Gloucestershire Emerging New Minerals Plan
Hydrogeological Assessment - Stowfield
Gloucestershire County Council

31 March 2016
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# Executive summary

## Project Outline
Gloucestershire County Council is preparing a new county-wide Minerals Local Plan to replace its 2003 plan. Consideration is being given to expanding several crushed rock (limestone) quarries throughout the county. Before any decisions are taken hydrogeological impact assessments are being conducted. Atkins Ltd has been commissioned to assess the effect of potential expansions of limestone (crushed rock) quarries in the Cotswolds and Forest of Dean and the development of a new sand and gravel quarry in the Severn Vale area.

## Site Overview
The site at Stowfield is located within the Wye Valley AONB, approximately 2 km north of Tewkesbury. The option consists of a 19.6 ha area contained within the existing Stowfield Quarry proposed to be deepened by an additional 20 m beyond its current depth.

## Geology
No superficial deposits are present onsite or in the immediate surrounding area. The site is underlain by Lower Dolomite (Carboniferous) composed of medium-bedded to massive, compact dolomite.

Lower Limestone Shales, interbedded mudstones, packstones and grainstones (Carboniferous), confine the Tintern Sandstone Formation, red and yellow sandstones (Devonian/Carboniferous), beneath the Lower Dolomite.

## Hydrology / Hydrogeology
The site is located within the upper catchment of the Whippington Brook and Swan Pool (ordinary watercourses), tributaries of the River Wye (main river).

The Lower Dolomite is classified as a Principal aquifer by the Environment Agency, capable of supplying potable supply and/or river base flow on a strategic scale. Groundwater flow is dominated by fracture flow, and intergranular permeabilities are low. A spring is present in the sump at Stowfield Quarry.

## Land Designations
A groundwater Source Protection Zone 3 (total catchment) is present approximately 1 km west of the existing quarry boundary, the associated potable supply spring source is located approximately 2 km south west of the site.

Dingle Wood SSSI is located 130 m east of the site option boundary, and four Key Wildlife Sites are located within 1 km of the site.

## Impact Appraisal
The main risk of quarrying onsite is related to flooding and adverse impact to the adjacent SSSI (Significant), assuming that during/after quarrying, open areas will be backfilled with low permeability inert material. As a result of this restoration surface water runoff may be increased and groundwater flow paths altered. Low significance impacts are expected to be felt in the Lower Dolomite and nearby Blake’s Wood Key Wildlife Site.

## Mitigation Measures
It is considered that the potential impacts could be mitigated by good design including the use of Sustainable Drainage Systems and including measures to maintain groundwater connectivity.

## Site Investigation and monitoring recommendations
It is recommended that a programme of site monitoring be carried out; monthly monitoring of groundwater levels for a period of at least 12 months prior to new quarrying works, and that this should continue through the operational phase. Monitoring during the aftercare period should also be continued to demonstrate that any mitigation measures included are effective. Locations should be...
agreed with the Mineral Planning Authority in advance if possible and should ensure that there is adequate spatial coverage to understand groundwater flow around the sites. Collaboration with other proposed minerals sites in the area may be required. Precipitation data can be collected from the Environment Agency/Meteorological Office to supplement this. Water quality should also be monitored to identify any potential contamination, focusing on the Whippington Brook. The monitoring routine can follow the same as that for groundwater levels.

| Conclusions | Backfilling of the site using low permeability material will inhibit groundwater flow in the area and result in lower groundwater levels. If mitigation measures are properly implemented, risk of flooding and adverse impact to the Dingle Wood SSSI will be reduced during quarrying and following the restoration of the site. |
1. Introduction

1.1. Background

Gloucestershire County Council (herein referred to as “the County Council”) is the Mineral Local Planning Authority (MPA) for the entirety of Gloucestershire. The County Council is preparing a new county-wide Minerals Local Plan to replace its previously adopted minerals local plan, which has been in place since 2003.

As part of this work, Atkins Limited (Atkins) has been commissioned by the County Council to undertake a review of previous hydrological studies and undertake a hydrogeological assessment concerning a number of potential mineral extraction sites across the Cotswolds, Forest of Dean and Severn Vale mineral resource areas. These sites are described by the Council as ‘site options’ and are currently under consideration for inclusion within the new county wide minerals local plan.

Atkins has completed hydrogeological impact assessments to cover each of the 6 extraction site options under consideration for inclusion within a new county-wide minerals local plan. This equates to 5 quarries to extract crushed rock (limestone) and one for sand and gravels (see Figure 1 for the site option locations).

This report provides an appraisal using existing local evidence, much of which has been provided by the County Council. This includes water resources information that has been submitted to accompany mineral planning applications, which are either likely to have an influence or encompass the areas identified as site options, and technical work in support of other environmental strategies, plans and proposals.

1.2. Policy and legislative context

This initial hydrogeological assessment will be carried out line with the statutory and non-statutory guidance set out in the national, regional and local plans below:

EU Legislation:
- Water Framework Directive (WFD)¹

UK legislation:
- Town and Country Planning Act 1990 (as amended)
- The Environmental Permitting (England and Wales) Regulations 2010 (as amended)

National policy:
- Groundwater Protection: Policy and Practice (GP3)³
- Catchment Flood Management Plans
- The National Planning Policy Framework (NPPF)⁴ published in March 2012
- The Planning Practice Guidance to the NPPF⁵.

Local policy:
- Gloucestershire Waste Core Strategy⁶
- Gloucestershire Revised Minerals and Waste Development Scheme (MWDS)⁷

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2. Assessment method

2.1. WFD WebTAG methodology

Assessment criteria have been used based on the methodology for appraising the impact of projects (plan level appraisal) set out in the Department for Transport’s (DfT) Transport Analysis Guidance (TAG) Unit A3 Environmental Impact Appraisal\(^8\) and the specific guidance for the water environment sub-objective set out in TAG Unit 10.2 (10.2.12 Impact Appraisal)\(^9\). Although this methodology has been developed for the assessment of road and bridge projects it can be used to assess the impacts of other developments such as the proposed mineral extraction sites.

The methodology takes into account the importance of a feature, the magnitude of the predicted impact and thereby derived a significance of predicted effects on the water environment. Importance is based on the value of the feature or resource (Table 2-1) where the magnitude of a potential impact is estimated based on the likely effects and is independent of the importance of the feature (Table 2-2).

The severity of a specific potential effect is then derived by considering the importance (or sensitivity) of the feature and the magnitude of the impact (impacts must be quantified where possible, estimating the change from the baseline conditions and the range of uncertainty). The significance of the impacts must be identified. This has been addressed in the derivation of significance of potential effects matrix shown in Table 2-3 which gives the significance of effect as a function of the sensitivity of the receptor and magnitude of impact.

### Table 2-1 Importance of water feature or resource

<table>
<thead>
<tr>
<th>Importance</th>
<th>Criteria</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High</td>
<td>Feature with a high quality and rarity, regional or national scale and limited potential for substitution.</td>
<td>Aquifer providing potable water to a large population (Groundwater).  &lt;br&gt; Important fish population (Surface water).  &lt;br&gt; Floodplain or defence protecting more than 100 residential properties (Flood Risk).</td>
</tr>
<tr>
<td>High</td>
<td>Feature with a high quality and rarity, local scale and limited potential for substitution.  &lt;br&gt; Feature with a medium quality and rarity, regional or national scale and limited potential for substitution.</td>
<td>WFD “High” status water body (Surface water).  &lt;br&gt; Aquifer providing potable water to a small population (Groundwater).  &lt;br&gt; Notable fish population (Surface water).  &lt;br&gt; Floodplain or defence protecting up to 10 industrial premises (Flood risk).</td>
</tr>
<tr>
<td>Medium</td>
<td>Feature with a medium quality and rarity, local scale and limited potential for substitution.  &lt;br&gt; Feature with a low quality and rarity, regional or national scale and limited potential for substitution.</td>
<td>WFD “Good” status water body (Surface water).  &lt;br&gt; Aquifer providing abstraction water for agricultural or industrial use (Groundwater).  &lt;br&gt; Floodplain or defence protecting up to 10 industrial premises (Flood risk).</td>
</tr>
<tr>
<td>Low</td>
<td>Feature with a low quality and rarity, local scale and limited potential for</td>
<td>WFD “Less than good” status (Surface water).</td>
</tr>
</tbody>
</table>

---


<table>
<thead>
<tr>
<th>Importance</th>
<th>Criteria</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>substitute.</td>
<td>Unproductive strata (Groundwater).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Floodplain with limited existing development (Flood risk).</td>
<td></td>
</tr>
</tbody>
</table>

Table 2-2  Magnitude of potential impacts

<table>
<thead>
<tr>
<th>Magnitude</th>
<th>Criteria</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Adverse</td>
<td>Results in loss of feature</td>
<td>- Loss of important fishery.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Change in WFD classification of river reach.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Compromise employment source.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Loss of flood storage/increased flood risk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Pollution of potable source of abstraction.</td>
</tr>
<tr>
<td>Moderate Adverse</td>
<td>Results in adverse impact on integrity of feature or loss of part of feature.</td>
<td>- Loss in productivity of a fishery.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Contribution of a significant proportion of the effluent in the receiving river, but deemed insufficient to change its’ WFD classification.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Reduction in the economic value of the feature.</td>
</tr>
<tr>
<td>Slight Adverse</td>
<td>Results in minor adverse impact on feature.</td>
<td>- Measurable changes in feature, but of limited size and/or proportion.</td>
</tr>
<tr>
<td>Negligible</td>
<td>Results in an impact on feature but of insufficient magnitude to affect use/integrity.</td>
<td>- Discharges to watercourse but no significant loss in quality, fishery productivity or biodiversity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- No significant impact on the economic value of the feature.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- No increase in flood risk.</td>
</tr>
<tr>
<td>Slight beneficial</td>
<td>Results in minor beneficial impact on feature or a reduced risk of adverse effect occurring.</td>
<td>- Measurable changes in feature, but of limited size and/or proportion.</td>
</tr>
</tbody>
</table>
Moderate beneficial

Results in moderate improvement of feature

- Enhanced productivity of a fishery.
- Reduction in a significant proportion of the effluent in a receiving river, but not sufficient to change its WFD classification.
- Moderate reduction in flood risk.

Large beneficial

Results in major improvement of feature

- Removal of major existing polluting discharge to a watercourse.
- Major reduction in flood risk.

<table>
<thead>
<tr>
<th>Magnitude of potential impact</th>
<th>Importance / Sensitivity of attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very high</td>
<td>High</td>
</tr>
<tr>
<td>Large Adverse</td>
<td>Very Significant</td>
</tr>
<tr>
<td>Moderate Adverse</td>
<td>Highly Significant</td>
</tr>
<tr>
<td>Slight Adverse</td>
<td>Significant</td>
</tr>
<tr>
<td>Negligible</td>
<td>Low Significance</td>
</tr>
</tbody>
</table>

In applying this methodology to both construction and operational stages, significant effects would be those of low significance or above. Effects of negligible sensitivity are termed insignificant. If an adverse significant effect is identified, whether it is of low, medium or high significance, then potential mitigation measures have been developed to reduce or mitigate this effect. When beneficial impacts are identified, then opportunities for further environmental enhancement can be considered.
3. Baseline conditions

3.1. Site option
The site option is located in the Wye Valley Area of Outstanding National Beauty (AONB), approximately 1 km south of Staunton and 1.3 km west of Coleford. The site option area is approximately 19.6ha which is fully contained within the current Stowfield Quarry which is proposed to be deepened by an additional 20 m beyond its current 165 m AOD limit. The area is located at National Grid Reference location 355605, 211346, an overview plan of the site option is provided in Figure 2.

The existing Stowfield Quarry is bounded on three sides by woodland; Bond’s Wood to the north and west and Blake’s Wood to the east. The southern quarry boundary is constrained by Scowles Road and the subsequent village of Scowles. The site is situated on the southern boundary of the Forest of Dean; the surrounding land is undulating and land use is dominated by woodland, with some agricultural land and sporadic settlements.

Several properties lie within 1 km of the site option; Stowfield quarry offices c. 100 m to the south, Scowles caravan park c. 300m to the south, Cherry Orchard Farm c. 480 m to the south west, High Meadow Farm c. 656 m to the south, Saw Mills c. 650 m to the north east and the village of Scowles c. 591 m to the south east.

3.2. Surface water and drainage
The surface water bodies within 1 km of the site, and their associated flood zones are presented on Figure 3 and details of the main rivers, watercourses and drains are presented within Table 3-1.

3.2.1. Main rivers
No main rivers are mapped within a 1 km radius of the site option. The closest, the River Wye, is located approximately 2.3 km west of the site option at Redbrook.

3.2.2. Ordinary watercourses (Lead local flood authority (GCC))
The site option is located within the upper catchment of the Whippington Brook (an ordinary watercourse), which is a tributary of the River Wye. The Brook is located approximately 800 m north east of the site option and flows away from the site to the north west.

Swan Pool, a tributary of the River Wye is located approximately 570 m south west, a named dammed pond, Swan Pool is located at the origin of the Swan Pool tributary. A drain which feeds the Valley Brook is located approximately 820 m north east of the site.

No drains are shown within 1 km of the site boundary on the available mapping, however it is possible that some agricultural drainage ditches are not shown. A spring is known to be present in the sump at Stowfield Quarry, which discharges to the quarry floor (flow rate of 0.25 l/s was recorded on 13 December 2005). Several other springs are mapped in area surrounding the quarry.

3.2.3. Lakes and ponds
Two lakes or ponds are indicated within 1 km of the site option on OS and satellite mapping, and a seasonal lagoon associated with the workings of Stowfield Quarry is present immediately to the east. The locations of these ponds are presented within Table 3-1.

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10 GCC, 2015. Addendum to the Minerals Local Plan Site Options and Draft Policy Framework Consultation: Additional Site Option.
3.2.4. Water Framework Directive status

Table 3-1  Surface water bodies within 1 km of the site option

<table>
<thead>
<tr>
<th>Water body name / ID</th>
<th>Location (NGR)</th>
<th>Hydromorphological status</th>
<th>Current ecological quality (Certainty)</th>
<th>Current chemical quality (Certainty)</th>
<th>Value/Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whippington Brook</td>
<td>800 m north east of Site (356218, 212429)</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Medium</td>
</tr>
<tr>
<td>Swan Pool (tributary)</td>
<td>570 m south west of the site (355134, 210629)</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Medium</td>
</tr>
<tr>
<td>Drain</td>
<td>820 m north east of the site (365541, 212660)</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Low</td>
</tr>
<tr>
<td>Stowfield Quarry lagoon</td>
<td>35 m east of Site (355834, 211147)</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Low</td>
</tr>
<tr>
<td>Pond/Lake</td>
<td>620 m north east of Site (356231, 211829)</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Low</td>
</tr>
<tr>
<td>Swan Pool (pond)</td>
<td>600 m south west of Site (354612, 210660)</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Not designated</td>
<td>Low</td>
</tr>
</tbody>
</table>

3.3. Flood risk
This section summarises the relevant data on flooding that is available for the site option.

3.3.1. Surface water flooding
The majority of the site is recorded as not at risk of surface water flooding. Surface water flooding is highlighted in line with the topography of the current quarry workings and risk of surface water flooding is from events with annual probabilities of occurrence up to 3.3%.

3.3.2. River flooding
Figure 3 shows that no river flood zones are present within 1 km of the site.

3.3.3. Groundwater flooding
No information on the probability of groundwater flooding occurring is available, however information on the areas susceptible to groundwater flooding has been provided by the Environment Agency. As indicated on Figure 4, the site is situated within an area where <25% of each 1 km grid square is susceptible to groundwater flooding.

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The data should not be interpreted as identifying areas where groundwater is actually likely to flow or pond, thus causing flooding, and does not give any indication of the probability of frequency that flooding may occur.

### 3.3.4. Sewer flooding

As the site option is in a relatively rural area and it is unlikely that significant discharges to sewers will be required, sewer flooding has not been considered.

### 3.4. Geology

This section provides a summary of the geology that underlies the site option. The geological units that are present beneath the site are listed within Table 3-2. The geology of the area is dominated by the Forest of Dean limestone basin. Local to Stowfield Quarry is the western flank of the Worcester Syncline with beds dipping eastwards, some minor localised faulting occurs in the south west area of the Quarry[14]. No superficial deposits are mapped onsite; a map of the bedrock geology underlying the site option is provided in Figure 5[15].

Consistent with the succession outlined in Table 3-2, BGS borehole SO51SE56[16], located adjacent to Stowfield Quarry on Scowles Road, logs fractured limestone interspersed with mudstone and clay horizons overlying grey/red sandstone at depth (96 mbgl, approximately 85 mAOD).

<table>
<thead>
<tr>
<th>Geological formation (geological period)</th>
<th>Member</th>
<th>Geological description</th>
<th>Approximate thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superficial deposits</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedrock</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black Rock Limestone Subgroup aka Lower</td>
<td>Undifferentiated</td>
<td>Medium bedded to Massive, compact dolomite.</td>
<td>65 - 120 m</td>
</tr>
<tr>
<td>Dolomite (Carboniferous)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subcrop geology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Limestone Shales (Carboniferous)</td>
<td>Undifferentiated</td>
<td>Interbedded mudstones, packstones and grainstones.</td>
<td>55 - 65 m</td>
</tr>
<tr>
<td>Tintern Sandstone Group (Devonian/Carboniferous)</td>
<td>Undifferentiated</td>
<td>Red and yellow sandstone with quartz conglomerate at its base</td>
<td>90 – 200 m</td>
</tr>
</tbody>
</table>

### 3.5. Hydrogeology

This section provides a summary of the hydrogeology for the site option.

#### 3.5.1. Aquifers

The bedrock aquifer is classified as a Principal aquifer by the Environment Agency[16] and is comprised of a medium-bedded to massive, compact finely crystalline dolomite[14]. Intergranular permeabilities and storage are low; the main flow mechanism is fracture flow which may be enhanced by solution[17].


The Environment Agency considers the bedrock aquifer to be Highly Vulnerable to pollution\textsuperscript{19}. This means the area is able to easily transmit pollution through to groundwater. Such areas are typically characterised by high leaching soils, and the absence of low permeability drift deposits.

### 3.5.2. Aquifer properties

There is no available hydrogeological assessment of the properties of the aquifer beneath the site or within close proximity of the site. As such the transmissivity, porosity, yield and hydraulic conductivity of the aquifer is not known. Therefore it is recommended that a full hydrogeological assessment of the aquifer beneath the site is conducted prior to the start of the mineral extraction operations in order to fully evaluate the potential risks of the operations at the site.

### 3.5.3. Groundwater elevation and fluctuations

An Environmental Impact Assessment (EIA)\textsuperscript{14} produced for the previous quarry expansion provides details of the groundwater level monitoring and elevations from the period 1991 – 2007 (prior to the merging of Stowfield and Rogers’ Quarries, including Northern Extension and The Spine). No monitoring data was made available from 2007 to present.

The extent of the Lower Dolomite aquifer is detailed as follows; the base and western limit are defined by the underlying low permeability Lower Limestone Shale, the upper and eastern limit are delimited by the low permeability Whitehead Limestone (refer to Figure 5). Data from 12 piezometers in and around the quarry monitoring the Lower Dolomite indicate that a maximum groundwater level of 179 mAOD was recorded in February 2001. Groundwater levels are reported to have exceeded 165 mAOD (the current quarry sump level) during the winter in six of the nine years for which monitoring data is available\textsuperscript{14}. The sole mechanism of recharge to the aquifer is rainfall and the large fluctuation of groundwater levels recorded in several of the piezometers (Table 3-3), indicates low aquifer storage.

<table>
<thead>
<tr>
<th>Borehole ID</th>
<th>Approximate water level range 1991 – 2007 (mAOD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST41/90</td>
<td>135 - 179</td>
</tr>
<tr>
<td>ST35/90</td>
<td>135 - 154</td>
</tr>
<tr>
<td>ST5/98</td>
<td>141 - 165</td>
</tr>
<tr>
<td>ST3/97</td>
<td>153 - 160</td>
</tr>
<tr>
<td>ST33/90</td>
<td>154 - 172</td>
</tr>
<tr>
<td>ST36/90</td>
<td>148 - 172</td>
</tr>
<tr>
<td>ST2/98</td>
<td>128 - 157</td>
</tr>
<tr>
<td>ST5/98</td>
<td>142 - 153</td>
</tr>
<tr>
<td>ST097-3A</td>
<td>No data</td>
</tr>
<tr>
<td>ST097-3B</td>
<td>No data</td>
</tr>
<tr>
<td>ST40/90</td>
<td>133 - 165</td>
</tr>
<tr>
<td>STp1/92</td>
<td>No data</td>
</tr>
</tbody>
</table>

It is possible that ingress to the quarry may increase as the works are deepened; however this is largely dependent on the interception of any water-bearing fissures. The EIA notes that fissures will only be fed for a maximum of four months during the winter period by a limited recharge area\textsuperscript{14}, consequently producing very low flow rates. A borehole (BGS SO51SE56) installed in December 2000 for the quarry operator records groundwater ingress during drilling at 3, 47, 71 and 104 mbgl\textsuperscript{18}. The quarry currently operates active water management for removal of any groundwater ingress\textsuperscript{14}.

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3.5.4. Monitoring locations and groundwater flow

The Centre of Ecology and Hydrology (CEH) have a number of surface water monitoring points throughout the UK\(^{19}\). One of which is located approximately 2.3 km west of the site boundary on the River Wye at Redbrook. The BGS monitors groundwater throughout the UK and stores it on a publically available database, the UK Hydrometric Register, however there are no nearby groundwater monitoring stations in the limestone. The available monitoring stations are summarised in Table 3-4.

<table>
<thead>
<tr>
<th>Surface/groundwater monitoring station</th>
<th>Grid reference</th>
<th>Area covered (km(^2))</th>
<th>Mean flow (m(^3)/s)</th>
<th>Groundwater level L(^{95}) (mAOD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface: 55023 – Wye at Redbrook</td>
<td>SO52701100</td>
<td>4010</td>
<td>73.3</td>
<td>-</td>
</tr>
</tbody>
</table>

3.5.5. Water Framework Directive status

The WFD status of groundwater bodies is determined using quantitative and quality components and is measured as being either Good or Poor. The limestone bedrock beneath the site option is contained within the Severn Vale/Wye Carboniferous Limestone Forest of Dean Groundwater Body\(^{20}\).

<table>
<thead>
<tr>
<th>Waterbody name (ID)</th>
<th>Current quantitative quality (Certainty)</th>
<th>Current chemical quality (Certainty)</th>
<th>Overall risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severn Vale/Wye Carboniferous Limestone Forest of Dean (GB4091G202700)</td>
<td>Good (No information available)</td>
<td>Good (No information available)</td>
<td>Probably at risk</td>
</tr>
</tbody>
</table>

3.6. Land designations

This section summarises the relevant protected areas and historic land uses within 1 km of the site option.

3.6.1. Source protection zones

At its closest point, a Source Protection Zone 3 is located approximately 1 km west of the site boundary. The associated potable supply spring source, and Source Protection Zone 1 are located approximately 2 km south west of the site.

3.6.2. Historical land use and pollution incidents

According to Environment Agency mapping\(^{21,16}\), no pollution incidents or historic landfills are reported within 1 km of the site option.

3.6.3. Protected areas

The site option is located within the Wye Valley Area of Outstanding Natural Beauty and a SSSI Impact Risk Zone. There is one SSSI site located within 1 km of the site boundary\(^{22}\). Dingle Wood SSSI (9.95 ha) is located 130 m to the east of the site option and is designated for its biological interest as an example of

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\(^{19}\) Centre For Hydrology and Ecology & British Geological Survey, UK Hydrometric Register (2008)  
\(^{20}\) WFD Cycle 2 Groundwater Body Classifications and Objectives  
https://ea.sharefile.com/share?cmd=d&id=s0c6fa39b82a46e9a#view=s0c6fa39b82a46e9a?_k=zbz7l8 Accessed on 18 February 2016.  
https://ea.sharefile.com/share?cmd=d&id=s0c6fa39b82a46e9a#view=s0c6fa39b82a46e9a?_k=zbz7l8  
Carboniferous limestone woodland habitat\textsuperscript{23}. Three Scheduled Monuments are located within 1 km of the site.

Gloucestershire County Council Key Wildlife Sites are designated areas with a rich diversity of habitats that provide refuges and corridors for wildlife across Gloucestershire. Some of which may contain plant species sensitive to groundwater levels, or aquatic life sensitive to changes in water quality. Three Key wildlife sites are located within 1 km of the site, and Broad Woods KWS is located onsite. Key Wildlife Sites are presented on Figure 6.

Table 3-5  
**Ecological sites within 1 km of the site option**

<table>
<thead>
<tr>
<th>Type/ designation</th>
<th>Name</th>
<th>Location relative to the site option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSSI</td>
<td>Dingle Wood SSSI</td>
<td>130 m to the east</td>
<td>High</td>
</tr>
</tbody>
</table>

In addition there are 4 Key Wildlife Sites located within 1 km of the site boundary, as shown on Figure 6.

### 3.6.4. Abstractions

There are two licensed abstractions on-site and it is known that water management takes place under an exemption from licensing. Details of all licensed and un-licensed (private) abstractions within 1 km are summarised in Table 3-6 below. Bigwell, a large Severn Trent Water Ltd spring source for potable supply, located at Redbrook 2.2 km to the west of the site option has been included for information.

The borehole onsite is known to abstract from the confined Tintern Sandstone Group beneath the quarry. The two private abstractions are also highlighted in the EIA\textsuperscript{14} to be sourced in the Tintern Sandstone.

Table 3-6  
**Type and number of surface water and groundwater abstractions within 1 km of the site option**

<table>
<thead>
<tr>
<th>WFD water body Name</th>
<th>Location</th>
<th>Purpose</th>
<th>Max annual abstraction (m\textsuperscript{3}/year)</th>
<th>Maximum daily abstraction / volume (m\textsuperscript{3}/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAW Groundwater</td>
<td>Onsite</td>
<td>Industrial, commercial and public services</td>
<td>42625</td>
<td>155</td>
</tr>
<tr>
<td>Quarry lagoon</td>
<td>Onsite</td>
<td>Industrial, commercial and public services</td>
<td>6001</td>
<td>287.8</td>
</tr>
<tr>
<td>Tintern Sandstone</td>
<td>1 km south</td>
<td>Private (Tunnel House)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tintern Sandstone</td>
<td>700 m north east</td>
<td>Private (Marian’s Well)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>EAW Surface Water</td>
<td>2.2 km west of site</td>
<td>Potable supply</td>
<td>16,638000</td>
<td>55,000</td>
</tr>
</tbody>
</table>


4. Hydrogeological and hydrological risk assessment

4.1. Review of activities proposed and potential impacts

It is proposed that the GCC allocate several sites throughout the county for further mineral extraction and expansion. One of the sites which is being considered for limestone (crushed rock) extraction is located at Stowfield Quarry. This study aims to carry out a hydrogeological assessment of the site area and examine the risks posed by any future development to specific receptors and the pathways that may cause this risk to affect receptors within the boundary of the proposed development area. For the purposes of this assessment it has been assumed that work has taken place and the quarried areas have been backfilled with lower permeability material such of overburden, silt or imported materials, therefore this is an assessment of the worst case scenario.

The proposed activities at the site and across all site options involve mineral extraction within the parcel. The mineral resource of interest at Stowfield is (crushed rock) limestone which underlies the entire site option.

The most significant potential impacts are focused on flooding (Table 4-2). The restoration of the site using low permeability inert infill will present a barrier to groundwater flow, resulting in an elevated risk of groundwater flooding. Surface run-off will be increased due to the reduction in permeability of subsurface deposits.

4.2. Receptors

A summary of the receptors for the site option at Stowfield is presented in Table 4-1.

<table>
<thead>
<tr>
<th>Controlled waters</th>
<th>Sensitive land use</th>
<th>Flood risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wippington Brook</td>
<td>Key wildlife sites</td>
<td>Stowfield Quarry offices</td>
</tr>
<tr>
<td>Swan Pool</td>
<td>Dingle Wood SSSI</td>
<td>Scowles caravan park</td>
</tr>
<tr>
<td>Principal aquifer</td>
<td></td>
<td>High Meadow Farm</td>
</tr>
<tr>
<td>Lakes/Ponds</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The limestone bedrock beneath the site option is classified as a Principal aquifer, two licensed abstractions (surface water and groundwater) are located onsite, and no private abstractions are located within a 1 km radius of the site. The Environmental Impact Assessment indicates no risk of quarry-related derogation to the onsite groundwater borehole abstraction as the water is drawn from the Tintern Sandstone Group which is confined beneath the Lower Limestone Shale. There are no known boreholes which abstract water from the Lower Dolomite, however the water in the quarry sump lagoon onsite which is licensed for abstraction is sourced from the Lower Dolomite and removed for use on site.

The Swan Pool and Wippington Brook (ordinary watercourses) are the closest surface waterbody receptors to the site option, which converge with the River Wye (main river) downstream.

A number of ponds/lakes within 1km of the site all represent potential receptors; however the significance of these are relatively low owing to their distances from the site with the closest 620 m north east of the site boundary. There are five sensitive land uses located within 1km of the site boundary; four GCC Key Wildlife Sites (areas with a rich diversity of habitats that provide refuges and corridors for wildlife across Gloucestershire) and a SSSI.

4.3. Identification of pathways

There are three main pathways which will be affected by any change in flow paths:
- Groundwater;
- Surface (overland flow) water; and
- Fluvial (river) water pathways

The main pathway for any potential flooding issues is surface water runoff, and surface water induced flooding will be exacerbated by the local undulating topography and the reduction in infiltration due to the low permeability restoration material.

### 4.4. Appraisal of magnitude of impact on receptors

The significance of any effect on the identified receptors is likely to vary depending on a number of factors, such as the sensitivity of the relevant waters, the current conditions within the site and the magnitude of any impact. There are a number of potential issues that could arise from the development, most notably the impact of the excavation on Dingle Wood SSSI and the increased incidence of flooding.

Such impacts have been displayed have been displayed in Table 4-2. This section uses the criteria set out in Section 2 to assess the impact, magnitude and significance of any change on the receptors, due to mineral extraction work, within the site area. It must be noted that this table details possible effects that could occur in the absence of appropriate mitigation. It is expected that applicants will complete detailed assessment and develop appropriate mitigation measures. It is likely therefore that the impacts of any particular scheme would not approach those detailed.
# Table 4-2  Appraisal of Magnitude of Impact on Receptors

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Importance</th>
<th>Impact</th>
<th>During operation</th>
<th>After restoration</th>
<th>Significance</th>
</tr>
</thead>
</table>
| Lakes                          | Low        | Increase or decrease in water levels due to groundwater diversion and dewatering | **Negligible**  
The aquifer is small and hydraulically isolated from surrounding aquifers by low permeability units.  
Dewatering to facilitate mineral extraction will not impact beyond the aquifer boundary. | **Negligible**  
The aquifer is small and hydraulically isolated from surrounding aquifers by low permeability units.  
Dewatering to facilitate mineral extraction will not impact beyond the aquifer boundary. | Insignificant  |
| Principal aquifer               | Medium     | Dewatering and diversion of groundwater from this area of the aquifer. Decrease in water quality. | **Slight Adverse**  
De-watering activities from quarrying is likely to result in a decrease of water levels in the aquifer surrounding any quarrying activities. This reduction in levels is likely to impact on any abstractions within the aquifer in close proximity to the quarry.  
Pollution of the aquifer from chemicals used during quarrying may decrease water quality in the aquifer. | **Slight Adverse**  
The aquifer is small and hydraulically isolated from surrounding aquifers by low permeability units.  
Any alteration to the quality or lowering of the groundwater table due to de-watering will only impact locally and will not impact upon nearby potable supplies. | Low significance  |
| Whippington Brook and Swan Brook| Medium     | Changes to base flow as a result of dewatering and/or inert infill. | **Slight Adverse**  
De-watering activities during operations may result in diversion of water from the Whippington Brook and Swan Brook as groundwater flow paths are interrupted. | **Slight Adverse**  
The river is a considerable distance from the site and as such any impacts on groundwater flow as a result of the small area proposed for working are unlikely to be significant in terms of the river’s overall flow. This will need to be confirmed during the details work to support any | Insignificant  |
<table>
<thead>
<tr>
<th>Receptor</th>
<th>Importance</th>
<th>Impact</th>
<th>Magnitude</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blake’s Wood KWS</td>
<td>Medium</td>
<td>Changes in groundwater levels and/or quality can impact sensitive vegetation and have knock-on impacts of faunal interest.</td>
<td><strong>Moderate Adverse</strong>&lt;br&gt;Due to the close proximity of the site to the KWS it is likely that an adverse impact may be observed</td>
<td>Low significance</td>
</tr>
<tr>
<td>Whitecliffe Recreation Ground KWS</td>
<td>Medium</td>
<td>Changes in groundwater levels and/or quality can impact sensitive vegetation and have knock-on impacts of faunal interest.</td>
<td><strong>Slight Adverse</strong>&lt;br&gt;Due to the distance from the site it is considered unlikely that any impact will be observed</td>
<td>Insignificant</td>
</tr>
<tr>
<td>Staunton Woods KWS and Satunton Meend KWS</td>
<td>Medium</td>
<td>Changes in groundwater levels and/or quality can impact sensitive vegetation and have knock-on impacts of faunal interest.</td>
<td><strong>Slight Adverse</strong>&lt;br&gt;Due to the distance from the site and the presence of a fault between the site and the KWS it is considered unlikely that any impact will be observed</td>
<td>Insignificant</td>
</tr>
<tr>
<td>Dingle Wood (SSSI)</td>
<td>High</td>
<td>Changes to water availability. Discharge of polluted water.</td>
<td><strong>Slight Adverse</strong>&lt;br&gt;As a designated SSSI any potential change in hydrological conditions could potentially impact on integrity of the site. The SSSI is not known to be water-dependent, however it is within close proximity of the site so there is potential for adverse impact.</td>
<td>Low Significance</td>
</tr>
<tr>
<td>Flood Risk</td>
<td>High</td>
<td>Increased risk of flooding from rivers, surface water and</td>
<td><strong>Moderate Adverse</strong>&lt;br&gt;Dewatering is likely to be required and discharge of this water may give rise</td>
<td>Significant</td>
</tr>
<tr>
<td>Receptor</td>
<td>Importance</td>
<td>Impact</td>
<td>Magnitude During operation</td>
<td>Magnitude After restoration</td>
</tr>
<tr>
<td>----------</td>
<td>------------</td>
<td>--------</td>
<td>---------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>groundwater</td>
<td></td>
<td></td>
<td>to an increased risk of flooding if the capacity of the receiving stream is exceeded. Any stockpiling of materials within areas susceptible to surface water flooding may increase the risk of flooding off site due to a reduction in water storage.</td>
<td>permeability material is likely to increase the amount of runoff from the site following a rainfall event and may therefore increase the risk of flooding.</td>
</tr>
</tbody>
</table>
4.5. Mitigation measures

It is recognised that the proposed mineral extraction activities could, absent any mitigation, have various adverse impacts upon the water environment. However, it is anticipated that potential operators would, as part of their applications, undertake detailed site investigations and monitoring and provide a more detailed assessment of the impacts. Where a development is an EIA development this would be presented in the relevant chapter of the Environmental Statement as well as within a flood risk assessment compatible with the requirements of the NPPF. For non-EIA developments it is still expected that the effects of the development on the water environment, with particular attention to flood risk, will be properly considered and documented. Where necessary it is expected that mitigation measures will be detailed within the application to reduce the impacts to acceptable levels.

Mitigation measures to reduce the impact of dewatering are likely to include some or all of:

- Subdivision of the working area into smaller cells to reduce the active perimeter; and
- Control of dewatering volumes, and if necessary suspension of pumping during storm event, to ensure receiving waters have appropriate capacity for the flow.

Mitigation measures to reduce impact on water quality are likely to include some or all of:

- Use of bunded tanks and drip trays to prevent spillages;
- Use of settlement (silt) ponds or proprietary equipment to reduce the silt content of discharged water;
- Compliance with quality limits set by the Environment Agency; and
- Use of inert materials only for restoration.

Measures to minimise the impact of flood risk are likely to include some or all of:

- Placing buildings, stockpiles and other infrastructure outside the flood plain and outside areas at risk of surface water flooding where ever possible;
- Where storage within a flood risk areas is required, place it at as low a risk as possible, which will commonly be as close to the edge of the zone as possible;
- Restore the site to, at most, existing ground level and no higher so as not to impact upon flood plain storage;
- Provide flow balancing using sustainable drainage systems such that the greenfield (pre-development) rate of runoff is not exceeded in line with current SuDS guidance; and
- Provide safe pathways for groundwater to move around or through the infilled site such the groundwater levels do not rise above the pre-development levels.

4.6. Residual effects

If mitigation measures are implemented with the addition of a stringent monitoring programme, the residual effects of the mineral extraction activities at Stowfield should be negligible.

5. Site investigation and monitoring

It is recommended that the following parameters be monitored before, during and after quarry operations:

- **Groundwater levels** – Monthly monitoring for a period of 12 months prior to quarrying during operation (at a higher frequency if required) and during the aftercare and management period. Locations should be identified to provide good coverage of the proposed site, taking into account the need to understand groundwater/surface water interaction and should as far as possible be located so that they can function for the whole of the period required.

- **Precipitation** – Data can be obtained from Environment Agency or Meteorological Office at the same times, and for the same period, as groundwater levels are recorded.

- **Water Quality** – pH, dissolved oxygen, Biochemical Oxygen Demand (BOD), conductivity, ammonia, nitrates, suspended solids and other relevant chemical parameters should be measured to ensure Rivers Eye and Windrush are not contaminated.
6. Conclusions

6.1. Overall
The proposed site at Stowfield, located within the current Stowfield Quarry, is under consideration by the GCC for extended mineral extraction. This report provides a hydrogeological impact assessment for the proposed works, using existing information and baseline conditions at the site and a review of the aforementioned works has been carried out. The key conclusions are outlined below:

- The main risk of concern is an elevated flood risk (assuming backfilling using low permeability material). Flood risk scattered areas across the site are at high risk of flooding from surface water, however the site is not at risk from flooding from rivers or the sea and less than 25% of the site area is susceptible to groundwater flooding.
- Dewatering will lower groundwater levels on a local scale in the Lower Dolomite (a Principal aquifer).
- All quarrying works within the site option will require environmental monitoring. Groundwater level monitoring has been recommended prior to, during and post operations in addition to precipitation and water quality monitoring.
- Mitigation measures implemented during operations can reduce the significance of any negative residual impacts.

6.2. Operation
The current workings at Stowfield Quarry are extended to 165 mAOD, the proposed quarry deepening by 20 m in the site option area is likely to result in water pooling in the sump during the winter months.

The Lower Limestone Shale Formation which underlies the quarried Lower Dolomite provides a low permeability confining layer for the Old Red Sandstone aquifer beneath. It is imperative that these shales not be impacted by the works to prevent potentially negative dewatering and quality impacts on the aquifer beneath.

6.3. Restoration
It is assumed that the site be restored to agriculture using inert fill, as this is likely to have greatest potential to impact the water environment. This restoration has the potential to increase flood risk, by increasing surface water runoff and damming groundwater flow paths.

Mitigation measures to manage these risks are available and the council should ensure that well designed mitigation is included in any applications that are submitted.