

Transport, Environment & Design

Zig Zag Quarry Gas Risk Assessment

November 2025



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Revision	Author	Description	Date
1	Jamie Howourth	Report issued as final.	12-Sep-2024
2	Alex Large	Minor edits including updated drawings (Appendix A).	19-Nov-2025

1. Introduction

1.1 Commission

- 1.1.1 Horizon Consulting Engineers Limited (Horizon) was commissioned by BT Jenkins Limited (BTJ) to prepare a Gas Risk Assessment (GRA) in support of an application to the Environment Agency to vary the existing Environmental Permit (Reference: HB3705XG) at Zig Zag Quarry.

1.2 Report Layout

- 1.2.1 This report has been prepared with reference to the Environment Agency's outline template for GRA and Environment Agency guidance, in particular LFTGN03¹. Although the proposed works are classified as waste recovery rather than as landfilling, the principles of the guidance are still valid and relevant with respect to recovery sites.

1.3 Site Context

- 1.3.1 A variation is required to the existing Environmental Permit to facilitate the final restoration of the Site under Devon County Council (DCC) Planning Permission Reference DCC/4339/2023.
- 1.3.2 The overarching aim is to infill the void, restoring the Site to pre-quarrying levels. The Site is to be restored to a long-term end use of pastoral grazing fields separated by Devon hedge banks together with scrub and woodland habitats.
- 1.3.3 A GRA is required on the basis of the thickness of fill being greater than 2 metres. Although the fill material is of low gas generation potential, a qualitative risk assessment has been carried out for the 1.5 million tonnes of proposed material import (predominantly inert subsoil).
- 1.3.4 It is assumed the reader of this GRA has read and is familiar with the CSM report². The CSM for the purposes of this GRA been developed based on relevant information presented in the CSM report².

1.4 Aims and Objectives

- 1.4.1 The aim of this GRA is to provide the Environment Agency with sufficient detail in relation to the potential risks associated with landfill gas generation to establish the appropriate mitigation measures if required.

¹ Environment Agency (September 2004) Guidance on the Management of Landfill Gas. Ref: LFTGN03

² Horizon (November 2025). Zig Zag Quarry. Conceptual Site Model. Ref: HCE0269.CSM.Rev3

2. CSM: Source

2.1 Historical Activity

- 2.1.1 For the purposes of this GRA, the source is considered to be any landfill gas (e.g. carbon dioxide, methane plus trace gases such as carbon monoxide and hydrogen sulphide) either generated from material deposited at the Site or from background sources (e.g. nearby landfilled waste, natural soils with elevated organic carbon content or Made Ground / contaminated land).
- 2.1.2 The Site history has been assessed based on Ordnance Survey historical maps (reproduced in Appendix F of the CSM² report) supported by anecdotal evidence supplied by the Client.
- 2.1.3 Table 3-1 in the CSM report² summarises key features both on-Site and immediately adjacent from historical mapping.
- 2.1.4 In summary, the Site was historically agricultural fields and woodland from at least 1888 with a small sand pit feature in the west of the Site. The main quarry workings were established on-site and adjacent to the north from the 1930s onwards. The quarry workings on-Site and surrounding area expanded throughout the 20th Century until restoration commenced in some areas from the 2000s onwards.
- 2.1.5 On 01 December 2021 the existing Environmental Permit (reference: EPR/HB3705XG) was granted. This permit, and the associated waste recovery plan (WRP³), enabled the partial infilling of Zig Zag Quarry, plus the silt lagoons associated with Aller Quarry to the north, to meet the restoration requirements as per an earlier planning permission. Along with available indigenous material, a total of 285,000 tonnes of suitable material was approved for import in 2019.
- 2.1.6 The import of suitable material was undertaken both under the CL:AIRE DOWCOP⁴ scheme and the existing Environmental Permit with reference to the approved quantities in the 2019 WRP³.

2.2 Proposed Activity

- 2.2.1 The Site is currently permitted for a waste recovery operation (Environmental Permit reference: HB3705XG) although a variation is required to facilitate the final restoration of the Site under Devon County Council (DCC) Planning Permission Reference DCC/4339/2023.
- 2.2.2 The overarching aim is to infill the void, restoring the Site to pre-quarrying levels. Relevant drawings from the Planning Permission are included in Appendix A of the CSM report².
- 2.2.3 There are no remaining indigenous restoration materials on-Site and no suitable material to create a stable landform and associated growing medium. Accordingly, this report has been prepared to support the proposed transfer of suitable soil types conforming to the following waste codes:

Waste Code	Description
01 04 08	Waste gravels and crushed rocks other than those mentioned in 01 04 07
01 04 09	Waste sand and clays
17 05 04	Soil and stones other than those mentioned in 17 05 03

Table 2-1: Waste Codes

³ Aardvark (20 December 2019) Zig Zag Quarry Environmental Permit. Waste Recovery Plan. Ref: 1922-R001. Revision: FINAL 2

⁴ CL:AIRE (March 2011) The Definition of Waste: Development Industry Code of Practice. Version 2

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- 2.2.4 Environmental monitoring and surveillance will be undertaken throughout the works as per the Environmental Setting & Site Design (ESSD) report⁵ to demonstrate the effectiveness of the design principles. In summary, a low permeability clay liner is to be placed to a thickness of at least 1 m. This will either be formed from imported cohesive soils or use of existing cohesive restoration soils. Any existing topsoil placed as part of the restoration is to be stripped and stockpiled for future use prior to placement of the liner.
- 2.2.5 Only the waste codes listed in **Table 2-1** above are permitted for use in the deposit for recovery including the material that will form the liner. Material will be brought to Site and checked in accordance with the Site's Waste Acceptance Procedures⁶.
- 2.2.6 It is proposed to carry out the works broadly in three phases working from the rear (north-east) of the quarry, towards the south-west, progressing the final landform shape. A veneer of topsoil (typically 150 mm thick) is to be placed over the subsoil to complete the restoration works. Topsoil is to be placed in phases with the Site returning to agricultural land in a phased approach.
- 2.2.7 On the basis of the above, the inert subsoil deposited for the purpose of restoring the Site is considered to comprise the principal potential source of any gas generated. Secondary sources such as contamination associated with the Site's historic use or background ground gas are not considered to be significant sources in the overall context of the works.
- 2.2.8 The generation of landfill gasses such as carbon dioxide and methane from soil requires readily degradable organic material within the soil to be present. Other factors controlling the rate of landfill gas generation include the moisture content, nature of degradable material, soil pH, and method of landfilling (in particular degree of compaction) The subsoil to be deposited at the Site is required to meet the inert WAC limits and will therefore have a low organic content (maximum Total Organic Carbon (TOC) of 3%, in reality the average TOC will be significantly lower than this).

⁵ Horizon (November 2025) Zig Zag Quarry. Environmental Setting & Site Design Report. Ref: HCE0269.ESSD.Rev2

⁶ Horizon (September 2024). Zig Zag Quarry. Waste Acceptance Procedures Ref: HCE0269.WAP.Rev1

3. CSM: Pathways and Receptors

3.1 Pathways

- 3.1.1 For the purposes of this GRA, pathways are defined as the processes or mechanisms by which ground gases migrate from the source to a receptor. **Table 3-1** has been developed with reference to LFTGN03¹ to evaluate active pathways associated with the Site through which receptors may be exposed to gas emissions:

Pathway	Applicable?	Discussion
Direct release to the atmosphere	Yes	Other than a thin layer of topsoil, a capping layer is not proposed to be placed over the deposited subsoil with the Site restored for agricultural land-use. On that basis, there is the potential for direct release of gases to atmosphere, with subsequent dispersion controlled by the prevailing wind direction and speed with emissions from the surface of the Site. Subsoil imported will be inert with limited gas generating potential. Furthermore, visual inspections will take place throughout restoration works to ensure no unacceptable material is deposited.
Sub-surface migration through the ground or along service ducts and/or pipelines.	No	Sub-surface migration relates to the lateral migration through more permeable geology or along preferential pathways (e.g. backfill around underground pipes). Sub-surface or lateral migration through the vadose zone is typically a function of either advection or diffusion. There are limited underground services on-Site with the only services being water mains to the existing site office and cabins.
Indirect release to atmosphere, e.g. from subsurface landfill gas migration, or dissolution from leachate and condensate.	Yes	Given the nature of the waste to be placed in the Site (reasonably well compacted inert subsoil) the potential for leachate generation and subsequent indirect release of ground gases to atmosphere is considered to be low.
Direct release of combustion products to atmosphere, e.g. enclosed flares and engines.	No	No landfill gas controls (e.g. flares and engines) are proposed.

Table 3-1: Evaluation of Pathways

- 3.1.2 On the basis of the above, gas movement is likely to be limited to direct release to atmosphere as a result of passive advective flow influenced primarily by fluctuations in atmospheric pressure. Management of the working area will be required to ensure effective surface water control (details as set out in the ESSD⁵) to minimise the potential for ponding and reduce infiltration of surface water into the fill material until the restoration is complete.

3.2 Receptors

- 3.2.1 Existing and potential future receptors that may be at risk from the developments emissions have been identified in the CSM report² Specifically, with respect to gas risk, these receptors are summarised in the table below with reference to LFTGN03¹. A plan showing sensitive receptors in the vicinity of the Site is reproduced from the CSM report in **Appendix A**.

Receptor	Receptor Type	Location
Public Bridleway	Recreational	Adjacent to the north of the Site – follows northern boundary of Site
Café	Commercial	Adjacent to the west of the Site
Town of Kingskerswell (Residential Properties)	Residential	Main town of Kingskerswell adjacent to the south of the Site
Town of Newton Abbot	Residential	Main town of Kingskerswell adjacent to the north of the Site
Isolated residential properties and local farmsteads.	Residential	Various with the nearest located adjacent to the north-east of the Site.
Static caravan park	Residential / Leisure	50 m south.
Caravan dealership	Commercial	75 m south.
Farm and Farm shop	Commercial	150 m north-west
Pub	Commercial	150 m west.
Minor commercial / industrial units	Commercial	100 m south-west and 170 m west

Table 3-2: Evaluation of Existing Receptors

4. Gas Risk Assessment

4.1 The Nature of the Gas Risk Assessment

- 4.1.1 Given the strict waste controls to be applied and low organic content of the subsoil to be deposited at the Site a qualitative screening approach has been adopted to the assessment of risks from landfill gas.
- 4.1.2 The GRA principally considers the risks from carbon dioxide and methane. Risks from trace gases (e.g. carbon dioxide, hydrogen sulphide etc) are considered to be low, and mitigating risks from carbon dioxide and methane will mitigate risks from trace gases.
- 4.1.3 In line with the recommendations in LFTGN03¹, no numerical modelling has been undertaken as part of this project. The subsoil accepted is to be not hazardous and when classified per WM3 meets inert WAC limits. As noted in LGN03, *“new inert landfills ought not to pose a landfill gas hazard. The emphasis in the risk assessment should, therefore, be placed on the WAP and particularly the waste characterisation and compliance monitoring measures introduced to ensure that only inert waste is deposited at the Site.”*

4.2 Risks to the Environment and Human Health

- 4.2.1 The risk assessment has been developed by Horizon on the basis of the information presented above including the proposed activities on the Site and is the principal output of this report. The UK contaminated land regime and associated guidance documents^{7,8} set out a risk-based framework of the assessment of contaminated sites. A source-pathway-receptor linkage is required to exist in order for a risk to be present. This means that there must be a contaminant present (i.e. landfill gas for the purposes of this GRA), a receptor that could be harmed by this contaminant, and a pathway linking the two.
- 4.2.2 The principal source of gas emissions associated with the Site will be any biodegradable materials within the deposited waste mass which have the potential to generate gas as they degrade.
- 4.2.3 A full list of the permitted waste types is presented in the **Table 2-1**, however it is intended that predominantly inert subsoil (compliant with European Waste Code 17-05-04) be deposited at the Site as part of the proposed works. Project specific WAP⁶ include details of Operator assessment of the inert nature of soils (e.g. analysis of chemical data), visual inspections and verification testing. The Operator may reject waste for any reason, including on the grounds of potential to jeopardise waste stabilisation and/or environmental protection systems.
- 4.2.4 Of importance to this GRA, waste types identified in LFTGN03¹ as having a high fraction of biodegradable materials which contain cellulose and hemicellulose are not acceptable at the Site. These include:
- Readily biodegradable materials;
 - Subsoil with elevated TOC above the inert WAC limit; and
 - Any waste loads with anthropogenic materials (e.g. paper, cardboard, packaging), putrescible materials (e.g. garden waste, wood), textiles or sewage sludge.

⁷ <https://www.gov.uk/guidance/land-contamination-how-to-manage-the-risks/stage-1-risk-assessment>

⁸ DEFRA (2012) Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance

4.2.5 On the basis of the above, the potential for gas generation from deposited material at the Site is considered to be low. In addition to the above:

- The low permeability natural soils underlying the Site will limit the potential for lateral migration of gas; and
- The organic content of subsoil accepted will be limited. The inert WAC limit of 3% will be used to screen out subsoils with potentially high organic content. In reality, the overall average TOC of the waste mass will be significantly below 3%.

4.2.6 A summary of the contaminant linkages is summarised below based on the information presented above:

Source	Pathway	Receptor
Imported subsoil (conservatively up to 3% degradable material albeit in reality anticipated to be significantly less than 3% degradable material).	Lateral migration through sub-surface, low permeability sub-grade and subsequent build-up within sub-surface and confined spaces.	Off-Site: residential properties (town of Kingskerswell and Newton Abbot plus isolated residential properties), and commercial properties (Pub, Public Bridleway, Static caravan park, Farm and Farm shop and Cafe) / industrial properties.
	Direct release to atmosphere.	On-Site: Transient users of the Site.
	Lateral migration through sub-surface, low permeability sub-grade, into surrounding rock and subsequent direct release to atmosphere.	Off-Site: residential properties (town of Kingskerswell and Newton Abbot plus isolated residential properties), and commercial properties (Pub, Public Bridleway, Static caravan park, Farm and Farm shop and Cafe) / industrial properties.

Table 4-1: Summary of Risk Assessment (Pathways and Receptors)

4.3 Discussion

4.3.1 The most sensitive receptor is considered to be isolated residents. Although there are urbanised areas to the south-west and south of the Site, given the where the Site sits topographically in relation to the surrounding area (topographically higher than the areas to the west, south-west and south), any lateral migration of ground gas will come out the side of the restoration landform and diffuse in the atmosphere.

4.3.2 Isolated residents and farmsteads are present in close proximity to the north-east of the Site and although these areas are at risk from lateral migration, given the low permeability of the liner (anticipated to less than 1×10^{-7} m/s), and the negligible concentrations of gas produced, the risk to these receptors is considered to be low.

4.3.3 The Site is to be restored for agricultural land use which will integrate with the surrounding agricultural land to the north and east of the Site. No cap is proposed on the waste mass, with the surface layer to comprise a mixture of imported and existing topsoil to be placed over the imported subsoil. On that basis, the most credible complete source-pathway-receptor linkage is considered to be agricultural crops in the field immediately adjacent to the Site and any crops grown on the Site following its restoration for agricultural purposes.

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- 4.3.4 As noted in LFTGN03¹ “...landfill gas can cause damage to vegetation on adjacent land and crop die-back (chlorosis). Although plant death in many situations has been attributed to root zone oxygen displacement by the bulk components of landfill gas, several trace components of the gas are known to exert phytotoxic effects when borne in subsurface gas or ambient air. In addition, products of landfill gas combustion (e.g. acid gases such as hydrogen chloride, hydrogen fluoride and oxides of nitrogen and sulphur) will produce emissions that are potentially damaging to vegetation and ecosystems.
- 4.3.5 The intention is to restore the Site with inert subsoil under strict Waste Acceptance Procedures to restore the Site for beneficial agricultural purposes, on which basis the flux of landfill gases from the waste is anticipated to be very low. The crops are anticipated to be of low sensitivity and whilst a capping layer is not proposed, the overall risk associated with this contaminant linkage is considered to be very low.

5. Completion Criteria

- 5.1.1 In order to surrender an Environmental Permit, the Environment Agency must be satisfied that:
- *“the Site has ceased accepting waste;*
 - *relevant closure procedures have been complied with;*
 - *an appropriate period of aftercare has passed to allow the waste to stabilise and to gather evidence to demonstrate that the pollution control measures are no longer necessary;*
 - *the deposits of waste are in a satisfactory state that, if left undisturbed, will not cause pollution of the environment.”*
- 5.1.2 No active management systems are planned.
- 5.1.3 With reference to [EPR5.02⁹](#) it is intended to demonstrate through records including waste details, CQA reports and audits that the subsoil accepted is genuinely inert. On that basis the surrender application should be considered in the low-risk category and gas monitoring post completion of deposition and restoration is not required.
- 5.1.4 Ground gas monitoring from perimeter monitoring wells BH01, BH02, BH03 and BH04 will be used to support the assessment. For monitoring purposes, the methane and carbon dioxide concentrations will be assessed with reference to the Scenario 1 completion criteria in [EPR5.02⁹](#) (i.e. below 5% for carbon dioxide and below 1.5% for methane).

⁹ <https://www.gov.uk/government/publications/landfill-epr-502-and-other-permanent-deposits-of-waste-how-to-surrender-your-environmental-permit/landfill-and-deposit-for-recovery-aftercare-and-permit-surrender#completion-criteria-landfill-gas>

6. Gas Management Plan

6.1 Control Measures & Management

- 6.1.1 No active gas control measures are proposed.

6.2 Monitoring and Sampling Plan

- 6.2.1 Gas monitoring is not a requirement of the existing Environmental Permit and has not been undertaken during the placement of restoration soils to date. More recently, gas monitoring commenced from boreholes BH01, BH02, BH03 and BH04 in March 2025, with monitoring of boreholes BH05 and BH06 scheduled to commence in November 2025.
- 6.2.2 Gas monitoring will be conducted on a quarterly basis with all available boreholes monitored on each occasion. The proposed ground gas monitoring frequency and sampling methodology is set out in the ESSD⁵.

6.3 Action Plan

- 6.3.1 This action plan has been developed in the event of evidence that there may be a potential risk of gas affecting sensitive receptors associated with the Site on the basis of:
- Complaints from Site staff or nearby residents;
 - Evidence of unexpected vegetation die back in vicinity of the Site;
 - Evidence of gas affecting local air quality or infrastructure; or
 - A change in the Site design or evidence that the assumptions in this GRA are incorrect.
- 6.3.2 The course of action to be adopted in the event that one or more of the above events occurs is as follows:
- The Site manager is to be informed directly and if a significant risk is identified work should cease on-Site;
 - Upon instruction from the Site manager a suitably qualified geoenvironmental engineer is to undertake an assessment of the immediate risk to human health, crops and infrastructure. If appropriate, emergency measures to be implemented in agreement with the Environment Agency or other regulators.
 - In the event an immediate risk is not identified, gas monitoring infrastructure is to be installed to enable a risk-based review of monitoring results and evidence by a suitably qualified geoenvironmental engineer. Additional testing (e.g. investigations of waste quality) may be undertaken in order to inform an updated GRA. If appropriate, a remedial strategy including changes to Site engineering may be developed for agreement with the Environment Agency.
 - This GRA is to be updated to reflect any changes on-Site.

7. Conclusions

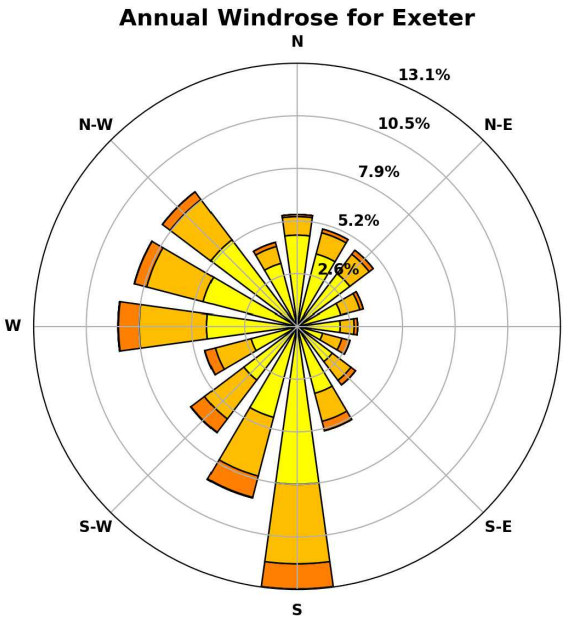
- 7.1.1 This gas risk assessment has been developed in relation to the proposed use of primarily inert subsoil to enable the restoration of Zig Zag Quarry per the approved Planning Permissions. The Site is to be restored to original ground levels for long-term agricultural use.
- 7.1.2 A risk-based framework has been adopted for the assessment of potential risks to receptors associated with the Site with a complete source-pathway-receptor linkage required to exist in order for a risk to be present. This means that there has to be a contaminant present (i.e., landfill gas for the purposes of this GRA), a receptor that could be harmed by this contaminant, and a pathway linking the two.
- 7.1.3 Given the Site is to be restored primarily with inert subsoil under strict Waste Acceptance Procedures, with no biodegradable wastes (e.g. paper, cardboard, wood, garden refuse, textiles, sewage sludge) accepted, the potential for gas generation is considered to be very low.
- 7.1.4 On the basis of the above, no measures to control the accumulation and migration of gas are proposed at the Site and the risk to receptors associated with the Site is considered to be low.

Appendix A

Drawings

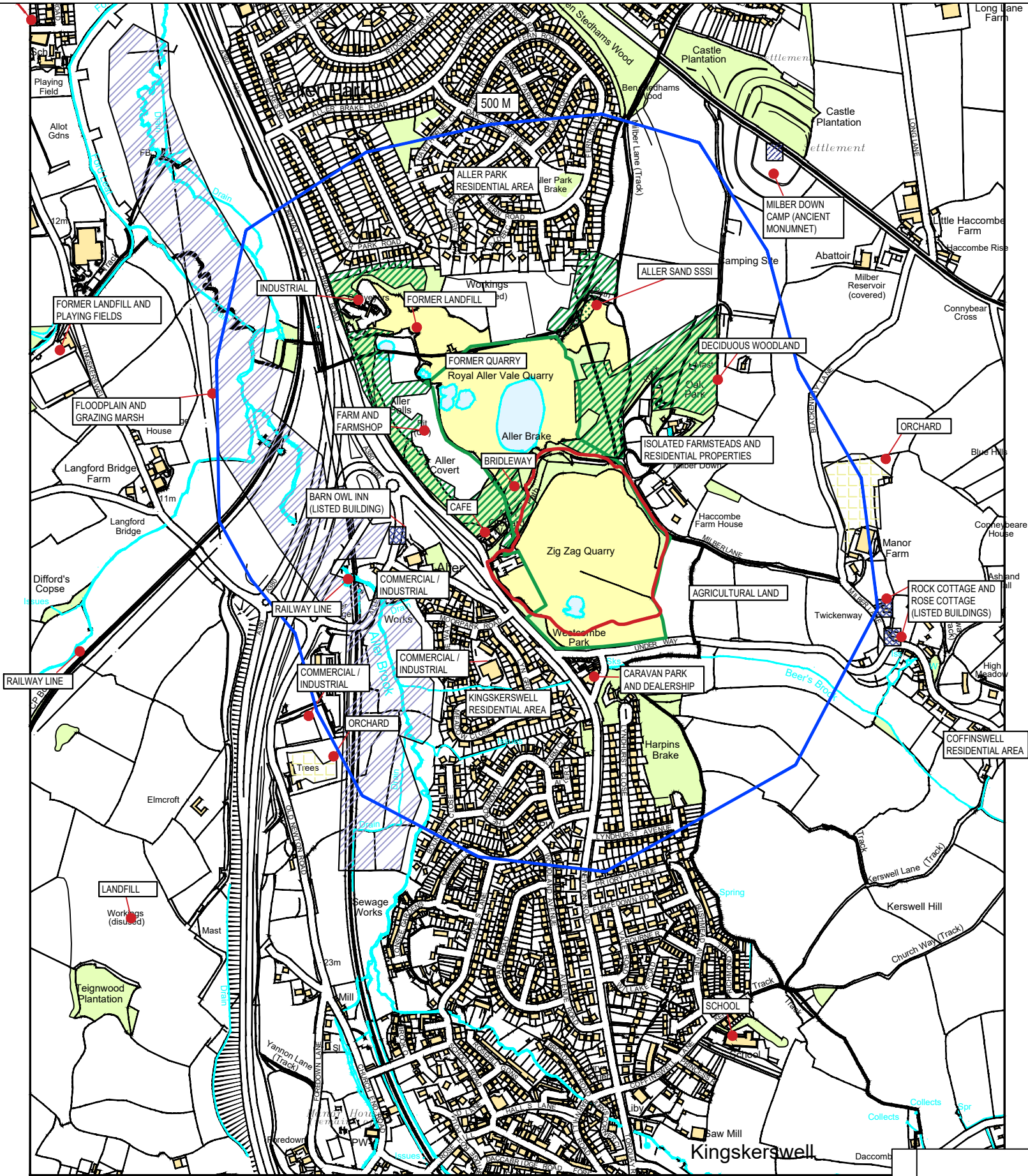
NOTES: GENERAL

1. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH ALL RELEVANT SCHEME DRAWINGS AND SPECIFICATIONS.



SOURCE: MET OFFICE

- KEY:
- SITE BOUNDARY (2023 PLANNING PERMISSION)
 - PERMIT BOUNDARY
 - ANCIENT MONUMENT
 - ANCIENT BUILDING
 - PRIORITY HABITAT – DECIDUOUS WOODLAND
 - PRIORITY HABITAT – FLOODPLAIN GRAZING MARSH
 - PRIORITY HABITAT – TRADITIONAL ORCHARD



Rev	Description	Drn	Chk	Date
REVISIONS				
Preliminary	Approval	Tender	Const.	
DRAWING STATUS				
DATE	OCT '25	DRAWN	JH	CHECKED
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