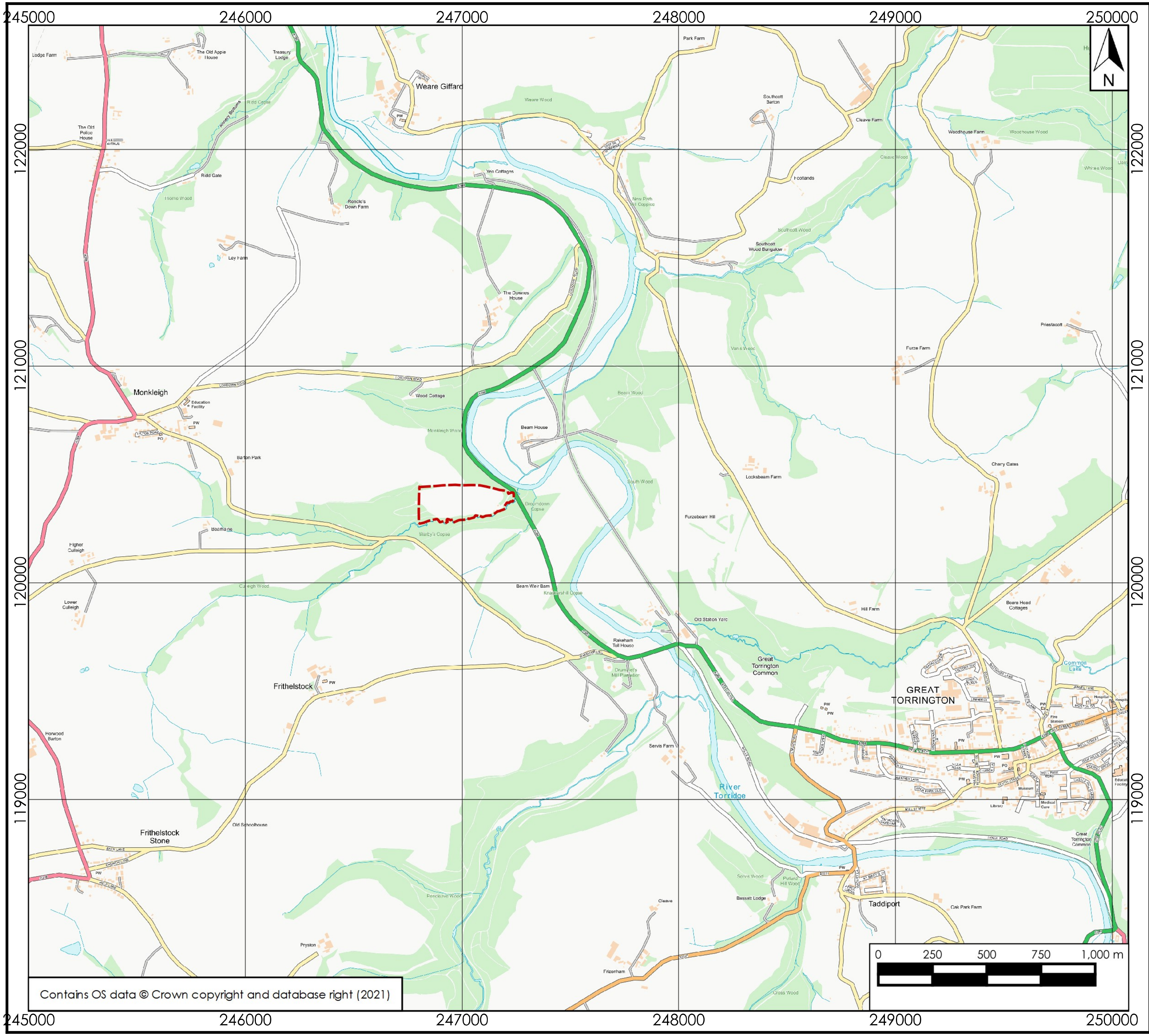
The risk assessment has demonstrated that under normal operational and post-operational phases of restoration, Hazardous substances will not be present in controlled waters in the vicinity of the site in concentrations discernible above background and Non-hazardous pollutants will not be present in concentrations such that pollution of the waters is caused. **It is therefore considered that the site will be compliant with respect to the Environmental Permitting (England and Wales) Regulations (2016).**

6 REFERENCES

Environment Agency, February 2016. Landfill developments: groundwater risk assessment for leachate.
https://www.gov.uk/guidance/landfill-developments-groundwater-risk-assessment-for-leachate

Environment Agency, March 2010. Hydrogeological risk assessment template. Version 1.
https://www.gov.uk/government/publications/hydrogeological-risk-assessment-report-template

DRAWINGS



Legend

Application Area

Scale correct at A4

Client	L J Developments		
Title	Site Location		
Project	Beam Quarry		
Drawing	2908/HRA/01	Version	1
Date	Nov 2021	Scale	1:25,000

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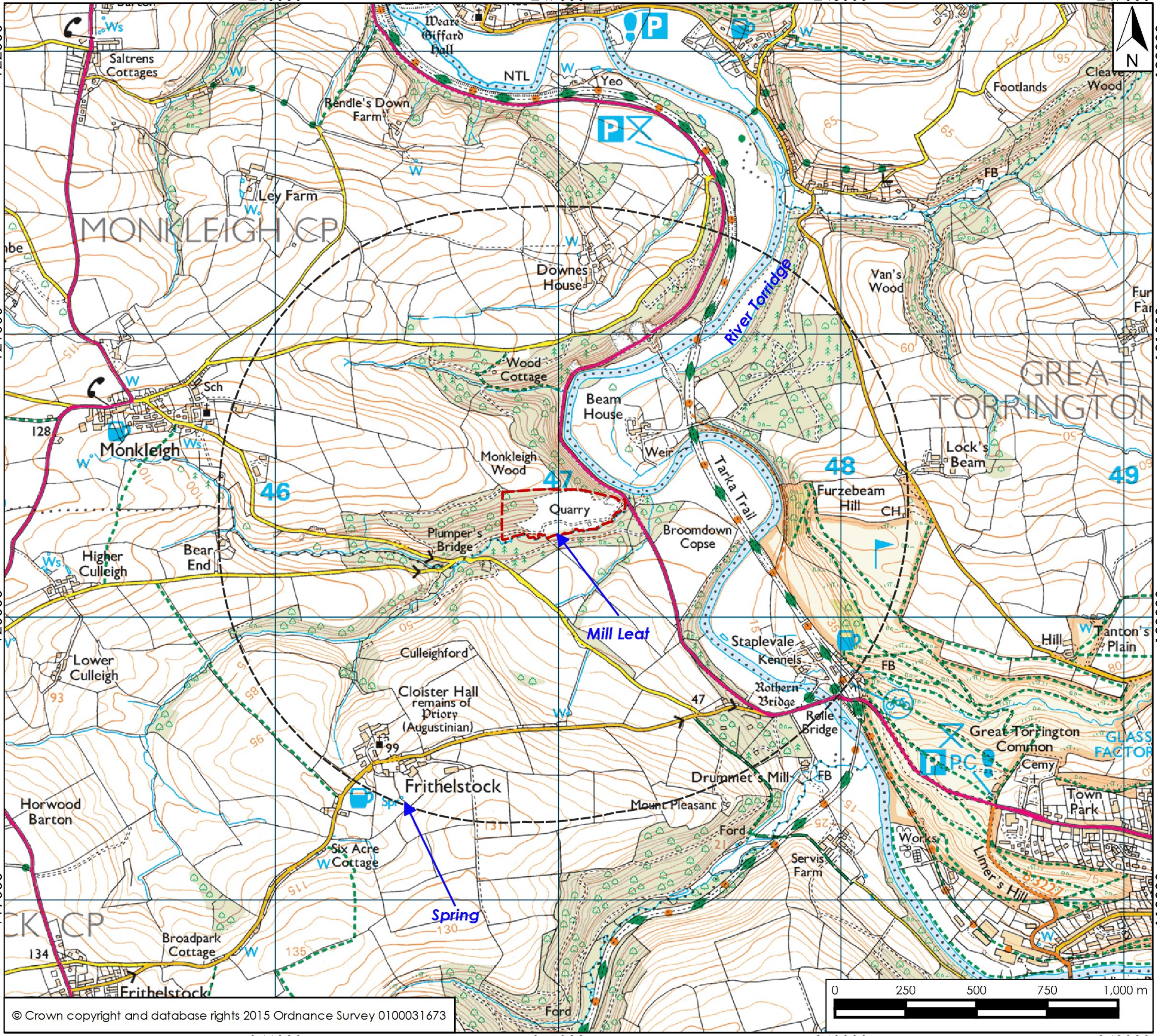

Legend

- Application Area
- 1km Buffer

Scale correct at A4

Client	L J Developments
Title	Water features
Project	Beam Quarry
Drawing	2908/HRA/02
Version	1
Date	Nov 2021
Scale	1:20,000

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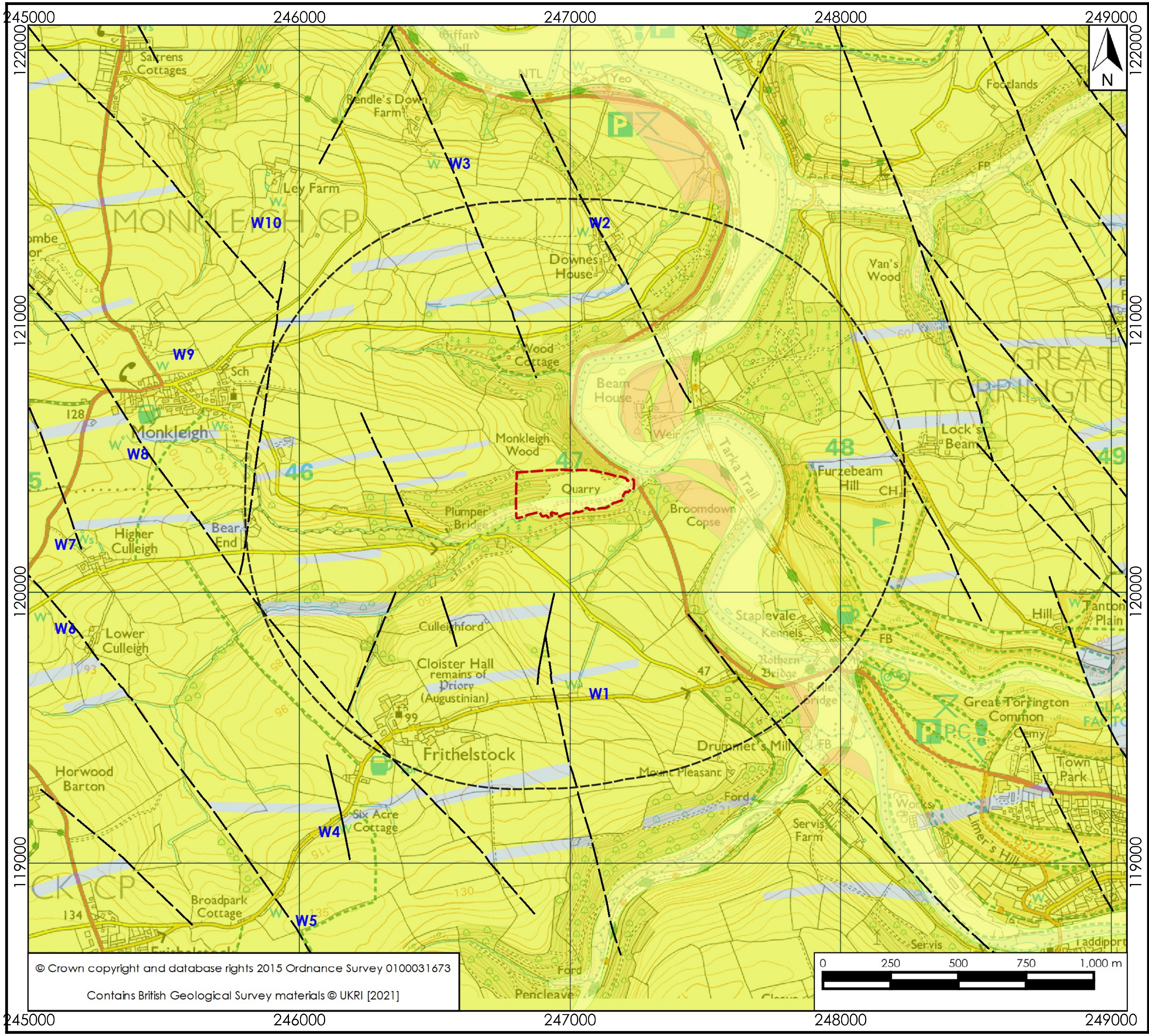

Legend

- Application Area
- 1km Buffer

Geology Key

- Alluvium
- River Terrace Deposit
- Bude Formation (MDST)
- Bude Formation (SST)

Scale correct at A4

Client	L J Developments
Title	Geological setting
Project	Beam Quarry
Drawing	2908/HRA/03
Version	1
Date	Nov 2021
Scale	1:20,000

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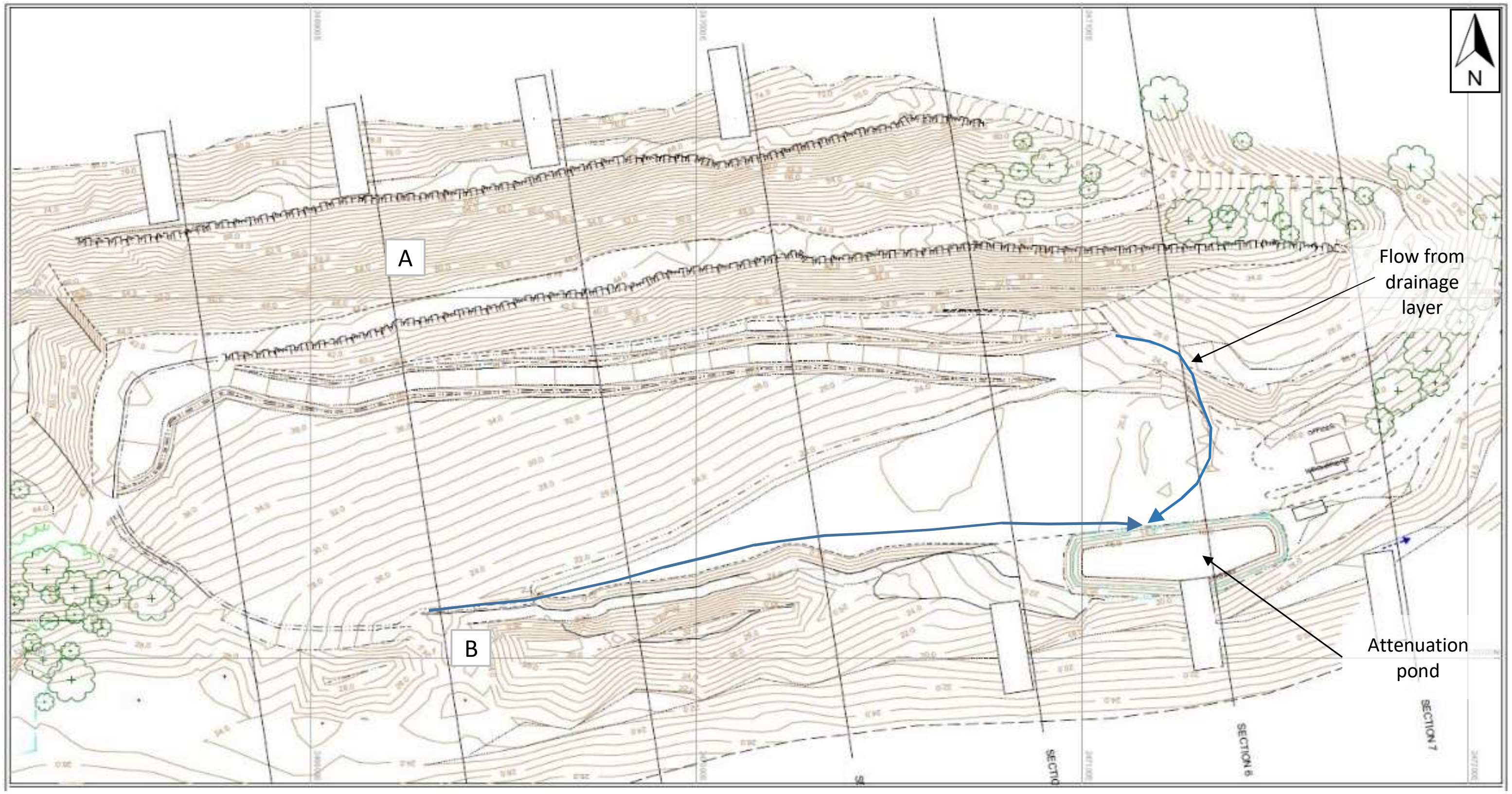

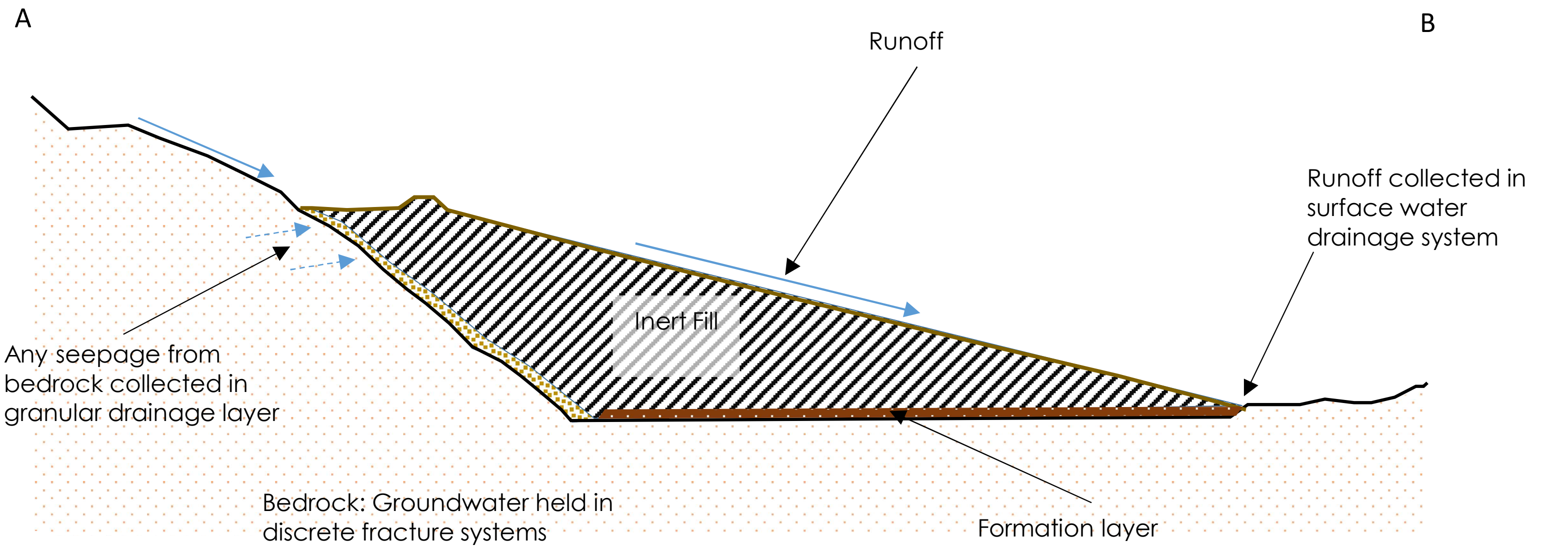

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Title	Conceptual model
Project	Beam Quarry
Drawing	2908/HRA/04
Version	1
Date	Nov-21
Scale	n/a

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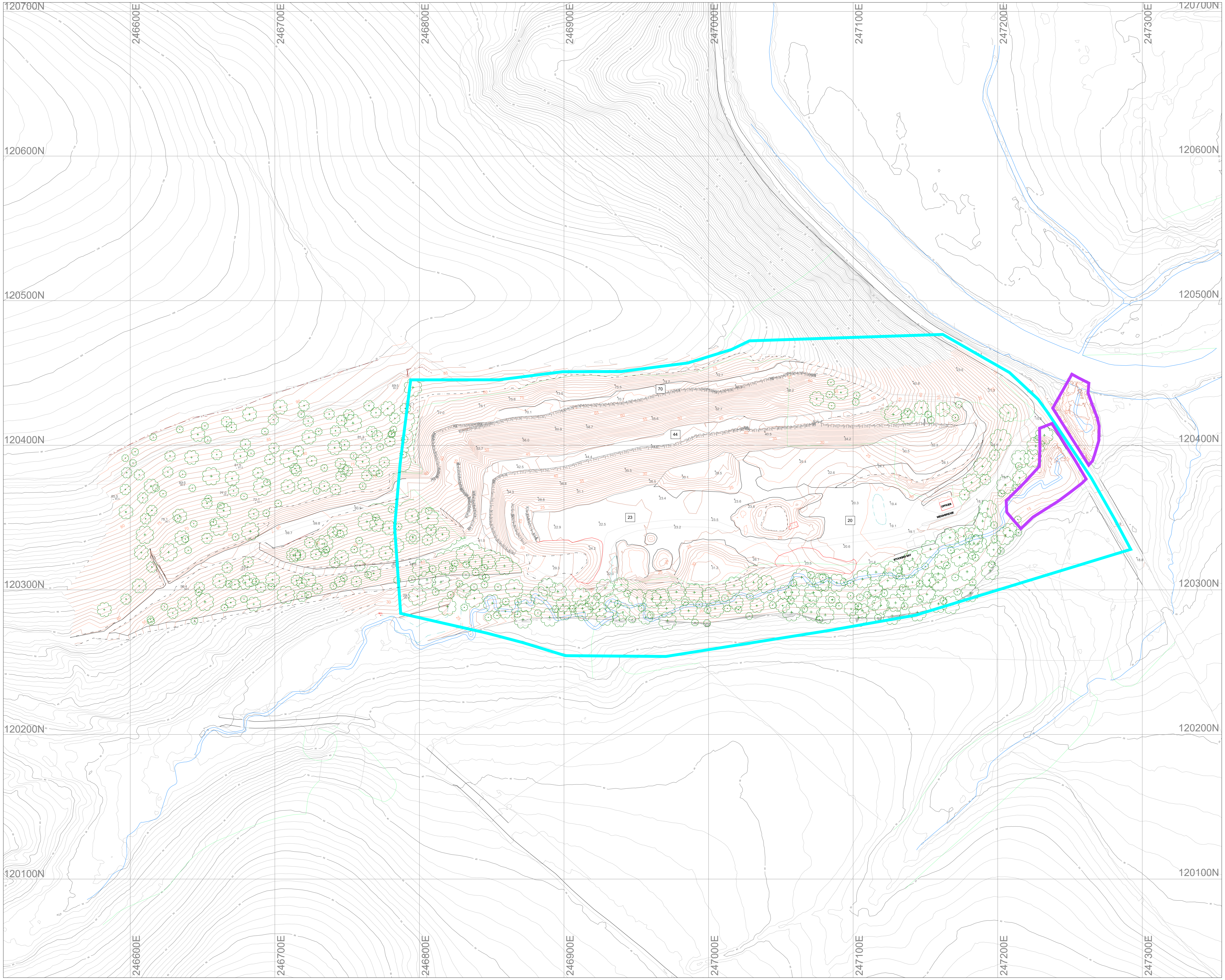
APPENDIX 2908/HRA/A1

Site plan



Legend-

Extent of LiDAR Survey undertaken on 23rd July 2020

Extent of UAV Survey Undertaken on 23rd July 2020

Please Note-
Contours shown in grey have been taken from an opensource data portal and have been used for the sole purpose of providing context

The area to the West of the UAV Survey has been taken from a previous survey undertaken by QuarryDesign on 13th November 2015

Topographical Survey

N

SITE: 00464 Beam Quarry

TITLE: UAV and LiDAR Topographical Survey

SHEET SIZE	ORIGINAL SCALE	Drawn by- DJP	Checked by- APW	Issued to- SL
A3	1:2500	Date- 18/08/20	Date- 18/08/20	Date- 18/08/20

Drawing No.- 00464-200723-01 | Rev.1

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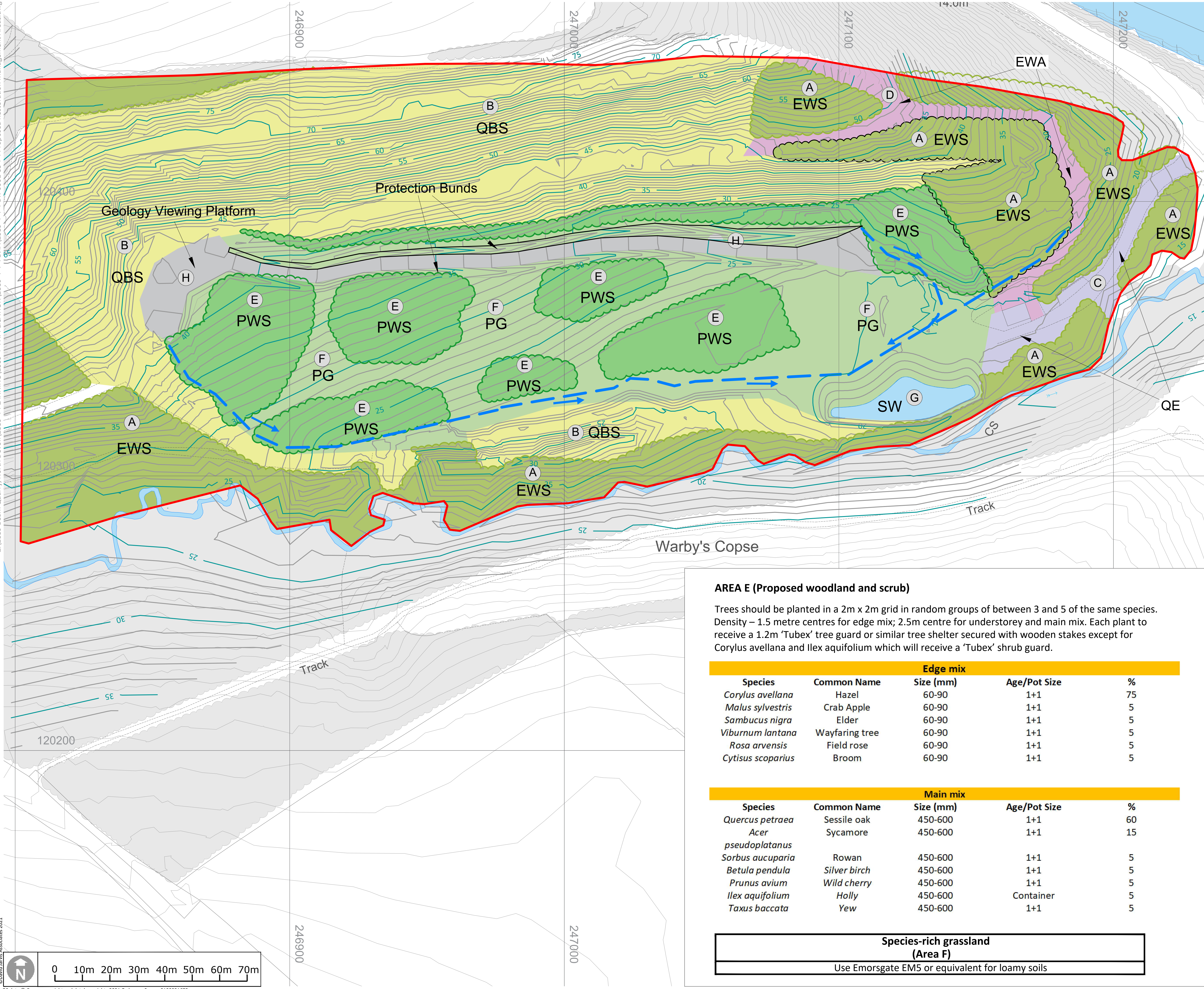
APPENDIX 2908/HRA/A2

Restoration plan



AREA E (Proposed woodland and scrub)

Trees should be planted in a 2m x 2m grid in random groups of between 3 and 5 of the same species. Density – 1.5 metre centres for edge mix; 2.5m centre for understorey and main mix. Each plant to receive a 1.2m 'Tubex' tree guard or similar tree shelter secured with wooden stakes except for Corylus avellana and Ilex aquifolium which will receive a 'Tubex' shrub guard.

Edge mix

Species	Common Name	Size (mm)	Age/Pot Size	%
Corylus avellana	Hazel	60-90	1+1	75
Malus sylvestris	Crab Apple	60-90	1+1	5
Sambucus nigra	Elder	60-90	1+1	5
Viburnum lantana	Wayfaring tree	60-90	1+1	5
Rosa arvensis	Field rose	60-90	1+1	5
Cytisus scoparius	Broom	60-90	1+1	5

Main mix

Species	Common Name	Size (mm)	Age/Pot Size	%
Quercus petraea	Sessile oak	450-600	1+1	60
Acer pseudoplatanus	Sycamore	450-600	1+1	15
Sorbus aucuparia	Rowan	450-600	1+1	5
Betula pendula	*Silver birch*	450-600	1+1	5
Prunus avium	*Wild cherry*	450-600	1+1	5
Ilex aquifolium	*Holly*	450-600	Container	5
Taxus baccata	*Yew*	450-600	1+1	5

Species-rich grassland (Area F)

Use Emorsgate EM5 or equivalent for loamy soils

KEY

- Boundary: Application Site
- Contours 1m Interval
- Proposed Restoration Contours 1m Interval
- (A) Existing Peripheral Woodland & Scrub (EWS) 13,960m²
- (B) Quarry Benches and Slopes (QB) 21,270m²
- (C) Former quarry office weighbridge and access roads (QE) 1,250m²
- (D) Existing woodland access roads (EWA) 1,600m²
- (E) Proposed Woodland & Scrub (PWS) 8,900m²
- (F) Proposed Grassland (PG) 10,080m²
- (G) Attenuation Lagoon (SW) 820m²
- (H) Proposed Access Track to Geology Viewing Platform 2,040m²
- Proposed Drainage & Flow Direction

Status: **PLANNING**

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Client: L.J DEVELOPMENT

Project: BEAM QUARRY

Drawing Title: PROPOSED RESTORATION MANAGEMENT AREAS

Scale	Sheet Size	Date
1:1,250	A3	06/05/2021

Client Ref.	Drawing Ref.	Status
-	2889-4-4-4-DR-0001-S5	P4

APPENDIX 2908/HRA/A3

Results from RAM model

A3.1 Risk assessment modelling

To support the application for bespoke environmental permit, a 'rogue load' assessment using the RAM spreadsheet modelling software has been undertaken.

A3.1.1 Priority contaminants to be assessed

For groundwater and surface waters, Environmentally Acceptable Levels (EALs) are used as a measure against which the results of models can be compared. EALs have been determined on the basis of available water quality standards for the parameters below in the absence of background groundwater concentrations.

The Environmental Permitting (England and Wales) Regulations 2016 (EPR, 2016) require there to be no discernible discharge of hazardous substances to controlled waters. Therefore, the appropriate EAL would be the concentration at which they become 'discernible'.

Hazardous contaminants

Six hazardous substances detailed in the Inert WAC have been modelled including arsenic, total chromium, mercury, lead, benzene (a BTEX substances) and benzo-a-pyrene (a typical PAH).

Non-hazardous contaminants

Non-hazardous sulphate, which may be present in brick has been selected as a conservative, non-reactive/degradable/retarded parameter. Phenol a non-hazardous organic has also been modelled.

A3.1.2 Regulatory guideline values

In the absence of background data, to determine if a substance presents a significant risk, Environmentally Acceptable Levels (EALs) have been used as guideline values to compare with model output concentrations. If modelled output parameter concentrations exceed the EAL's, there is a potential risk to controlled waters. Output parameter concentrations below the EALs are unlikely to present a risk to controlled waters.

Minimum reporting values were used for Hazardous substances where available together with UK Drinking Water Standards and the EA Environmental Quality Standards (EQS), 2016 for the modelling. In each case, the most stringent guideline value was used; results are presented in *Tables 2908/HRA/TA3.1 and 2908/HRA/TA3.2*.

2908/HRA/TA3.1: EALS for Hazardous substances			
Substance	UK Drinking Water Standard (µg/l)	MRV/loq (µg/l)	Resultant EAL (µg/l)
Arsenic	7.5	5	5
Total chromium	37.5	-	37.5
Mercury	0.75	0.01	0.01
Lead	7.5	0.2	0.2
Benzene	0.75	1	1
Benzo-a-pyrene	7.5×10^{-3}	5×10^{-5}	5×10^{-5}

2908/HRA/TA3.2: EALS for Non-hazardous substances			
Substance	UK Drinking Water Standard (mg/l)	Fresh Water EQS (mg/l)	Resultant EAL (mg/l)
Sulphate	250		250
Phenol		0.03	0.03

A3.2 Numerical modelling

A3.2.1 Justification for modelling approach and software

The assessment has been undertaken using ESI's Risk Assessment Model (RAM) which was developed in collaboration with the EA. The tool is widely recognised and accepted by the regulators and wider industry as a robust and accurate fate and transport modelling tool. The model assumes the following:

- The main body of waste sits on a clean, cohesive, compacted foundation layer through which contaminants from a rogue load would pass
- On reaching the quarry floor 'leachate' would flow across the bedrock and enter the surface water drainage system and into the flow balancing pond. The flow balancing pond acts as the compliance point before water is discharged to the receptor, the Mill Leat
- The rogue load has been represented by assuming that the waste body has concentrations of the Priority substances at concentrations equivalent to half the Inert Waste WAC and the 'rogue load' is represented as comprising 5% of the waste volume with concentrations equivalent to two times the inert waste WAC

A3.2.2 Model parameterisation

The parameters used in the RAM assessment are described together with justification for their use within the RAM model in *Table 2908/HRA/TA3.3*. Where known, locally-derived hydraulic properties have been used. In the absence of site-derived data, published and literature-based data has been used to run the model. The following pathway has been modelled.

The RAM model simulates the resultant concentrations in the balancing pond based on initial source concentrations (derived as above) and a declining source term.

2908/HRA/TA3.3: Model input parameters		
Parameter	**Value/distribution**	**Justification**
SOURCE TERM		
Waste volume (m^3)	86,996	Based on phasing plans-less 10,000 m^3 restoration soils for the unfilled part of the quarry
GENERAL CONTAMINANT INFORMATION		
Free water diffusion coefficient (m^2/s): Sulphate Phenol Chromium Arsenic Lead Mercury Benzene BaP	 1.07×10^{-9} 8.7×10^{-10} 1.0×10^{-9} 9.05×10^{-10} 1.0×10^{-9} 2.0×10^{-9} 6.64×10^{-10} 3.67×10^{-10}	 S R Buss et al 2004 Chloride, benzene, phenol, chromium from Buss et al, 2004, Table 3.1 Arsenic from Allison & Allison, 2005 Mercury from EA Soil guideline values
HYDROGEOLOGICAL UNITS		
Thickness (m): Formation layer	1 m	Approximate thickness
Hydraulic conductivity (m/s): Formation layer	1×10^{-7} m/s	Estimated maximum conservative value for cohesive soils
Hydraulic gradient: Formation layer	1	Assumed reasonable worst case
Porosity: Formation layer	0.25	Estimated
Tortuosity	5	Assumed generic value for all hydrogeological layers
Horizontal travel distance (m):	1	

2908/HRA/TA3.3: Model input parameters		
Parameter	**Value/distribution**	**Justification**
ATTENUATION PARAMETERS		
Dispersivity	1 10th of travel distance	
Mixing depth	1 m	Based on thickness of foundation layer and assumption this is saturated
Bulk density (kg/m³): Foundation layer	1600	As per geotechnical stability modelling
Fraction of organic carbon: Foundation layer	0.01	Average FoC from https://www.itrcweb.org/DNAPL-ISC_tools-selection/Content/Appendix%20I.%20Foc%20Tables.htm
Sulphate Partition coefficient (kd) (L/kg) Half Life Phenol Koc Partition coefficient (k_d) (L/kg) Half life (days) Chromium Partition coefficient (k_d) (L/kg) Half life (days) Arsenic Partition coefficient (kd) (L/kg) Half life (days) Lead Partition coefficient (kd) (L/kg) Half life (days) Mercury Partition coefficient (kd) (L/kg) Half life (days)	0 No decay 29 Calculated No decay 6.3 No decay 1584 No decay 5011 No decay 3981 for clay No decay	Allison & Allison, 2005 US EPA Allison & Allison 2005 Allison & Allison 2005 Allison & Allison 2005 Allison & Allison 2005
Benzene Koc Partition coefficient (k_d) (L/kg) Half life in	135 calculated 36	Average from Earl, et al, 2003

2908/HRA/TA3.3: Model input parameters		
Parameter	**Value/distribution**	**Justification**
groundwater (days)		Highest value in CONSIM files
BaP Koc Partition coefficient (k_d) (L/kg) Half life in groundwater (days)	1.17 x 10^6 Calculated 2993	Allison & Allison, 2005 Wild et al, 1992
WATER BALANCE		
Precipitation (mm/yr) Infiltration Factor Infiltration area (m^2)	1047 0.25 21,363	MAFF Technical Bulletin 34, Area 42 Based on NCB nomogram accounting for slope, vegetation & soil type (run-off coefficient of 0.75) Area of waste
DILUTION IN POND		
Run-off Factor Run-off area (m^2)	0.75 65,325	As per run-off coefficient Catchment area used in FRA and drainage design

References

Allison JD & Allison TL, 2005. Partition coefficients for metals in surface water, soil and waste. United States Environmental Protection Agency, Report EPA/600/R-05/074

Buss SR, Herbert AW, Morgan P & Thornton SF, 2003. Review of ammonium attenuation in soil and groundwater. Environment Agency NGWCLC report N° NC/02/49

Buss SR, Herbert AW, Green KM & Atkinson C. 2004. Contaminant fluxes from hydraulic landfills – a review. Environment Agency Science Report SC0310/SR

California EPA & Department of Toxic Substances Control, 1994. Intermedia transfer factors for contaminants found at hazardous waste sites

Earl N, Cartwright CD, Horrocks SJ, Worboys M, Swift S, Kirton A, Askan AU, Kellener H & Nancarrow DJ, 2003. Review of the fate and transport of selected contaminants in the soil environment. Environment Technical Report P5-079/TR1

Morgan H et al. Soil guidelines values for mercury in soil. Environment Agency Science Troup Reports CO50221/Mercury SGV

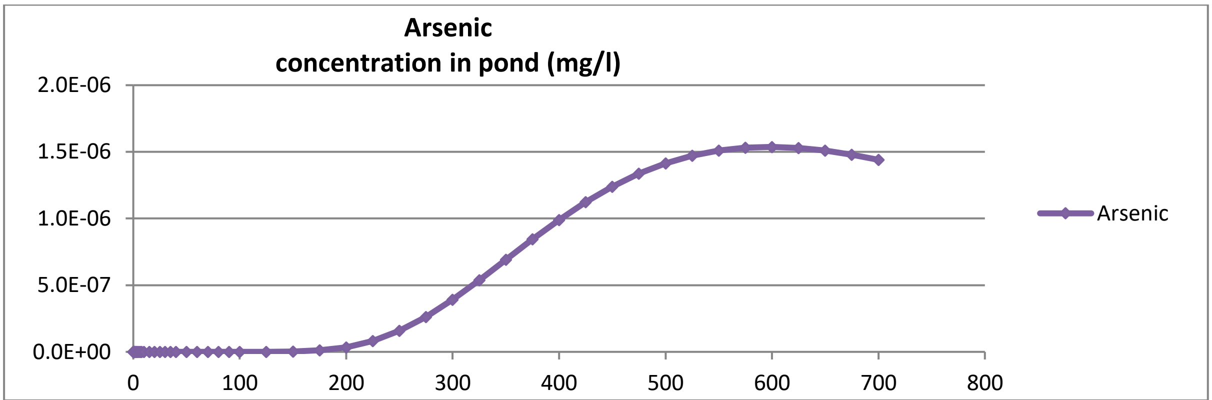
Thrasher J, Morgan P & Buss SR, 2004. Attenuation of mecoprop in the subsurface. Environment Agency Science Group report NC/03/12

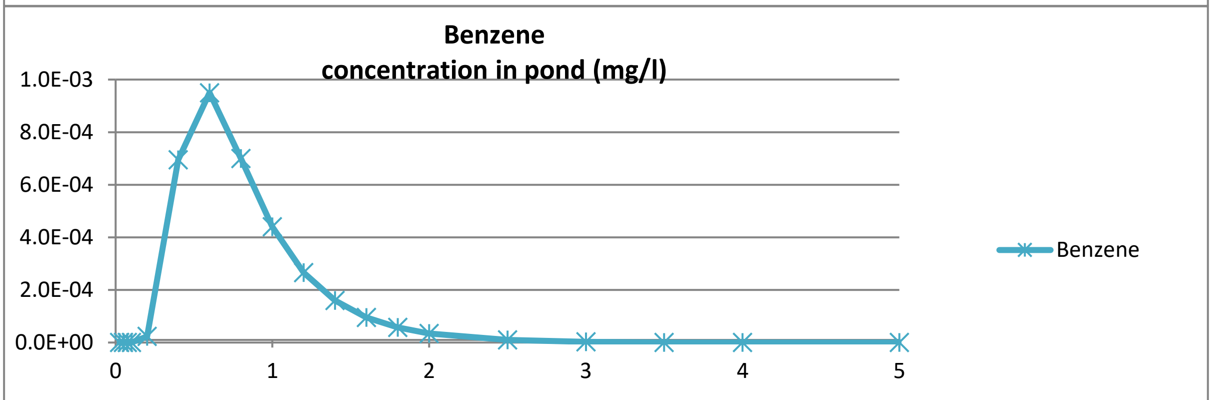
Wild et al, 1992. EA UK soil and herbage pollutant survey. Environmental concentrations of polycyclic aromatic hydrocarbons in UK soil and herbage. UKSHS Report 9

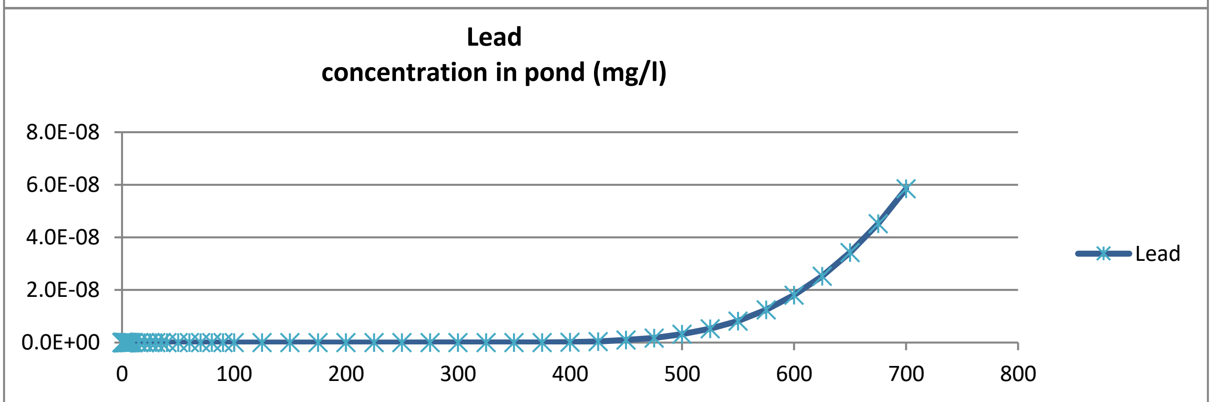
A3.2.3 Results of the risk assessment

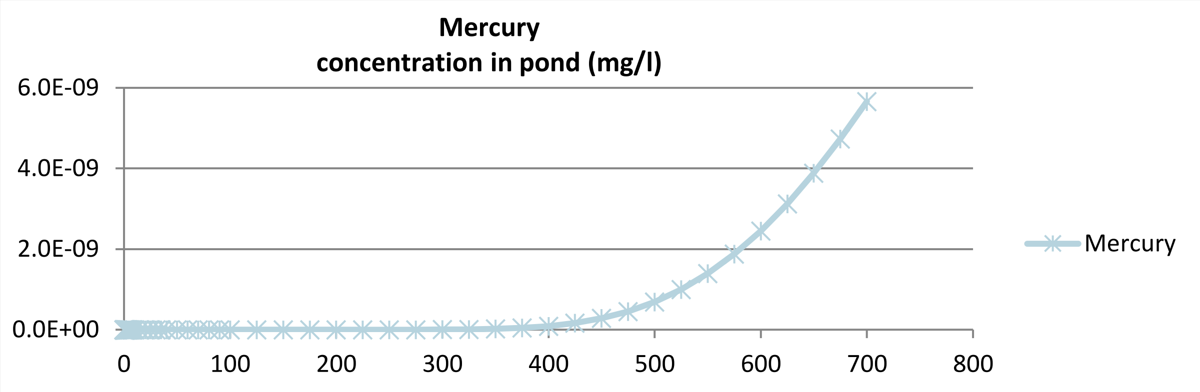
The peak concentrations recorded in the pond are presented in *Table 2908/HRA/TA3.4* together with the time to reach the peak. The breakthrough curves are provided below.

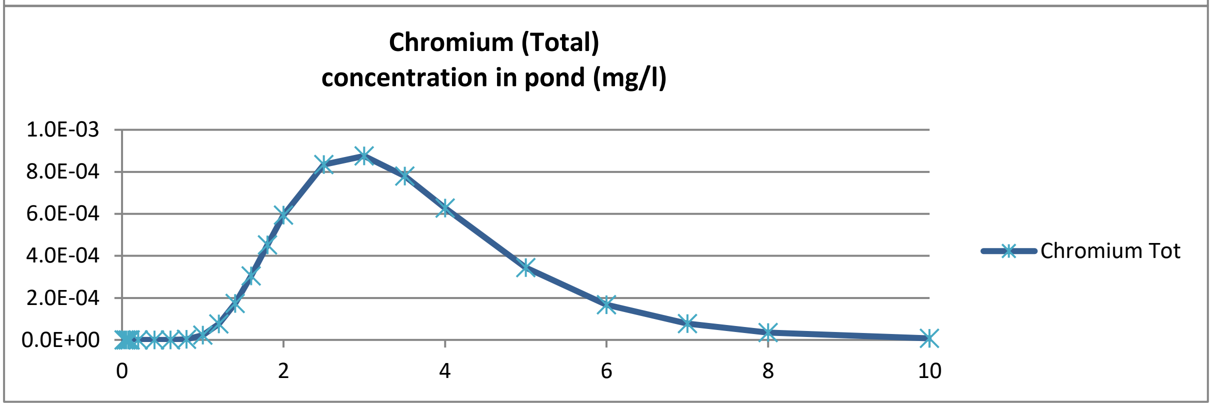
2908/HRA/TA3.4: Results of quantitative risk assessment		
Determinand	**Peak concentration mg/l (µg/l)**	**Time to peak**
Hazardous:		
Chromium	0.00088	3 years
Arsenic	1.54 x 10-6	600 years
Lead	5.85 x 10^{-5}	Peak not reached after 700 years
Mercury	5.66 x 10-9	Peak not reached after 700 years
Benzene	0.00095	0.6 years
Benzo-a-pyrene	-	No peak recorded after 700 years
	4.43 x 10^{-3}	
Non-hazardous:		
Sulphate	10.36	0.2 years
Phenol	0.0083	0.4 years

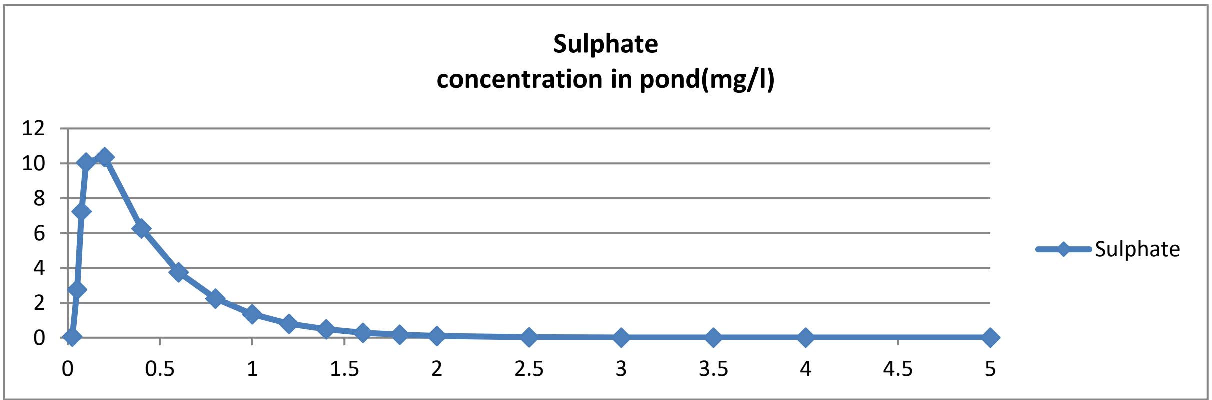


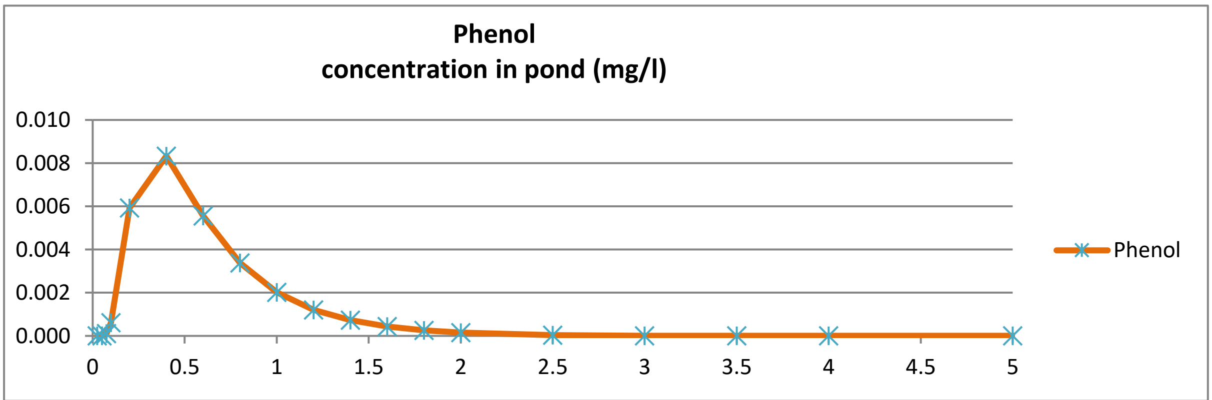





Mercury
concentration in pond (mg/l)
6.0E-09
4.0E-09
2.0E-09
0.0E+00
0
100
200
300
400
500
600
700
800
Mercury


Chromium (Total)
concentration in pond (mg/l)
1.0E-03
8.0E-04
6.0E-04
4.0E-04
2.0E-04
0.0E+00
0
2
4
6
8
10
Chromium Tot


Sulphate
concentration in pond(mg/l)
12
10
8
6
4
2
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Sulphate


Phenol
concentration in pond (mg/l)
0.010
0.008
0.006
0.004
0.002
0.000
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Phenol

The results of the quantitative modelling indicate that if 5% of the waste entering the site contained concentrations up to 2 x Inert WAC, breach of the EALs would not occur. Although some substances did not peak during the modelled period the concentrations recorded after 700 years are very low.

This indicates that the technical precautions proposed are sufficient to prevent pollution.