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FLOOD RISK ASSESSMENT

LAND SOUTH OF HAYWOOD LANE, WELLINGTON, HEREFORDSHIRE

Report Reference: 2732/FRA
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Report prepared for:

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GENERAL NOTES

Title of report: Flood Risk Assessment

Site: Land south of Haywood Lane, Wellington, Herefordshire

Report ref: 2732/FRA

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Draft version D1	July 2018	GP Planning Ltd
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1 INTRODUCTION

1.1 Background

Herefordshire Quarries Ltd propose to develop a greenfield site at Haywood Lane, located east of Wellington and approximately 7 km north of Hereford. It is proposed to extract sand and gravel with progressive restoration to existing levels through placement of inert fill.

Hafren Water has been commissioned to undertake a Flood Risk Assessment (FRA) for the proposed development to accompany the Planning Application.

1.2 Pre-application advice

This assessment has been informed by scoping opinion received from Herefordshire Council dated 31st March 2021 which in terms of flood risk has requested information relating to:

- What is the location of temporary stockpiles relative to flood zone extents?
- What is the potential for the development to increase flood risk to external areas?
- If inundation of working areas occurs from river flooding, will excess water be pumped off-site and at what rate? Also, what measures will be taken to limit pollution risk to the River Lugg?
- Is there a requirement for controlled discharge from clean water lagoons?
- What measures will be used to separate/treat polluted water from the washdown area?

1.3 Data sources

The following data sources were used in this assessment:

GP Planning
- Site plans

Environment Agency web service
- Flood map for planning
- Surface water flood map

British Geological Survey (BGS)
- [Online] Geology of Britain Viewer (http://mapapps.bgs.ac.uk)
- Geological borehole logs

Ordnance Survey (OS)
- 1:25,000 and 1:10,000 scale mapping

Herefordshire Council (HC)

- Strategic Flood Risk Assessment (April 2019)
- Strategic Flood Risk Assessment Update (February 2015)
- Strategic Flood Risk Assessment for Herefordshire – 3rd Edition (March 2009)
- Herefordshire Local Plan Core Strategy 2011 - 2031 (October 2015)

1.4 National Planning Policy Framework (NPPF) and Planning Practice Guidance (PPG)

This FRA has been undertaken in accordance with the statutory requirements of the NPPF and with reference to the PPG with regard to development and flood risk. This ensures that flood risk is taken into account at all stages of the planning process and avoids inappropriate development in areas potentially at risk of flooding.

PPG classifies the flood risk vulnerability of sites used for sand and gravel extraction as 'water compatible' development.

1.5 Local policy

Herefordshire Council (HC) is the Lead Local Flood Authority (LLFA) and Local Planning Authority for the site.

HC's '*Local Plan Core Strategy 2011 – 2031*', adopted October 2015, includes the following relevant policies (NB information has been précised or paraphrased in places):

Policy SS7 – Addressing climate change

"Development proposals will be required to include measures which will mitigate their impact on climate change.

… Key considerations in terms of response to climate change include:

- *Minimising the risk of flooding and making use of sustainable drainage methods;"*

Policy SD3 – Sustainable water management and water resources

"Measures for sustainable water management will be required to be an integral element of new development in order to reduce flood risk; to avoid an adverse impact on water quantity; to protect and enhance groundwater resources and to provide opportunities to enhance biodiversity, health and recreation. This will be achieved by ensuring that:

1. *development proposals are located in accordance with the Sequential Test and Exception Tests (where appropriate) and have regard to the Strategic Flood Risk Assessment (SFRA) 2009 for Herefordshire;*

2. *development is designed to be safe, taking into account the lifetime of the development and the need to adapt to climate change by setting appropriate floor levels, providing safe pedestrian and vehicular access, where appropriate, implementing a flood evacuation management plan and avoiding areas identified as being subject to Rapid Inundation from a breach of a Flood Defence;*

3. *where flooding is identified as an issue, new development should reduce flood risk through the inclusion of flood storage compensation measures, or provide similar betterment to enhance the local flood risk regime;*

4. *development will not result in the loss of open watercourse and culverts should be opened up where possible to improve drainage and flood flows. Proposals involving the creation of new culverts (unless essential to the provision of access) will not be permitted;*

5. *development includes appropriate sustainable drainage systems (SuDS) to manage surface water appropriate to the hydrological setting of the site. Development should not result in an increase in runoff and should aim to achieve a reduction in the existing runoff rate and volumes, where possible;*

6. *water conservation and efficiency measures are included in all new developments, specifically:*

    - *residential development should achieve Housing - Optional Technical Standards - Water efficiency standards. At the time of adoption the published water efficiency standards were 110 litres/person/ day; or*

    - *non-residential developments in excess of 1,000 m2 gross floor space to achieve the equivalent of BREEAM 3 credits for water consumption as a minimum;*

7. *the separation of foul and surface water on new developments is maximised;*

8. *development proposals do not lead to deterioration of EU Water Framework Directive water body status;*

9. *development should not cause an unacceptable risk to the availability or quality of water resources; and*

10. *in particular, proposals do not adversely affect water quality, either directly through unacceptable pollution of surface water or groundwater, or indirectly through overloading of Wastewater Treatment Works.*

Development proposals should help to conserve and enhance watercourses and riverside habitats, where necessary through management and mitigation measures for the improvement and/or enhancement of water quality and habitat of the aquatic environment. Proposals which are specifically aimed at the sustainable management of the water environment will in particular be encouraged, including where they are required to support business needs such as for agriculture. Innovative measures such as water harvesting, winter water storage and active land use management will also be supported. In all instances it should be demonstrated that there will be no significant adverse landscape, biodiversity or visual impact.

The above-mentioned objectives, and Herefordshire Council's Strategic Flood Risk Assessment (SFRA), have been reviewed and this FRA has been undertaken in accordance with the relevant objectives.

1.6 Regulatory requirement for this assessment

The site at Haywood Lane is partially located within the Environment Agency's indicative Flood Zone 3, where the probability of fluvial flooding in any one year is 1 in 100 or greater (Annual Exceedance Probability, AEP <1%).

Due to the site's location in Flood Zone 3 a Flood Risk Assessment (FRA) is required in accordance with the Planning Practice Guidance (PPG) and the Environment Agency's Flood Risk Standing Advice for Local Planning Authorities.

1.7 Summary of experience and competence

This assessment has been prepared by Peter Dunn and reviewed by Lawrence Brown.

This assessment has been prepared by Peter Dunn, Principal Hydrologist with Hafren Water. He is a specialist in surface water assessment and flood risk assessment with over 37 years' experience in environmental consultancy. He holds a Bachelor of Science degree (with Honours) in Environmental Science and Master of Science degrees in 'Engineering

Hydrology' and 'Hydrogeology'. He is familiar with assessment and management of surface water interactions and flood risk for developments comprising mineral extraction.

Lawrence Robert Brown, Principal Hydrogeologist with Hafren Water has reviewed this report. He has over 40 years' experience in groundwater assessment and management, most of which has been in a professional consultancy capacity.

He holds a Bachelor of Science degree in Geology from the City of London Polytechnic and a Master of Science in Mineral Production Management from Imperial College, London.

Lawrence Brown has been employed by Hafren Water since 2007. He is a Chartered Geologist (CGeol) and a Fellow of the Geological Society of London (FGS) and is familiar with the Code of Conduct of the Geological Society.

2 BASELINE CONDITIONS

2.1 Location and setting

The Application Area (the 'site') covers approximately 20.8 hectares (ha) of agricultural land and is located to the east of Wellington, approximately 7 km north of Hereford. The site is centred on National Grid Reference (NGR) SO 504 482 as shown on D*rawing 2732/FRA/01*.

The site comprises an area of land that is bound to the north by Haywood Lane, the A49 to the west, Wellington Brook to the south and Wellington Quarry to the southeast. Wellington Quarry is managed by Tarmac Ltd. Haywood Industrial Estate is situated to the south of Haywood Lane, and is surrounded by the site to the east, west and south.

2.2 Landform

The site is located on low-lying agricultural land within the floodplain of the River Lugg. Elevations at the site range from 59 to 55 metres Above Ordnance Datum (mAOD). Elevations increase northwestwards to Wellington Wood (210 mAOD), and westwards beyond the village of Wellington at Adzor Bank (up to 116 mAOD). To the east of the River Lugg elevations increase eastwards at Nash Hill and Sutton Walls Fort up to 100 mAOD.

2.3 Hydrology

The locations of the water features discussed in this section are shown on *Drawing 2732/FRA/02*.

2.3.1 Watercourses

The main watercourse in the vicinity of the site is the River Lugg which is located approximately 230 m to the northeast (at its closest approach) to the site. The river flows southeast to its confluence with the River Wye some 12.5 km downstream. The River Lugg is a Site of Specific Interest (SSSI) for conservation of natural habitats and wild flora and fauna and a Special Area of Conservation (SAC).

Wellington Brook is a tributary of the River Lugg and flows southeastwards, adjacent to the southern site boundary, to its confluence with the River Lugg approximately 1.3 km to the southeast of the site.

Some small drains are associated with the railway line some 200 m to the east of the site. The drains are located parallel to the railway and flow southwards where they outfall into Wellington Brook, approximately 1 km south of the site.

2.3.2 Waterbodies

The waterbody located immediately east of the site, at NGR SO 5074 4816, is a former sand and gravel extraction area.

There are ten waterbodies to the south, southeast and southwest of the site, these are associated with the adjacent Wellington Quarry and comprise worked out flooded quarry voids. The closest is approximately 90 m from the southwest boundary of the site. Their locations are shown on *Drawing 2732/FRA/02*.

2.4 Ground conditions

The bedrock on-site comprises of Raglan mudstone, which is described as a red silty mudstone with calcretes and sandstones. It has an approximate thickness of 800 m. The Raglan mudstone is designated by the Environment Agency as a 'Secondary A' aquifer; meaning there are "permeable layers capable of supporting water supplies at a local rather than strategic level, and in some cases forming an important source of base flow to rivers."

Locally, the superficial deposits comprise of Alluvium (mainly clays, silts, sands and gravels) overlying Glaciofluvial sheet deposits (sand and gravels). The superficial deposits are designated by the Environment Agency as a 'Secondary A' aquifer.

Most of the soil on-site is classified as loamy and clayey floodplain soils with natural high groundwater. The western area, which is not within the floodplain, is classified as freely draining slightly acidic loamy soils.

A summary stratigraphic column of the ground conditions within the site is given in *Table 2732/FRA/T1*.

2732/FRA/T1: Ground conditions

Strata	Lithology	
Soil	Loamy and clayey flood plain soils in the east Freely draining slightly acidic loamy soils in the west	
Superficial	Alluvium (clay, silt, sand and gravel)	Secondary A Aquifer
	Glaciofluvial sheet deposits (sand and gravel)	Secondary A Aquifer
Bedrock	Raglan Mudstone Formation (interbedded siltstone and mudstone)	Secondary A Aquifer

Additional detail on the regional and local geology is provided in the accompanying Hydrogeological Impact Assessment report (HIA) (*Hafren Water - 2732/HIA, August 2021*).

2.5 Groundwater levels

Groundwater levels are monitored at eight boreholes within the site. Monitoring commenced in October 2017. Results are given in *Table 2732/FRA/T2* below. The accompanying Hydrogeological Impact Assessment report (HIA) (*Hafren Water - 2732/HIA, August 2021*) provides additional detail.

2732/FRA/T2: Groundwater levels				
Borehole	Easting	Northing	Water level (mbgl)	
			Minimum	Maximum
01/17	350525	248051	1.28	2.61
02/17	350103	248141	2.33	>4
03/17	350136	248580	2.02	>3
04/17	350363	248731	1.06	2.62
05/17	350676	248658	1.42	2.92
06/17	351135	2488524	1.55	3.08
07/17	351099	248157	1.41	2.16
08/17	350657	248395	1.13	2.31

3 PROPOSED DEVELOPMENT

3.1 General

Full details of the proposed development are given elsewhere within the Planning Application. However, a brief summary is provided herein for context. A proposed site layout plan and cross-section profile is included as *Appendix 2732/FRA/A1.*

The Application Area is approximately 20.8 ha in extent. The proposed development comprises phased extraction of sand and gravel and progressive restoration by inert landfill back to pre-existing ground levels. The mineral extraction area covers 14.9 ha, with extraction taking place across three phases.

The plant site compound, weighbridge, offices and conveyor between sites will be located in the northwest of the site.

3.2 Plant and lagoon area

The mineral processing plant and lagoon area will be stripped of soil and stored in perimeter bunds, before construction of the plant and offices commences.

Clean water lagoons will be constructed to the west of the plant site. Water will be circulated from the mineral washing plant through the silt settlement lagoons and back to the wash plant. Top-up water, which will be necessary to replenish that lost to evaporation losses and in mineral processing, will be supplied from groundwater.

3.3 Mineral extraction

Following completion of the western lagoons, extraction will begin in Phase 1 and progress westwards. The mineral will be extracted over a period of ten years in wet conditions without dewatering. This will require a long-reach excavator to extract the material and 2 or 3 dump trucks to transport the material to the as-raised stockpile at the plant area.

3.4 Restoration

It is proposed that the site will be restored to pre-existing ground levels involving a wetland-based habitat surrounded by species-rich grasslands. The proposed layout of the restoration was not available at the time of writing.

4 APPROACH TO THE FLOOD RISK ASSESSMENT

4.1 'Flood risk'

This assessment considers the likelihood of flooding, the associated hazards and the vulnerability of the flood receptor using a mixture of quantitative and qualitative methods. These factors are combined to produce the single measure, 'flood risk'.

4.2 Climate change

Within the UK, projections of future climate change indicate that there will be more frequent, short duration, high intensity rainfall events and periods of long duration rainfall. The National Planning Policy Framework (NPPF) recommends that the effects of climate change are incorporated into Flood Risk Assessments. Recommended precautionary sensitivity ranges for peak rainfall intensities and peak river flows are outlined in the Environment Agency document, 'Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities' (last updated 27 July 2021) and are summarised in *Table 2732/FRA/T3*, below.

2732/FRA/T3: Recommended increases in rainfall parameters due to climate change			
Peak Rainfall Intensity - Applies across all of England	Years		
	'2020s'(2015 to 2039)	'2050s' (2040 to 2069)	'2080s' (2070 to 2115)
Upper estimate	+10%	+20%	+40%
Central estimate	+5%	+10%	+20%

The quarry is expected to have a working lifespan of 10 years. A conservative adjustment to peak rainfall intensities of 20% for climate change (cc) has been used to calculate run-off rates and volumes for the site. Calculations are also included for a 40% cc allowance scenario (see *Appendix 2732/FRA/A2*).

The Environment Agency does not have detailed flood modelling for the River Lugg or its tributaries. To assess potential climate change effects on fluvial flood risk to the site, it is assumed that the extent of flooding during a climate change adjusted 1% AEP event (Annual Exceedance Probability) is comparable to the extent of flooding during an event with a 0.1% AEP, ie the boundary between Flood Zones 1 and 2.

4.3 Flood receptors

4.3.1 Receptors internal to the site

In the current scenario, the Application Area is used for agricultural purposes. The flood vulnerability class of such areas, as defined in the PPG, is 'less vulnerable'.

The proposed site use will be for sand and gravel extraction. Therefore, during the operational phase, the site will be classified as 'water compatible' (as defined in the PPG).

The site will be restored back to agricultural use, classified as 'less vulnerable'.

4.3.2 Receptors external to the site

Potential receptors will tend to be located down-gradient of the site, which is in areas to the east and south. Residential properties form 'more vulnerable' receptors within the locality of the site. This level of vulnerability increases the potential severity of the consequences of flooding for these receptors. The overall degree of flood risk may thus be higher for such receptors for a given severity of flood event.

Residential properties associated with Wellington (railway) Crossing are located approximately 230 m east of the site. The residential area of Wellington is located 50 m to the west of the site on the opposite side of the A49 and is up-gradient of the site. Properties in Wellington Marsh are located 1 km to the south of the site on the opposite side of Wellington Brook. Therefore, the properties at Wellington Crossing are the only potential sensitive receptor down-gradient and in proximity of the site. Even so, the distance from the site makes it highly unlikely that the development will have a direct hydraulic connection with Wellington Crossing.

Other receptors outside the site, comprising roads, agricultural fields, and Wellington Quarry located immediately southeast of the site, are all classed as 'less vulnerable' and the consequences of flooding will be relatively mild.

4.4 Design events and flooding pathways

As required by the PPG, the return period to be considered for fluvial and rainfall events is 100 years and the effects of climate change will be factored in as described in Section 4.2 of this report. This design event will be referred to as the climate-changed, 1% AEP event.

This FRA considers the following hydrological components:

- Fluvial flow
- Surface water run-off
- Groundwater flow
- Sewer and/or water mains leakage

Within this assessment, flood risk to both internal and external receptors is assessed with reference to interactions between the development site and the hydrological components itemised above. For internal, but not external, receptors this gives information on the degree of flood hazard and hence the degree of flood risk. In the case of external receptors, flood hazard and hence flood risk during the design events is not evaluated. Instead, the potential for the development to qualitatively increase or decrease flood risk at external receptors is assessed so that targeted measures to ensure a qualitative reduction can subsequently be taken, if necessary.

4.5 Sequential and Exception Test

NPPF aims to steer new development to areas with the lowest probability of flooding. This also applies to the internal layout of developments where a site overlaps with areas of varying flood risk.

The site layout has complied with a sequential approach by locating offices, parking and weighbridge towards the northwest corner of the site where flood risk is lowest.

Remaining areas of the site associated with mineral extraction are considered water compatible and are therefore an appropriate land use within areas of higher flood risk. Whilst the development does not require an Exception Test, a precautionary approach regarding safe working has been requested by Herefordshire Council and appropriate mitigation is provided (Section 7).

5 FLOOD RISK TO SITE

5.1 Background

The risk of flooding at the site has been assessed by examining the likelihood of flooding, the hazard caused if it were to flood and its vulnerability. This has been undertaken for a range of likely mechanisms using both quantitative and qualitative methods. In terms of NPPF Flood Risk Vulnerability Classification, the proposed site use of sand and gravel extraction is classed as 'water compatible' development.

5.2 Fluvial flooding

5.2.1 General

The Environment Agency does not have detailed flood models of the River Lugg or its tributaries near the site and therefore flood level information is not available.

The Environment Agency's indicative Flood Map for Planning (shown on *Drawing 2732/FRA/03)* illustrates that part of the site, including Phases 1 and 2 of sand and gravel extraction, are located within Flood Zone 2 (1% – 0.1% AEP) and Flood Zone 3 (≥1% AEP). The areas designated as Flood Zone 2 and Flood Zone 3 are associated with flooding from the River Lugg to the north and east of the site, and the Wellington Brook to the south.

There is an absence of detailed flood models for nearby watercourses. It has been assumed that the potential effects of climate change on the extent of fluvial flooding during a 1% AEP event are reflected by the boundary between Flood Zones 1 and 2 (0.1 % AEP).

5.2.2 During mineral extraction

The northwestern part of the site, which includes the plant and processing area, is designated as Flood Zone 1 (> 0.1% AEP). As the plant and processing area (including site office), and all soil storage, will be located entirely within Flood Zone 1, the overall risk to these areas, even with potential effects of climate change, is 'very low' and mitigation measures are not required.

The mineral will not be dewatered. It will be extracted using a long-reach excavator and conveyed by dump trucks to the as-raised stockpile in the plant area. No excavated material will be stored on-site other than within the proposed plant area (in Flood Zone 1). Given a 'Water Compatible' vulnerability classification for sand and gravel extraction, the overall risk of flooding during mineral extraction is 'low', and mitigation measures are discussed in Section 7.2.

5.2.3 Post-restoration

The site will be restored to existing elevations comprising wetland-based habitats surrounded by species-rich grasslands. This will be 'less vulnerable' to flooding and the overall risk of flooding to these areas will not change from the pre-development scenario and mitigation measures are not required.

5.3 Surface water flooding

5.3.1 Flooding mechanism

Surface water flooding occurs when rainwater does not drain away through normal drainage systems or soak into the ground but lies on or flows across the ground instead. This is sometimes referred to as 'pluvial flooding'.

5.3.2 During mineral extraction

The Environment Agency's 'Risk of flooding from surface water' map indicates several small localised 'low risk' areas (0.1%-1% AEP) and a few isolated areas of 'medium risk' (1%-3.3% AEP) at the southeastern extent of Haywood Industrial Estate (see *Drawing 2732/FRA/04*). Surface water flood depths in areas of 'low risk' are typically <300 mm. These areas are likely to be associated with topographic lows which together with other areas of the excavated site will be altered by quarry operations. Any surface water accumulating within the operational extraction area will be retained by the quarry sides. Although the flood risk map indicates that a small part of the mineral extraction area has a 'low' risk of surface water flooding, water depths will be <300 mm.

The Plant Site will include a site office, internal access roads and a car parking area. Slightly higher ground occurs to the west of the site but is generally of similar elevation in other directions (Drawing *2732/FRA/02)*. Surface run-off from upslope areas to the west and any localised run-off from the industrial estate to the east would be prevented from entering the Plant by perimeter screening bunds. To the north of the site gradients are relatively flat and the potential for run-off to enter the Plant is limited. Run-off in areas to the south of the Plant will be captured by the excavated void.

Given the flood risk vulnerability of excavated areas ('water compatible') and the Plant ('low vulnerability'), the overall risk of surface water flooding to the site is 'very low'.

5.3.3 Post-restoration

The site will be returned to existing elevations comprising wetland-based habitats surrounded by species-rich grasslands. This will be 'less vulnerable' to flooding and the overall risk to surface water flooding will revert to existing levels which are generally 'very low'. As such, mitigation measures are not proposed.

5.4 Groundwater flooding

5.4.1 Background

Groundwater flooding usually occurs in low-lying areas underlain by permeable rock and aquifers that allow groundwater to rise to the surface following long periods of wet weather. Low-lying areas are generally more susceptible to groundwater flooding because the watertable may be closer to ground level.

Herefordshire Council's SFRA states that groundwater flooding is not expected to be a significant issue "*since the extent of aquifers within Herefordshire is somewhat limited*". There are no records of groundwater flooding on-site, according to the Council's SFRA.

5.4.2 During mineral extraction

Groundwater levels rise naturally to close to ground level, with levels recorded on-site between 1.13 mbgl and over 4 mbgl, as noted in *Table 2732/FRA/T2*.

The mineral will be worked wet with no dewatering during extraction. It will be extracted using a long-reach excavator and placed into dump trucks to transport the material to the as-raised stockpile in the plant area.

Therefore, during the extraction phase it is considered that the risk of groundwater flooding to the site is 'very low' for internal receptors. As such, mitigation measures are not considered to be necessary.

5.4.3 Post-restoration

It is proposed to restore the site to wetland-based habitats surrounded by species-rich grasslands. Wetlands are likely to be in direct contact with groundwater and water levels will respond to seasonal changes in groundwater conditions. There are no reports of groundwater rising to the surface and the impact of seasonal changes in groundwater conditions will be limited to the low-lying wetland areas of the restored site.

The less vulnerable and water compatible land use of the restored site causes the risk of groundwater flooding to be 'very low' and mitigation measures are not proposed.

5.5 Flooding from sewers and water mains

Water pipes may be associated with Haywood Industrial Estate although exact locations are unknown. Due to the site's rural location, it is considered unlikely to interact with flooding from sewers or water mains. However, any potential leakage would subsequently be discharged downslope directly into the watercourse along the northeast boundary; utility organisations would subsequently repair the broken pipes. Flood risk posed by site interaction with mains leakage is not considered significant.

6 FLOOD RISK FROM THE SITE TO THE SURROUNDING AREA

6.1 Fluvial flooding

6.1.1 Flood mechanism

Increased fluvial flood risk to external areas can be caused by a loss of floodplain storage or changes to flood pathways.

6.1.2 During mineral extraction

The Environment Agency's indicative Flood Map for Planning (shown on *Drawing 2732/FRA/03* shows the northwestern part of the site, which includes the plant and processing area (including site office) and all soil storage, is located within Flood Zone 1 (> 0.1% AEP).

Phases 1 and 2 of sand and gravel extraction, are located within Flood Zone 2 (1% – 0.1% AEP) and Flood Zone 3 (≥1% AEP). The mineral will be extracted using a long-reach excavator. No excavated material will be stored on-site other than within the proposed plant area, hence there will be no ground raising within Flood Zones 2 or 3 or loss of floodplain storage. In the event of a flood, water would continue to flow into and out of the site as per the pre-development site, as ground elevations will not be raised above existing levels within Flood Zone 2 or 3.

Therefore, the overall risk of increased fluvial flooding to external receptors during mineral extraction is 'very low' and mitigation measures are not required.

6.1.3 Post-restoration

The site will be restored to near pre-development elevations involving wetland-based habitats surrounded by species-rich grasslands. This will not alter flood flow paths and will cause a slight increase in floodplain storage which will reduce flood risk to external areas.

Therefore, post-restoration the likelihood of increased fluvial flooding to external receptors is 'very low' and mitigation measures are not required.

6.2 Surface water flooding

6.2.1 During mineral extraction

The proposed topsoil and subsoil bunds on the perimeter of the site have a small footprint and are not in direct contact with the flood risk areas identified on the Environment Agency's surface water flood map such as Wellington village (*Drawing 2732/FRA/04*). Any run-off from the outer flanks of bunds along the A49 will be managed by roadside drains or verges.

Hence the likelihood of increased surface water flooding to external receptors is considered 'negligible'.

As the mineral will be worked wet, direct rainfall into extraction areas will either infiltrate or disperse naturally into groundwater. During mineral extraction all soils will be stripped from the extraction areas creating a shallow void on top of the mineral. This will modify run-off characteristics by increasing the infiltration potential and reduce the volume of run-off that could potentially leave the site. Any water accumulating in the quarry void will be contained by the quarry sides. Therefore, the likelihood of surface water run-off leaving the site is very low. This together with the 230 m distance to the nearest sensitive receptor, makes the risk of increased surface water flooding to external areas during mineral extraction 'very low'.

The Plant Site will include a site office, internal access roads and a car parking area which will modify run-off characteristics, increasing the volume of run-off and potentially increasing flood risk to external areas. The rates and volumes of surface water run-off that need to be managed from the Plant are given in Section 0.

The 230 m distance to the nearest down-gradient sensitive receptor at Wellington (railway) Crossing causes the risk of flooding to be 'very low'. Precautionary measures to further reduce surface water flood risk are proposed in Section **Error! Reference source not found.**.

6.2.2 Post-restoration

Post-restoration, the site will be restored to wetland-based habitats surrounded by species-rich grasslands. Topsoil and subsoils removed prior to the extraction phase will be used for ground profiling. It is assumed that final land profiles will be sympathetic to existing elevations and ground profiles will provide sufficient freeboard to contain increased run-off within areas occupied by permanent waterbodies.

Therefore, the overall risk to external receptors is 'very low' and only precautionary measures regarding land profiling are proposed.

6.3 Groundwater flooding

6.3.1 During mineral extraction

The mineral will be worked wet without dewatering. Therefore, it is considered that the risk of increased groundwater flooding from the site is 'very low' for external receptors, and mitigation measures are not proposed.

6.3.2 Post-restoration

It is proposed to restore the site to wetland-based habitats surrounded by species-rich grasslands. Wetlands are likely to be in direct contact with groundwater and water levels will respond to seasonal changes in groundwater conditions. There are no reports of groundwater rising to the surface and groundwater induced changes in wetland water levels will be contained within the site. The wetlands will also limit the potential for up-gradient changes in groundwater level.

Therefore, the risk of groundwater flooding from the post-restoration site to external areas is considered 'very low' and mitigation measures are not proposed.

6.4 Interaction with other hydrological components

The degree of flood risk associated with the site's hydrological interaction with the surrounding area is unlikely to be significant. Therefore, further mitigation measures are not considered necessary.

7 MITIGATION MEASURES

7.1 Background

The combinations of flooding sources and receptors which require mitigation are summarised in *Table 2732/FRA/T4* below.

2732/FRA/T4: Flooding pathways requiring mitigation				
Flood mechanism	During operation		Post-restoration	
	Internal receptor	External receptor	Internal receptor	External receptor
Fluvial	**Required**	Not required	Not required	Not required
Surface water	Not required	**Required**	Not required	**Required**
Groundwater	Not required	Not required	Not required	Not required
Sewer and/or mains-Derived	Not required	Not required	Not required	Not required

7.2 Flood risk posed to internal receptors

7.2.1 Fluvial flooding to the site

Flood risk posed by site interaction with fluvial waters is 'low' for any internal receptors. The following mitigation measures should be observed as 'best practice' to maintain safe working during mineral extraction:

- No permanent plant or buildings to be in extraction areas
- Registration with Environment Agency flood warning service
- Establish safe egress routes from the extraction areas to areas of lowest flood risk (Plant Area and external areas to the west along the A49) for personnel and plant during all stages of working
- Creation of a Flood Emergency Plan that documents responsible personnel and procedures to be followed should a flood warning be received

The site is located within the EA Flood Alert Area for 'River Lugg south of Leominster' (EA Ref 031WAF116). The site is not located within a Flood Warning Area, however the 'River Lugg at Bodenham' (EA Ref 031FWFLU60) Warning Area is located approximately 1.9 km upstream of the site.

A 'Flood Alert' is issued two hours to two days in advance of flooding, and a 'Flood Warning' is issued half an hour to one day in advance.

The Environment Agency flood warning service issues warnings by phone, e-mail or text message. Registration can be completed on the Environment Agency's website or by contacting their Floodline on 0345 988 1188.

7.2.2 Fluvial flooding to external areas

During extreme events, fluvial flooding from the River Lugg and Wellington Brook may inundate working areas. It is assumed that operations would cease until flood levels have fallen to normal levels through natural infiltration and evaporation.

It is recommended that excess water from inundated areas is not pumped off-site. This could otherwise mobilise sediment in excavations and potentially contaminate nearby watercourses.

7.3 Flood risk to external receptors

7.3.1 Surface water flooding

During operations the Plant Site will include a site office, internal access roads and a car parking area. These low permeability areas will increase the volume of run-off with the potential to increase flood risk to external areas. As a precautionary measure, it is recommended that surface run-off is directed to a sump and thereafter directed to the clean water lagoon for subsequent use in mineral processing. No off-site discharge is anticipated. Estimates of surface run-off and containment storage capacity requirements are given below.

Following restoration, the site will contain wetland and grassland areas. It is recommended that ground profiling will direct surface run-off towards the wetland to limit potential increases in flood risk to external areas. Estimates of surface run-off from the restored site and wetland freeboard requirements are given below.

7.3.2 Greenfield run-off rates

The peak run-off rate from the greenfield site has been estimated using the IH124 method (equation 7.1, Institute for Hydrology Report N° 124, 1994). Off-site discharge is not anticipated but estimates of greenfield run-off are provided which represent the limiting rate and volume should off-site discharge be required. The IH124 method to give mean annual peak flow (Q_{BAR}) is of the form:

$$Q_{BAR(rural)} = 0.00108AREA^{0.89}SAAR^{1.17}SOIL^{2.17}$$

Where:		
	$Q_{BAR(rural)}$	mean annual flood, with a return period of 2.3 years (m^3/s)
	AREA	catchment area (km^2)
	SAAR (4170)	Standard Average Annual Rainfall (1941 to 1970) (mm)
	SOIL	soil index

This method does not account for slope or storm duration and provides a conservative (low) estimate of the peak greenfield run-off rate. $Q_{BAR(rural)}$ can be multiplied using the UK Flood Studies Report regional growth curves to produce peak flood flows for any return period.

Run-off rates from the Plant Site

The peak run-off rates for the Plant Site, for a storm duration of 6 hours, have been estimated using the Rational Method. The Rational Method to give peak flows (Q_p) is of the form:

$$Q_p = 2.78\ CiA$$

Where:		
	C =	run-off co-efficient (dimensionless)
	i =	rainfall intensity (mm/hr)
	A =	catchment area (ha)

The run-off co-efficient, C, varies for different surfaces. The values of C used for this assessment are consistent with the 'Wallingford Procedure for design and analysis of urban storm drainage' (HR Wallingford, 1981) and other published literature, with a value of 0.8 for parking and road surfaces, and 0.95 for roof areas.

Rainfall intensities at the site were obtained from the FEH Web Service, specifically the FEH 2013 rainfall model. Rainfall intensity is dependent on storm duration, which is taken as 6 hours in *Table 2732/FRA/T5* for the Plant Site, representing a conservative estimate in terms of volume of the critical duration for the receiving drainage system. The effect of climate change on rainfall intensities has been taken into account in accordance with the National Planning Policy Framework (NPPF), with allowances of 20% and 40%.

Sheets in *Appendix 2732/FRA/A2* provide estimates of pre-development (greenfield) run-off using IH124 method, and post-development run-off, using the Rational Method. Key information from these calculations is summarised in *Table 2732/FRA/T5*. Mitigation measures are proposed in the following section.

2732/FRA/T5: Run-off volumes and attenuation storage					
Area	**Phase of development**	**Method**	**Return period**	***1 Run-off rate (l/s)**	***1 Run-off volume (m³)**
Total Application Area (20.8 ha)	Greenfield	IH124	Q_{Bar}	36.1	780
			1 in 1-year	31.7	685
			1 in 30-year	64.2	1387
			1 in 100-year	78.6	1698
	Restored *3	Rational	1 in 100-year (+CC 40%)	759	16,385
Total Extraction Area (14.9 ha)	Greenfield	IH124	Q_{Bar}	25.8	557
			1 in 1-year	22.7	490
			1 in 30-year	46.0	994
			1 in 100-year	56.0	1210
Plant Area *2 (positively drained 0.333 ha)	Greenfield	IH124	Q_{Bar}	0.6	13
			1 in 1-year	0.5	11
			1 in 30-year	1.0	22
			1 in 100-year	1.3	28
	During extraction	Rational	1 in 1-year	2.7	58
			1 in 30-year	6.6	143
			1 in 100-year	8.8	189
			1 in 100-year (+CC 20%)	10.5	227
			1 in 100-year (+CC 40%)	12.3	265

*1 For a 6-hour critical storm duration
*2 Positively drained areas = car park 881 m², roads 1909 m², roofs 540 m²., {undrained natural ground 14,670 m²}
*3 Assuming restored wetland area 14.9 ha and restored grassland 5.9 ha

7.3.3 Surface water management in Plant Area

As a precautionary measure, it is recommended that run-off from low permeability surfaces (roads, parking and roofs) within the Plant Area is directed to sumps and the proposed lagoons to the west of the Plant Area. No off-site discharge is assumed with storm water being used in the Plant or allowed to infiltrate through the base or evaporate.

Run-off from washdown areas will be directed to a dedicated sump where it is recommended that an oil interceptor trap is installed to catch and hold any oil residue before it reaches the lagoon. Captured oil and sludge will need to be removed at regular intervals.

Estimates of the run-off volume from low permeability surfaces in the Plant Area during the 6-hour 1 in 100-year plus 20% and 1 in 100-year plus 40% climate change storm events are 227 m^3 and 265 m^3, respectively (*Table 2732/FRA/T5*). This would equate to a theoretical water level rise of up to 31 mm within the lagoons during the storm events.

Potential evaporation rates of up to 3 mm/day in summer months and infiltration rates into sand of typically 1 x 10^{-6} m/s (86 mm/day) can be expected between storm events.

Therefore, lagoons with a minimum depth of 0.5 m would provide sufficient volume to contain design storm run-off from the low permeability areas of the Plant, which will mitigate the risk of flooding to external receptors and contamination of the River Lugg and Wellington Brook.

Should storm events occur that have volumes greater than a 6-hour 1 in 100-year plus 40% climate change event, the lagoons may overflow. It is recommended that provision is made in the lagoon embankment for emergency overflow to occur to the southeast towards the excavated area of the site. The depth of the excavated void would limit the flooding and water quality impacts of emergency overflow on external areas including the River Lugg and Wellington Brook.

7.3.4 Surface water management in restored site

Following restoration ground profiling will direct surface run-off towards the proposed wetland within the site. To limit potential increases in flood risk to external areas, wetland areas will require a freeboard depth to contain the volume of run-off from the restored site. An estimate of the volume of run-off in a 6-hour 1 in 100-year plus 40% climate change event from the restored site is 16,385 m^3 (*Table 2732/FRA/T5*). This translates to a water depth in the wetland (14.9 ha) of 110 mm.

Therefore, it is recommended that ground profiling creates a 0.3 m freeboard above normal rest water levels in wetland areas to mitigate flood risk to external receptors.

Should storm events occur that have volumes greater than a 6-hour 1 in 100-year plus 40% climate change event, wetland freeboard depth may be exceeded and water could overflow from the site. In this instance exceedance flow will follow existing gradients of surrounding ground and drain southwards towards Wellington Brook and northwards to the River Lugg.

7.4 Responses to Scoping Opinion

The following is a summary of responses to issues raised by the Council's Scoping Opinion:

- What is the location of temporary stockpiles relative to flood zone extents?

Stockpiles will be in the Plant Area which is an area of lowest flood risk.

- What is the potential for the development to increase flood risk to external areas?

The generally very low risk of increased flooding to external areas by the development will be further reduced by containment of surface run-off within the site. Also, no above ground structures will overlap medium and high fluvial flood risk areas that could otherwise reduce floodplain storage or alter flood flow paths.

- If inundation of working areas occurs from river flooding, will excess water be pumped off-site and at what rate? Also, what measures will be taken to limit pollution risk to the River Lugg?

No pumping of excess water is anticipated. It is assumed that operations will cease until flood levels in excavated voids have fallen by natural infiltration and evaporation. Surface run-off will be contained on-site with no controlled discharge to watercourses.

- Is there a requirement for controlled discharge from clean water lagoons?

No discharge is anticipated. Water will be used in the Plant with any excess water infiltrating or evaporating.

- What measures will be used to separate/treat polluted water from the washdown area?

It is recommended that an oil separator is installed in the sump draining the washdown area.

8 SUMMARY and CONCLUSIONS

Herefordshire Quarries Ltd propose to develop a greenfield site at Haywood Lane, located east of Wellington and approximately 7 km north of Hereford. It is proposed to extract sand and gravel with restoration to existing levels involving a wetland-based habitat surrounded by species-rich grasslands.

The Application Area is approximately 20.8 ha with the proposed mineral extraction area limited to 14.9 ha. The nearest sensitive receptor down-gradient of the site is at Wellington Crossing, 230 m to the northeast.

The Environment Agency's indicative Flood Map for Planning illustrates that part of the site, including Phases 1 and 2 of sand and gravel extraction, are located within Flood Zone 2 (1% – 0.1% AEP) and Flood Zone 3 (≥1% AEP). The northwestern part of the site, which includes the plant and processing area, is designated as Flood Zone 1 (> 0.1% AEP).

The risk of flooding to the site from fluvial ('low'), surface water ('very low'), groundwater ('very low') and sewage/water mains ('negligible') has been considered. The risk of flooding from the site from fluvial ('very low'), surface water ('low'), groundwater ('very low') and sewage/water mains ('negligible') has been considered. Following restoration the excavated voids will increase floodplain storage which will reduce flood risk to external areas.

The mineral will not be dewatered and there is no requirement for controlled discharge off-site. Mineral will be extracted using a long-reach excavator and transported to the as-raised stockpile in the plant area by dump trucks. No excavated material will be stored on-site other than within the proposed plant and processing area (in Flood Zone 1). Should inundation of working areas occur it is recommended that work ceases until water levels revert to normal, and no off-site pumping is carried out which could otherwise contaminate external watercourses.

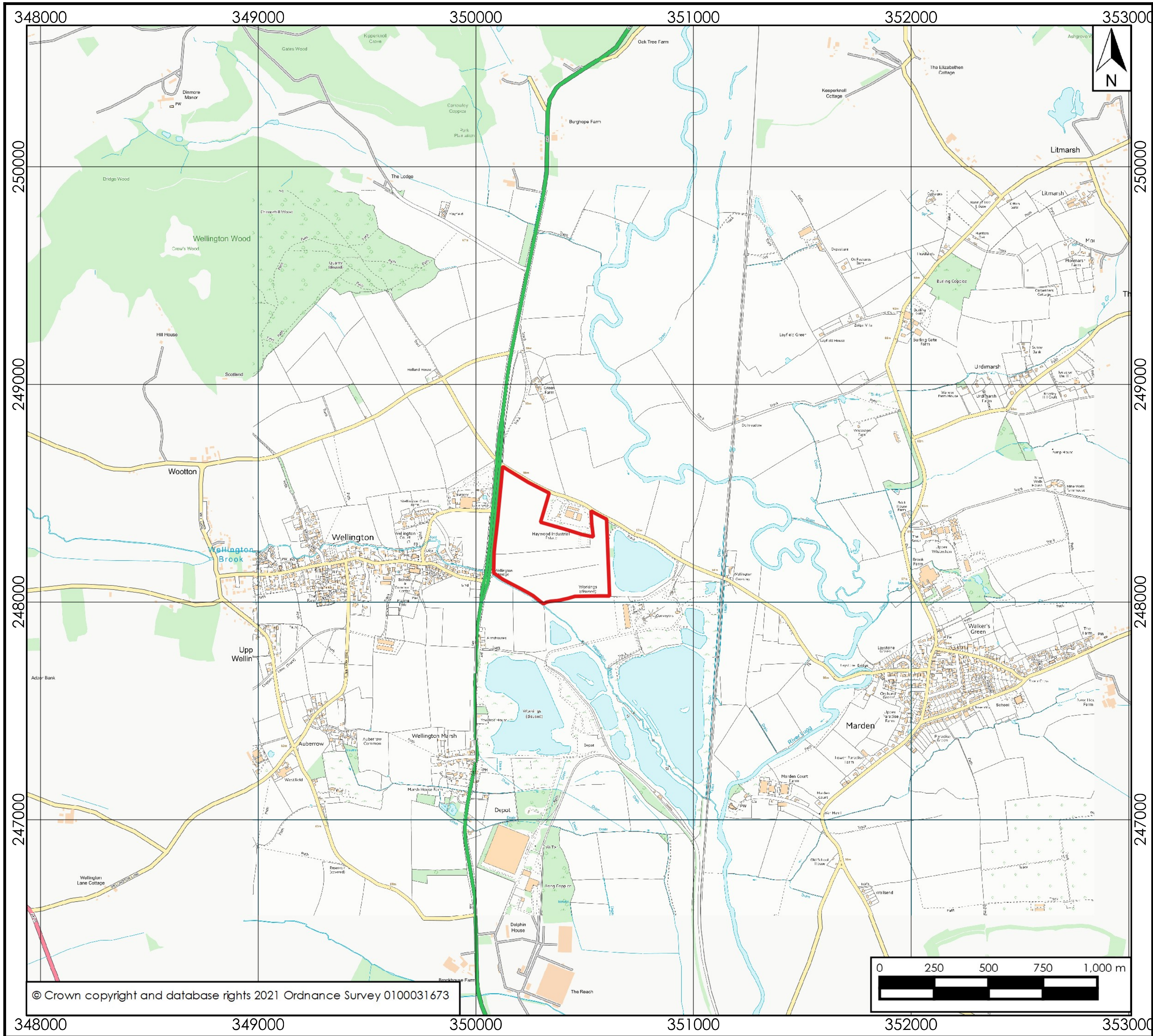
It is recommended that a Flood Emergency Plan is created to help maintain safe working. The Plan will require the site to be registered with the Environment Agency's flood warning service and will identify safe egress routes for personnel and plant during all stages of working. No permanent buildings or plant will be in extraction areas.

The proposed plant site will contain low permeability areas associated with roads, parking and roofs. This will increase run-off relative to greenfield conditions. This excess run-off will need to be collected in a sump and directed to the clean water lagoon. The proposed lagoons west of the plant site will provide sufficient containment volume for run-off during a 6-hour 1 in 100-year event plus 40% climate change (16,385 m^3). Contamination from wash-down areas will be limited by the installation of an oil separator.

It is recommended that ground profiling directs site run-off towards internal wetlands. Also, that the restoration creates a minimum freeboard in wetlands of 300 mm to retain increased run-off from wetland areas and due to the potential effects of climate change.

In light of the above, the Application Area is considered to satisfy the flood risk requirements of the NPPF and associated technical guidance. It has also responded to the queries raised in the Council's Scoping Opinion.

DRAWINGS



Legend

Application Boundary

Scale correct at A4

Client	Hereford Quarries Ltd
Title	Site Location Plan
Project	Haywood Lane
Drawing	2732/FRA/01
Version	1
Date	Aug 2021
Scale	1:25,000

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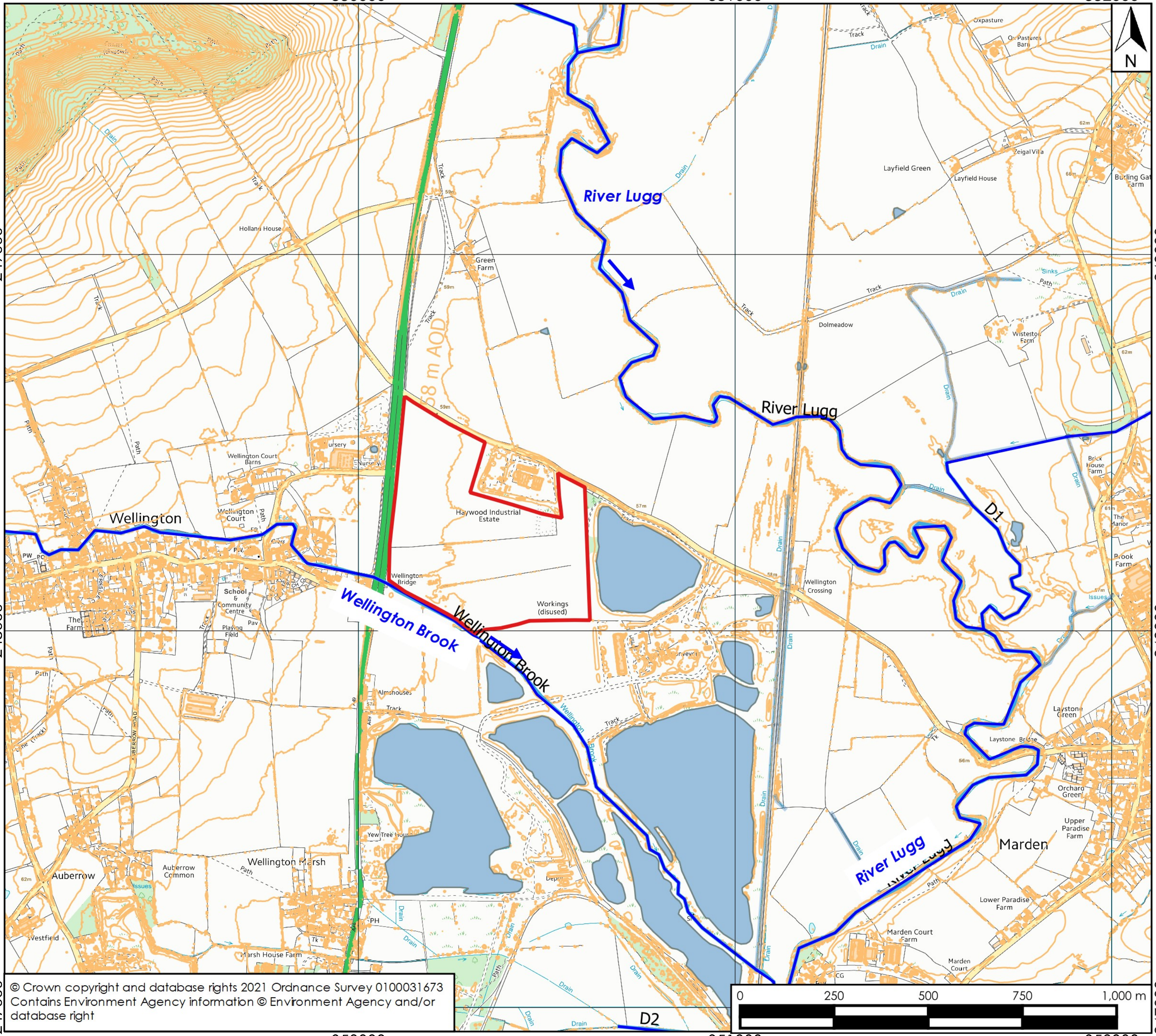

Legend

- Application Boundary
- Watercourses
- Waterbodies
- LiDAR 2 m contours

Scale correct at A4

Client	Hereford Quarries Ltd
Title	Water Features
Project	Haywood Lane
Drawing	2732/FRA/02
Version	1
Date	Aug 2021
Scale	1:15,000

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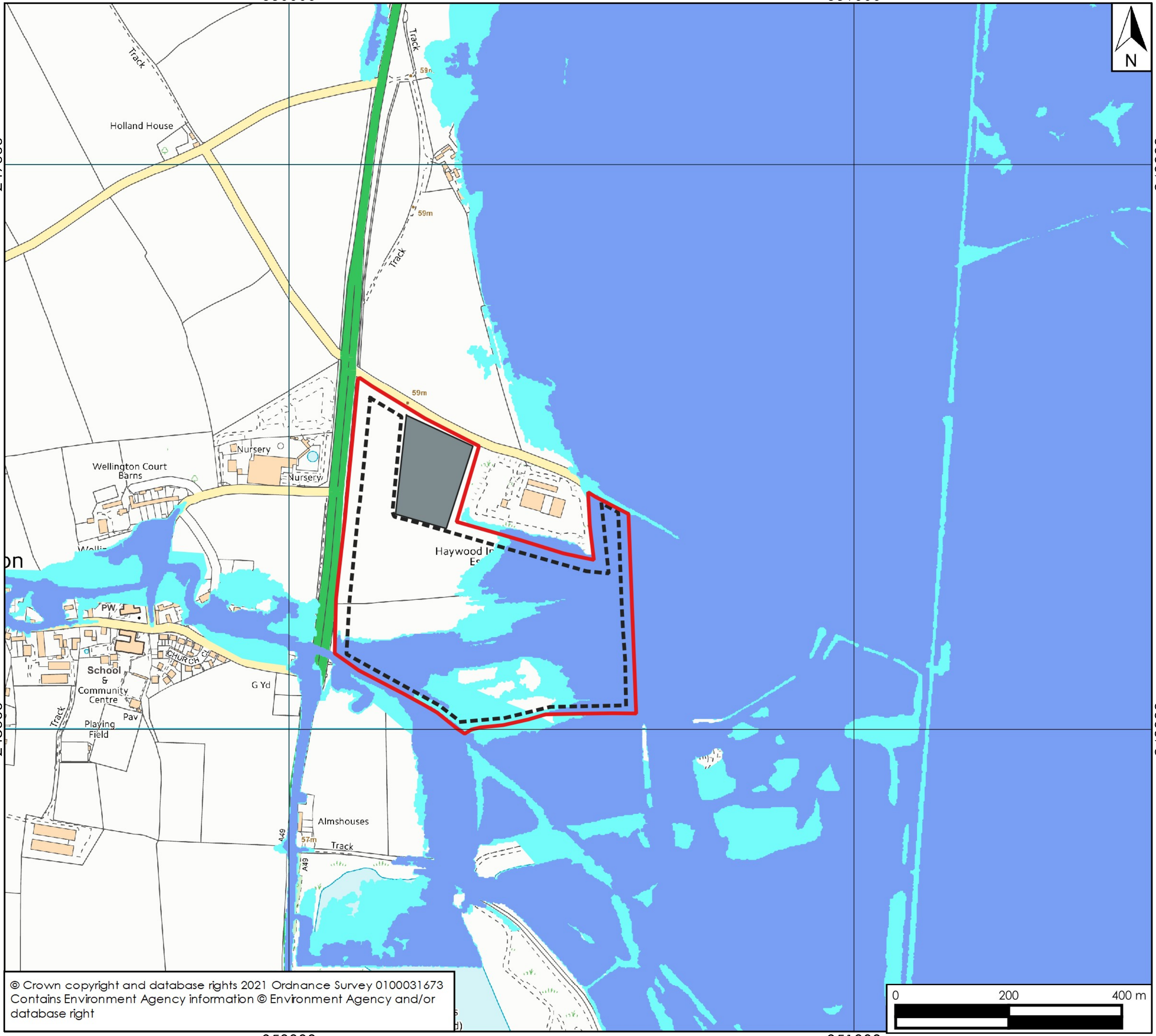

Legend

- Application Boundary
- Flood Zone 1
- Flood Zone 2
- Flood Zone 3
- Extraction Area
- Pant Area

Scale correct at A4

Client	Hereford Quarries Ltd.
Title	EA Flood Map for Planning
Project	Haywood Lane
Drawing	2732/FRA/03
Version	2
Date	Aug 2021
Scale	1:10,000

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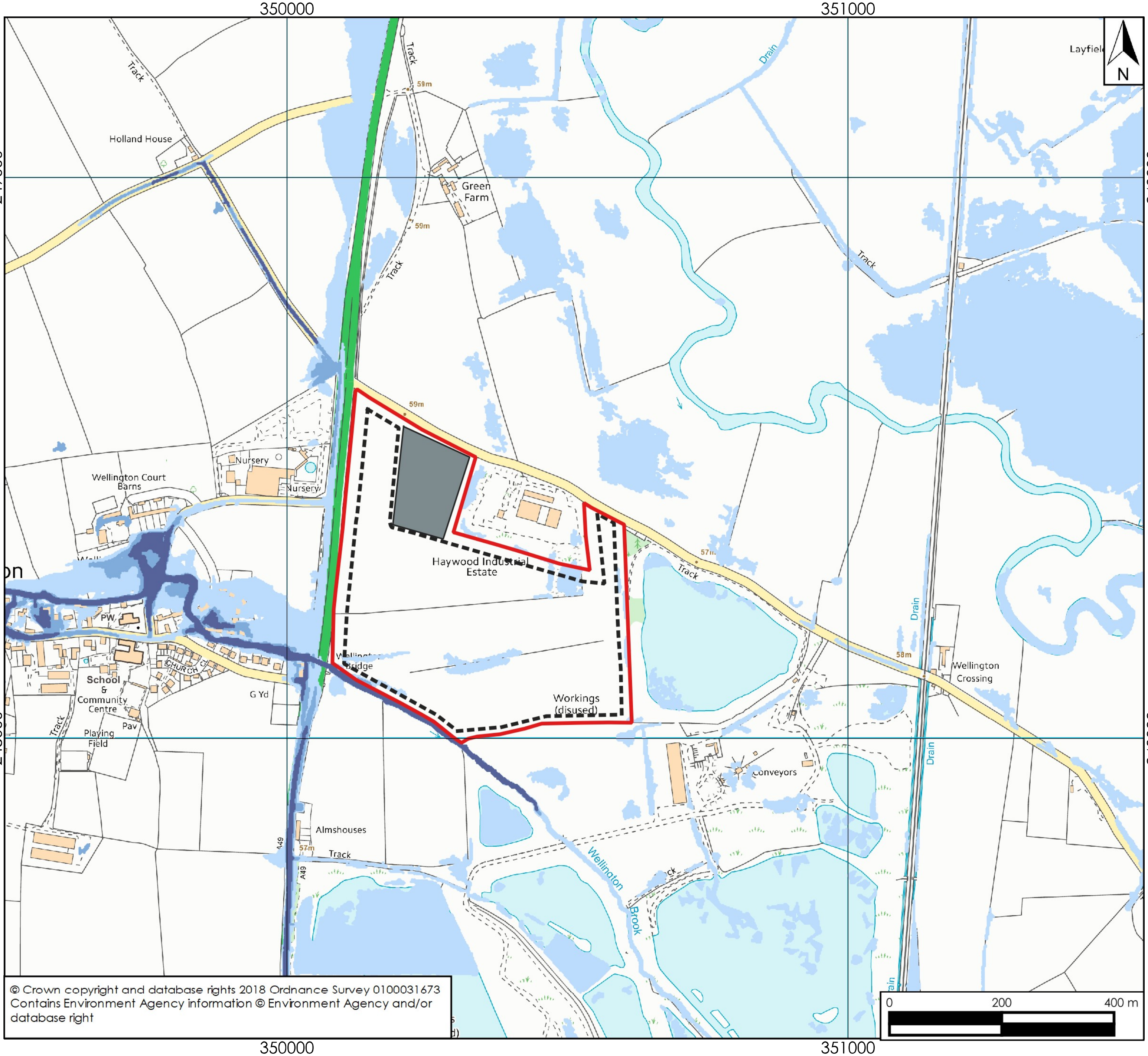

Legend

- Application Boundary
- 1 in 30 High Risk
- 1 in 100 Medium Risk
- 1 in 1000 Low Risk
- Pant Area
- Extraction Area

Scale correct at A4

Client	Hereford Quarries Ltd
Title	EA Surface Water Flood Risk
Project	Haywood Lane
Drawing	2732/FRA/04
Version	1
Date	Aug 2021
Scale	1:10,000

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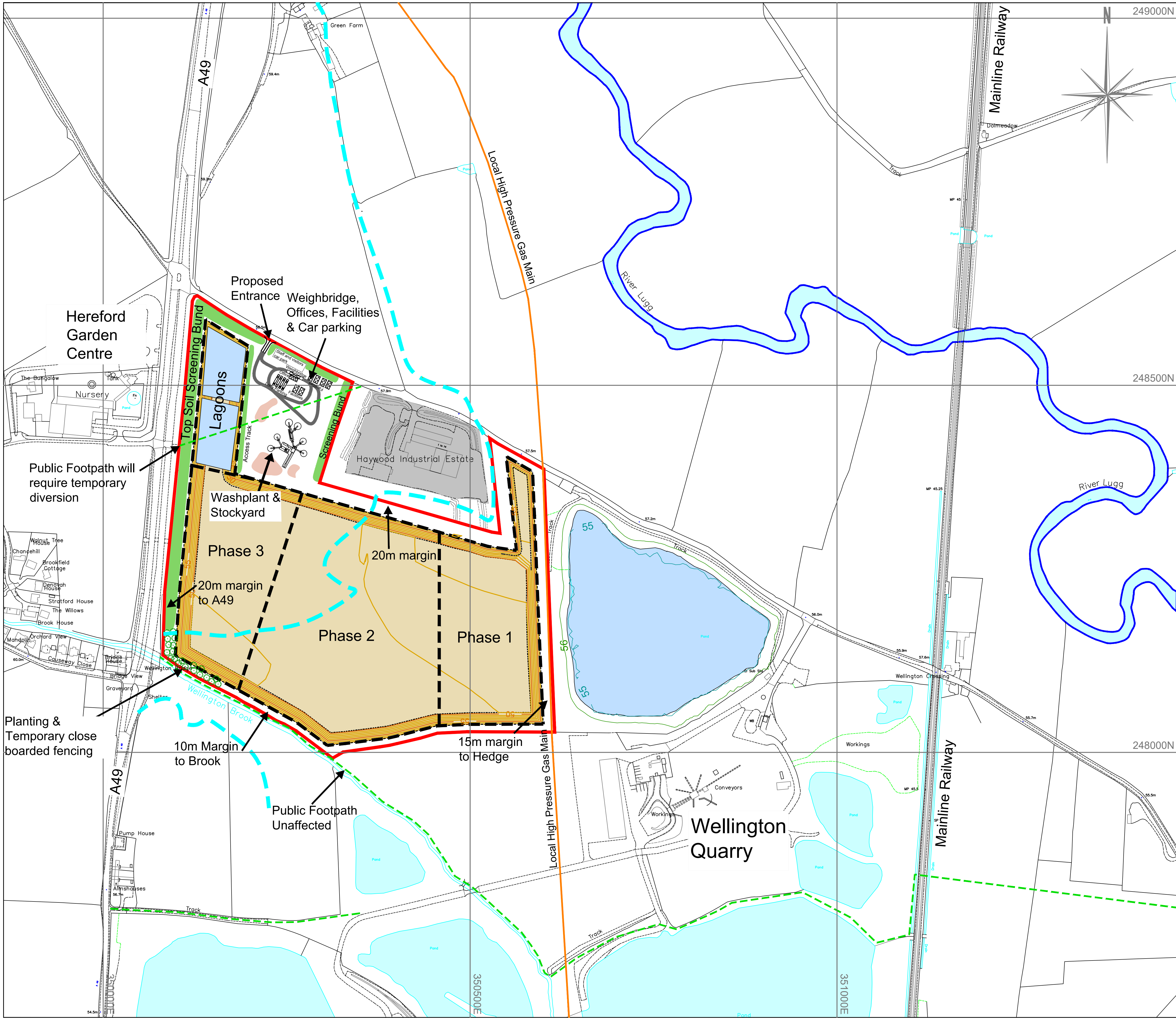
APPENDIX 2732/FRA/A1

Proposed site layout plan and cross-section



Key

- Proposed Site Boundary
- Haywood Industrial Estate
- Proposed Extraction Area
- Proposed Lagoons
- Proposed Screening Bunds
- Stockpiles/ Material Storage
- River Lugg (SSSI & SAC)
- EA Mapped Floodplain Line

Scale
0m 100m 200m

All phasing and reserves based on c1985 Redland borehole data provided by the Client

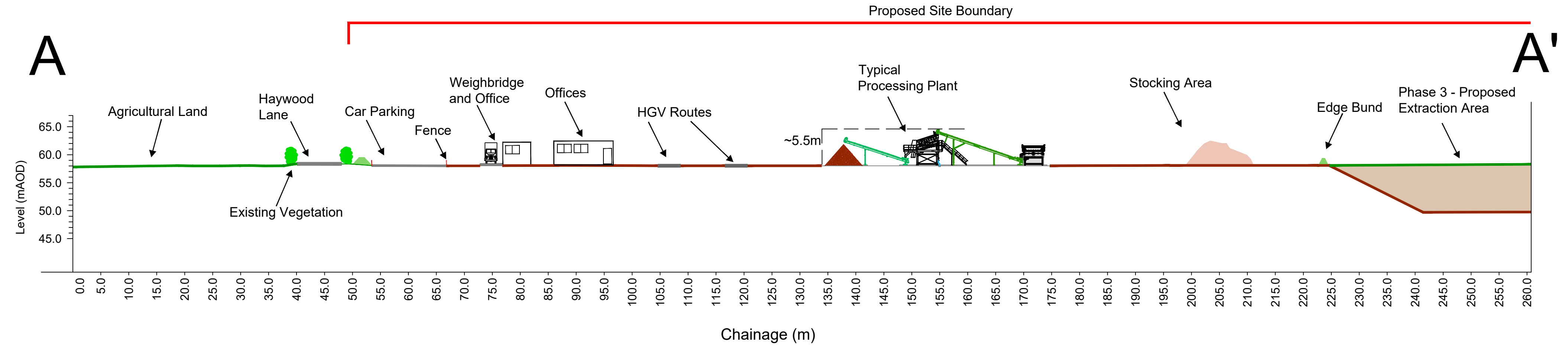
Site
Land off A49, Nr Wellington, Herefordshire

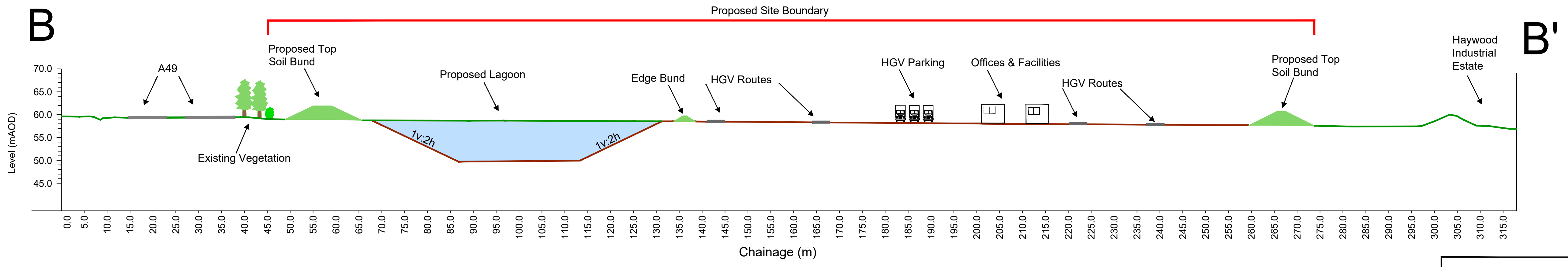
Project
Scoping Opinion

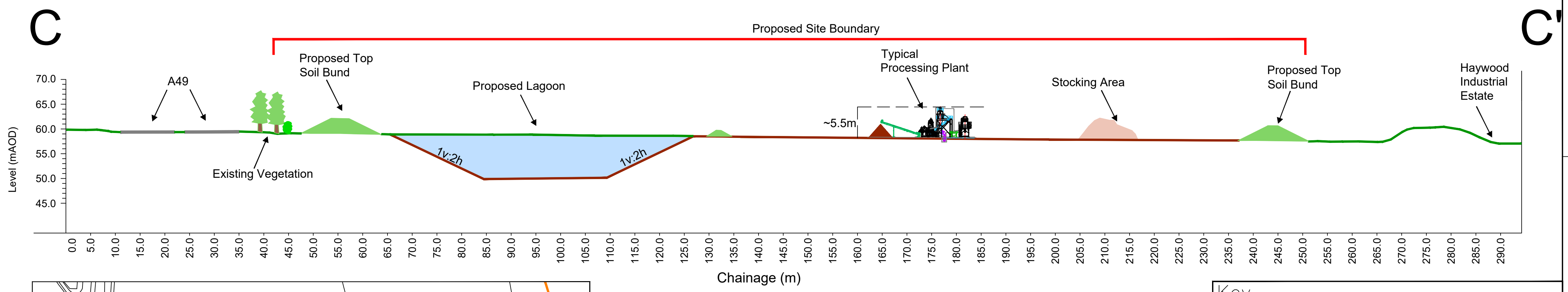
Title
Plan DME 21-A
Proposed Site Layout & Phasing

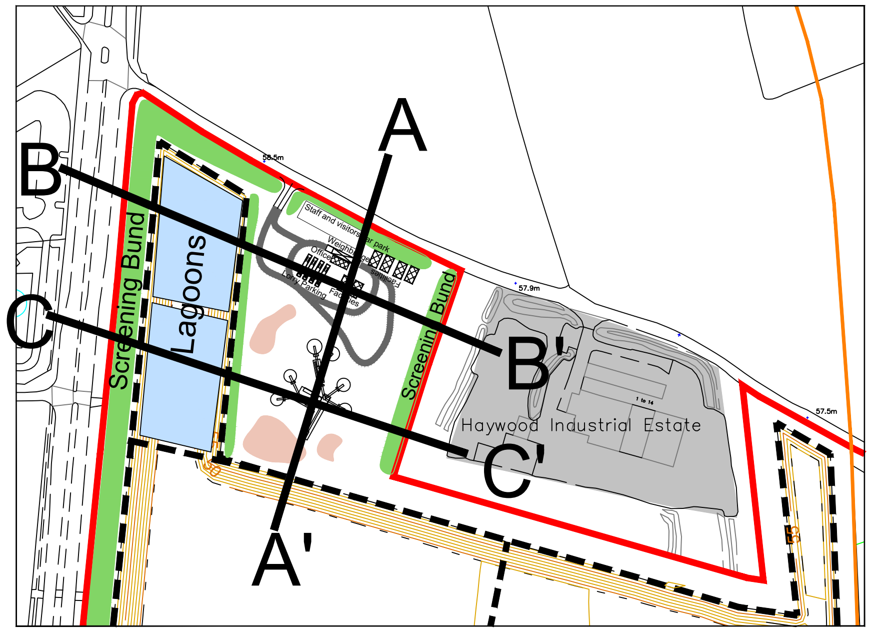
Scale:	1:5,000 @ A3
File:	DME21-A Site Layout & Phase
Project No.	DME/LA49/100
Drawn by:	TJS Date: 02/02/2021

Greenfield enviro
1 Commercial Road, Keyworth, Nottingham NG12 5JS
Email: admin@greenfieldenviro.co.uk
Tel: 0115 937 2002









Key

- Proposed Site Boundary
- Haywood Industrial Estate
- Proposed Extraction Area
- Proposed Screening Bunds
- Lagoons
- Proposed Topography
- Current Topography
- HGV Routes

Scale

0m 20m 40m

Site
Land off A49, Nr Wellington, Herefordshire

Project
Scoping Opinion

Title
Plan DME 21-B
Schematic Cross Sections

Scale:	1:1,000 @ A3
File:	DME21-B Plant Cross Section
Project No.	DME/LA49/100
Drawn by:	TJS
Date:	02/02/2021

Greenfield enviro
1 Commercial Road, Keyworth, Nottingham NG12 5JS
Email: admin@greenfieldenviro.co.uk
Tel: 0115 937 2002

APPENDIX 2732/FRA/A2

Run-off calculations

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Hafren Water Appendix 2.1
Site name:	Hatwood Lane
Site location:	Application Area

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site Details

Latitude:	52.13241° N
Longitude:	2.72894° W
Reference:	2532858114
Date:	Aug 26 2021 09:45

Runoff estimation approach

IH124

Site characteristics

Total site area (ha):	20.8

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	2	2
HOST class:	N/A	N/A
SPR/SPRHOST:	0.3	0.3

Hydrological characteristics

	Default	Edited
SAAR (mm):	671	671
Hydrological region:	9	9
Growth curve factor 1 year:	0.88	0.88
Growth curve factor 30 years:	1.78	1.78
Growth curve factor 100 years:	2.18	2.18
Growth curve factor 200 years:	2.46	2.46

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):	36.08	36.08
1 in 1 year (l/s):	31.75	31.75
1 in 30 years (l/s):	64.22	64.22
1 in 100 year (l/s):	78.65	78.65
1 in 200 years (l/s):	88.75	88.75

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Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Hafren Water Appendix 2.2
Site name:	Hatwood Lane
Site location:	Extraction Area

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance “Rainfall runoff management for developments”, SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site Details

Latitude:	52.13064° N
Longitude:	2.72633° W
Reference:	434581948
Date:	Aug 26 2021 09:46

Runoff estimation approach

IH124

Site characteristics

Total site area (ha): 14.9

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	2	2
HOST class:	N/A	N/A
SPR/SPRHOST:	0.3	0.3

Hydrological characteristics

	Default	Edited
SAAR (mm):	671	671
Hydrological region:	9	9
Growth curve factor 1 year:	0.88	0.88
Growth curve factor 30 years:	1.78	1.78
Growth curve factor 100 years:	2.18	2.18
Growth curve factor 200 years:	2.46	2.46

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):	25.84	25.84
1 in 1 year (l/s):	22.74	22.74
1 in 30 years (l/s):	46	46
1 in 100 year (l/s):	56.34	56.34
1 in 200 years (l/s):	63.57	63.57

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Hafren Water Appendix 2.3
Site name:	Haywood Lane
Site location:	Plant {positively drained area}

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site Details

Latitude:	52.12890° N
Longitude:	2.7259° W
Reference:	3223108886
Date:	Aug 26 2021 14:45

Runoff estimation approach

IH124

Site characteristics

Total site area (ha): 0.333

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	2	2
HOST class:	N/A	N/A
SPR/SPRHOST:	0.3	0.3

Hydrological characteristics

	Default	Edited
SAAR (mm):	671	671
Hydrological region:	9	9
Growth curve factor 1 year:	0.88	0.88
Growth curve factor 30 years:	1.78	1.78
Growth curve factor 100 years:	2.18	2.18
Growth curve factor 200 years:	2.46	2.46

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):	0.58	0.58
1 in 1 year (l/s):	0.51	0.51
1 in 30 years (l/s):	1.03	1.03
1 in 100 year (l/s):	1.26	1.26
1 in 200 years (l/s):	1.42	1.42

Storage Volumes vs Storm Duration (1-in-100-year +40%cc storm) for the Plant Area

	Car Park	Roads	Roofing
Contribution Coefficient	0.8	0.8	0.95
Area Ha	0.088	0.191	0.054

Climate change (% rainfall increase)	40	%

Discharge	0.0	l/s
Groundwater Inflow Rate (-ve for Outflow)	0.0	l/s

The Rational Method to give peak flow Q_p is in the form:

$$Q_p = 2.78\ CiA$$

Where:

C co-efficient of run-off (dimensionless)
i rainfall intensity (mm/hr)
A catchment area (Ha)

Duration	Rainfall *[2]	Rainfall intensity	Accretion Rate from Car Park *[3]	Accretion Rate from Roads *[3]	Accretion Rate from Roofing *[3]	Accretion Rate from Groundwater *[3]	Accretion Rate from Watercourse *[3]	Net Accretion Rate in Storage	Net Accretion Volume in Storage
	100 year event								
hours	mm	mm/hr	l/s	l/s	l/s	l/s	l/s	l/s	m^3
0.25	29.6	118.5	32.5	70.4	23.7	0.0	0	126.6	114.0
0.5	38.9	77.8	21.3	46.3	15.5	0.0	0	83.1	149.7
1	48.6	48.6	13.3	28.9	9.7	0.0	0	52.0	187.1
2	57.4	28.7	7.9	17.0	5.7	0.0	0	30.6	220.6
4	65.1	16.3	4.5	9.7	3.2	0.0	0	17.4	250.3
6	68.9	11.5	3.2	6.8	2.3	0.0	0	12.3	265.1
8	71.4	8.9	2.4	5.3	1.8	0.0	0	9.5	274.7
12	74.8	6.2	1.7	3.7	1.2	0.0	0	6.7	287.5
16	77.1	4.8	1.3	2.9	1.0	0.0	0	5.1	296.6
20	79.0	3.9	1.1	2.3	0.8	0.0	0	4.2	303.8
24	80.6	3.4	0.9	2.0	0.7	0.0	0	3.6	310.1
28	82.1	2.9	0.8	1.7	0.6	0.0	0	3.1	315.9
32	83.5	2.6	0.7	1.6	0.5	0.0	0	2.8	321.3
36	84.9	2.4	0.6	1.4	0.5	0.0	0	2.5	326.5
40	86.2	2.2	0.6	1.3	0.4	0.0	0	2.3	331.6
44	87.5	2.0	0.5	1.2	0.4	0.0	0	2.1	336.5
48	88.7	1.8	0.5	1.1	0.4	0.0	0	2.0	341.3

*[2] Obtained from FEH CD-ROM v3

*[3] Climate change factored into rainfall intensity at this stage

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Client: **Hereford Quarries Ltd**

Title: Runoff rates and retention volumes for roads, roofs and parking areas in the Plant Area

Project: Haywood Lane

Calc Sheet: A2.4

Date: Aug-21

Storage Volumes vs Storm Duration (1-in-100-year +40%cc storm) for restored site

		Restored Grassland	Restored Wetland
Contribution Coefficient		0.35	1.00
Area	Ha	5.900	14.900

Climate change (% rainfall increase)	40	%

Discharge	0.0	l/s
Groundwater Inflow Rate (-ve for Outflow)	0.0	l/s

The Rational Method to give peak flow Q_p is in the form:

$$Q_p = 2.78\ CiA$$

Where:

C co-efficient of run-off (dimensionless)
i rainfall intensity (mm/hr)
A catchment area (Ha)

Duration	Rainfall *2	Rainfall intensity	Accretion Rate from Grassland *3	Accretion Rate from Wetlands *3	NOT USED	Accretion Rate from Groundwater *3	Accretion Rate from Watercourse *3	Net Accretion Rate in Storage	Net Accretion Volume in Storage
	100 year event								
hours	mm	mm/hr	l/s	l/s	l/s	l/s	l/s	l/s	m^3
0.25	29.6	118.5	952.5	6873.1	0.0	0.0	0	7825.6	7043.1
0.5	38.9	77.8	625.4	4512.8	0.0	0.0	0	5138.3	9248.9
1	48.6	48.6	390.9	2820.7	0.0	0.0	0	3211.6	11561.7
2	57.4	28.7	230.5	1663.5	0.0	0.0	0	1894.0	13636.8
4	65.1	16.3	130.8	943.7	0.0	0.0	0	1074.4	15471.9
6	68.9	11.5	92.3	666.2	0.0	0.0	0	758.5	16384.7
8	71.4	8.9	71.8	517.7	0.0	0.0	0	589.5	16976.5
12	74.8	6.2	50.1	361.3	0.0	0.0	0	411.4	17770.5
16	77.1	4.8	38.7	279.5	0.0	0.0	0	318.2	18329.0
20	79.0	3.9	31.7	229.0	0.0	0.0	0	260.8	18775.9
24	80.6	3.4	27.0	194.8	0.0	0.0	0	221.8	19165.8
28	82.1	2.9	23.6	170.1	0.0	0.0	0	193.7	19522.3
32	83.5	2.6	21.0	151.4	0.0	0.0	0	172.4	19857.5
36	84.9	2.4	19.0	136.8	0.0	0.0	0	155.7	20180.7
40	86.2	2.2	17.3	125.0	0.0	0.0	0	142.3	20492.1
44	87.5	2.0	16.0	115.3	0.0	0.0	0	131.3	20796.4
48	88.7	1.8	14.9	107.2	0.0	0.0	0	122.1	21093.5

*2 Obtained from FEH CD-ROM v3

*3 Climate change factored into rainfall intensity at this stage

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Client: **Hereford Quarries Ltd**

Title: Runoff rates and retention volumes for restored site

Project: Haywood Lane

Calc Sheet: A2.5

Date: Aug-21