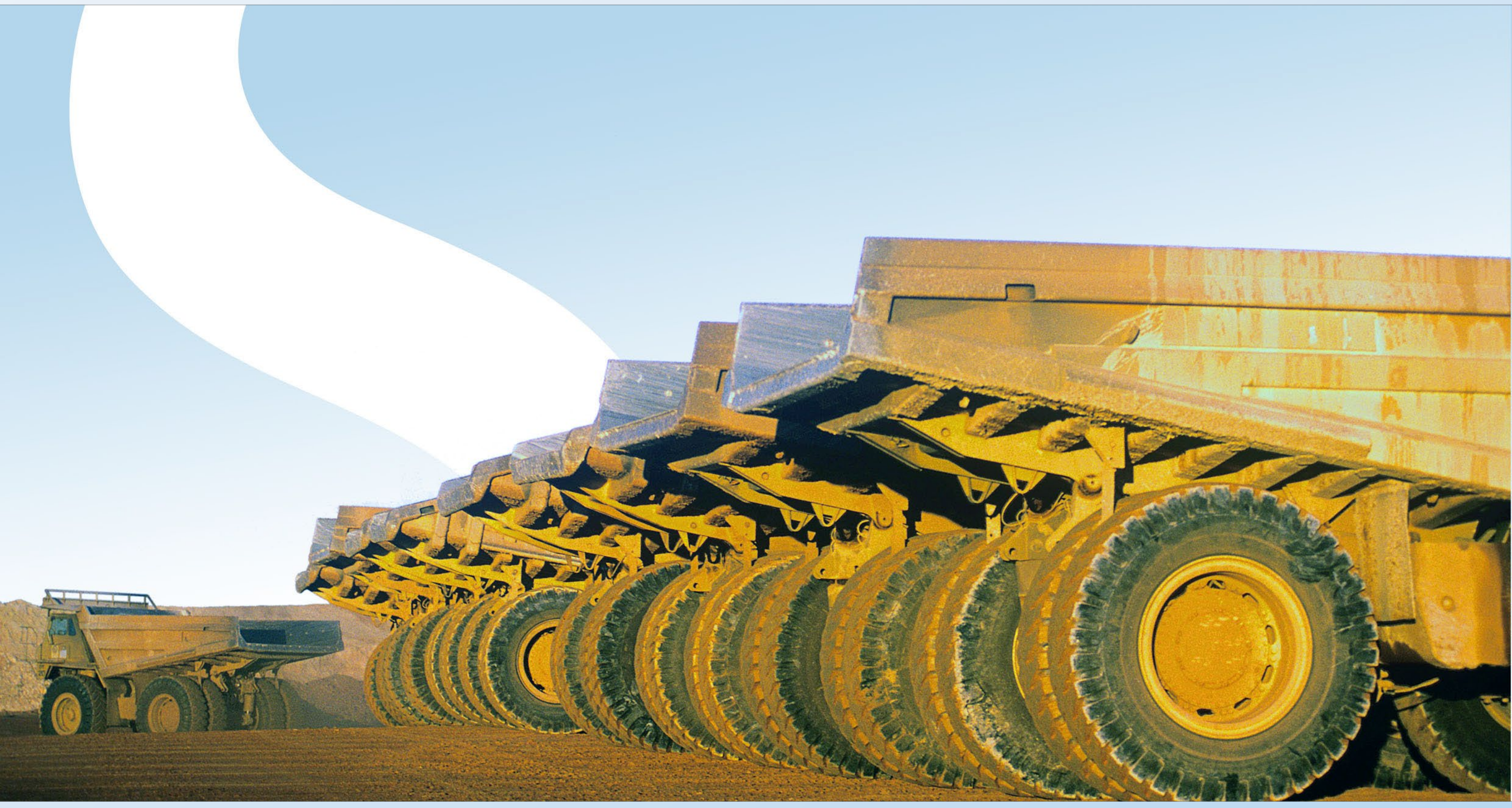
Heidelberg Materials

TYTHERINGTON QUARRY: 6 MILLION TONNES ADDITIONAL RESERVES

Flood Risk Assessment (FRA) Report



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MAY 2024

CONFIDENTIAL

Heidelberg Materials

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Flood Risk Assessment (FRA) Report

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1 INTRODUCTION

1.1 OVERVIEW OF THE PROPOSED SCHEME

1.1.1. Heidelberg Materials, previously known as Hanson UK, plan to secure the continued extraction of all consented limestone reserves, and extraction of further unconsented reserves, within the existing footprint of Tytherington Quarry, near Thornbury, Bristol (hereafter referred to as the 'Proposed Scheme'). To achieve this, Heidelberg Materials is seeking planning permission to amend the existing working method at Tytherington Quarry to allow for the deepening of the Woodleaze area of the quarry to release an additional 3 million tonnes as well as enable the extraction of a further 3 million tonnes from the southern part of the quarry, beneath the existing soil store area. This will increase the site's overall mineral reserve and ensure that principles of sustainable mineral extraction are adhered to through ensuring that all workable deposits at the permitted site can be extracted. The proposed extension of the quarry out towards the soil store area falls outside the Red Line Boundary (RLB) of the extant principal planning consent for Tytherington Quarry (NA/IDO/002/A) but falls wholly within the RLB of the extant planning consent P93/2645 which is referenced in the principal consent. Therefore, any reference to the proposed extension of the quarry in this report, implies extension to the existing extraction limits and would be contained within the extant planning application boundary. As such, the following two planning applications are being made to South Gloucestershire Council (SGC):

- Section 73 planning application to vary conditions 1 (duration of permission)[1] and 25 (restoration and aftercare) to the extant principal planning consent NA/IDO/002/A (dated February 2006) for Tytherington Quarry; and
- Section 73 planning application to vary conditions 4 & 5 (approved working scheme), 17 & 18 (overburden and topsoil storage) to the extant planning consent P93/2645 (dated December 2002) covering the soil store area.

1.1.2. The two Section 73 planning applications are accompanied by a single overarching Environmental Impact Assessment (EIA), the results of which are reported in the Environmental Statement (ES), which this Flood Risk Assessment (FRA) supports.

1.1.3. A site location and layout plan is provided in **Figure 1.1**.

1.1.4. Further details of the Proposed Scheme can be found in **Section 2.2**.

1.2 PURPOSE OF THIS REPORT

1.2.1. WSP has been commissioned by Heidelberg Materials to produce a Flood Risk Assessment (FRA) in support of the ES and Planning Application submissions, in order to secure the continued

[1] Despite the title of this condition, Heidelberg Materials are **not** seeking to change the duration of the permission but rather to amend the condition to reference the approved documents relevant to the permission.

extraction of all consented limestone reserves, and extraction of further unconsented reserves, within the existing footprint of Tytherington Quarry, near Thornbury, Bristol.

1.2.2. Tytherington is one of Heidelberg Material's flagship sites. Its rail link means that this quarry is one of the only across England that has the ability to supply wider UK markets – and most notably those of markets in London and the southeast of England, where geology dictates that the majority of crushed rock requirements must be met by imports of material from other English regions. The consenting of this additional limestone resource will provide continuity of a further 6mt limestone reserve to important rail-based markets in the short to medium term and safeguard the regionally significant quarry operations at Tytherington.

1.2.3. To secure the continuity of supply and operations at Tytherington in the short to medium term, as well as sustainable minerals extraction, Heidelberg Materials are seeking an amendment to the extraction limits and working scheme at Tytherington Quarry to allow for the deepening of the Woodleaze area (**Figure 1.1** 'southern void') and extension into the consented soil store area (covered by extant consent P93/2645) in the southern part of the quarry. This will increase the site's overall mineral reserve and ensure that principles of sustainable mineral extraction are adhered to through ensuring that all workable deposits at the permitted site are extracted and help secure the continuity of limestone provision locally and regionally.

1.2.4. The area of the current soil store, which Heidelberg Materials wish to extract limestone from, falls within an allocated Preferred Area for mineral extraction in the adopted South Gloucestershire Local Plan (SGLP) 2017. It is estimated that the 6mt from the soil store area and deepening of the Woodleaze area will provide Tytherington Quarry an extra 3 years of reserve based on current extraction rates but not extend beyond the extant 2042 end date of the principal planning consent.

1.2.5. This report provides an assessment of flood risk from all sources and outlines a surface water management strategy to accompany the Proposed Scheme, in-line with the requirements of the National Planning Policy Framework (NPPF)[2]

1.3 REPORT STRUCTURE

1.3.1. The structure of the report is as follows:

- **Section 1:** Introduction;
- **Section 2:** Site Description, Development Proposal and Planning Context;
- **Section 3:** Flood Risk Assessment;
- **Section 4:** Surface Water Management and Drainage Strategy;
- **Section 5:** Flood Risk Management; and
- **Section 6:** Conclusion.

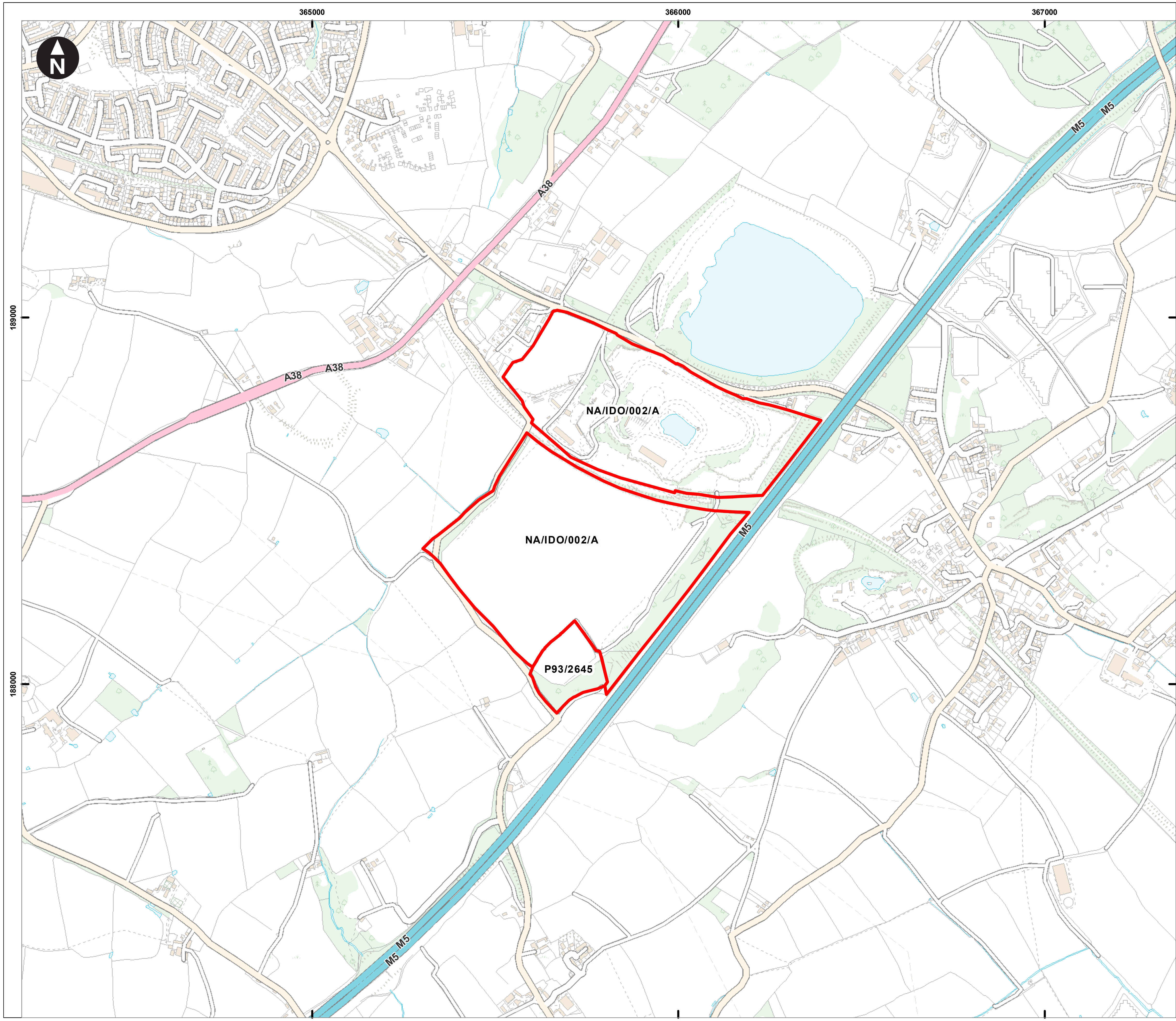
[2] Ministry of Housing Communities and Local Government, 2023. National Planning Policy Framework [online] available at: https://assets.publishing.service.gov.uk/media/65a11af7e8f5ec000f1f8c46/NPPF_December_2023.pdf (Last accessed 29/01/2024)

1.4 DATA SOURCES

1.4.1. Table 1.1 details the sources of data used in the preparation of this report.

Table 1.1 Data used in the completion of the FRA

Data	Sourced
Topographical Mapping	Department for Environment Food & Rural Affairs (Defra) LiDAR Composite DTM 2022 1m Index https://environment.data.gov.uk/survey (Last accessed 29/01/2024) Bing Maps https://www.bing.com/maps/?cp=53.468839%7E-2.484283&lvl=11.0 (Last accessed 10/04/2024) Historic OS map based on maps, dating from the 1920s to the 1940s (National Library of Scotland, 2024) https://maps.nls.uk/geo/explore/#zoom=14.0&lat=51.72994&lon=-3.15008&layers=161&b=1 (Last accessed 10/04/2024)
Geological Mapping	British Geological Survey (BGS), 2024. Geology of Britain Viewer. https://geologyviewer.bgs.ac.uk/?_ga=2.222322331.1455909940.1688979673-1322936737.1688979673 (Last accessed 10/04/2024)
Hydrogeological Data: Aquifers Bedrock Designation Mapping; and Source Protection Zone (SPZ) Mapping	Department of Food and Rural Affairs, 2024. Multi-Agency Geographic Information for the Countryside (MAGIC). https://magic.defra.gov.uk/magicmap.aspx (Last accessed 10/04/2024)
Fluvial Flood Risk Mapping	Environment Agency, 2024. Flood Map for Planning. https://flood-map-for-planning.service.gov.uk/ (Last accessed 10/04/2024)
Surface Water and Reservoir Flood Risk Mapping	Environment Agency, 2024. https://www.gov.uk/check-long-term-flood-risk (Last accessed 10/04/2024)
Information on Existing Water Management at the Quarry	Tytherington Quarry Hydrometric Monitoring Report (September 2023)



Key

Extant planning permissions

0 250 500 m

Scale at A3: 1:10,000

Heidelberg Materials
Tytherington Quarry - 6 Million Tonne Additional Reserves
Flood Risk Assessment (FRA) Report

Figure 1.1
Proposed scheme redline boundary

April 2024

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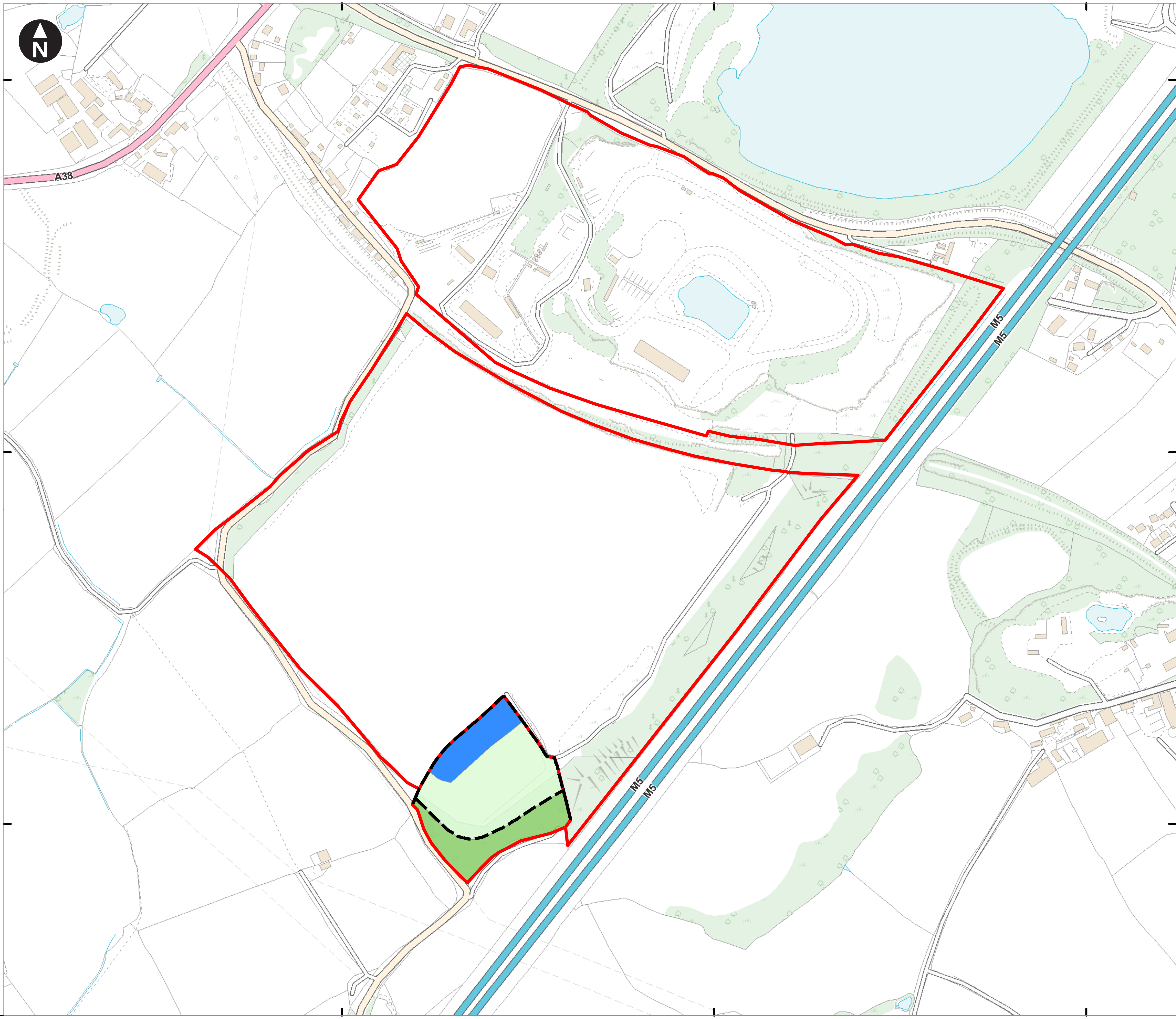

Key

- Extant planning permissions
- Area draining to void
- Previous development area south draining
- Restoration area
- Restoration lagoon area

0 100 200 300 m

Scale at A3: 1:5,000

Heidelberg Materials
Tytherington Quarry - 6 Million Tonne Additional Reserves
Drainage Report

Figure 1A
Drainage strategy

April 2024

wsp

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2 SITE DESCRIPTION, DEVELOPMENT PROPOSAL AND PLANNING CONTEXT

2.1 SITE DESCRIPTION

THE SITE

2.1.1. Tytherington Quarry is an operational limestone quarry, which is located west of the village of Tytherington. Other settlements in close proximity to Tytherington Quarry include the market town of Thornbury which is located approximately 1.5 kilometres (km) north-west from the quarry; the village of Alveston which is located approximately 2.5km south-west from the quarry; and the village of Cromhall which is located approximately 3km north-east from the quarry. The nearest residential receptors are located on Itchington Road, circa 20m north of the Woodleaze area of the quarry. The focus of the FRA is based upon the extant planning application boundary and covers a total area of 57.1 hectare (ha).

2.1.2. The main approach route is from the west via Tytherington Road, which runs in a north-west/south-east direction and accessed from the A38. The quarry is adjacent to the M5, which forms the eastern site boundary. The Thornbury Branch Line is a dedicated freight rail line which passes the quarry sidings from Grovesend Overbridge.

2.1.3. Tytherington Quarry comprises two historic quarries. Grovesend Quarry was the initial quarry to the north of Itchington Road and comprises the main quarry offices, weighbridge, processing plant and quarry railway sidings. Woodleaze Quarry is located to the south of Itchington Road but is only accessible from Grovesend Quarry via a tunnel underneath the road. All ongoing mineral extraction is currently taking place from within Woodleaze Quarry.

TOPOGRAPHY

2.1.4. The proposed site sits atop a ridgeline watershed and consists of two open pit voids of the Woodleaze (south-western) and Grovesend (north-eastern) Quarries and a soil store area near the southern corner of the Woodleaze Quarry. Being a soil store area, it contains the highest point in the centre of the soil storage mound at a height of 106mAOD. This area, along with the Quarry perimeter screening bund (along the Quarry’s eastern boundary), are the high points. The perimeter screening bund extends along the southern boundary of the soil store area with a high point of 103mAOD. The natural ground surface level below the bunds and surrounding the upper edges of the quarry voids ranges from 95mAOD to 97mAOD. Along the north-western boundary of Tytherington Quarry, there is a ridge line between the quarry and Thornbury village, of which the highest point is ~106mAOD and 103mAOD within the site boundary. Between the perimeter screening bund along the south-eastern boundary and the ridgeline along the northwestern boundary, the site drains inwards towards the quarry voids. Along the south-western boundary of the Woodleaze Quarry area, the land slopes southwards from 95mAOD at the boundary, towards a valley with a south-east slope with a low point of 78mAOD near the M5 motorway. The Grovesend and Woodleaze Quarries are separated by a railway cutting with a low point of 91mAOD, which cuts the ridgeline between the Quarry and Thornbury village.

HYDROLOGY AND DRAINAGE

2.1.5. There are no natural watercourses within the site boundary (**Figure 2.1**). The site as a whole sits across a headland watershed between three WFD waterbody catchments. The northeastern boundary of the site marks the border between the Tortworth Brook – source to confluence with River Little Avon and the Oldbury Naite Rhine. The southwestern area of the Woodleaze Quarry is located across the boundary between the Oldbury Naite Rhine to the north-east and the Laddon Brook – source to confluence with River Frome (Bristol)[3] to the southwest.

2.1.6. The Oldburg Naite Rhine catchment drains in a northwestern direction, the Laddon Brook in a southeastern direction, and the Tortworth Brook in a north direction. Considering the site topography, and perimeter bunds around the boundaries, surface water runoff is contained within the site boundary and drains towards the quarry voids. The outer slopes of the perimeter bunds do provide a point for surface water runoff to drain off-site, with the drainage direction towards the southeast between the M5 and the perimeter bund and onto Itchington Road, and to the southwest onto the neighbouring agricultural fields and into the small watercourses which drain to the Ladden Brook. Without the presence of the existing Woodleaze Quarry void, the entire site would drain into the Laddon Brook surface water catchment.

2.1.7. As the site is a highpoint and within the head waters of three WFD waterbody catchments, the site cannot be directly affected by the hydrology of the nearby watercourses or upslope areas.

GEOLOGY AND HYDROGEOLOGY

Geology

2.1.8. The BGS online geology mapping[4], as illustrated in **Figure 2.2**, indicates that the bedrock underlying the site ranges from Black Rock Limestone Subgroup Limestone and Dolostone formations to Gully Oolite formation limestones from northwest to southeast. The southern corner of the Woodleaze Quarry and soil store area sits over Penarth Group, Cromhall Sandstone Formation and Clifton Down Limestone Formations. These predominantly contain carboniferous mudstones and limestones. There are no superficial deposits within or around the boundary of the site.

Hydrogeology

2.1.9. The Environment Agency's aquifer designations reflect the importance of aquifers in terms of groundwater as a resource (drinking water supply), but also their role in supporting surface water flows and wetland ecosystems. The aquifer designation maps show the various aquifer types for both superficial deposits and the bedrock. These are accessible on-line and have been reviewed in order to correlate the geologic strata identified around the quarry from the geology maps with the various aquifer types.

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[3] Spelt Laddon Brook when referring to WFD catchment, and spelt Ladden Brook when referring to the watercourse.
[4]BGS Geology Viewer [online] available at: https://geologyviewer.bgs.ac.uk/?_ga=2.222322331.1455909940.1688979673-1322936737.1688979673 (Last accessed 04/04/2024)

2.1.10. The Magic Map[5] application indicates that the proposed site boundary is located over predominately bedrock geology that is classified as a 'Principal' aquifer, which is defined as having "*high intergranular and/or fracture permeability – meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as a major aquifer*". Through the central southern portion of the site boundary, the bedrock geology is classified as a "Secondary (undifferentiated)" aquifer which is allocated in cases when "*it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type*". Along the northeastern boundary the bedrock geology is classified as a "Secondary A" aquifer which is allocated in cases when they "*comprise permeable layers that can support local water supplies, and may form an important source of base flow to rivers*".

2.1.11. The Groundwater Vulnerability is High with Soluble Rock Risk for the site and surrounding area. The Defra Magic Maps Groundwater Source Protection Zones[6] indicates that the proposed site is not located within any groundwater source protection zones, with the nearest zone located 11.3km to the east.

2.1.12. Soilscapes mapping[7] indicates that the majority of the site is underlain by 'Freely draining slightly acid but base-rich soils'. The soil store area section of the site is underlain by 'Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils'. It should be noted however, that being a soil store area, the composition of soils within the site could be different and mixed in nature, and the majority of the Woodleaze and Grovesend Quarry sites have been mined out.

2.1.13. The site is not located within a Drinking Water Safeguard Zone[8]. The nearest safeguard zone (surface water) is located ~12.9km to the north, indicating that any activities within the site would pose little risk to drinking water safety. Drinking Water Safe Zones are an area where action to address water contamination will be targeted, so that extra treatment by water companies can be avoided. Safeguard Zones are a joint initiative between the Environment Agency and Water Companies.

2.1.14. Further details of the geology and hydrogeology in and around the site can be found in **ES Chapter 9**.

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[5] Magic Map Aquifer Designations [online] Available at: https://magic.defra.gov.uk/magicmap.aspx (Last accessed 04/04/2024)
[6] Magic Map Groundwater Source Protection Zones [online] Available at: https://magic.defra.gov.uk/magicmap.aspx (Last accessed 30/01/2024)
[7] Soilscapes [online] Avaliable at: https://www.landis.org.uk/soilscapes/ (Last accessed 30/01/2024)
[8] Magic Map Drinking Water Safeguard Zone [online] Available at: https://magic.defra.gov.uk/magicmap.aspx (Last accessed 30/01/2024)

2.2 DEVELOPMENT PROPOSAL

2.2.1. Extraction of the mineral, both existing permitted reserves as well as the additional 6mt of new mineral, within the existing Woodleaze Quarry and soil store area will happen concurrently with progressive restoration. As extraction progress to depth, progressive restoration will follow behind.

2.2.2. The Proposed Scheme will be undertaken within three development phases over a period of circa 6 to 7.5 years subject to market conditions, but not extend beyond the extant 2042 end date of the principal planning consent. The phasing plans are illustrated in **ES Figures 3.1 to 3.3**. Extraction of mineral will continue within the existing Woodleaze area working in a south-eastern direction (including the soil store area) towards the eastern quarry edge alongside the M5 motorway. The phases of development are described in **Table 2.1**.

Table 2.1 Development Phases

Phase	Anticipated dates	Corresponding ES Figure	Activities
Phase 1	Up to the end of Year 4	3.1	**Woodleaze Quarry** ▪ Continued extraction of permitted mineral reserves at southern end; ▪ Limestone worked in seven benches in a south-eastly direction; ▪ Top quarry level will remain at 95mAOD; ▪ Maximum extraction depth to be -10mAOD in accordance with quarry's existing working plan. ▪ A small sump will be created on the quarry floor; ▪ No topsoil or subsoil will need to be removed; ▪ Deepening of the quarry will continue as per existing permitted arrangements for extraction using the permitted plant and equipment and access arrangements. ▪ An estimated 8mt of permitted mineral reserve will be extracted; ▪ Use of the existing weighbridge and office area will also continue as per the extant principal IDO consent. **Soil Store Area** ▪ Progressive soil stripping of the soil store area to begin; ▪ Stripped soils and other overburden materials, notably mudstone, would be stored on site and used for progressive restoration.
Phase 2	Up to the end of Year 7	3.2	**Woodleaze Quarry** ▪ Continued deepening of Woodleaze would be worked in two additional benches with safe working heights of 15m; ▪ The top quarry level will remain at 95mAOD and the maximum extraction depth during this phase will be to -40mAOD, taking the deepening of Woodleaze quarry void to its maximum depth; ▪ All other operations including use of the weighbridges and office will continue to be used as per consented arrangements.

Phase	Anticipated dates	Corresponding ES Figure	Activities
			Soil Store Area ▪ The limestone from the soil store area would be worked to a minimum 7m wide benches with a safe working heights of up to 15m; ▪ Extraction of the soil store and surroundings area will require the removal of approximately 60,000m^3 of overburden and topsoil which will be used in progressive restoration; ▪ The topsoil and overburden will be used temporarily until required, as a perimeter screening bund around the soil store area; ▪ The topsoil will also extend the existing screening bund alongside the M5 to an approximate height of between 3 to 7m; and ▪ Extraction of the soil store area will be accessed via an internal access haul road to which excavators, other equipment and HGVs will be used to work the area.
Phase 3	Up to the end of Year 9	3.3	**Woodleaze Quarry** ▪ Continued deepening and extraction of the Woodleaze Quarry floor and additional work of all bench levels; ▪ Limestone will be worked in a total of nine benches with safe working heights of up to 15m; ▪ Top quarry level will remain at 95mAOD, and the maximum extraction depth during this phase will be -40mAOD, taking the deepening of Woodleaze quarry void to its maximum depth. **Soil Store Area** ▪ Extraction of the soil store area complete and restoration in situ.
Progressive Restoration	Up to the end of year 9	3.4	▪ Progressive restoration will take place across the site. **Woodleaze Quarry** ▪ Upper benches above final water levels (i.e. above 68-70mAOD) would be restored through the placement of quarry waste and soils as soon as upper faces have been taken back to final face positions; ▪ These upper benches would feature a combination of calcareous grassland on areas of shallow soils with clumps of trees and shrubs across corresponding areas of deeper soils; ▪ Natural regeneration of scrub may also occur on any inaccessible areas of bench. ▪ Rock trap bunds would be installed on wide benches; ▪ Trial over-tipping of the steep and inaccessible dip-slope within Woodleaze Quarry would be undertaken to allow substrate to collect on rough ledges and

Phase	Anticipated dates	Corresponding ES Figure	Activities
			provide for varied natural regeneration of both wildflowers and scrub.
Restoration		3.5	**Woodleaze Quarry** ▪ The quarry would continue to be restored to a deep-water body with upper benches and a mix of woodland and grassland habitat; ▪ The proposals allow for the total re-use of indigenous soils and quarry waste on-site and consequently, no material import is required for restoration; ▪ The restoration plan assumes that water would rebound at 68-70mAOD in line with the permitted restoration scheme. **Soil Store Area** ▪ The screenbank adjacent to the soil store and modified to accommodate the storage of soils in Phases 2 and 3, would be returned to a landform which is similar to baseline conditions; ▪ Where trees have been removed from the internal face of the screenbank during the operational phases, native trees and shrubs would be re-planted as part of the restoration to recreate the woodland belt; ▪ The remainder of the soil store area would be restored to deliver habitat gain; ▪ Species-rich grassland (calcareous or neutral depending on the soil chemistry beneath the soil store) would extend across the area alongside a mosaic of small ponds/scrapes and bare ground for the benefit of invertebrates, reptiles and amphibians. ▪ A new hedgerow with hedgerow trees would extend along the northern edge of this area to provide connectivity between the lengths of remaining hedgerow along the access track and the existing woodland belt along the western perimeter of the site.

2.3 PLANNING CONTEXT

NATIONAL PLANNING POLICY FRAMEWORK (NPPF) AND PLANNING PRACTICE GUIDANCE (PPG)

2.3.1. The National Planning Policy Framework (NPPF[9]) provides guidance for local planning authorities and decision-makers, both in drawing up plans and making decisions about planning applications. This is supported by online Planning Practice Guidance (PPG) on Flood Risk and Coastal Change[10].

2.3.2. Then NPPF aims to minimise flood risk, both to new development and to existing third party development, by preferentially directing new development to areas at a then lowest risk of flooding.

2.3.3. Further to this, the Environment Agency has produced guidance on climate change allowances for flood risk assessments and drainage design[11] to support the NPPF.

2.3.4. Whilst withdrawn as official government guidance, the Environment Agency's Pollution Prevention Guidelines (PPGs)[12] represent the best available guidance on water quality best practice measures. These can be relevant with regard to any water, including that to be discharged off-site. The PPGs set out guidance on safe storage of hazardous materials (e.g. oil storage tanks, use of oil separators), vehicle washing and cleaning, and pollution incident response planning.

LOCAL GUIDANCE

2.3.5. As a unitary authority, South Gloucestershire Council is the Lead Local Flood Authority (LLFA), the Local Planning Authority (LPA), and the Mineral Planning Authority (MPA) for the wider administrative area within which the quarry is located. It has produced the County Gloucestershire Plan, which provides the policy framework for development in the county, and the County South Gloucestershire Minerals Local Plan, which provides policies for planning applications for the extraction of minerals.

2.3.6. It has also produced several reports which appraise flood risk and provide guidance on flood risk at a strategic level. There include a Preliminary Flood Risk Assessment (PFRA), Strategic Flood Risk Assessment ((SFRA) Levels 1 and 2) and a Surface Water Management Plan (SWMP). These documents have been reviewed to inform this FRA.

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[9] Department for Levelling Up, Housing and Communities and Ministry of Housing, Communities and Local Government, 2012 (Updated 2023). National Planning Policy Framework (NPPF) [online] Available at: https://www.gov.uk/government/publications/national-planning-policy-framework--2 (Last accessed 10/04/2024)
[10] Department for Levelling Up, Housing and Communities and Ministry of Housing, Communities and Local Government, 2014 (Updated 2022). National Planning Policy Framework. Planning Practice Guidance: Flood Risk and Coastal Change [online] Available at: https://www.gov.uk/guidance/flood-risk-and-coastal-change (Last accessed 19/01/2024)
[11] Environment Agency Guidance on Climate Change Allowances for Flood Risk Assessments [online] Available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances (Last accessed 30/01/2024)
[12] Environment Agency Pollution Prevention Guidelines (PPGs) [online] Available at: https://assets.publishing.service.gov.uk/media/5a758f5aed915d6faf2b3eed/pmho1107bnkg-e-e.pdf (Last accessed 30/01/2024)

South Gloucestershire Local Plan Core Strategy

2.3.7. The South Gloucestershire Local Plan Core Strategy[13] was adopted in 2013 and provides the policy framework for development in the county up to 2027. The Plan was prepared in accordance with the NPPF and the PPG. The South Gloucestershire Local Plan Policies, Sites and Places Plan[14] was adopted in November 2017 and forms part of the South Gloucestershire Local Plan along with the Core Strategy and the Joint Waste Core Strategy. Relevant policies are set out in **Table 2.2**.

Table 2.2 South Gloucestershire Plan: Relevant Policies

Policy Ref.	Policy wording
CS1 – High Quality Design	Development proposals will be required to demonstrate that: (11) take account of the South Gloucestershire Strategic Flood Risk Assessments and provide, where appropriate, measures to manage flood risk and prepare surface water management plans. The Level 1 and Level 2 South Gloucestershire Strategic Flood Risk Assessments appraise the risk of flooding, including the effects of climate change, and should be used to avoid inappropriate development in areas at risk of flooding and to direct development away from areas at highest risk. Where new development is exceptionally necessary, proposals will need to ensure that risk is managed and reduced through location, layout and design and through sustainable methods of dealing with surface water.
CS2 – Green Infrastructure	The Council and its partners will ensure that existing and new Green Infrastructure (GI) is planned, delivered and managed as an integral part of creating sustainable communities and enhancing quality of life, considering the following GI objectives: (1) realising the potential of Green Infrastructure to assist with mitigation of, and adaption to, climate change. Green Infrastructure assets include open spaces, recreational areas, parks, allotments, biological and geological conservation sites, landscape and heritage features, water courses, water features, sustainable drainage schemes, woodlands, trees, cycleways, pedestrian routes, bridleways, public rights of way and open access land and managed countryside. Green Infrastructure provides opportunities to manage water resources, by reducing run-off, providing flood storage and acting as a natural soakaway. GI has a role in absorbing carbon dioxide, reducing 'urban heat island' effects, improving air quality and providing opportunities for increasing habitats and connections to help enable wildlife to adapt. Assets can provide opportunities for local food cultivation, contributing to local food security, and are also important for biodiversity. GI can encourage walking and cycling, by providing pleasant traffic free routes thus helping to reduce greenhouse gas emissions from car travel. GI can also incorporate space for renewable energy resources.

[13] South Gloucestershire Local Plan Core Strategy [online] Available at: https://www.southglos.gov.uk/documents/cleanversionforinterimpublication2.pdf (Last accessed 30/01/2024)
[14] South Gloucestershire Local Plan Policies, Sites and Places Plan [online] Available at: https://beta.southglos.gov.uk/static/90efa5d673f208a3109ed111ba963a01/PSP-Plan-Nov2017.pdf (Last accessed 30/01/2024)

Policy Ref.	Policy wording
CS9 – Managing the Environment and Heritage	The natural and historic environment is a finite and irreplaceable resource. In order to protect and manage South Gloucestershire's environment and its resources in a sustainable way, new development will be expected to: (5) reduce and manage the impact of flood risk through location, layout, design, choice of materials and the use of Sustainable Drainage Systems (SuDS); (6) protect the quality and quantity of the water environment and its margins; (8) utilise natural resources, including minerals, soils and water, in an efficient and sustainable way.
CS10 - Minerals	Provides details on the mineral extraction context in South Gloucestershire. No flood risk specific guidance therein.
PSP20 – Flood Risk, Surface Water and Watercourse Management	<u>1. Flood Risk and Surface Water Management</u> All development proposal(s) should follow the sequential approach to flood risk, for all potential flood risk sources. Development proposal(s) will be expected to: (i) Reduce surface water discharge from the site, wherever practicable and feasible on: (a) Previously developed land, by reducing post development runoff rates for events up to and including the 1 in 100 year return period, with an allowance for climate change, to that of a greenfield condition. Where it can be demonstrated that this is not practical or feasible, a 30% betterment to the existing condition will be required; (b) Greenfield sites, by restricting discharge to a watercourse or surface water sewer to the estimate3d mean Greenfield runoff rate (QBAR) by means of a controlled outflow. The drainage system should be designed so that flooding does not occur on any part of the development for the 3.33% (1 in 30 year) rainfall event other than in those areas/systems designated to store or convey water. Flooding within the development site should not occur in any part of a building or utility plant susceptible to water during a 1% (1 in 100 year) event, with an allowance for climate change; and (ii) Incorporate Sustainable Drainage Systems (SuDS) to reduce surface water runoff and minimise the flood risk, supported by an appropriate surface water drainage strategy; and (iii) Ensure that surface water drainage proposals are designed to not increase off-site flood risk; and (iv) Wherever practicable achieve the top tier of the following Surface Water Discharge Hierarchy, providing justification where lower tiers are considered appropriate: (1) Infiltration; (2) Surface water body (watercourse/ditch) (non-infiltration); (3) Surface water sewer (non-infiltration); and (4) Combined sewer (non-infiltration). <u>2. Land Drainage and Water Quality</u> Development proposals will be acceptable where:

Policy Ref.	Policy wording
	i) Watercourses, ponds and lakes are retained, protected and enhanced as natural landforms, floodplains and wildlife habitats; ii) It is designed and located to protect the existing floodplain and enable suitable access for maintenance; iii) Practicable the water environment is left in its natural state, and designed to avoid engineering activities which would cause harm to the water environment; and iv) Prevention and mitigation measures are sensitively designed to minimise the risk of pollution to the water environment. 3. Operation and Maintenance Applicants must provide evidence of appropriate arrangements for future ownership, operation and maintenance of new and existing surface water drainage features, including SuDS, for the lifetime of the development proposal(s).
PSP23 – Mineral Working and Restoration	Provides details on the expectations for mineral working/restoration in South Gloucestershire. No flood risk specific guidance therein.

South Gloucestershire Council Preliminary Flood Risk Assessment

2.3.8. The PFRA[15] notes that following a review in 2017 of the local flood risk and indicative Flood Risk areas for South Gloucestershire Council, there is no significant change to the assessment of local flood risk.

South Gloucestershire Council Strategic Flood Risk Assessment

2.3.9. The SFRA[16] identified that historically during the winter of 2013/2014, the Laddon Brook was one of several watercourses in the county which experienced localised flooding caused by extensive rainfall. The Tytherington Community also reported one flood event between November 2000 and February 2021. The Ladden Brook has also been highlighted as a watercourse within the county that has long been associated with fluvial flooding.

2.3.10. The SFRA also indicates that the vast majority of South Gloucestershire is considered at low risk of groundwater flooding.

2.3.11. Within the Tytherington postcode of GL12, four incidents of sewer flooding were recorded, one each year from 2009 to 2013.

[15] South Gloucestershire Council Preliminary Flood Risk Assessment [online] Available at: https://assets.publishing.service.gov.uk/media/5acc956d40f0b64fed0aff27/PFRA_South_Gloucestershire_Council_2017.pdf (Last accessed 30/01/2024)
[16] South Gloucestershire Council Level 1 Strategic Flood Risk Assessment [online] Available at: https://beta.southglos.gov.uk/static/777cfdc6b8907d8ab9e1e4f97e59474e/Main-Report-Level_1_SFRA-2021.pdf (Last accessed 30/01/2024)

2.3.12. Thornbury and Tytherington are the two main settlements to the site. The SFRA states that "*Thornbury is not located on any Main Rivers, but several smaller streams do run through the town, and small areas of the town are consequently in flood zones 2 and 3. The town is not included in any historic flood outlines*". "*Tytherington is located near the headwaters of a tributary of the Ladden Brook, although the associated flood zones 2 and 3 extents to not extend into the village. There is a small, recorded flood outline in the south-east of the village, on the corner of Duck Street and Stidcot lane, due to fluvial flood from an ordinary watercourse*".

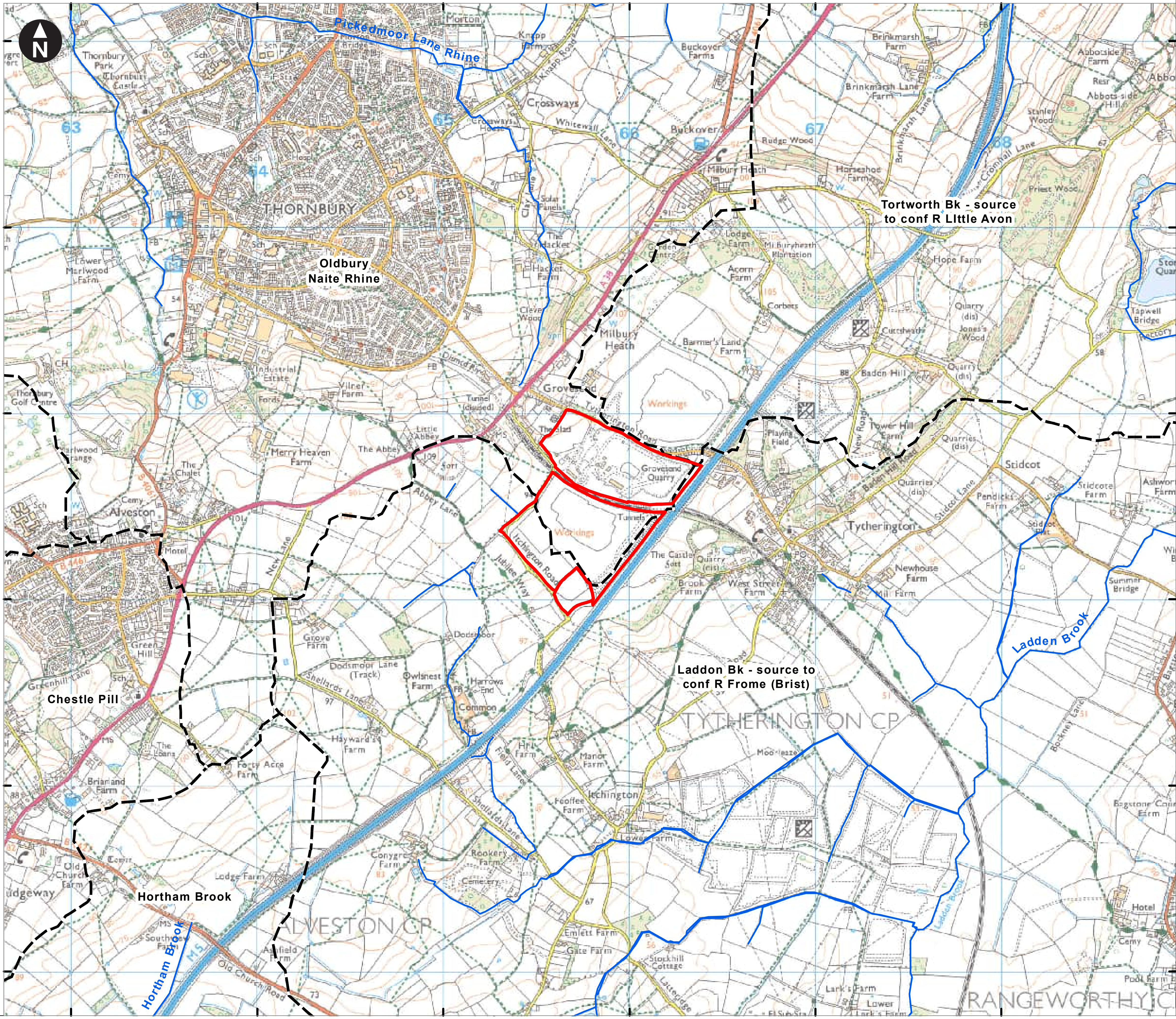
The Sequential Test

2.3.13. The Sequential Test is set out in the NPPF and explained further in the accompanying Planning Practice Guidance. A sequential, risk-based approach to the location of development is required, both in terms of locating the site itself (the Sequential Test) and then the layout of the site (a sequential approach within site). The Sequential Test aims to direct new development to the areas of lowest flood risk by a process of appraising other reasonable available sites within a suitable 'area of search'. Only when it is confirmed that there are no other suitable sites will development be permitted in areas of Flood Zone 2 and then sequentially Flood Zone 3. Even then, the development must account for the flood risk vulnerability of the proposed land use and to apply the Exception Test if required.

2.3.14. The NPPF also requires that a sequential approach should be applied to the layout and design when allocating land for development and land use types within development sites.

The Exception Test

2.3.15. The Exception Test, as set out in paragraph 160 of the NPPF, is a method to demonstrate and help ensure that flood risk to people and property will be managed satisfactorily, while allowing necessary development to go ahead in situations where suitable sites at a lower risk of flooding are not available. The need for the Exception Test will depend on the potential vulnerability of the site and of the development proposed, in line with the Flood Risk Vulnerability Classification set out in national planning guidance.



Key

- Extant planning permissions
- WFD surface waterbody catchment
- Watercourse

0 500 1,000 m

Scale at A3: 1:20,000

Heidelberg Materials
Tytherington Quarry - 6 Million Tonne Additional Reserves
Flood Risk Assessment (FRA) Report

Figure 2.1
Hydrology

April 2024

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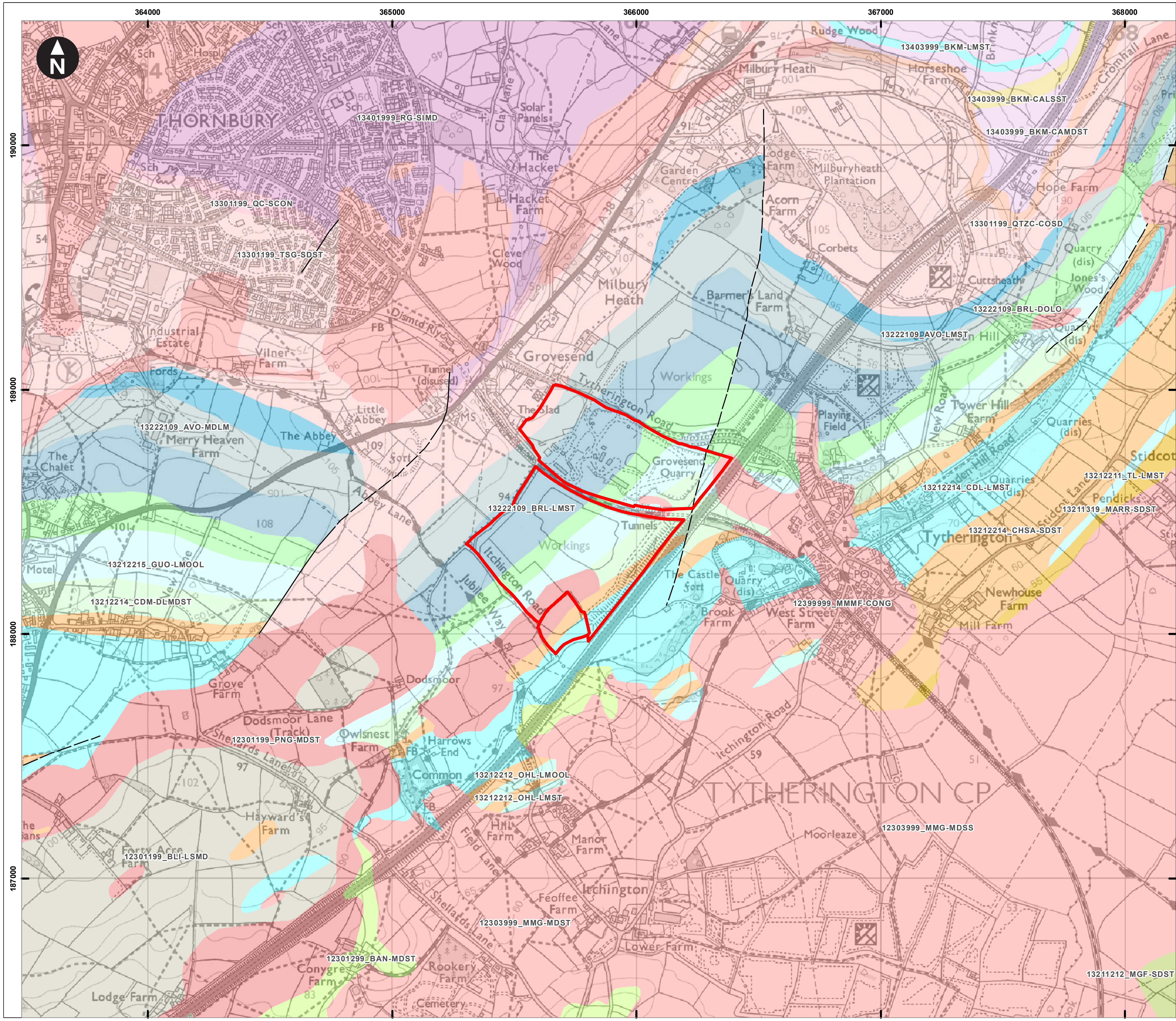

Key

Extant planning permissions

Linear feature

Fault inferred downthrow unspecified

Fault observed downthrow unspecified

Bedrock

- BLI-LSMD
- PNG-MDST
- BAN-MDST
- MMG-MDSS
- MMG-MDST
- MMMF-CONG
- MGF-SDST
- MARR-SDST
- TL-LMST
- OHL-LMOOL
- OHL-LMST
- CDL-LMST
- CDM-DLMDST
- CHSA-SDST
- GUO-LMOOL
- AVO-LMST
- AVO-MDLM
- BRL-DOLO
- BRL-LMST
- QC-SCON
- QTZC-COSD
- TSG-SDST
- RG-SIMD
- BKM-CALSST
- BKM-CAMDST
- BKM-LMST

0 250 500 750 m

Scale at A3: 1:15,000

Heidelberg Materials
Tytherington Quarry - 6 Million Tonne Additional Reserves
Flood Risk Assessment (FRA) Report

Figure 2.2
Bedrock geology

April 2024

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3 FLOOD RISK ASSESSMENT

3.1 TERMINOLOGY

3.1.1. In this report, the probability of a flood occurring is expressed in terms of annual exceedance probability (AEP), which is the inverse of the annual maximum return period. For example, the 100-year flood can be expressed as the 1% AEP flood, which has a 1% chance of being exceeded in any given year.

3.1.2. **Table 3.1** is provided to clarify the use of the AEP terminology as well as a description of the Flood Zone definitions as set out in the NPPF.

Table 3.1 Flood Zone Definitions and Associated Annual Exceedance Probabilities

Flood Zones	Probability of flooding	AEP	Definition
Zone 1	Low Probability	<0.1% AEP of river or sea flooding	Land having a less than 1 in 1,000 probability of river or sea flooding in any year.
Zone 2	Medium Probability	1% - 0.1% AEP of river flooding 0.5% - 0.1% AEP of sea flooding	Land having between a 1 in 100 and 1 in 1,000 probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 probability of sea flooding.
Zone 3a	High Probability	>1% AEP of river flooding >0.5% AEP of sea flooding	Land having a 1 in 100 or greater probability of river flooding in any year; or Land having a 1 in 200 probability or greater of sea flooding in any year.
Zone 3b	Functional Floodplain	NA	Land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly in agreement with the Environment Agency (Not separately distinguished from Zone 3a on the Flood Map).

3.2 POTENTIAL SOURCES OF FLOODING

3.2.1. All potential sources of flooding to the site have been considered, as summarised in **Table 3.2**. Sources requiring additional discussion are described in more detail in the following sections.

Table 3.2 Screening of all potential sources of flooding

Source	Potential Connection to Site	Screened in?
Fluvial flood risk	The proposed scheme, as shown in **Figure 3.1**, is located entirely within Flood Zone 1. The closest area of Flood Zone 2 and 3 are associated with the Ladden Brook. This area of flood risk is approximately 920m southeast of the site and at an elevation of	No

Source	Potential Connection to Site	Screened in?
	26.5m below the outer margins of the site. Risk of fluvial flooding is not considered further in this assessment.	
Tidal flood risk	The site is located entirely within Flood Zone 1. The outer margins of the site are located in excess of 95mAOD and is therefore not at risk of tidal flooding. Tidal flood risk is not considered further in this assessment.	No
Surface water flood risk	The EA's Surface Water Flood Risk Map shows, as illustrated in **Figure 3.2**, areas of the proposed scheme with low (0.1% AEP) to high (>3.3% AEP) surface water flood risk pathways. Surface water flooding is assessed in **Section 3.4**.	Yes
Artificial flood risk	The EA's Flood Risk from Reservoirs Mapping shows that the proposed scheme is not located within a flood risk area. The closest areas of reservoir flood risk are 3.7km south-east of the site. The risk of reservoir flooding to the site will therefore not be considered further within this assessment.	No
Groundwater flood risk	In the SFRA, Tytherington is not indicated as having had groundwater flooding in the past, or having a ground water flooding risk, with it stated that the vast majority of South Gloucestershire is considered at low risk of groundwater flooding. Owing to the principal aquifer beneath the site, local geology is therefore capable of storing and conveying large volumes of groundwater. Considering that the proposed scheme is to include quarry works undertaken below the water table, or if quarry extraction works and restoration influence the depth of the water table, then there is a potential risk of groundwater flooding, in the absence of appropriate flood risk mitigation measures. Groundwater flood risk is therefore assessed further in **Section 3.5**.	Yes
Sewer flood risk	The proposed scheme is situated away from developed areas, and it is assumed that there are few sewer drainage networks within the vicinity of the proposed scheme which could cause flooding on site. The SFRA reports that historically there have been four incidences of sewer flooding within Tytherington Village postcode. This is, however, likely to have occurred within the village, and would not have any impact or cause flooding within the site area, as the site is upslope and separated by the M5 highway. Owing to a lack of source, the risk of sewer flooding in the will therefore not be considered further within this assessment.	No
Off-site dewatering discharge flood risk	The proposed schemes discharge consent location for the dewatering of the Woodleaze and Grovesend Quarry is situated in Tytherington Village as shown in **Figure 3.4.** The SFRA also outlines that flood has taken place along Duck Street associated with the water course into which the discharge occurs. The discharge is a potential fluvial flood risk to the houses and infrastructure located downstream of the discharge point within Tytherington Village as well as the larger Ladden Brook catchment. The associated flood risk of the Tytherington Quarry discharge is assessed further in **Section 3.6**.	Yes

3.3 HISTORIC FLOOD RECORDS

3.3.1. Historic flood mapping[17] has been obtained from the Environmental Agency (EA). It shows that the nearest recorded historic flood occurred ~1.1km south of the site and was related to fluvial flooding of a minor portion of small watercourse near Itchington. There are no records of historical flooding at the site.

3.3.2. The SFRA shows the closest historical flood events recorded by the Council were in the winter of 2013/2014 extensive rainfall caused localised flood incidents, of which one of the main rivers affected was the Ladden Brook, which flows 2.2km southwest of the site. In addition, 1 recorded flood incident by the community within South Gloucestershire between 2000 and 2021 was recorded for the village of Tytherington, which is located ~1km to the northeast of the site.

3.3.3. This does not categorically prove that the site has never flooded in the past, simply that no flooding has been recorded. However, given the overview of flood risk (**Table 3.2**), it is likely that there has been no significant historic flooding at the quarry site.

3.4 SURFACE WATER FLOODING

3.4.1. As outlined in **Table 3.2**, the outer margins of the site effectively form a watershed, such that the quarry void has no notable upslope area. As such, there is minimal surface water run-on to the site and surface water flood risk at the site is associated with the accumulation and pathways of rainfall draining to the void base.

3.4.2. Based on the EA Flood Map for Planning for Surface Water Flood Risk, gives an indication of the broad areas likely to be at risk of surface water flooding at present, i.e. areas where surface water would be expected to flow or pond. The Proposed Scheme area consists of mostly very low risk of surface water flooding (0.1% AEP) as illustrated in **Figure 3.2**. However, there are areas of low to high flood risk (0.1% to >3.3% AEP) associated with the topographic low points within and around the Woodleaze and Grovesend Quarry voids and the preferential flow paths associated with the haul roads. There are also areas of ponding below the perimeter bund on the eastern boundary of Woodleaze Quarry, which appears to form a small cut against the M5 motorway. There is also a notable area on the southern boundary of the Woodleaze Quarry adjacent to the soil store area boundary which then drains across the agricultural fields to the southwest, and then into a minor watercourse. This watercourse the flows into the Ladden Brook. This area of mapped flood risk is no longer present, since this area of land has now been worked as an extension to the Woodleaze Quarry. All current flood risk within the Grovesend Quarry void will not change as no changes in operation within this area are proposed.

3.4.3. The EA Climate Change Allowances[18] for the Avon Bristol and North Somerset Streams Management Catchment, states that the upper end forecast for increase in rainfall intensity is 40%

[17] Environment Agency Historic Flood Map [online] Available at: https://www.data.gov.uk/dataset/76292bec-7d8b-43e8-9c98-02734fd89c81/historic-flood-map (Last accessed 10/04/2024)
[18] Environment Agency Climate Change Allowances [online] Available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances (Last accessed 10/04/2024)

for the period 2022 to 2060 (covering Phases 1 to 3 and progressive restoration phase) and 45% for the period 2061 to 2125 (covering the restoration phase). This could exacerbate surface water flood risk in the lowest elevation areas of the quarry, in the absence of appropriate surface water drainage strategy. The quarry excavation works are projected to end around 2032 provided work starts by 2025.

3.4.4. **Working Phase:** The quarrying operations will impact the ground levels across the Proposed Scheme, both in terms of excavation which will deepen the ground elevations as well as the placement of materials which will increase ground elevations. Such activities provide the potential to affect surface water flood risks across the site. The soil store area provides a potential source of surface runoff when being stripped, and this may need to be mitigated and managed. The development of bare and compact land associated with the limestone extraction, haul roads and overburdened storage mounds and bunds, all have the potential to increase the overall extent of less permeable areas within the Proposed Scheme. These increases will slightly increase the peak runoff rates and volumes; however, runoff will be captured in the base of the quarry void, and dissipate to ground, or require pumping to the sump in Grovesend Quarry. If the rate of required site discharge changed, this could therefore result in an increase in flood risk to any low-lying development within Tytherington Village beside the watercourse that receives dewatering flows.

3.4.5. Minor adjustments to the screening bund will result in negligible changes to runoff quantity owing to the overall increase in the void area, reducing the area of land that drains off-site.

3.4.6. **Restoration Phase:** With the restoration of the soil store area to grassland with a mosaic of small ponds, this will in the long term reduce runoff to the new restoration lagoon in Woodleaze Quarry. The soil store area provides a potential source of surface runoff when infilled and reprofiled during restoration. Reprofiling will direct runoff into the remaining quarry void since if unmitigated, these could lead to an increase in off-site surface water flood risk.

3.4.7. Potential receptors of surface water flood risk in Tytherington Village are several residential buildings along Duck Street. Of particular concern, based on the EA Surface Water Flood Risk Map, is a residential building between Duck Street and Walnut Field Street (**Figure 3.5**). Additionally, a significant area of surface water flood risk is located at the end of Duck Street where it becomes Sidcot Lane (**Figure 3.5**). This was outlined in the SFRA as a point of high flood risk in Tytherington Village. The residential gardens around this area, despite being already land at risk, are identified as potential receptors, as this area would receive all flood water that would flow down Duck Street.

3.4.8. Based on the LiDAR, it is evident that the residential land and buildings to the northeast of Duck Street are on higher ground, while the residential land and buildings to the southeast are on lower land (**Table 3.3**), which becomes progressively lower with distance to the south. The majority of residential buildings are outside the surface water flood areas, with the exception being the buildings marked on **Figure 3.5**, on the land at the boundary between Duck Street and Walnut Field Street, and in the area where Duck Street becomes Sidcot Lane. Using the LiDAR, the elevations of the bank top of the channel, the land beside each receptor building, and land at the edge of the surface water flood risk areas for the 3.3%, 1.0% and 0.1% AEP events, have been detailed in **Table 3.3**.

3.4.9. Initial analysis of peak flows from wider catchment runoff for the Tytherington Stream catchment above the discharge point indicates a discharge rate of 575l/s for the 1% AEP runoff event plus Climate Change (CC).

3.4.10.

Table 3.3 Elevations of receptors and land southwest of Duck Street

Receptor	Bank top at open channel (mAOD)	Land beside building (mAOD)	Land within 3.3% AEP Surface Water Flood Risk (mAOD)	Land within 1% AEP Surface Water Flood Risk (mAOD)	Land within 0.1% AEP Surface Water Flood Risk (mAOD)
Building #1	65.0	64.1	64.2	64.5	64.6
Building #2	59.0	59.1	58.5	58.6	58.7
Building #3	59.0	58.7	58.7	58.8	58.9
Building #4	59.1	59.5	59.3	59.5	59.6

3.4.11. **Section 4** of this report describes the drainage strategy, and **Section 5** outlines appropriate measures to manage surface water to ensure that surface water flood is appropriately managed with no significant increase over baseline to offsite flood risk.

3.5 GROUNDWATER FLOOD RISK TO THE SITE

3.5.1. Groundwater flooding occurs as a result of water issuing to the surface from the underlying aquifers. This tends to occur after long periods of sustained high rainfall, with areas most at risk being situated on permeable geology which is low-lying compared to the local water table, and where no watercourse is available to drain the water away.

3.5.2. The SFRA states that within South Gloucestershire is considered at low risk of groundwater flooding. However, as the site is located over bedrock classified as a Principal Aquifer, a risk of groundwater flooding could exist. Under baseline conditions any emergence of rising groundwater is likely to be contained within the Woodleaze Quarry void and managed by dewatering and via consented discharge, thus not posing any risk to potential flood risk receptors.

3.5.3. **Working phase:** As outlined in **Table 3.2**, there is the potential for groundwater flood risk if quarry works are undertaken below the water table or if quarry works influence the depth of the water table, in the absence of appropriate flood risk mitigation measures. Considering that Woodleaze Quarry is proposed to be deepened to a maximum of -40mAOD, there is a potential risk of groundwater flooding. Groundwater ingress, as is currently occurring, will be contained within the sump at the base of the Woodleaze Quarry void and when required, pumped to the Grovesend Quarry attenuation sump from where it can be discharged off site via the consented discharge. There is no planned change to the manner in which groundwater dewatering is to be handled. It is normal for quarry operations to be subject to groundwater ingress and dewatering operations and thus it is anticipated that operators of the quarry will be fully engaged with the dewatering process such that groundwater flooding would be managed and actively addressed/reacted to as necessary to ensure the risk to site is dealt with appropriately. As such, the risk of groundwater flooding detrimental to extraction operations during the working phase is considered low.

3.5.4. **Restoration Phase:** Restoration of Woodleaze Quarry to a lagoon with a base elevation of -40mAOD suggest that groundwater ingress into the base of the quarry will occur and is expected to equilibrate with natural groundwater levels at the anticipated rest mean water level of 68-70mAOD. Based on the HM report[19], from December 2012 to March 2019, no dewatering of Woodleaze Quarry took place, and the water level within the void was left to recover. The water level settled at 64mAOD. There are no reports of flooding of the surrounding land associated with the quarry water levels during this period of time.

3.5.5. **Section 5** of this report describes appropriate measures to manage and mitigate groundwater flood risk.

3.6 OFF SITE DISCHARGE OF DEWATERED SURFACE WATER RUNOFF AND GROUNDWATER

3.6.1. Tytherington Quarry operates under a discharge consent which came into effect on 11th July 1987. Under this consent, the water accumulating in the quarry void is permitted to be discharged at the discharge location NGR ST 6689 8832. The following conditions considered relevant to downstream flood risk are imposed with regards to the consent:

- The volume shall be no more than 6,820m^3/ day; and
- The rate cannot exceed 79l/s (4,736l/min as stated in discharge consent document).

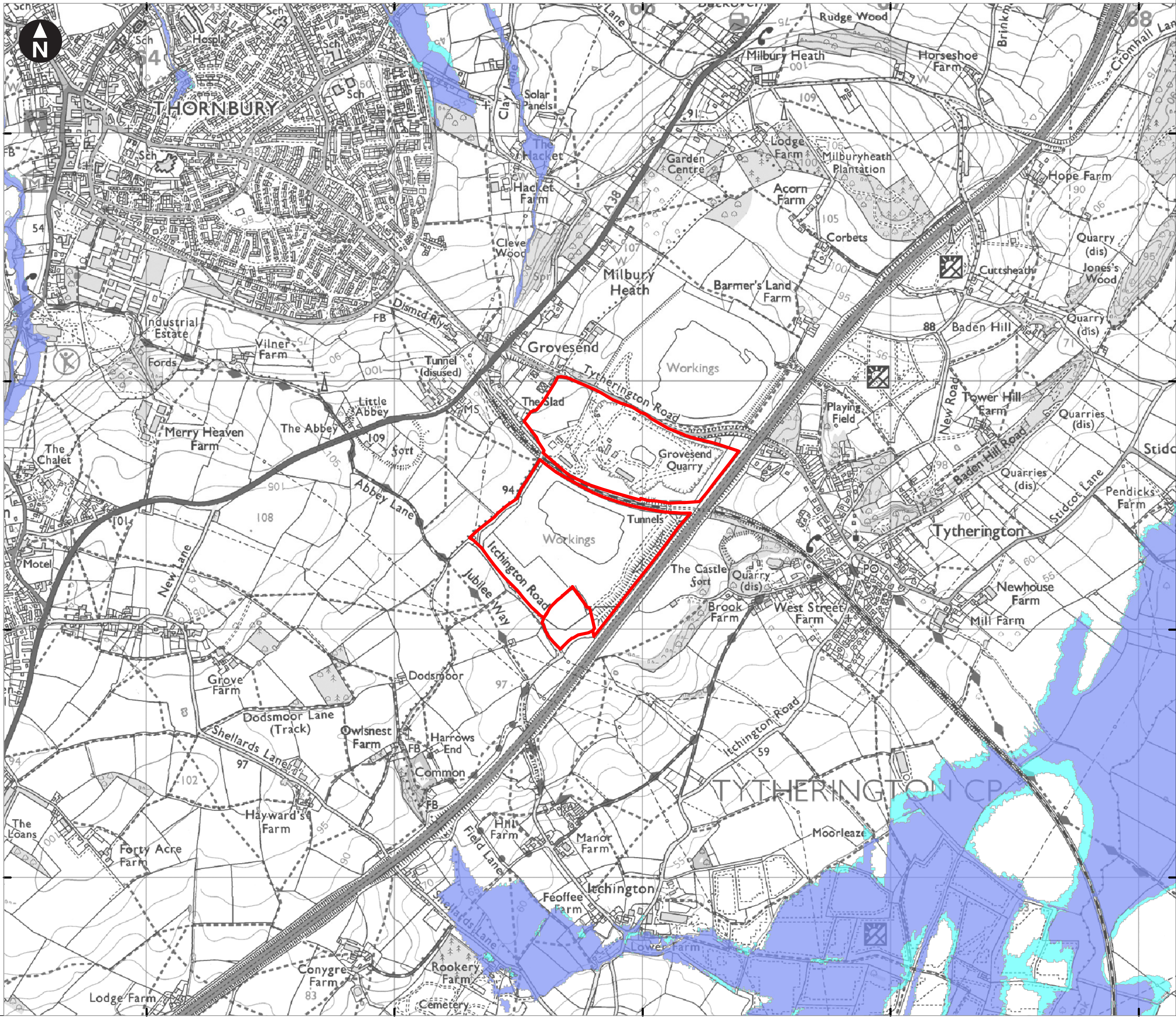
3.6.2. A site visit to Tytherington Village to identify and observe the discharge point and downstream channel was conducted between 10:15 and 11:00 on 26 March 2024. The discharge point was identified to be beside Duck Street in Tytherington Village and is shown daylighting in the channel in **Plate 3-1**. The discharged water flows out of the right culvert into a concrete square channel below the stone fence and flows in a southeast direction.

Plate 3.1 Consented discharge location in Tytherington Village up close (left) and from downstream (right)

3.6.3. The layout of the Tytherington Quarry Water Management System is illustrated in **Plate 3.1**. The open channel through Tytherington Village is square in cross-section and has a consistent width throughout of ~0.6m. The culverts along the channel range in diameter from 0.40 to 0.45m and consist of box or semi-circle shape. The smallest of the culverts is that immediately downstream of the discharge point and has a cross-sectional area of around 0.06m^2. Based on a high-level assessment, provided that the maximum consented discharge rate is 79l/s, this utilises 80% of the culvert's capacity. Under dry weather conditions, this culvert is considered adequate.

3.6.4. The channel receiving the discharge runs parallel to Duck Street (on its southeastern side) and consists of a series of open channels and culverts. The sections of open channel range from 15m to 160m in length. After crossing under Walnut Field Street, the channel runs parallel to an agriculture field. At the end of the agricultural field and Duck Street, a residential property is located at the point of the final culvert. It is then understood that the channel daylights again in the agricultural fields to the southwest of Tytherington Village where the watercourse continues in a natural open channel before joining the Ladden Brook 1.3km southeast of Tytherington. This section was not visited as it was located on private land.

3.6.5. The principal component of the dewatering discharge is dewatering of the Woodleaze Quarry (from groundwater and surface water contributions). With the proposed deepening of Woodleaze Quarry (and minor additional contributions from the south-eastern extension of the void into the soil store area, slightly increasing the area of the open quarry void). There is expected to be no appreciable increase above the current 'with-quarrying baseline' volume of water requiring dewatering in order to prevent flooding in the base of the Woodleaze Quarry. Therefore, it is considered that there will be no increase in potential flood risk to downstream receptors located within Tytherington Village above the current baseline.



Key

- Extant planning permissions
- Environment Agency Flood Zone 3 (> 1% AEP of fluvial flooding)
- Environment Agency Flood Zone 2 (between 0.1% and 1% AEP of fluvial flooding)
- Environment Agency Flood Zone 1 (<0.1% AEP of fluvial flooding)

0 500 m

Scale at A3: 1:15,000

Heidelberg Materials
Tytherington Quarry - 6 Million Tonne Additional Reserves
Flood Risk Assessment (FRA) Report

Figure 3.1
Fluvial flood risk

April 2024

wsp

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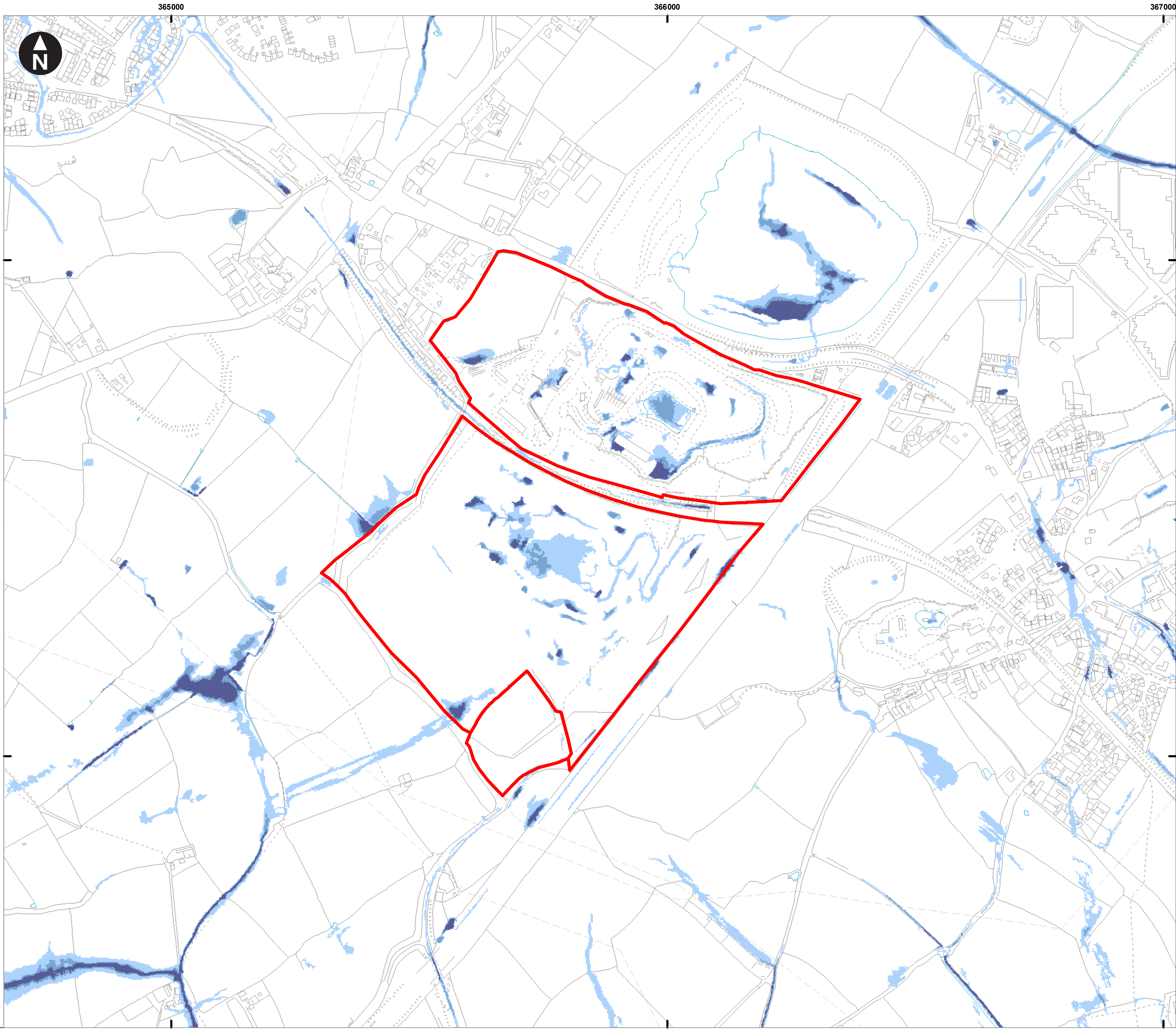

Key

- Extant planning permissions
- >3.3% AEP - High risk of surface water flooding
- 1 to 3.3% AEP - Medium risk of surface water flooding
- 0.1 to 1% AEP - Low risk of surface water flooding
- <0.1%AEP - Very low risk of surface water flooding

0 100 200 300 400 m

Scale at A3: 1:7,500

Heidelberg Materials
Tytherington Quarry - 6 Million Tonne Additional Reserves
Flood Risk Assessment (FRA) Report

Figure 3.2
Surface water flood risk

April 2024

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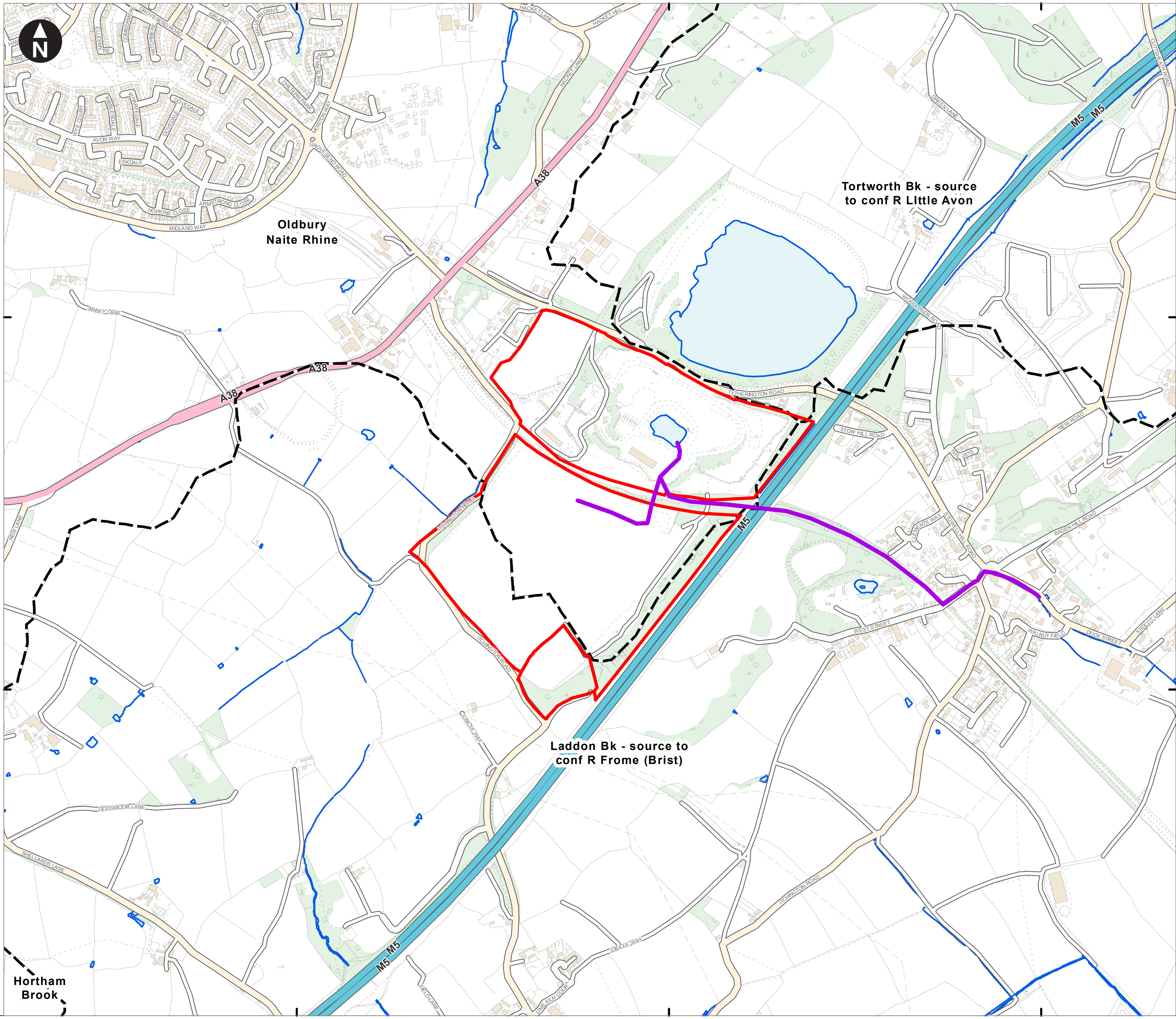

Heidelberg Materials
Tytherington Quarry - 6 Million Tonne Additional Reserves
Flood Risk Assessment (FRA) Report

Figure 3.4
Water management layout

April 2024

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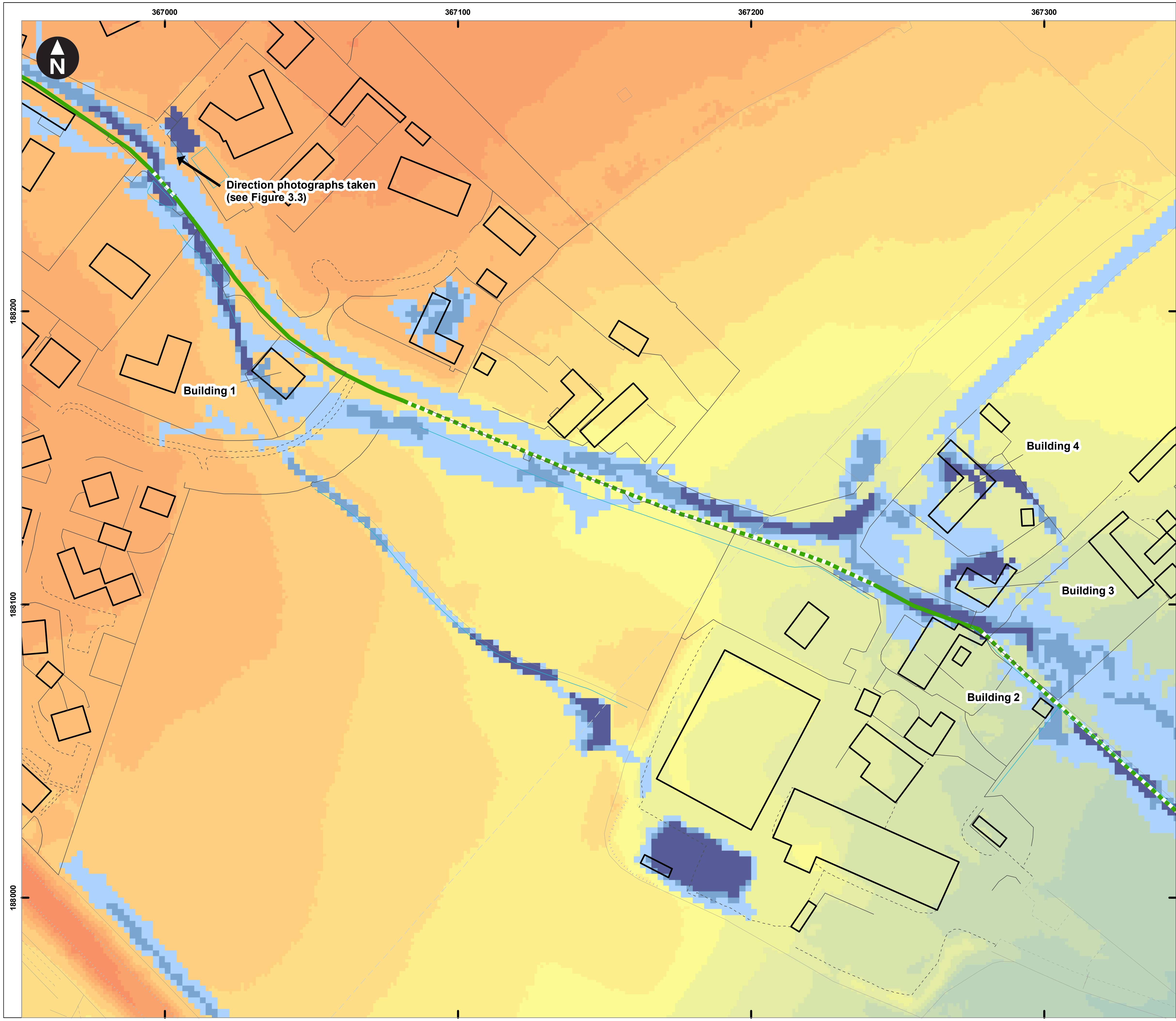

Key

Culverted channel

Open channel

>3.3% AEP - High risk of surface water flooding

1 to 3.3% AEP - Medium risk of surface water flooding

0.1 to 1% AEP - Low risk of surface water flooding

<0.1%AEP - Very low risk of surface water flooding

Elevation mAOD

55 - 56
56 - 57
57 - 58
58 - 59
59 - 60
60 - 61
61 - 62
62 - 63
63 - 64
64 - 65
65 - 66
66 - 67
67 - 68
68 - 69

0 25 50 75 m

Scale at A3: 1:1,250

Heidelberg Materials
Tytherington Quarry - 6 Million Tonne Additional Reserves
Flood Risk Assessment (FRA) Report

Figure 3.5
Flood risk associated with quarry discharge in Tytherington village

April 2024

62282762-FG0061_P01

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4 SURFACE WATER MANAGEMENT AND DRAINAGE STRATEGY

4.1.1. The creation of bare/compacted land associated with mineral extraction, haul roads, overburden storage mounds, bunds and hardstanding and restoration operations at Tytherington Quarry has the potential to increase surface water run-off rates, volumes and pathways. As outlined in **Section 3.4**, there is the potential for surface water flood risk to be exacerbated by climate change, in the absence of an appropriate surface water management and drainage strategy to ensure risks to on-site and off-site (down gradient) third party receptors are appropriately addressed:

- Potential to increase surface water flood risk to the site and offsite; and
- Potential for the discharge of collected surface and groundwater in Woodleaze Quarry via the approved discharge consent to the watercourse at Duck Street in Tytherington Village to exacerbate flood risk to adjacent residential properties.

4.1.2. This section outlines the surface water management and drainage strategy to ensure that there is no increase in surface water flood risk to the site or to third parties as a result of the Proposed Scheme, accounting for climate change. The surface water management strategy will be designed for the site to address surface water run-off (surface water originating from within the site), surface water run-on (surface water originating from outside the site), and groundwater ingress (which is anticipated will be dealt with alongside surface water).

4.1.3. Information about the baseline management of water on site has been obtained from the Tytherington Quarry Hydrometric Monitoring Report[19]. **Figure 3.4** shows the current site water management system. The system consists of two sumps and a series of pipes and pumps which discharge the water to a watercourse beside Duck Street in Tytherington Village. There is no planned change to be made to this system, whilst maximum pumping rate will not increase, the intensity and duration of the dewatering pumping regime within this will be altered to meet the future quarry operation's dewatering requirements.

4.2 EXISTING SURFACE WATER MANAGEMENT

4.2.1. Current surface water management at Tytherington Quarry consists of the pumping of water from Woodleaze Quarry void to an attenuation sump within Grovesend Quarry. Limited consumptive amounts of this water are used for dust suppression and wheel wash purposes within the site (on average less than 20m^3/day). The water in the Grovesend Quarry sump is then pumped to the discharge point off-site in Tytherington Village. This is the only method for the control of water levels within the quarry voids at Tytherington Quarry.

4.3 PROPOSED WATER MANAGEMENT SYSTEM

4.3.1. The following section summaries the estimates of changes in runoff rates and therefore possible changes to attenuation requirements in the working and restoration phases of Woodleaze Quarry.

[19] Tytherington Quarry Hydrometric Monitoring Report: August 1998 – September 2023.

As no activities or changes are proposed for the operation or layout of Grovesend Quarry, it has not been considered in the following sections.

WORKING PHASE

4.3.2. The proposed water management system for Woodleaze Quarry (including the soil store area) during the working phases is described below:

- When required, surface water and groundwater entering the Woodleaze Quarry void will be managed through pumping from the basal sump installed at the base of the workings into a sump in Grovesend Quarry. The Grovesend sump will not change location or size throughout the working phase.
- Following settlement, the water will then be pumped out from the Grovesend sump and conveyed by pipeline to the discharge point within Tytherington village. The discharge consent pumping rate and volumes will be maintained and not exceeded.
- The haul roads/trafficked areas would be reprofiled to direct all runoff to the Woodleaze Quarry void to collect the runoff in the base, from where it will be pumped to the Grovesend sump.
- In the instance of heavy rainfall beyond the capacity of the pump in the Woodleaze Quarry void and/or beyond the capacity of the Grovesend Quarry sump, the Woodleaze Quarry excavation itself would be allowed to flood and simply dewatered again once the rainfall event had passed. The risk of flooding within the Woodleaze Quarry void would be actively monitored and managed by the quarry operators/managers, and if necessary, in response to short term fluctuations in water levels, personnel and plant will be moved to upper levels of the quarry.

RESTORATION PHASE

4.3.3. The proposed water management system for Woodleaze Quarry (including the soil store area) is described below:

- Surface water and groundwater entering Woodleaze Quarry will be contained within the newly formed Woodleaze restoration lagoon which will be formed following the completion of excavation and the suspension of dewatering;
- The screenbank within the soil store area will be profiled in a way to promote the drainage of surface water towards the Woodleaze Quarry restoration lagoon; and
- Surface water runoff from the restored areas of the soil store area will drain towards and be captured by the Woodleaze Quarry restoration lagoon.

Site runoff rates

4.3.4. The quarry void already exists, and receives both direct rainfall, and runoff from minor areas adjacent to the lip of the quarry. The Proposed Scheme will mean that a small 3.03ha area to the south of the Woodleaze Quarry void is excavated and temporarily drains into the void. At present a soil bund acts as a drainage divide on the Site. The area south of the soil bund drains southwards off site and the area north of the soil bund drains northwards to the void. The soil bund will be reinstated at the restoration phase as such, by scheme completion there will be no change to the size of area draining off site to the south of the soil bund. The area draining to the void will also remain the same under the restoration scenario compared to the existing scenario. Additional runoff to the void will be managed in the void. During the operational phase the void will be pumped out to discharge.

4.3.5. After restoration the void will part flood and water will dissipate as it equalises with groundwater levels. No discharge will occur. There will be no increase in discharge off site from the void or the area south of the bund in the restoration scenario. Surface water runoff calculations for both areas under existing and restoration scenarios are presented in **Table 4.1**. A full drainage strategy is included in **Appendix A**.

Table 4.1 Existing and restoration phase peak runoff rates

	Draining to void	Draining to south
Existing site		
Site area (ha)	2.2	0.83
Proportion of site	0.73	0.27
Peak 1% greenfield runoff (l/s)	19.12	7.21
Operational Phase		
Site area (ha)	2.2 (0.82ha worked area + 1.38ha greenfield area)	0.83
Future proportion of site	0.73	0.27
Peak 1% + 45% CC runoff rate (l/s)	54.4 (35.96 + 18.44)*	11.07
Restoration Phase		
Site area (ha)	2.2	0.83
Future proportion of site	0.73	0.27
Peak 1% + 45% CC greenfield runoff rate (l/s)	29.34	11.07

*Peak runoff rate for the Operational phase is the sum of the worked area runoff rate and the greenfield area runoff rate

4.3.6. In the context of runoff draining into the void for management by the existing quarry dewatering system, these minimal increases (due to inclusion of climate change allowances) in runoff rates during the operational phase to the void are considered negligible. There will be no increase in runoff rates to third party land away from the quarry operation. The proportion of land draining to the void and away from the void will at restoration match the proportions at present.

5 FLOOD RISK MANAGEMENT

5.1 FLOOD RISK MANAGEMENT MEASURES

5.1.1. Based on the assessment undertaken in **Section 3**, the main flood mechanisms across the Proposed Scheme were identified as surface water and groundwater flood risks to quarry operations during working and restoration phases as well as the downstream flood risk associated with the discharge point within Tytherington Village.

5.1.2. This section outlines key flood risk management measures to ensure the Proposed Scheme is safe from flooding, and flood risk is not increase to offsite receptors for both the working and restoration phases.

AVOIDANCE OF FLOOD ZONES

5.1.3. Within the Proposed Scheme, there is no mineral extraction, soil/overburden storage, ground raising, or attenuation basins/lagoons proposed in areas of Flood Zones 2 or 3. The Proposed Scheme is mapped entirely within Flood Zone 1. The only mapped surface water flood risk is associated with runoff collecting in the voids themselves, which will remain the case, and is considered acceptable for the type of development associated with the Proposed Scheme.

5.1.4. Based on this, for the Proposed Scheme, the Sequential Test is considered to be met, and therefore consideration of the Exception Test is not required.

GROUNDWATER FLOOD RISK

5.1.5. **Baseline:** Considering that Woodleaze Quarry is currently being excavated, the management of surface water runoff and groundwater ingress into the quarry void is managed effectively by the current water management system. Communication from Heidelberg Materials indicate that the average summer dewatering pumping rate is around 1,600m^3/day and 4,800m^3/day in winter.

5.1.6. **Working phase:** During the working phase of the Proposed Scheme, deepening of Woodleaze Quarry comes with the potential for an increase in groundwater ingress and therefore groundwater flood risk, due to the quarry void being located below the natural groundwater level. The current dewatering system will remain in place to manage water levels within the Woodleaze Quarry void. The risks associated with a failure of the dewatering system will be managed by the fact that changes to water levels in the quarry (owing to pump failure, heavy rainfall) would be slow, allowing time for personnel and plant to be moved to upper levels of the quarry. The risks associated with the dewatering discharge is discussed in the next section.

Restoration phase: Following restoration, and the development of the Woodleaze restoration lagoon, it is assumed that the groundwater ingress will result in the water level equilibrating at the proposed 68 to 70mAOD. Whilst groundwater levels would recover, owing to the elevation of the land at the lip of the quarry (95mAOD), land here would not be at increased risk of flooding. However, as the wider 'cone of depression' associated with dewatering drawdown naturalises, groundwater levels could recover to affect receptors either more recently built than the quarry, or that have not been at risk for decades due to the quarry. Based on the hydrogeological assessment this appears unlikely in Tytherington village

5.1.7. Considering the need for dewatering, primarily associated with deepening of the quarry and the management of groundwater ingress, it is understood that the pumping regime will lead to no appreciable increase above the current ‘with-quarrying baseline’ discharge regime. The existing discharge consent (permit number 021407) requirements were set in 1987 via a consent originally issued by Wessex Water Authority (WWA).

5.1.8. Under baseline conditions, based on communication from Heidelberg Materials, the discharge rate on average is 1,600m^3/day in summer and 4,800m^3/day in winter. This is well under the maximum discharge consent licence condition of 6,820m^3/day. The current maximum peak pumping rate is 79l/s, and this will not change under the Proposed Scheme.

5.1.9. To examine downstream flood risk, checks have been made on the capacity of the watercourse and culverts downstream of the dewatering discharge point. Looking at the channel though Tytherington Village below the discharge point, and considering that the cross-sectional area the smallest culvert is around 0.06m^2, the design of the channel and infrastructure below the consented discharge point is adequate to accommodate dewatering discharge during normal flow conditions.

5.1.10. However, as with any watercourse with associated in-channel structures a risk of culvert blockage remains. The responsibility for maintaining culverts along a watercourse rests with the respective riparian landowners.

5.1.11. Based on EA LiDAR data and using the EA Surface Water Flood Risk Map (**Figure 3.5**), were a culvert to become blocked, or the capacity of the culvert or channel was exceeded, during the 1% of greater flood event, the preferential flow path for flood water would be along Duck Street in a southeast direction. A portion of this flood water will flow onto the lower lying land already at risk to the southeast of Duck Street. The majority of the lower land will consist of flooding of residential gardens only, with the exception being the residential building bordering both Duck Street and Walnut Field. The remaining flood water would continue into the agricultural field next to Duck Street.

5.2 DRAINAGE STRATEGY

5.2.1. **Section 4** outlined the proposed surface water management system designed for the scheme to address surface water run-off, run-on and groundwater ingress. A summary of peak runoff rates for the soil store area for the existing site and restoration phase are presented in **Table 4.1**. The runoff calculations for the Site show that there will be an increase in runoff to the void in the restoration scenario. This additional runoff will be managed in the void and there will be no increase in discharge in the restoration scenario. Full calculations and drainage strategy are included in **Appendix A**.

6 CONCLUSIONS

6.1.1. This FRA accompanies the ES submission for the proposal to secure the continued extraction of all consented limestone reserves, and extraction of further unconsented reserves, within the existing footprint of Tytherington Quarry.

6.1.2. The Proposed Scheme is not at risk from fluvial flooding, tidal flooding, artificial flooding or sewer flooding. Within the Proposed Scheme, there is no mineral extraction, soil/overburden storage, ground raising, or attention basins/lagoons within areas of Flood Zones 2 or 3, and the Proposed Scheme is mapped entirely in Flood Zone 1 for the lifetime of the development. The Sequential Test was considered to be met as outlined in **Section 5**.

6.1.3. Surface water and groundwater flood risk were identified as the main flooding mechanisms across the Proposed Scheme, as well as the downstream flood risks associated with the consented discharge point within Tytherington Village.

6.1.4. Surface water runoff on-site is captured by the quarry void both at present, during operation and following restoration. Drainage calculations for the site show that there will be an increase in runoff into the void during the operational phase associated with 2.2ha of land draining to the void during this phase only. In the restoration phase, the direction and rate of runoff from this 2.2ha area will revert to baseline levels, albeit elevated slightly due to the effects of climate change on rainfall intensity. However, given the area of land in question the potential for flood risk to be increased by these minor changes to runoff is considered to be negligible.

6.1.5. To address the groundwater flood risk within the Woodleaze Quarry void, the rate of water level rise would be very gradual – metres over days. Workers and equipment could therefore be removed from the lowest levels within the quarry void in timely fashion in the event of heavy rainfall that could result in surface water run-off ponding in the base of the void causing flooding, or periods where pumping ceases and groundwater rises.

6.1.6. Groundwater flood risk is considered negligible following restoration.

6.1.7. Considering the downstream flood risks associated with the consented discharge point, it is considered that there would be no increase in flood risk above the current baseline within Tytherington Village. This is since it is also understood that with the activities of the Proposed Scheme, there will be no appreciable increase above the current 'with-quarrying baseline' rate of pumping for quarry dewatering.

6.1.8. The Proposed Scheme with the flood risk management measures described above in place, would not pose unacceptable risks to site operations, and would not result in a significant change in flood risk to off-site flood risk receptors.

Appendix A

DRAINAGE REPORT

Tytherington Quarry – Surface Water Management

DATE:	31 May 2024	**CONFIDENTIALITY:**	Confidential
SUBJECT:	Surface Water Drainage Strategy		
PROJECT:	Tytherington Quarry: 6 Million Tonnes Additional Reserves	**AUTHOR:**	James English
CHECKED:	Richard Breakspear	**APPROVED:**	Nienke Pengelly

INTRODUCTION

Potential increases in surface runoff due to excavations and restoration operations at Tytherington Quarry could increase surface water flood risk. This short technical note provides a basic calculation to illustrate the modest changes to runoff rates and directions associated with the Proposed Scheme.

Climate Change

To account for the influence of climate change on rainfall intensities during the lifetime of the development, the climate change allowances have been considered in accordance with Environment Agency guidance. Due to the lifetime of the development and the phased nature of the works, two climate change allowances have been considered. The Environment Agency peak rainfall allowances for the Avon Bristol and North Somerset Streams Management Catchment[1], states that the Upper end allowance for increase in rainfall intensity is 40% for the period 2022 – 2060 (covering Phases 1-3 and progressive restoration phase) and 45% for the period 2061 to 2125 (covering the restoration phase) (**Table 1**). The more conservative 45% allowance has been applied all climate change drainage calculations.

Table 1 – Peak rainfall allowances

Epoch	Upper end allowance
2050s	40%
2070s	45%

Software

The modelling for this assessment has been undertaken using the plot scale option of ReFH 2 ver.2.3. produced by Wallingford Hydrosolutions.

[1] Environment Agency Climate Change Allowances [online] Available at: Climate change allowances for peak rainfall (data.gov.uk) (Last accessed 11/04/2024)

DATE:	31 May 2024	**CONFIDENTIALITY:**	Confidential
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MODELLING OF SURFACE RUNOFF

Approach to Calculating Greenfield Runoff

FEH point data was used to establish relevant Site characteristics and FEH22 design rainfall. The FEH point data is presented in **Table 2** as received from the UK Centre for Ecology and Hydrology FEH Web Services[2].

Table 2 – FEH point descriptors and values

Descriptor	Value
NGR	ST 65724 88030
BFIHOST	0.541
BFIHOST19	0.522
PROPWET	0.35
SAAR6190	800 mm

Approach to Modelling Site Runoff

The quarry void already exists, and receives both direct rainfall, and runoff from minor areas adjacent to the lip of the quarry. The Proposed Scheme will mean that a small 3.03ha area to the south of the Woodleaze Quarry void is excavated and temporarily drains into the void. At present a soil bund acts as a drainage divide on the Site. The area south of the soil bund (0.83ha) drains southwards off site and the area north of the soil bund drains northwards to the void (2.2ha). ReFH2 was used to calculate peak runoff for the whole 3.03ha area and was then prorated for the area draining to the void and the area draining to the south.

For the Operational Phase it has been assumed that the worked void area will result in an increase in impermeability relative to the existing site, due to the exposure of the underlying material. To simulate this,

[2] Flood Estimation Handbook Web Service [online] Available at: https://fehweb.ceh.ac.uk/ (Last accessed 11/04/24)

the BFIHOST (providing a measure of catchment responsiveness) has been revised to 0.17, which is the lowest allowable value.

The soil bund will be reinstated at the restoration phase as such, by scheme completion there will be no change to the size of area draining off site to the south of the soil bund. The area draining to the void will also remain the same under the restoration scenario compared to the existing scenario. Additional runoff to the void will be managed in the void. During the operational phase the void will be pumped out to discharge. In the restoration phase both the area draining to the south and the area draining to the void are modelled as greenfield.

Site Runoff Rates

The 1% Annual Exceedance Probability (AEP) greenfield runoff rate is presented for both the existing site and restoration phase. The runoff to the void from the existing Site is 19.12 l/s in the 1% AEP event. In the restoration scenario the runoff to the void will be 29.34 l/s in the 1% AEP + 45% CC event. The 1% AEP runoff rate draining to the south will remain as 7.21 l/s in the restoration phase. Runoff rates for the 1% AEP + 45% CC event are provided for the areas draining to void and away from the void in both the pre-development and restoration in **Table 5**. Full ReFH2 model outputs are presented in **Annex A**.

Table 5 – Existing and restoration phase site peak runoff rates

	Area draining to void	Area draining south
Existing site		
Site area (ha)	2.2	0.83
Existing proportion of site	0.73	0.27
Peak 1% greenfield runoff rate (l/s)	19.12	7.21
Operational Phase		
Site area (ha)	2.2 (0.82ha worked area + 1.38ha greenfield area)	0.83

DATE:	31 May 2024	**CONFIDENTIALITY:**	Confidential
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	Area draining to void	Area draining south
Future proportion of site	0.73	0.27
Peak 1% + 45% CC runoff rate (l/s)	54.4 (35.96 + 18.44)*	11.07
Restoration phase		
Site area (ha)	2.2	0.83
Future proportion of site	0.73	0.27
Peak 1% + 45% CC greenfield runoff rate (l/s)	29.34	11.07

*Peak runoff rate for the Operational phase is the sum of the worked area runoff rate and the greenfield area runoff rate.

In the context of runoff draining into the void for management by the existing quarry dewatering system, these minimal increases in runoff rates (associated with inclusion of a climate change allowance) during the operational phase to the void are considered negligible. There will be no increase in runoff rates to third party land away from the quarry operation. The proportion of land draining to the void and away from the void will at restoration match the proportions at present.

Site Drainage Infrastructure

EXISTING INFRASTRUCTURE

Current surface water management at Tytherington Quarry consists of the pumping of water from the Woodleaze Quarry void to an attenuation sump within Grovesend Quarry. The water in the Grovesend Quarry sump is then pumped to the discharge point off-site in Tytherington Village. This is the main method for the control of water levels within the quarry voids at Tytherington Quarry.

WORKED PHASE INFRASTRUCTURE

Surface water and groundwater entering the Woodleaze quarry void will be managed through pumping from the flooded base of the workings into a sump and then pumped to the Grovesend attenuation sump. The Grovesend sump will not change location or size throughout the working phase.

Following settlement, the water will then be pumped out from the Grovesend attenuation sump to the discharge point within Tytherington Village. The pumping rate and overall daily volumes specified within the extant Discharge Consent will not be exceeded. The haul roads/trafficked areas would be reprofiled to direct all runoff to the Woodleaze Quarry void to collect the runoff in the base, from where it will be pumped to the Grovesend sump.

In the instance of heavy rainfall beyond the capacity of the pump in the Woodleaze Quarry void and/or beyond the capacity of the Grovesend Quarry sump, the Woodleaze Quarry excavation itself would be allowed to flood and simply dewatered again once the rainfall event had passed. The risk of flooding within the Woodleaze Quarry void would be actively monitored and managed by the quarry operators/managers, and the Emergency Flood Response Plan enacted to evaluate the quarry void itself if necessary.

RESTORATION INFRASTRUCTURE

The proposed water management system for Woodleaze Quarry (including the soil store area) is described below:

- Surface water and groundwater entering Woodleaze Quarry will be contained within the newly formed Woodleaze restoration lagoon which will be formed following the completion of excavation and the suspension of dewatering;
- The screenbank within the soil store area will be profiled in a way to promote the drainage of surface water towards the Woodleaze Quarry restoration lagoon; and
- Surface water runoff from the restored areas of the soil store area will drain towards and be captured by the Woodleaze Quarry restoration lagoon.

Water Quality

Water quality measures will remain the same as the current water management arrangements on Site. The sumps on site allow for a level of sediment settlement before discharge.

Maintenance

Due to the potential surface water flood risk for the downstream receptors in Tytherington Village, a requirement is regular maintenance and checks of culverts downstream of the discharge point through the village of Tytherington is advised to reduce the potential flood risk associated with a blockage occurring.

ANNEX A – DRAINAGE CALCULATIONS

UK Design Flood Estimation

Generated on Friday, April 12, 2024 7:52:11 AM by UKJWE776
Printed from the ReFH2 Flood Modelling software package, version 4.0.8560.23190

Summary of estimate using the Flood Estimation Handbook revitalised flood hydrograph method (ReFH2)

Site details Checksum: 1E6B-EC52

Site name: FEH_Point_Descriptors_365724_188030_v5_0_1

Easting: 365724

Northing: 188030

Country: England, Wales or Northern Ireland

Catchment Area (km^2): 0.03 [0.5]*

Using plot scale calculations: Yes

Model: 2.3

Site description: None

Model run: 100 year

Summary of results

Rainfall - FEH22 (mm):	54.23	Total runoff (ML):	0.29
Total Rainfall (mm):	36.59	Total flow (ML):	1.01
Peak Rainfall (mm):	7.13	Peak flow (m^3/s):	0.03

Parameters

Where the user has overriden a system-generated value, this original value is shown in square brackets after the value used.
** Indicates that the user locked the duration/timestep*

Rainfall parameters (Rainfall - FEH22)

Name	Value	User-defined?
Duration (hh:mm:ss)	03:15:00	No
Timestep (hh:mm:ss)	00:15:00	No
SCF (Seasonal correction factor)	0.68	No
ARF (Areal reduction factor)	0.99	No
Seasonality	Winter	No

Loss model parameters

Name	Value	User-defined?
Cini (mm)	94.08	No
Cmax (mm)	429.86	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	1.73 [1]	Yes
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0	No
BL (hr)	39.99 [32.24]	Yes
BR	2.5	No

Urbanisation parameters

Name	Value	User-defined?
Sewer capacity (m^3/s)	0	No
Exporting drained area (km^2)	0	No
Urban area (km^2)	0	No
Urbext 2000	0	No
Impervious runoff factor	0.7	No
Imperviousness factor	0.4	No
Tp scaling factor	0.75	No
Depression storage depth (mm)	0.5	No

Time series data

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
00:00:00	0.6511	0.0000	0.1430	0.0000	0.000824	0.000824
00:15:00	1.0083	0.0000	0.2234	0.0000	0.000819	0.000852
00:30:00	1.5559	0.0000	0.3494	0.0001	0.000815	0.000963
00:45:00	2.3900	0.0000	0.5476	0.0004	0.000815	0.00121
01:00:00	3.6448	0.0000	0.8607	0.0008	0.000819	0.00166
01:15:00	5.4775	0.0000	1.3517	0.0016	0.000833	0.00244
01:30:00	7.1340	0.0000	1.8651	0.0029	0.000863	0.00374
01:45:00	5.4775	0.0000	1.5124	0.0049	0.000918	0.0058
02:00:00	3.6448	0.0000	1.0450	0.0076	0.00101	0.00859
02:15:00	2.3900	0.0000	0.7020	0.0107	0.00115	0.0119
02:30:00	1.5559	0.0000	0.4642	0.0141	0.00133	0.0154
02:45:00	1.0083	0.0000	0.3038	0.0173	0.00157	0.0189
03:00:00	0.6511	0.0000	0.1974	0.0203	0.00185	0.0221
03:15:00	0.0000	0.0000	0.0000	0.0225	0.00218	0.0246
03:30:00	0.0000	0.0000	0.0000	0.0236	0.00252	0.0261
03:45:00	0.0000	0.0000	0.0000	0.0235	0.00287	0.0263
04:00:00	0.0000	0.0000	0.0000	0.0225	0.00321	0.0257
04:15:00	0.0000	0.0000	0.0000	0.0210	0.00353	0.0245
04:30:00	0.0000	0.0000	0.0000	0.0191	0.00382	0.0229
04:45:00	0.0000	0.0000	0.0000	0.0170	0.00408	0.0211
05:00:00	0.0000	0.0000	0.0000	0.0150	0.0043	0.0193
05:15:00	0.0000	0.0000	0.0000	0.0132	0.0045	0.0176
05:30:00	0.0000	0.0000	0.0000	0.0115	0.00466	0.0162
05:45:00	0.0000	0.0000	0.0000	0.0101	0.0048	0.0149
06:00:00	0.0000	0.0000	0.0000	0.0088	0.00492	0.0137
06:15:00	0.0000	0.0000	0.0000	0.0076	0.00502	0.0126
06:30:00	0.0000	0.0000	0.0000	0.0064	0.00509	0.0115
06:45:00	0.0000	0.0000	0.0000	0.0053	0.00515	0.0105
07:00:00	0.0000	0.0000	0.0000	0.0042	0.0052	0.00944
07:15:00	0.0000	0.0000	0.0000	0.0032	0.00522	0.00846
07:30:00	0.0000	0.0000	0.0000	0.0023	0.00523	0.00755
07:45:00	0.0000	0.0000	0.0000	0.0015	0.00523	0.00676
08:00:00	0.0000	0.0000	0.0000	0.0009	0.00522	0.00615
08:15:00	0.0000	0.0000	0.0000	0.0005	0.0052	0.00573
08:30:00	0.0000	0.0000	0.0000	0.0003	0.00517	0.00545

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
08:45:00	0.0000	0.0000	0.0000	0.0001	0.00514	0.00527
09:00:00	0.0000	0.0000	0.0000	0.0000	0.00511	0.00516
09:15:00	0.0000	0.0000	0.0000	0.0000	0.00508	0.00509
09:30:00	0.0000	0.0000	0.0000	0.0000	0.00505	0.00505
09:45:00	0.0000	0.0000	0.0000	0.0000	0.00502	0.00502
10:00:00	0.0000	0.0000	0.0000	0.0000	0.00499	0.00499
10:15:00	0.0000	0.0000	0.0000	0.0000	0.00495	0.00495
10:30:00	0.0000	0.0000	0.0000	0.0000	0.00492	0.00492
10:45:00	0.0000	0.0000	0.0000	0.0000	0.00489	0.00489
11:00:00	0.0000	0.0000	0.0000	0.0000	0.00486	0.00486
11:15:00	0.0000	0.0000	0.0000	0.0000	0.00483	0.00483
11:30:00	0.0000	0.0000	0.0000	0.0000	0.0048	0.0048
11:45:00	0.0000	0.0000	0.0000	0.0000	0.00477	0.00477
12:00:00	0.0000	0.0000	0.0000	0.0000	0.00474	0.00474
12:15:00	0.0000	0.0000	0.0000	0.0000	0.00471	0.00471
12:30:00	0.0000	0.0000	0.0000	0.0000	0.00468	0.00468
12:45:00	0.0000	0.0000	0.0000	0.0000	0.00465	0.00465
13:00:00	0.0000	0.0000	0.0000	0.0000	0.00462	0.00462
13:15:00	0.0000	0.0000	0.0000	0.0000	0.0046	0.0046
13:30:00	0.0000	0.0000	0.0000	0.0000	0.00457	0.00457
13:45:00	0.0000	0.0000	0.0000	0.0000	0.00454	0.00454
14:00:00	0.0000	0.0000	0.0000	0.0000	0.00451	0.00451
14:15:00	0.0000	0.0000	0.0000	0.0000	0.00448	0.00448
14:30:00	0.0000	0.0000	0.0000	0.0000	0.00445	0.00445
14:45:00	0.0000	0.0000	0.0000	0.0000	0.00443	0.00443
15:00:00	0.0000	0.0000	0.0000	0.0000	0.0044	0.0044
15:15:00	0.0000	0.0000	0.0000	0.0000	0.00437	0.00437
15:30:00	0.0000	0.0000	0.0000	0.0000	0.00434	0.00434
15:45:00	0.0000	0.0000	0.0000	0.0000	0.00432	0.00432
16:00:00	0.0000	0.0000	0.0000	0.0000	0.00429	0.00429
16:15:00	0.0000	0.0000	0.0000	0.0000	0.00426	0.00426
16:30:00	0.0000	0.0000	0.0000	0.0000	0.00424	0.00424
16:45:00	0.0000	0.0000	0.0000	0.0000	0.00421	0.00421
17:00:00	0.0000	0.0000	0.0000	0.0000	0.00418	0.00418
17:15:00	0.0000	0.0000	0.0000	0.0000	0.00416	0.00416
17:30:00	0.0000	0.0000	0.0000	0.0000	0.00413	0.00413

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
17:45:00	0.0000	0.0000	0.0000	0.0000	0.00411	0.00411
18:00:00	0.0000	0.0000	0.0000	0.0000	0.00408	0.00408
18:15:00	0.0000	0.0000	0.0000	0.0000	0.00406	0.00406
18:30:00	0.0000	0.0000	0.0000	0.0000	0.00403	0.00403
18:45:00	0.0000	0.0000	0.0000	0.0000	0.00401	0.00401
19:00:00	0.0000	0.0000	0.0000	0.0000	0.00398	0.00398
19:15:00	0.0000	0.0000	0.0000	0.0000	0.00396	0.00396
19:30:00	0.0000	0.0000	0.0000	0.0000	0.00393	0.00393
19:45:00	0.0000	0.0000	0.0000	0.0000	0.00391	0.00391
20:00:00	0.0000	0.0000	0.0000	0.0000	0.00388	0.00388
20:15:00	0.0000	0.0000	0.0000	0.0000	0.00386	0.00386
20:30:00	0.0000	0.0000	0.0000	0.0000	0.00383	0.00383
20:45:00	0.0000	0.0000	0.0000	0.0000	0.00381	0.00381
21:00:00	0.0000	0.0000	0.0000	0.0000	0.00379	0.00379
21:15:00	0.0000	0.0000	0.0000	0.0000	0.00376	0.00376
21:30:00	0.0000	0.0000	0.0000	0.0000	0.00374	0.00374
21:45:00	0.0000	0.0000	0.0000	0.0000	0.00372	0.00372
22:00:00	0.0000	0.0000	0.0000	0.0000	0.00369	0.00369
22:15:00	0.0000	0.0000	0.0000	0.0000	0.00367	0.00367
22:30:00	0.0000	0.0000	0.0000	0.0000	0.00365	0.00365
22:45:00	0.0000	0.0000	0.0000	0.0000	0.00362	0.00362
23:00:00	0.0000	0.0000	0.0000	0.0000	0.0036	0.0036
23:15:00	0.0000	0.0000	0.0000	0.0000	0.00358	0.00358
23:30:00	0.0000	0.0000	0.0000	0.0000	0.00356	0.00356
23:45:00	0.0000	0.0000	0.0000	0.0000	0.00353	0.00353
24:00:00	0.0000	0.0000	0.0000	0.0000	0.00351	0.00351
24:15:00	0.0000	0.0000	0.0000	0.0000	0.00349	0.00349
24:30:00	0.0000	0.0000	0.0000	0.0000	0.00347	0.00347
24:45:00	0.0000	0.0000	0.0000	0.0000	0.00345	0.00345
25:00:00	0.0000	0.0000	0.0000	0.0000	0.00343	0.00343
25:15:00	0.0000	0.0000	0.0000	0.0000	0.0034	0.0034
25:30:00	0.0000	0.0000	0.0000	0.0000	0.00338	0.00338
25:45:00	0.0000	0.0000	0.0000	0.0000	0.00336	0.00336
26:00:00	0.0000	0.0000	0.0000	0.0000	0.00334	0.00334
26:15:00	0.0000	0.0000	0.0000	0.0000	0.00332	0.00332
26:30:00	0.0000	0.0000	0.0000	0.0000	0.0033	0.0033

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m³/s)	Net Rain (mm)	Runoff (m³/s)	Baseflow (m³/s)	Total Flow (m³/s)
26:45:00	0.0000	0.0000	0.0000	0.0000	0.00328	0.00328
27:00:00	0.0000	0.0000	0.0000	0.0000	0.00326	0.00326
27:15:00	0.0000	0.0000	0.0000	0.0000	0.00324	0.00324
27:30:00	0.0000	0.0000	0.0000	0.0000	0.00322	0.00322
27:45:00	0.0000	0.0000	0.0000	0.0000	0.0032	0.0032
28:00:00	0.0000	0.0000	0.0000	0.0000	0.00318	0.00318
28:15:00	0.0000	0.0000	0.0000	0.0000	0.00316	0.00316
28:30:00	0.0000	0.0000	0.0000	0.0000	0.00314	0.00314
28:45:00	0.0000	0.0000	0.0000	0.0000	0.00312	0.00312
29:00:00	0.0000	0.0000	0.0000	0.0000	0.0031	0.0031
29:15:00	0.0000	0.0000	0.0000	0.0000	0.00308	0.00308
29:30:00	0.0000	0.0000	0.0000	0.0000	0.00306	0.00306
29:45:00	0.0000	0.0000	0.0000	0.0000	0.00304	0.00304
30:00:00	0.0000	0.0000	0.0000	0.0000	0.00302	0.00302
30:15:00	0.0000	0.0000	0.0000	0.0000	0.003	0.003
30:30:00	0.0000	0.0000	0.0000	0.0000	0.00299	0.00299
30:45:00	0.0000	0.0000	0.0000	0.0000	0.00297	0.00297
31:00:00	0.0000	0.0000	0.0000	0.0000	0.00295	0.00295
31:15:00	0.0000	0.0000	0.0000	0.0000	0.00293	0.00293
31:30:00	0.0000	0.0000	0.0000	0.0000	0.00291	0.00291
31:45:00	0.0000	0.0000	0.0000	0.0000	0.00289	0.00289
32:00:00	0.0000	0.0000	0.0000	0.0000	0.00288	0.00288
32:15:00	0.0000	0.0000	0.0000	0.0000	0.00286	0.00286
32:30:00	0.0000	0.0000	0.0000	0.0000	0.00284	0.00284
32:45:00	0.0000	0.0000	0.0000	0.0000	0.00282	0.00282
33:00:00	0.0000	0.0000	0.0000	0.0000	0.0028	0.0028
33:15:00	0.0000	0.0000	0.0000	0.0000	0.00279	0.00279
33:30:00	0.0000	0.0000	0.0000	0.0000	0.00277	0.00277
33:45:00	0.0000	0.0000	0.0000	0.0000	0.00275	0.00275
34:00:00	0.0000	0.0000	0.0000	0.0000	0.00274	0.00274
34:15:00	0.0000	0.0000	0.0000	0.0000	0.00272	0.00272
34:30:00	0.0000	0.0000	0.0000	0.0000	0.0027	0.0027
34:45:00	0.0000	0.0000	0.0000	0.0000	0.00268	0.00268
35:00:00	0.0000	0.0000	0.0000	0.0000	0.00267	0.00267
35:15:00	0.0000	0.0000	0.0000	0.0000	0.00265	0.00265
35:30:00	0.0000	0.0000	0.0000	0.0000	0.00263	0.00263

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
35:45:00	0.0000	0.0000	0.0000	0.0000	0.00262	0.00262
36:00:00	0.0000	0.0000	0.0000	0.0000	0.0026	0.0026
36:15:00	0.0000	0.0000	0.0000	0.0000	0.00259	0.00259
36:30:00	0.0000	0.0000	0.0000	0.0000	0.00257	0.00257
36:45:00	0.0000	0.0000	0.0000	0.0000	0.00255	0.00255
37:00:00	0.0000	0.0000	0.0000	0.0000	0.00254	0.00254
37:15:00	0.0000	0.0000	0.0000	0.0000	0.00252	0.00252
37:30:00	0.0000	0.0000	0.0000	0.0000	0.00251	0.00251
37:45:00	0.0000	0.0000	0.0000	0.0000	0.00249	0.00249
38:00:00	0.0000	0.0000	0.0000	0.0000	0.00247	0.00247
38:15:00	0.0000	0.0000	0.0000	0.0000	0.00246	0.00246
38:30:00	0.0000	0.0000	0.0000	0.0000	0.00244	0.00244
38:45:00	0.0000	0.0000	0.0000	0.0000	0.00243	0.00243
39:00:00	0.0000	0.0000	0.0000	0.0000	0.00241	0.00241
39:15:00	0.0000	0.0000	0.0000	0.0000	0.0024	0.0024
39:30:00	0.0000	0.0000	0.0000	0.0000	0.00238	0.00238
39:45:00	0.0000	0.0000	0.0000	0.0000	0.00237	0.00237
40:00:00	0.0000	0.0000	0.0000	0.0000	0.00235	0.00235
40:15:00	0.0000	0.0000	0.0000	0.0000	0.00234	0.00234
40:30:00	0.0000	0.0000	0.0000	0.0000	0.00232	0.00232
40:45:00	0.0000	0.0000	0.0000	0.0000	0.00231	0.00231
41:00:00	0.0000	0.0000	0.0000	0.0000	0.0023	0.0023
41:15:00	0.0000	0.0000	0.0000	0.0000	0.00228	0.00228
41:30:00	0.0000	0.0000	0.0000	0.0000	0.00227	0.00227
41:45:00	0.0000	0.0000	0.0000	0.0000	0.00225	0.00225
42:00:00	0.0000	0.0000	0.0000	0.0000	0.00224	0.00224
42:15:00	0.0000	0.0000	0.0000	0.0000	0.00223	0.00223
42:30:00	0.0000	0.0000	0.0000	0.0000	0.00221	0.00221
42:45:00	0.0000	0.0000	0.0000	0.0000	0.0022	0.0022
43:00:00	0.0000	0.0000	0.0000	0.0000	0.00218	0.00218
43:15:00	0.0000	0.0000	0.0000	0.0000	0.00217	0.00217
43:30:00	0.0000	0.0000	0.0000	0.0000	0.00216	0.00216
43:45:00	0.0000	0.0000	0.0000	0.0000	0.00214	0.00214
44:00:00	0.0000	0.0000	0.0000	0.0000	0.00213	0.00213
44:15:00	0.0000	0.0000	0.0000	0.0000	0.00212	0.00212
44:30:00	0.0000	0.0000	0.0000	0.0000	0.0021	0.0021

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
44:45:00	0.0000	0.0000	0.0000	0.0000	0.00209	0.00209
45:00:00	0.0000	0.0000	0.0000	0.0000	0.00208	0.00208
45:15:00	0.0000	0.0000	0.0000	0.0000	0.00206	0.00206
45:30:00	0.0000	0.0000	0.0000	0.0000	0.00205	0.00205
45:45:00	0.0000	0.0000	0.0000	0.0000	0.00204	0.00204
46:00:00	0.0000	0.0000	0.0000	0.0000	0.00203	0.00203
46:15:00	0.0000	0.0000	0.0000	0.0000	0.00201	0.00201
46:30:00	0.0000	0.0000	0.0000	0.0000	0.002	0.002
46:45:00	0.0000	0.0000	0.0000	0.0000	0.00199	0.00199
47:00:00	0.0000	0.0000	0.0000	0.0000	0.00198	0.00198
47:15:00	0.0000	0.0000	0.0000	0.0000	0.00196	0.00196
47:30:00	0.0000	0.0000	0.0000	0.0000	0.00195	0.00195
47:45:00	0.0000	0.0000	0.0000	0.0000	0.00194	0.00194
48:00:00	0.0000	0.0000	0.0000	0.0000	0.00193	0.00193
48:15:00	0.0000	0.0000	0.0000	0.0000	0.00192	0.00192
48:30:00	0.0000	0.0000	0.0000	0.0000	0.0019	0.0019
48:45:00	0.0000	0.0000	0.0000	0.0000	0.00189	0.00189
49:00:00	0.0000	0.0000	0.0000	0.0000	0.00188	0.00188
49:15:00	0.0000	0.0000	0.0000	0.0000	0.00187	0.00187
49:30:00	0.0000	0.0000	0.0000	0.0000	0.00186	0.00186
49:45:00	0.0000	0.0000	0.0000	0.0000	0.00184	0.00184
50:00:00	0.0000	0.0000	0.0000	0.0000	0.00183	0.00183
50:15:00	0.0000	0.0000	0.0000	0.0000	0.00182	0.00182
50:30:00	0.0000	0.0000	0.0000	0.0000	0.00181	0.00181
50:45:00	0.0000	0.0000	0.0000	0.0000	0.0018	0.0018
51:00:00	0.0000	0.0000	0.0000	0.0000	0.00179	0.00179
51:15:00	0.0000	0.0000	0.0000	0.0000	0.00178	0.00178
51:30:00	0.0000	0.0000	0.0000	0.0000	0.00177	0.00177
51:45:00	0.0000	0.0000	0.0000	0.0000	0.00175	0.00175
52:00:00	0.0000	0.0000	0.0000	0.0000	0.00174	0.00174
52:15:00	0.0000	0.0000	0.0000	0.0000	0.00173	0.00173
52:30:00	0.0000	0.0000	0.0000	0.0000	0.00172	0.00172
52:45:00	0.0000	0.0000	0.0000	0.0000	0.00171	0.00171
53:00:00	0.0000	0.0000	0.0000	0.0000	0.0017	0.0017
53:15:00	0.0000	0.0000	0.0000	0.0000	0.00169	0.00169
53:30:00	0.0000	0.0000	0.0000	0.0000	0.00168	0.00168

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
53:45:00	0.0000	0.0000	0.0000	0.0000	0.00167	0.00167
54:00:00	0.0000	0.0000	0.0000	0.0000	0.00166	0.00166
54:15:00	0.0000	0.0000	0.0000	0.0000	0.00165	0.00165
54:30:00	0.0000	0.0000	0.0000	0.0000	0.00164	0.00164
54:45:00	0.0000	0.0000	0.0000	0.0000	0.00163	0.00163
55:00:00	0.0000	0.0000	0.0000	0.0000	0.00162	0.00162
55:15:00	0.0000	0.0000	0.0000	0.0000	0.00161	0.00161
55:30:00	0.0000	0.0000	0.0000	0.0000	0.0016	0.0016
55:45:00	0.0000	0.0000	0.0000	0.0000	0.00159	0.00159
56:00:00	0.0000	0.0000	0.0000	0.0000	0.00158	0.00158
56:15:00	0.0000	0.0000	0.0000	0.0000	0.00157	0.00157
56:30:00	0.0000	0.0000	0.0000	0.0000	0.00156	0.00156
56:45:00	0.0000	0.0000	0.0000	0.0000	0.00155	0.00155
57:00:00	0.0000	0.0000	0.0000	0.0000	0.00154	0.00154
57:15:00	0.0000	0.0000	0.0000	0.0000	0.00153	0.00153
57:30:00	0.0000	0.0000	0.0000	0.0000	0.00152	0.00152
57:45:00	0.0000	0.0000	0.0000	0.0000	0.00151	0.00151
58:00:00	0.0000	0.0000	0.0000	0.0000	0.0015	0.0015
58:15:00	0.0000	0.0000	0.0000	0.0000	0.00149	0.00149
58:30:00	0.0000	0.0000	0.0000	0.0000	0.00148	0.00148
58:45:00	0.0000	0.0000	0.0000	0.0000	0.00147	0.00147
59:00:00	0.0000	0.0000	0.0000	0.0000	0.00146	0.00146
59:15:00	0.0000	0.0000	0.0000	0.0000	0.00145	0.00145
59:30:00	0.0000	0.0000	0.0000	0.0000	0.00145	0.00145
59:45:00	0.0000	0.0000	0.0000	0.0000	0.00144	0.00144
60:00:00	0.0000	0.0000	0.0000	0.0000	0.00143	0.00143
60:15:00	0.0000	0.0000	0.0000	0.0000	0.00142	0.00142
60:30:00	0.0000	0.0000	0.0000	0.0000	0.00141	0.00141
60:45:00	0.0000	0.0000	0.0000	0.0000	0.0014	0.0014
61:00:00	0.0000	0.0000	0.0000	0.0000	0.00139	0.00139
61:15:00	0.0000	0.0000	0.0000	0.0000	0.00138	0.00138
61:30:00	0.0000	0.0000	0.0000	0.0000	0.00138	0.00138
61:45:00	0.0000	0.0000	0.0000	0.0000	0.00137	0.00137
62:00:00	0.0000	0.0000	0.0000	0.0000	0.00136	0.00136
62:15:00	0.0000	0.0000	0.0000	0.0000	0.00135	0.00135
62:30:00	0.0000	0.0000	0.0000	0.0000	0.00134	0.00134

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
62:45:00	0.0000	0.0000	0.0000	0.0000	0.00133	0.00133
63:00:00	0.0000	0.0000	0.0000	0.0000	0.00132	0.00132
63:15:00	0.0000	0.0000	0.0000	0.0000	0.00132	0.00132
63:30:00	0.0000	0.0000	0.0000	0.0000	0.00131	0.00131
63:45:00	0.0000	0.0000	0.0000	0.0000	0.0013	0.0013
64:00:00	0.0000	0.0000	0.0000	0.0000	0.00129	0.00129
64:15:00	0.0000	0.0000	0.0000	0.0000	0.00128	0.00128
64:30:00	0.0000	0.0000	0.0000	0.0000	0.00128	0.00128
64:45:00	0.0000	0.0000	0.0000	0.0000	0.00127	0.00127
65:00:00	0.0000	0.0000	0.0000	0.0000	0.00126	0.00126
65:15:00	0.0000	0.0000	0.0000	0.0000	0.00125	0.00125
65:30:00	0.0000	0.0000	0.0000	0.0000	0.00124	0.00124
65:45:00	0.0000	0.0000	0.0000	0.0000	0.00124	0.00124
66:00:00	0.0000	0.0000	0.0000	0.0000	0.00123	0.00123
66:15:00	0.0000	0.0000	0.0000	0.0000	0.00122	0.00122
66:30:00	0.0000	0.0000	0.0000	0.0000	0.00121	0.00121
66:45:00	0.0000	0.0000	0.0000	0.0000	0.00121	0.00121
67:00:00	0.0000	0.0000	0.0000	0.0000	0.0012	0.0012
67:15:00	0.0000	0.0000	0.0000	0.0000	0.00119	0.00119
67:30:00	0.0000	0.0000	0.0000	0.0000	0.00118	0.00118
67:45:00	0.0000	0.0000	0.0000	0.0000	0.00118	0.00118
68:00:00	0.0000	0.0000	0.0000	0.0000	0.00117	0.00117
68:15:00	0.0000	0.0000	0.0000	0.0000	0.00116	0.00116
68:30:00	0.0000	0.0000	0.0000	0.0000	0.00115	0.00115
68:45:00	0.0000	0.0000	0.0000	0.0000	0.00115	0.00115
69:00:00	0.0000	0.0000	0.0000	0.0000	0.00114	0.00114
69:15:00	0.0000	0.0000	0.0000	0.0000	0.00113	0.00113
69:30:00	0.0000	0.0000	0.0000	0.0000	0.00113	0.00113
69:45:00	0.0000	0.0000	0.0000	0.0000	0.00112	0.00112
70:00:00	0.0000	0.0000	0.0000	0.0000	0.00111	0.00111
70:15:00	0.0000	0.0000	0.0000	0.0000	0.0011	0.0011
70:30:00	0.0000	0.0000	0.0000	0.0000	0.0011	0.0011
70:45:00	0.0000	0.0000	0.0000	0.0000	0.00109	0.00109
71:00:00	0.0000	0.0000	0.0000	0.0000	0.00108	0.00108
71:15:00	0.0000	0.0000	0.0000	0.0000	0.00108	0.00108
71:30:00	0.0000	0.0000	0.0000	0.0000	0.00107	0.00107

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
71:45:00	0.0000	0.0000	0.0000	0.0000	0.00106	0.00106
72:00:00	0.0000	0.0000	0.0000	0.0000	0.00106	0.00106
72:15:00	0.0000	0.0000	0.0000	0.0000	0.00105	0.00105
72:30:00	0.0000	0.0000	0.0000	0.0000	0.00104	0.00104
72:45:00	0.0000	0.0000	0.0000	0.0000	0.00104	0.00104
73:00:00	0.0000	0.0000	0.0000	0.0000	0.00103	0.00103
73:15:00	0.0000	0.0000	0.0000	0.0000	0.00102	0.00102
73:30:00	0.0000	0.0000	0.0000	0.0000	0.00102	0.00102
73:45:00	0.0000	0.0000	0.0000	0.0000	0.00101	0.00101
74:00:00	0.0000	0.0000	0.0000	0.0000	0.00101	0.00101
74:15:00	0.0000	0.0000	0.0000	0.0000	0.001	0.001
74:30:00	0.0000	0.0000	0.0000	0.0000	0.000993	0.000993
74:45:00	0.0000	0.0000	0.0000	0.0000	0.000987	0.000987
75:00:00	0.0000	0.0000	0.0000	0.0000	0.000981	0.000981
75:15:00	0.0000	0.0000	0.0000	0.0000	0.000975	0.000975
75:30:00	0.0000	0.0000	0.0000	0.0000	0.000969	0.000969
75:45:00	0.0000	0.0000	0.0000	0.0000	0.000963	0.000963
76:00:00	0.0000	0.0000	0.0000	0.0000	0.000957	0.000957
76:15:00	0.0000	0.0000	0.0000	0.0000	0.000951	0.000951
76:30:00	0.0000	0.0000	0.0000	0.0000	0.000945	0.000945
76:45:00	0.0000	0.0000	0.0000	0.0000	0.000939	0.000939
77:00:00	0.0000	0.0000	0.0000	0.0000	0.000933	0.000933
77:15:00	0.0000	0.0000	0.0000	0.0000	0.000927	0.000927
77:30:00	0.0000	0.0000	0.0000	0.0000	0.000922	0.000922
77:45:00	0.0000	0.0000	0.0000	0.0000	0.000916	0.000916
78:00:00	0.0000	0.0000	0.0000	0.0000	0.00091	0.00091
78:15:00	0.0000	0.0000	0.0000	0.0000	0.000904	0.000904
78:30:00	0.0000	0.0000	0.0000	0.0000	0.000899	0.000899
78:45:00	0.0000	0.0000	0.0000	0.0000	0.000893	0.000893
79:00:00	0.0000	0.0000	0.0000	0.0000	0.000888	0.000888
79:15:00	0.0000	0.0000	0.0000	0.0000	0.000882	0.000882
79:30:00	0.0000	0.0000	0.0000	0.0000	0.000877	0.000877
79:45:00	0.0000	0.0000	0.0000	0.0000	0.000871	0.000871
80:00:00	0.0000	0.0000	0.0000	0.0000	0.000866	0.000866
80:15:00	0.0000	0.0000	0.0000	0.0000	0.00086	0.00086
80:30:00	0.0000	0.0000	0.0000	0.0000	0.000855	0.000855

Time (hh:mm:ss)	Rain (mm)	Sewer Loss (m^3/s)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
80:45:00	0.0000	0.0000	0.0000	0.0000	0.00085	0.00085
81:00:00	0.0000	0.0000	0.0000	0.0000	0.000844	0.000844
81:15:00	0.0000	0.0000	0.0000	0.0000	0.000839	0.000839

Appendix

Catchment descriptors *

Name	Value	User-defined value used?
BFIHOST	0.54	No
BFIHOST19	0.52	No
PROPWET	0.35	No
SAAR (mm)	800	No

Values in square brackets are the original values loaded from the FEH Web Service or FEH CD-ROM

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