

Minerals Local Plan Background Document

Worcestershire County Council: June 2019

Minerals and Climate Change

Minerals Planning Policy

1. Executive summary

- 1.1. Climate Change is the greatest environmental challenge facing the world today. The Climate Change Act 2008 commits the UK to a statutory target of reducing its Greenhouse Gas (GHG) emissions by 80% below 1990 emissions levels, by 2050.
- 1.2. This background paper considers the contribution that the Minerals Local Plan could play to reducing Worcestershire's climate change emissions and planning for and adapting to climate change.

Reducing Worcestershire's climate change emissions

- 1.3. **Energy efficiency:** There is potential to reduce energy consumption across different areas of the aggregates sector. This could result in significant reductions in CO₂ emissions, but any policy framework promoting this would need to enable necessary minerals development to take place.
- 1.4. **Use of renewable and low carbon energy:** The minerals industry is a significant energy consumer, accounting for 10% of all industrial energy consumption in 2011¹. Across the sector oils are the dominant fuel, with gas and electricity demand varying considerably depending on the mineral. The scope to use renewable or low-carbon energy supply will therefore depend on the processes involved. Signs from the industry show positive steps in relation to this issue.
- 1.5. **Generation of renewable and low carbon energy:** The potential for on-site generation will depend on many factors, including the size, location and anticipated life of workings, the renewable resources available, and the environmental and economic impacts of installing renewable technologies. .
- 1.6. **Reducing transport impacts:** Climate change emissions could be reduced through transporting minerals by water or rail rather than road, but opportunities for this are likely to be limited². The Minerals Local Plan has the potential to influence the proximity of workings to local markets, although this in itself will be limited by geology.
- 1.7. **Other emissions from the processing of minerals:** Not all of the climate change emissions from the minerals industry are from energy consumption. Some are from chemical reaction or other factors that cannot be 'engineered out' of the process. The Minerals Local Plan can have little influence over these factors.
- 1.8. **Thinking of the 'whole life' of mineral products:** Somewhere between 40%-45% of the energy used in the lifetime of a building may be accounted for in embodied energy, which includes the energy used for the abstraction, processing and manufacture of building materials, and their transportation and assembly on site³. The exact proportion can vary significantly, and will

¹ <http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx>

² Further detail is available in the 'Rail freight' and 'Water transport' background documents.

³ Institution of Civil Engineers, *Energy Briefing Sheet: Embodied Energy and Carbon*

depend upon - among other factors - the materials used, with different mineral products having different thermal insulation properties. Building design is not something that can be significantly influenced through the Minerals Local Plan, but it is useful to consider the industry in context.

- 1.9. **Impact of different land uses:** Traditionally some kinds of mineral workings have been restored by using landfill to fill the voids created by extraction. This is unlikely to be the case for the majority of minerals sites in the future in Worcestershire. The types of emissions and climate change impacts of other types of restoration schemes and land uses will vary, but there are clear advantages to be gained from incorporating green space or Green Infrastructure elements into all types of restoration schemes to reduce greenhouse gas emissions and mitigate climate change.

Planning for and adapting to the impacts of climate change

- 1.10. It is recognised that some of the impacts of climate change are now inevitable. Latest projections⁴ suggest that climate change trends will see "a move towards warmer, wetter winters and hotter, drier summers. However, natural variations mean that some cold winters, some dry winters, some cool summers and some wet summers will still occur". The Climate Change Strategy for Worcestershire⁵ makes it clear new developments need to be planned in a way that takes full account of adaptive measures. The natural environment is also vulnerable to the impacts of climate change, so realistic measures need to be taken to protect the natural environment and increase its resilience to change.
- 1.11. **Flooding: managing flood risk impacts on mineral workings:** Sand and gravel workings are identified in national guidance as '*water-compatible*' development⁶ which is suitable in all flood zones (including the functional flood plain) and other minerals and working processes are identified as '*less vulnerable*' development which is suitable in flood zones 1-3a. Flooding and water management issues are considered in a separate background document available at <http://www.worcestershire.gov.uk/minerals>.
- 1.12. **Reducing the causes of and impacts of flooding:** There is significant potential for restored mineral workings in the flood plain to provide flood benefits, but working outside the flood plain can also provide betterment or attenuation features. The nature of these benefits (and the schemes used to deliver them) would need to vary on a site-by-site basis depending on factors such as hydrology and geology. In general, 'softer' measures involving green infrastructure would have greater benefits, particularly where they integrate wider environmental benefits such as water quality improvements and habitat creation. The challenge for the Minerals Local Plan is to identify areas where minerals restoration for flood benefit would be most appropriate and to provide the right level of guidance and flexibility to ensure that the most appropriate methods can be used.

⁴ Defra/DBEIS/Environment Agency/Met Office (2018) UKCP18 Factsheet: Derived projections

⁵ Worcestershire Climate Change Strategy 2012-2020

⁶ Planning Practice Guidance, 'The sequential, risk-based approach to the location of development'

- 1.13. **Water Supply and Groundwater:** There is significant scope for the Minerals Local Plan to manage the impact of minerals development on water supply and ground water. Hydrogeological Impact Assessments (HIA) exploring the effects of quarry developments on water resources may be one means of addressing these issues.
- 1.14. Flooding and water management matters are considered as part of a separate background paper available at www.worcestershire.gov.uk/minerals.
- 1.15. **Habitat/species resilience:** The restoration of mineral workings can provide a unique opportunity to create habitats that are more resilient to climate change and to link existing sites and corridors to aid the dispersal of species. The principles of "more, bigger, better and joined" proposed as part of the Lawton Review⁷ could be implemented through mineral site restoration.
- 1.16. The conclusions of all of the sections above will be used to inform the development and content of the Minerals Local Plan.

⁷ Defra (2010) 'Making space for nature': a review of England's wildlife sites

Contents

1. Executive summary	2
Reducing Worcestershire’s climate change emissions	2
Planning for and adapting to the impacts of climate change	3
2. Introduction.....	6
Policy context	6
National Planning Policy Framework.....	6
Local Policies and Strategies	7
3. Reducing Worcestershire’s Climate Change emissions.....	8
Context.....	8
Energy Efficiency	8
Use of renewable and low carbon energy	11
Generation of renewable and low carbon energy	12
Reducing transport impacts.....	13
Other emissions from the processing of minerals.....	14
The ‘whole life’ of mineral products	14
Impact of different land uses	15
4. Planning for and adapting to the impacts of climate change.....	18
Flooding: Managing flood risk impacts on mineral workings	18
Flooding: Reducing the causes and impacts of flooding	19
Flood storage reservoirs.....	20
Creation of low-level flood plains.....	21
Providing additional channel conveyance	22
Increasing channel length and channel storage	22
Water supply and groundwater.....	24
Habitat/species resilience	25

2. Introduction

- 2.1. Climate change is the greatest environmental challenge facing the world today. The Climate Change Act 2008 commits the UK to a statutory target of reducing its Greenhouse Gas (GHG) emissions by 80% below 1990 emissions levels, by 2050.
- 2.2. The National Planning Policy Framework (NPPF) states that:

"The planning system should support the transition to a low carbon future in a changing climate, taking full account of flood risk and coastal change. It should help to: shape places in ways that contribute to radical reductions in greenhouse gas emissions, minimise vulnerability and improve resilience; encourage the reuse of existing resources ... and support renewable and low carbon energy and associated infrastructure".⁸

The Minerals Local Plan will set out the strategic priorities in relation to mineral extraction in Worcestershire. In doing this it must also include strategic priorities to deliver climate change mitigation and adaptation.

- 2.3. This background paper considers the relationship between minerals development and climate change mitigation and adaptation. It considers the contribution that the Minerals Local Plan could make in reducing Worcestershire's climate change emissions and planning for and adapting to climate change and flags up potential opportunities and concerns which could be considered when developing the Minerals Local Plan.

Policy context

National Planning Policy Framework

- 2.4. Much of the policy on climate change in the National Planning Policy Framework (NPPF) relates to the impacts of climate change on built development. Mineral extraction is fundamentally different to many types of development, but many of the over-arching principles apply equally to all types of development.
- 2.5. The NPPF states that "Plans should take a proactive approach to mitigating and adapting to climate change, taking into account the long-term implications for flood risk, coastal change, water supply, biodiversity and landscapes, and the risk of overheating from rising temperatures."⁹
- 2.6. The NPPF also sets out that "New development should be planned for in ways that [inter alia] avoid increased vulnerability to the range of impacts arising from climate change. When new development is brought forward in areas which are vulnerable, care should be taken to ensure that risks can

⁸ Ministry of Housing, Communities and Local Government (July 2018) National Planning Policy Framework, paragraph 148

⁹ Ministry of Housing, Communities and Local Government (July 2018) National Planning Policy Framework, paragraph 149

be managed through suitable adaptation measures, including through the planning of green infrastructure."¹⁰

- 2.7. This background document, alongside others prepared to support the development of the Minerals Local Plan, will provide the evidence base to address these issues.

Section 3 of this document identifies the issues which will need to be considered in the Minerals Local Plan in order to plan for new minerals development in Worcestershire in locations and ways which reduce greenhouse gas emissions. This takes account of the promotion of energy from renewable and low carbon sources and minimising energy consumption through the design of the development, both which are specifically mentioned in the NPPF.

Section 4 of this document considers the predicted long-term changes in climate which are likely to take place in Worcestershire and the impacts on flood risk, water supply and changes to biodiversity and landscape. It sets out ways in which these could be taken into account to help minerals development adapt to climate change and identifies ways that minerals development, and in particular restoration, could contribute towards climate change resilience in the wider context.

Local Policies and Strategies

Shaping Worcestershire's Future, Worcestershire County Council Corporate Plan 2017-2022

- 2.8. One of the four priorities of the council's corporate plan '*Shaping Worcestershire's Future*' is the environment. It recognises that "A sustainable environment is important for people's wellbeing, the economy and for the natural environment."

Flooding is a major issue for Worcestershire's residents, particularly those who live in areas most affected. The corporate plan states that the council will continue to minimise the impact of flooding on our transport network and reduce the frequency of closures related to flooding, and seek to increase the number of homes and businesses protected by investment in effective flood prevention and mitigation measures.

- 2.9. The success of the corporate plan's approach to the environment will be judged on how far we have minimised the amount of waste produced, improved the condition of our roads and pavements, reduced journey times and improved access to real-time journey information, maintained access to quality recreational green-space across the county, and the number of homes/businesses protected from flooding.

¹⁰ Ministry of Housing, Communities and Local Government (July 2018) National Planning Policy Framework, paragraph 150

3. Reducing Worcestershire's Climate Change emissions

Context

- 3.1. Worcestershire's homes, businesses, public organisations and transport (including motorways), generated an estimated 3.396 million tonnes of CO₂ in 2016, a reduction of around 27.5% since 2006.¹¹
- 3.2. While there have been slight fluctuations year-on-year, emissions rose during 2009 due to a very cold winter, as well as a short term national change to more carbon intensive energy generation, there currently appears to be an overall downward trend in emissions. This continues the trajectory observed in the Climate Change Strategy in 2012, which attributed the decline to the recession (from which there has since been recovery), a loss of heavy industry, a move to less carbon-intensive energy generation, and increasing energy efficiency measures.¹²
- 3.3. Worcestershire's emissions are accounted for as follows¹³:
 - Residential emissions: 28%
 - Business (industrial, commercial and agricultural) emissions: 25%.
 - Motorway transport: 20%
 - Road and other transport: 29%
- 3.4. Nationally the Climate Change Act 2008 sets a national target to reduce UK carbon dioxide emissions by at least 34% by 2022 and at least 80% by 2050, compared to 1990 levels.
- 3.5. Worcestershire has adopted similar goals at the county level, with an overall target to reduce total county-wide carbon emissions by 30% from 2005 levels by 2020 and put in place measures to enable reduction by 80% by 2050.¹⁴

Energy Efficiency

- 3.6. The Worcestershire Climate Change Strategy acknowledges that the targets will be challenging, and sets out a range of measures that will be needed to achieve them, including "utilising spatial planning processes to enable transition to a low carbon economy", which the Minerals Local Plan can help to deliver.
- 3.7. The winning and processing of minerals involves extraction machinery and processing plant and can be energy intensive. In 2015 the mining and quarrying sector in the UK consumed energy from fossil fuels equivalent to 5.6 million tonnes of oil, and emitted over 17 million tonnes of CO₂.¹⁵

¹¹ National Statistics, UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2016

¹² Worcestershire Climate Change Strategy 2012-2020

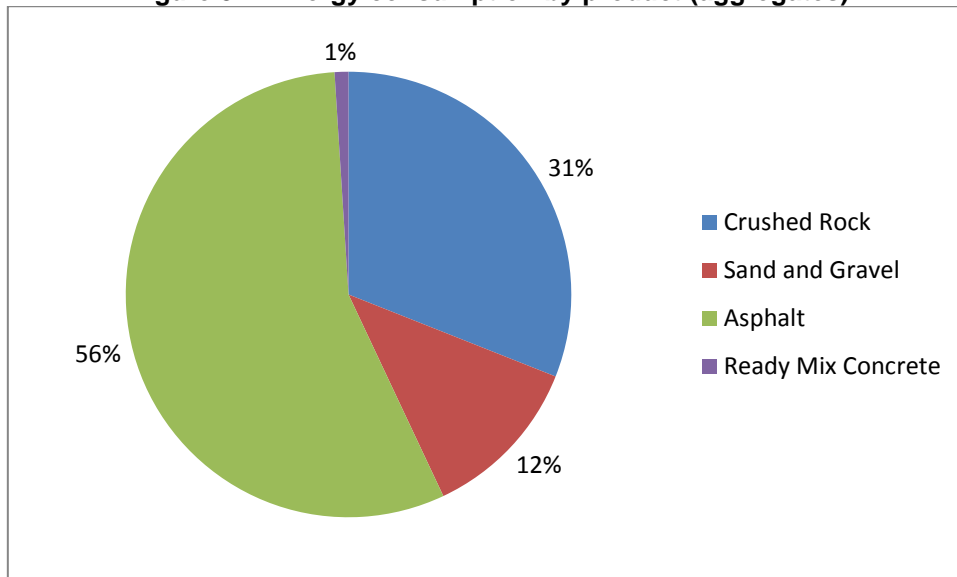
¹³ National Statistics, UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2016. Note that figures do not total.

¹⁴ Worcestershire Climate Change Strategy 2012-2020

¹⁵ Office for National Statistics (October 2017) UK environmental accounts: Estimates of oil and gas reserves, energy consumption, atmospheric emissions and material flows.

Recent statistics show that, behind 'iron and steel', the UK's industrial sub-sector with the largest year-on-year decrease in energy consumption was 'mineral products', which reduced consumption by 3.7% between 2016 and 2017¹⁶. Nevertheless, the scale of energy use means that opportunities to secure further reductions should be explored. Energy demands differ significantly depending on the material in question. Figure 3.1 illustrates the proportion of energy consumed during the winning and processing of different types of aggregates.

Figure 3.1. Energy consumption by product (aggregates)



Source: Carbon Trust (2011) *Aggregate Energy Consumption Guide: Summary Report*
 Note: percentage of whole aggregates sector based on 2009 data.

3.8. Research by the Carbon Trust¹⁷ looks at energy consumption across a variety of quarries and mineral workings at different scales. This research indicated that economies of scale can be beneficial for energy performance, but also found that some small sites had achieved energy performance levels which matched the larger ones, demonstrating the potential for small sites to become very efficient.

The research considered the energy consumption and CO₂ savings that could be made could be made across the sector if all sites operated to good practice benchmark benchmark standards¹⁸. This is summarised in

¹⁶ Department for Business, Energy & Industrial Strategy (July 2018) *Energy consumption in the UK 2018*

¹⁷ Carbon Trust (2011) *Aggregate Energy Consumption Guide: Summary Report*

¹⁸ The good practice benchmark is set as the upper quartile of performance. In other words, the energy consumption level that only 25% of sites are better than.

3.9. Table 1 overleaf.

Table 1. Average and good practice CO₂ emissions and energy consumption¹⁹ by sector: Potential savings

Sector	Production (million tonnes)	Average CO ₂ emissions per tonne (kgCO ₂ /t)	Average Energy consumption per tonne (kWh/t)	Good practice benchmark consumption per tonne (kWh/t)	Potential energy saving across sector	Carbon saving across sector if achieved (t CO ₂)
Crushed rock	105.5	4.6	14.2	10.6	17%	27,000
Sand and Gravel	46	4.0	11.7	8.4	27%	24,000
Asphalt	20.5	34.9	117.6	102.6	10%	40,500
Ready-mix Concrete	34.2	0.95	1.9	1.1	46%	8,800

Source: Collated from information in Carbon Trust (2011) Aggregate Energy Consumption Guide: Summary Report

3.10. The findings suggest that energy efficiency improvements to meet good practice levels could deliver an 8.4% reduction in energy consumption across the sector, with potential for greater savings if all sites had energy performance levels equivalent to the sector leaders. Across the industry there are examples of such improvements being achieved, with Tarmac seeing a 23.5% reduction in CO₂ per tonne of product since 1990 and setting a milestone to achieve a 37% reduction in CO₂ per tonne of product by 2020 compared to 1990 levels²⁰, and Wienerberger aiming for a 20% reduction in specific energy consumption for brick and tile and plastic pipes by 2020 compared to 2010²¹.

3.11. Energy reductions can be achieved through simple measures such as maintaining equipment or turning it off when it is not in use, each of which can reduce energy demand by up to 10%²². It may also be appropriate to consider how greater energy efficiency can be achieved through adapting processes, procedure and plant. The Waresley brick works in Worcestershire has improved energy efficiency by using the excess heat produced during the firing of bricks to dry bricks before they are fired. This process previously used heat from other sources.

Conclusions and recommendations for the Minerals Local Plan

3.12. There is potential to reduce energy demand across different parts of the aggregates sector by 10%-46% if all sites operated at current levels of 'good practice'. Local evidence suggests that energy efficiency improvements can also be delivered in the industrial minerals sector. As not all sites are currently delivering good practice levels of energy efficiency, the promotion of energy efficiency through the Minerals Local Plan could add impetus to improvements to significantly reduce CO₂ emissions, contributing towards climate change mitigation in Worcestershire.

¹⁹ Specific Energy Consumption: Energy used per unit of production.

²⁰ <http://sustainability-report-2016.tarmac.com/planet/climate-change/index.html>

²¹ <http://sustainabilityreport17.wienerberger.com/>

²² <http://www.aggregatescarbonreduction.com/resources.html> "A well-oiled machine" and "switch it off"

3.13. Any policy framework would need to be considered carefully. The evidence suggests that the potential to improve energy efficiency differs considerably according to the mineral being worked and the scale of the operation. More research is needed into the effectiveness and viability of measures and it is likely that a prescriptive policy framework in this area would date quickly; for the Minerals Local Plan a less prescriptive approach appears to be more suitable.

Use of renewable and low carbon energy

3.14. The minerals sector is a significant energy consumer, with the minerals industry accounting for 10% of all industrial energy consumption in 2011²³. The energy mix used in mineral extraction and processing differs considerably from other sectors of the economy. Of the energy consumed in the aggregates sector in 2009 approximately 18% was electricity, 7% natural gas, 75% gas or processed fuel oils and less than 1% was from biofuel or other sources²⁴. This compares to approximately 30% electricity and 40% natural gas in UK industry in general²⁵.

3.15. However there is significant variation across the sector, for example in 2007 20% of energy used in the quarrying of stone for construction was from electricity compared to 46% of that used in the operation of sand and gravel pits²⁶ and for the processing of Clays and Kaolin 37% of the fuel used was natural gas, compared to 16% or less for other mineral operations.

3.16. As the minerals sector is a significant consumer of energy, shifting towards the use of low-carbon energy sources could result in significant reductions in climate change emissions. There is evidence of some operations in Worcestershire already using low-carbon sources, with the brick works at Waresley getting 80% of its requirement for electricity from generators fuelled by landfill gas at the adjacent landfill site²⁷. Worldwide, Lafarge derived 12% of total fuel use in 2010 from alternative fuels such as waste or biomass and Cemex have also shifted from 0.8% alternative fuels in 2001 to 24.7% in 2011.

3.17. At present this shift is largely driven by the UK Carbon Reduction Commitment energy efficiency scheme which covers all organisations that use more than 6,000MWh per year of energy. There is scope to support this further through the Minerals Local Plan; however care would need to be taken not to duplicate existing regimes. In addition any provision made in the Minerals Local Plan would need to be flexible. Given the significant variations in energy consumption and energy mix across different activities prescribing specific measures in the Local Plan, such as the increased use of low-carbon or de-centralised electricity or of bio fuels would be difficult to implement and unlikely to be as effective in reducing emissions.

²³ <http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx>

²⁴ Carbon Trust (2011) Aggregate Energy Consumption Guide: Summary Report.

²⁵ <http://www.decc.gov.uk/assets/decc/11/stats/publications/energy-consumption/2327-factsheet-industrial-energy-consumption.pdf>

²⁶ <http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx> (note that these figures do not include the consideration of gas or processed fuel oils).

²⁷ <https://wienerberger.co.uk/about-us/sustainability-at-our-factories>

Conclusions and recommendations for the Minerals Local Plan

The minerals sector is a significant energy consumer, and any shift to more efficient use of energy or to generation from renewable or low-carbon sources could have a substantial impact on greenhouse gas emissions. Locally the shift to low-carbon/renewable energy use in new development is required by 'percentage' targets in some local plan policies. However the energy mix in the minerals sector differs significantly from domestic or general industrial processes and this approach is unlikely to be suitable in all circumstances. The role of the Mineral Local Plan in promoting this shift will therefore have to be balanced carefully.

Generation of renewable and low carbon energy

- 3.18. Renewable energy can contribute to both the mitigation of, and adaptation to climate change by reducing emissions that cause climate change and by providing a more secure means of supply²⁸. Renewable energy schemes can take many forms and be of a variety of scales.
- 3.19. The potential for renewable energy generation will vary by location, but there may be opportunities to incorporate renewable energy generation schemes into the working phases of a minerals site or as part of the restoration scheme. Opportunities might include geothermal, hydrothermal, hydroelectric, solar photovoltaic, or wind turbines.
- 3.20. In many cases mineral workings are short-term operations that take place in confined areas and involve only temporary buildings. In these instances the potential for energy generation may be limited to roof-mounted photovoltaic panels or similar. Other operations, such as brick works, may be longer term, with the NPPF requiring brick clay reserves of at least 25 years to support investment required for new or existing plant, and the maintenance and improvement of existing plant and equipment²⁹. In these circumstances the potential for renewable energy generation would be similar to that in any other industrial development.
- 3.21. The NPPF makes it clear that small-scale renewable or low carbon energy projects can provide a valuable contribution to cutting greenhouse gas emissions and that applicants for energy development should not be required to demonstrate the overall need for renewable or low carbon energy. Some small-scale schemes may be considered an ancillary part of a minerals working or restoration scheme, but in some cases separate planning permission might be required from the relevant district, city or borough council. In all cases permission would need to be in accordance with the provisions of the development plan as a whole.

Conclusions and recommendations for the Minerals Local Plan

- 3.22. Market evidence suggests there is significant potential for energy generation on some sites, with the potential for on-site generation depending on the size, location and anticipated life of workings. Renewable energy generation has not traditionally been a key consideration on many

²⁸ Worcestershire County Council, 2009, "Planning for Renewable Energy in Worcestershire".

²⁹ Ministry of Housing, Communities and Local Government (2018) *National Planning Policy Framework*, paragraph 208

minerals sites due to their temporary nature. However, as energy generation through small-scale measures, such as roof-mounted photovoltaics, becomes more viable, there is potential for the Minerals Local Plan to promote such measures.

- 3.23. There is greater potential for renewable energy generation where operations will be in place long enough to make grid connections for energy export viable. However the role the Minerals Local Plan can play in this may be limited, with such schemes likely to require planning permission from the relevant city, borough or district council.

Reducing transport impacts

- 3.24. One approach to reducing climate change emissions from transport is to encourage a modal shift away from road transport. National data suggests that road transport was the principal mode of transport for aggregates in 2014, accounting for 90.0 % of all aggregates moved, with rail transport accounting for 9.7%, and shipment by water 0.3%. The comparable proportions for 2009 were 88.5%, 11.0% and 0.6%, respectively³⁰.
- 3.25. At present there are no rail connections to mineral sites in the county. The Minerals Local Plan could encourage this form of transport, but developing new railheads would require significant investment and it is likely that only a large site with a long timescale, supplying more than a local market, would be able to justify the level of investment required³¹. There is, however, some potential for transport of minerals by water, as many of the sand and gravel deposits in the county are found along river valleys.
- 3.26. One operator in Worcestershire currently transports aggregates by river barge. The barge has a 350 tonne capacity and is used to transport sand and gravel two miles along the River Severn from the quarry in Ripple to processing plant at Ryall. In the recent past barges were also used to transport processed aggregates 14 miles along the River Severn to a ready-mixed concrete plant at Gloucester. Reductions in carbon emissions from moving minerals by water rather than road are substantial, as one barge can carry as much as 18 lorries and will run for a year on the fuel used by a lorry in a week³². These water movements were, however, only made possible by a Department for Transport freight facilities grant towards wharves and access roads³³ and financial viability could be a significant issue for future schemes in the county.
- 3.27. In addition to concerns over viability, the distribution of the market is also a limiting factor to water or rail transport. The majority of aggregates and

³⁰ National Statistics/Office of Rail and Road (7 June 2018) *Freight Rail Usage 2017-18 Q4 Statistical Release*. Figures relate to "the distribution of aggregate sales (for the majority of the journey) from quarries and wharves.

³¹ Network Rail's response to the First Draft Submission consultation on the Waste Core Strategy (reference WR25-4) stated that "Rail generally handles trainloads conveying up to 1000 tonnes payload and even on a weekly train basis a terminal/waste transfer station would need to have throughput of 52,000 tonnes a year".

³² <http://www.mineralproducts.org/sustainability/case-studies.html#resource>

³³ <http://www.mineralproducts.org/sustainability/case-studies.html#resource>

bricks are used at tens of thousands of construction sites dispersed across the UK, meaning that road will always be the main mode of delivery.³⁴

- 3.28. An alternative approach to reducing the climate change impacts of transport is to consider proximity to the market. The Minerals Local Plan could contribute toward this by enabling a network of local sites to serve the development needs of the county. There would inevitably be some limitations to this approach - not all minerals required for Worcestershire's needs are found in the county, and the market for some products (such as bricks) is national - but there could be significant gains if transport distances were reduced.

Conclusions and recommendations for the Minerals Local Plan

- 3.29. There is some potential for a reduction in climate change emissions from mineral workings through transporting minerals by water or rail rather than road, however this is likely to be limited. The Minerals Local Plan has greater potential to influence the proximity of workings to local markets, although this in itself will be limited by geology. Proximity to areas of future development could be one option considered in developing the spatial strategy for minerals extraction in the county.

Other emissions from the processing of minerals

- 3.30. Not all of the climate change emissions from the minerals industry are from energy consumption. As an example, 60% of the climate change emissions from cement manufacture come from the chemical reaction of heating calcium carbonate³⁵, a fundamental part of the process which cannot be 'engineered-out' of cement manufacture. It is therefore likely that the development of carbon capture and storage technology will be necessary in the longer term to reduce these emissions³⁶.

Conclusions and recommendations for the Minerals Local Plan

- 3.31. Although cement manufacture does not take place in Worcestershire the issues may still be of relevance to the Minerals Local Plan as cement is one of the components of concrete and concrete batching plants may be addressed through its policies. It is unlikely that the Minerals Local Plan can have significant influence over the reduction of emissions from these processes or the mitigation of their impacts.

The 'whole life' of mineral products

- 3.32. In addition to considering the impact of mineral extraction, processing and transportation, it is also important to consider the whole life cycle of a product. Aggregates, brick clay and cement are all used in construction, and buildings account for around 40% of final energy used globally.
- 3.33. Construction materials themselves can also have an impact on the energy consumption of buildings when they are occupied.

³⁴ <http://www.mineralproducts.org/sustainability/transport.html>

³⁵ <http://www.mineralproducts.org/sustainability/carbon-management.html>

³⁶ <http://www.mineralproducts.org/sustainability/carbon-management.html>

Conclusions and recommendations for the Minerals Local Plan

3.34. Although building design is not something that can be significantly influenced through the Minerals Local Plan it is useful to consider the industry in context.

Impact of different land uses

3.35. Traditionally some kinds of mineral workings have been restored by using landfill to fill the void created by extraction. The landfill of biodegradable or non-inert waste results in significant greenhouse gas emissions, with landfill estimated to be responsible for about 40% of all UK methane emissions and 2.5% of CO₂ emissions.

3.36. Restoration using landfill is now becoming less common due to the EU Waste Framework Directive which promotes the reduction, re-use and recycling of waste and considers landfill and disposal to be a last resort. Policy measures such as landfill tax which are implementing this directive are making landfill more expensive. At the same time, an increase in recycling is reducing the availability of material. In Worcestershire restoration by landfill will only be in accordance with the development plan in limited circumstances, as set out in Policy WCS5 of the Waste Core Strategy Local Plan:

- “a) Planning permission will not be granted for the landfill or disposal of waste except where it is demonstrated that:
- i. re-use, recycling, or energy or resource recovery are not practicable for the waste type to be managed and no landfill or disposal capacity exists in the county for that type of waste; or
 - ii. there will be a shortfall in landfill or disposal capacity necessary to achieve the aims and purpose of the strategy; or
 - iii. the proposal is essential for operational or safety reasons or is the most appropriate option.

3.37. This means that most mineral workings in the county will be restored using other methods and for other ends such as:

- **Habitat creation:** The impacts of any such restorations on Climate Change mitigation could be positive. Green spaces can benefit carbon storage. Vegetation absorbs CO₂ from the atmosphere. The more vegetation there is the more CO₂ will be taken up³⁷. Woodlands planted since 1990 have the potential to abate 10% of the UK's total greenhouse gas emissions by 2050³⁸ and grasslands can contribute to abatement through the roots helping to sequester carbon in soils. There has been increasing recognition of the importance of green space in the absorption of pollutants produced in the industrial sector

³⁷ Imperial College London, (2012) News item of 22 March 2012, 'Plants may absorb more carbon dioxide than previously thought', available at http://www3.imperial.ac.uk/newsandeventspggrp/imperialcollege/newssummary/news_22-3-2012-17-45-48

³⁸ 15MtCO₂ per year. 10% of UK emissions if current emission reduction targets are achieved: <http://www.forestry.gov.uk/forestry/infd-8m6hg9>

and transport systems in urban environments³⁹. The removal of air pollutants such as ozone, CO₂ and particulates can benefit people's health. Ground level concentrations of ozone are a particular problem during hotter weather due to the action of sunlight on the pollution. Ozone concentrations are likely to be higher on hot, sunny days. This means that with more frequent hotter days expected as the climate changes, the impact of ozone on respiratory illness will become more prevalent.

- **Agriculture:** Agriculture is responsible for 9% of the UK's greenhouse gases. Any impacts on climate change emissions will depend on what is farmed on the restored land and how it is managed. In England, nitrous oxide from the use of synthetic and organic fertilisers in soil nutrient management practices is the most significant agricultural greenhouse gas (61%). Around a third of emissions from agriculture are methane from the ruminant digestion processes in livestock animals and the production and use of manure and slurry. Less than 10% of emissions from agriculture are carbon dioxide from energy used for fuel and heating.⁴⁰

The Lawson review recommended the following objectives for England's ecological network:

- To restore species and habitats appropriate to England's physical and geographical context to levels that are sustainable in a changing climate, and enhanced in comparison with those in 2000.
- To restore and secure the long-term sustainability of the ecological and physical processes that underpin the way ecosystems work, thereby enhancing the capacity of our natural environment to provide ecosystem services such as clean water, climate regulation and crop pollination, as well as providing habitats for wildlife.
- To provide accessible natural environments rich in wildlife for people to enjoy and experience.

Incorporating Green Infrastructure (GI) into agricultural restoration schemes could provide benefits to agriculture, horticulture and wider food production whilst protecting and enhancing the natural environment. In the wider sense, GI supports well-functioning ecosystem services, such as clean water and soils, which are essential to growing foods and breeding healthy animals. For example, planting trees on the edge of a field can prevent pollutant run-off to watercourses and ensure long-term clean water provision. GI solutions are multifunctional; the same trees could perform a natural flood management role to prevent the area from flooding and will absorb carbon dioxide emissions throughout their life.

Agricultural and horticultural businesses could face damaging water shortages in the coming decades as a result of climate change and minerals restoration could provide an opportunity to incorporate water storage facilities to provide water supply for agricultural businesses in

³⁹ Forestry Commission (2012) <http://www.forestry.gov.uk/fr/URGC-7EDHQH>

⁴⁰ Defra (November 2012) *Review of Progress in Reducing Greenhouse Gas Emissions from English Agriculture*

dry periods alongside a wide range of green infrastructure benefits such as for biodiversity or landscape.

- **Access and recreation:** climate change is likely to create opportunities for increased outdoor activities from higher temperatures⁴¹ and an increased number of tourists could increase pressure on traditional tourist destinations in the county as well as on other services such as transport infrastructure and water resources. Many former minerals sites incorporate public access as part of their restoration and this could help to alleviate visitor pressure on established sites by providing alternative destinations, as well as providing the benefits of green spaces referred to above under "habitat creation" and "agriculture".
The Minerals Products Association has launched a "National Nature Park" map to highlight where restoration schemes have successfully integrated biodiversity gain and public access and recreation⁴². Restoration schemes which provide attractive and accessible green infrastructure can be a potential attractor for visitors contributing to the tourism sector as well as providing access to the natural environment for local residents.
Increased recreation, in conjunction with summer drought and high temperatures, could lead to an increase in wild fires. In itself this can be a source of very harmful emissions but there are also risks to agriculture, forestry, wildlife and heritage from changes in frequency and/or magnitude of extreme weather and wildfire events⁴³.
- **Built development:** Any impacts will depend on the nature of any particular built development. Some small-scale schemes may be considered an ancillary part of a minerals working or restoration scheme, but in most cases any larger schemes would require separate planning permission from the relevant district, city or borough council.

Conclusions and recommendations for the Minerals Local Plan

3.38. Traditionally some kinds of mineral workings have been restored by using landfill to fill the voids created by extraction. This is unlikely to be the case for the majority of minerals sites in the future in Worcestershire and the Minerals Local Plan will be able to influence the type of restoration and subsequent land-use of the restored site. The types of emissions and climate change impacts of each type of restoration scheme and land use will vary, but there are clear advantages from incorporating green space or Green Infrastructure elements into all types of restoration schemes to reduce greenhouse gas emissions and mitigate climate change. The Minerals Local Plan could consider how these elements could be encouraged in all restoration schemes.

⁴¹ Committee on Climate Change (2017) *UK Climate Change Risk Assessment 2017 Evidence Report, People & the built environment*

⁴² http://www.mineralproducts.org/nature_map.htm

⁴³ Committee on Climate Change (2017) *UK Climate Change Risk Assessment 2017 Evidence Report, Natural environment and assets*

4. Planning for and adapting to the impacts of climate change

- 4.1. It is recognised that some of the impacts of climate change are now inevitable. The Climate Change Strategy for Worcestershire⁴⁴ makes it clear that new developments need to be planned in a way that takes full account of adaptation measures. The natural environment is also vulnerable to the impacts of climate change, so realistic measures need to be taken to protect the natural environment and increase its resilience to change.
- 4.2. In Worcestershire high summer temperatures are expected to become more frequent and very cold winters are expected to be increasingly rare. The following changes in climate are likely to occur in Worcestershire by the 2080s:
- Annual mean temperature is likely to increase by 2.5°C - 4.1°C
 - Winter precipitation is likely to increase by 21%-23% but summer precipitation may decrease by 29%-50%. Greater rainfall intensity and more rain on heavy rainfall days is expected.
 - Summer cloud cover is predicted to decrease by 9%-15%
 - Winter wind speeds may increase by 4%-6%
 - Annual relative humidity may decrease by 3%-7%, with the largest decrease in the summer.

Over half of the severe weather events that occurred in Worcestershire between 1997 and 2007 were associated with flooding/heavy rainfall, with the second most common being those related to heat⁴⁵. The dominant geology of the county is clay, which has a fairly low absorption capacity of water, increasing the likelihood of flooding incidences. If clay soils dry out in hot weather this increases the risk of subsidence⁴⁶.

Flooding: Managing flood risk impacts on mineral workings

- 4.3. Flood risk needs to be considered when planning new development to avoid flood risk at the development site or increasing flood risk elsewhere. The NPPF sets out the flooding issues that should be taken into account when planning the location of new development, namely through the application of the sequential test and, if necessary, the exception tests, and the safeguarding of land that is required for current and future flood management. It also requires local planning authorities to use opportunities offered by new development to reduce the causes and impacts of flooding.
- 4.4. The technical guidance on the NPPF identifies sand and gravel workings as *water-compatible* development and other minerals and working processes as *less vulnerable*. This means that flood zones 1-3a are suitable for all mineral working and flood zone 3b (the functioning flood plain) is suitable for sand and gravel working.

⁴⁴ Worcestershire Climate Change Strategy 2012-2020

⁴⁵ Worcestershire County Council, *Planning for Climate Change in Worcestershire: Technical Research Paper*. 2008.

⁴⁶ Worcestershire County Council, *Planning for Climate Change in Worcestershire: Technical Research Paper*. 2008.

- 4.5. Although these land uses are considered to be either water compatible or less vulnerable to flooding, flood risk still needs to be taken into account in the design of operations. The technical guidance on the NPPF promotes the use of resilient construction with buildings that are designed to reduce the consequences of flooding and to facilitate recovery from the effects of flooding more quickly than conventional methods. This can include the use of water-resistant materials. Provision needs to be made to ensure risks are considered on sites that are likely to flood. On minerals sites this is also likely to encompass measures such as ensuring that plant and equipment can either be moved out of areas of risk or are secure, resilient and do not pose a risk during flood events. It may also be appropriate to consider flooding during the engineering or phasing of an extraction to ensure that there is no risk of the workforce being cut off by rising water.
- 4.6. With regard to restoration, waste disposal is usually considered unacceptable in the functional floodplain. This means that using inert fill to return land to previous levels in the floodplain is usually not an option.

Conclusions and recommendations for the Minerals Local Plan

- 4.7. The Minerals Local Plan will be able to influence the management of flood risk on and from mineral working. Sand and gravel workings are identified as *water-compatible* development which is suitable in all flood zones (including the functional flood plain) and other minerals and working processes are identified as *less vulnerable* development which is suitable in flood zones 1-3a. Flooding and water management issues will be considered through a separate background document that will be made available at <http://www.worcestershire.gov.uk/minerals> once finalised. The Minerals Local Plan could address these issues through considering how flood zones could be affected both in developing the spatial strategy for minerals extraction in the county and through the policy framework.

Flooding: Reducing the causes and impacts of flooding

- 4.8. Where mineral extraction sites are situated in floodplains there are many restoration options which have the potential to provide flood benefit. This could include flood storage reservoirs, restoring channels to reinstate more natural fluvial-floodplain processes or providing more sinuous and wider channels and greater flow variability. Any mineral extraction that provides additional channel conveyance, flood storage or increased channel length, should have a net downstream benefit on flood risk.
- 4.9. The most appropriate approach will vary according to site-specific circumstances and local priorities. In some cases flood risk reduction may be strategically important and a restoration design which maximises reduction of flood risk would be most suitable. This might involve detailed hydraulic design and engineered structures. In other circumstances, improving freshwater biodiversity may be more important and a mineral extraction site and restoration could facilitate this by providing a river

restoration scheme which promotes natural fluvial and floodplain processes, improving habitat variability and providing additional flood storage.⁴⁷

Flood storage reservoirs

- 4.10. Flood risk cannot realistically be managed by simply building ever bigger, harder defences. Softer approaches, such as flood storage and land management, can offer more sustainable ways of managing risk⁴⁸. The use of quarry voids within or adjacent to the flood plain is one of the softer approaches which can be used. This approach would be in line with the Flood and Water Management Act 2010 which emphasises the need for an integrated approach to flood storage through the innovative use of third party assets.
- 4.11. Low-level flood water storage options such as quarry voids are attractive for a number of reasons. Unlike hard engineering and above-ground flood retention reservoirs they don't restrict flood flows on the floodplain or have the risk of embankment failure.⁴⁹ Embankments of above-ground flood retention reservoirs are particularly susceptible to failure on sand and gravel floodplains,⁵⁰ which makes the use of sand and gravel voids particularly attractive.
- 4.12. In addition to improving flood resilience, flood storage reservoirs can also improve water quality. They slow the flow of water, allowing sedimentation to occur. As most pollution is run-off attached to sediment particles, the removal of sediment results in a significant reduction in pollutant loads.⁵¹ The removal of sediments can be through sedimentation basins and silt traps or through soft options such as wetlands and reed beds. Depending on which options are chosen, certain concerns will need to be addressed, including the potential for local erosion of pit slopes and the consideration of impacts on groundwater quality and groundwater flood risk.⁵²
- 4.13. There must also be mechanisms for returning flood storage reservoirs to pre-flood levels, so they are able to provide the same function for subsequent flooding events. This might be through drains or culverts or it may be possible to connect storage areas to a river via an existing small tributary or agricultural drain. By using an existing natural structure the

⁴⁷ GWP consultants for Mineral Industry Research Organisation (April 2011) *Restoring quarry voids for flood storage - Quantification of flood risk benefit and practical guidance for planning*

⁴⁸ The Pitt Review (June 2008) *Learning lessons from the 2007 floods*

⁴⁹ GWP consultants for Mineral Industry Research Organisation (March 2009) *Quantification of the beneficial effects of quarry voids in reducing flood risk and optimising quarry design criteria for flood risk reduction – a feasibility study*

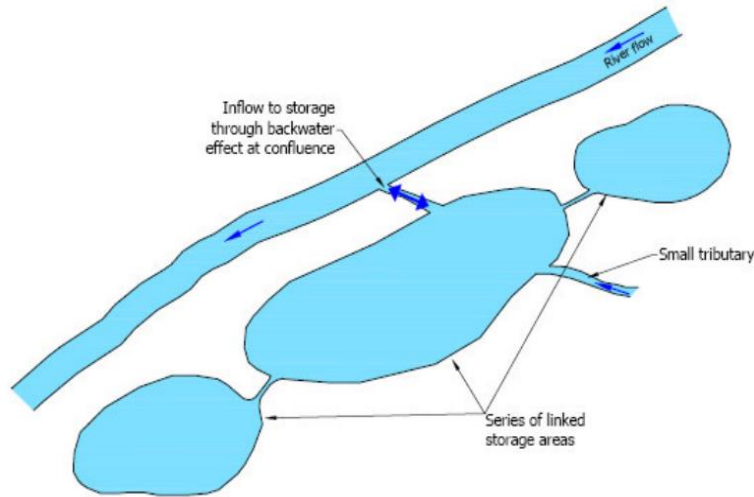
⁵⁰ GWP consultants for Mineral Industry Research Organisation (March 2009) *Quantification of the beneficial effects of quarry voids in reducing flood risk and optimising quarry design criteria for flood risk reduction – a feasibility study*

⁵¹ GWP consultants for Mineral Industry Research Organisation (March 2009) *Quantification of the beneficial effects of quarry voids in reducing flood risk and optimising quarry design criteria for flood risk reduction – a feasibility study*

⁵² GWP consultants for Mineral Industry Research Organisation (March 2009) *Quantification of the beneficial effects of quarry voids in reducing flood risk and optimising quarry design criteria for flood risk reduction – a feasibility study*

connecting channel is likely to be more stable.⁵³ In some cases it may be beneficial to lower the river bank so that water can move to the flood storage reservoirs before flooding the wider flood plain.⁵⁴

Figure 4.1. Example flood storage reservoir linked to water course



Source: **GWP consultants for Mineral Industry Research Organisation** (April 2011) *Restoring quarry voids for flood storage - Quantification of flood risk benefit and practical guidance for planning*

Creation of low-level flood plains

4.14. In addition to creating flood storage reservoirs there is potential for restoration to create a low-level flood plain which can also be used in habitat creation, such as wet woodlands. Figure 4.2 illustrates how a series of small channels and ponds can be provided to improve habitat variability within the restoration, particularly flow variability, which is crucial in providing refuge areas, and for aeration of water. Water can be diverted from the river at a designed and engineered off-take at a given upstream level using a structure or the restoration site can be allowed to flood regularly if sections of the bank are lowered.⁵⁵

4.15. The additional flow area across the composite channel which is created provides increased flow conveyance, but also many backwater and 'no flow' areas which provide storage. Additionally, by planting relatively densely in the floodplain, the 'hydraulic roughness' of the lowered washland is increased which will retard flood flow velocities and attenuate flood peaks.⁵⁶

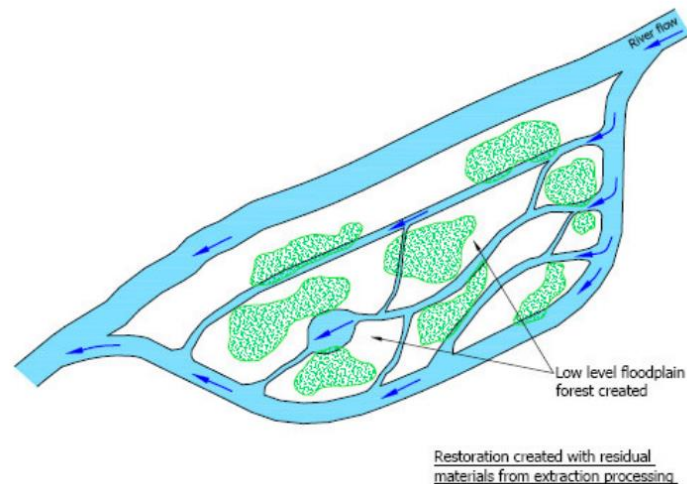
⁵³ GWP consultants for Mineral Industry Research Organisation (April 2011) *Restoring quarry voids for flood storage - Quantification of flood risk benefit and practical guidance for planning*

⁵⁴ GWP consultants for Mineral Industry Research Organisation (April 2011) *Restoring quarry voids for flood storage - Quantification of flood risk benefit and practical guidance for planning*

⁵⁵ GWP consultants for Mineral Industry Research Organisation (April 2011) *Restoring quarry voids for flood storage - Quantification of flood risk benefit and practical guidance for planning*

⁵⁶ GWP consultants for Mineral Industry Research Organisation (April 2011) *Restoring quarry voids for flood storage - Quantification of flood risk benefit and practical guidance for planning*

Figure 4.2. Example washland with flood water storage



Source: **GWP consultants for Mineral Industry Research Organisation** (April 2011) *Restoring quarry voids for flood storage - Quantification of flood risk benefit and practical guidance for planning*

Providing additional channel conveyance

4.16. Another alternative is to provide additional channel conveyance by increasing the channel cross-section or providing a secondary channel, which essentially increases cross-sectional area. This approach can reduce flooding locally but has little benefit downstream, in some cases compounding problems.⁵⁷

Increasing channel length and channel storage

4.17. Channel length can be increased by introducing meanders, and channel storage can be improved by widening the channel or producing braided channels. In some cases this may restore the river's historic course.

⁵⁷ GWP consultants for Mineral Industry Research Organisation (April 2011) *Restoring quarry voids for flood storage - Quantification of flood risk benefit and practical guidance for planning*

Figure 4.3. Example restored meander

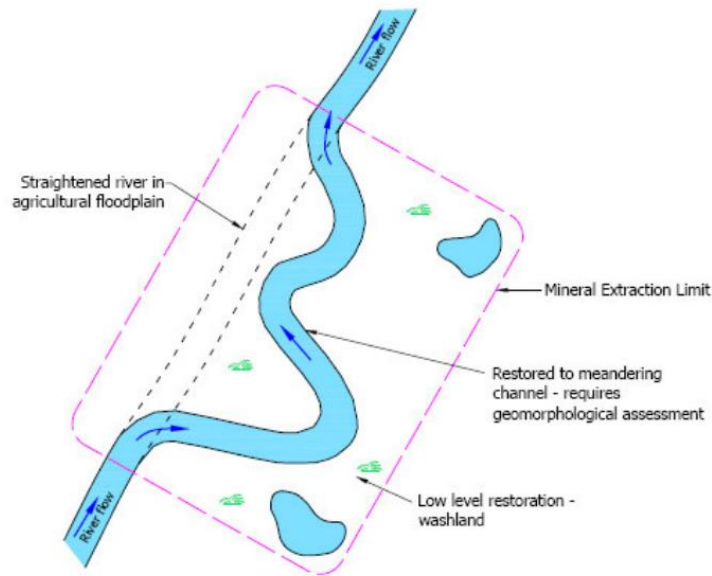
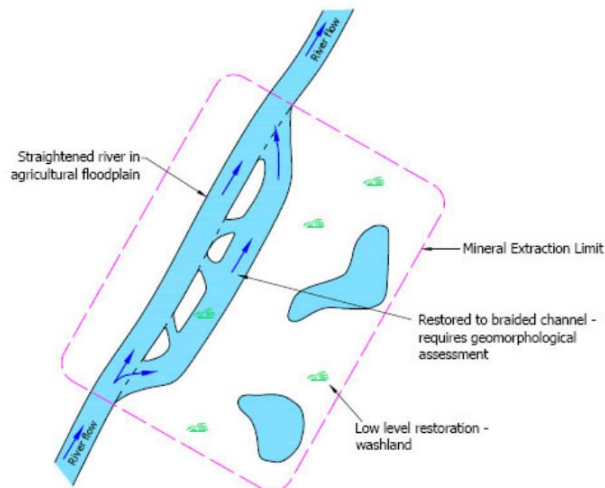


Figure 4.4. Example braided channel



Source: GWP consultants for Mineral Industry Research Organisation (April 2011) *Restoring quarry voids for flood storage - Quantification of flood risk benefit and practical guidance for planning*

- 4.18. These measures would require permission to extract minerals up to and including the river bank. Historically the Environment Agency has required a 10-20m development standoff for most main rivers, however recent cases suggest that this is negotiable where there are clear benefits for the water environment.
- 4.19. British rivers are often devoid of hydraulic and habitat variability due to historic agricultural practises of straightening, deepening and engineering

river channels, primarily for land drainage and agricultural purposes.⁵⁸ Reinstating natural stable river systems would not only increase flood capacity but would also assist in meeting Water Framework Directive goals. Such a concept would not be viable where the river is used for navigation⁵⁹.

Conclusions and recommendations for the Minerals Local Plan

- 4.20. There is significant potential for restored mineral workings in the flood plain to provide flood benefits. The nature of these benefits and schemes used would need to vary on a site-by-site basis dependent on factors such as hydrology and geology. In general softer measures would have greater benefits, particularly where they integrate wider environmental benefits such as water quality improvements and habitat creation.
- 4.21. The Minerals Local Plan could include policies to encourage restoration that provides flood benefit. The challenge for the Minerals Local Plan will be to identify areas where flood restoration for flood benefit would be most appropriate and to provide the right level of guidance and flexibility to ensure that the most appropriate methods can be used.

Water supply and groundwater

- 4.22. Mineral workings can affect water management whilst sites are being worked, including through changes to pollution and drainage patterns, drawing down groundwater or discharging into surface waters. Effects on these issues can also occur after the working phase, depending on the nature of the restoration, through the aftercare and after-use of sites.
- 4.23. Mineral workings can physically disturb aquifers by removing the geological strata which make up the aquifer where groundwater is stored. Mineral workings can also cause problems by draining groundwater from an aquifer, diverting groundwater flows which support the wider environment, or by connecting what were originally separate aquifers. They can also lower groundwater levels, affect groundwater quality or impede or intercept groundwater flow. Mining and quarrying activities often involve dewatering, sometimes for substantial periods of time over the lifetime of the quarry. Such dewatering can lead to the loss of water supply from wells and boreholes, the removal of natural groundwater discharges to ponds and streams and drying or deterioration of wetland ecosystems. All of these may require protection or the loss to be mitigated. The groundwater table may in some cases be permanently lowered, leading to irretrievable reduction or loss of spring and stream flows.
- 4.24. Mineral extraction from aquifers also leaves large void spaces which can have significant effects on reducing not only the quantity of groundwater available but also the quality of water resources. In particular, backfilling voids can have a detrimental effect on the water environment.

⁵⁸ GWP consultants for Mineral Industry Research Organisation (April 2011) *Restoring quarry voids for flood storage - Quantification of flood risk benefit and practical guidance for planning*

⁵⁹ GWP consultants for Mineral Industry Research Organisation (April 2011) *Restoring quarry voids for flood storage - Quantification of flood risk benefit and practical guidance for planning*

4.25. The Minerals Local Plan will need to ensure that adequate monitoring to provide evidence and enforcement over the long lifetime of mineral planning permissions is in place to enable effective resource management, pollution prevention and flood risk reduction. Mineral operations can have far-reaching effects on water catchments that must be investigated and confirmed prior to any grant of planning permission. Site-specific impact boundaries (rather than arbitrarily defined distances) may be a useful way to develop effective risk reduction strategies and mitigation measures.

Conclusions and recommendations for the Minerals Local Plan

4.26. There is significant scope for the Minerals Local Plan to manage the impact of minerals development on water supply and ground water. Policies could be developed to encourage proposals to have regard to these issues from the outset and Hydrogeological Impact Assessments (HIA) exploring the effects of quarry developments on water resources may be one means by which they can be addressed.

Habitat/species resilience

4.27. Climate change has already resulted in a number of changes to England's wild plants and animals. Predictions about future climate suggest that these changes will continue, with potentially catastrophic effects for some species, but benefits for others. On balance, in the longer term more species are likely to be negatively rather than positively affected⁶⁰. The Lawson review highlights the following changes resulting from climate change:

- **Shifts in species' ranges:** All species have a 'climate envelope' within which they can survive and reproduce, outside which they die. As the climate changes, so too climate envelopes will move, and to survive species will need to track these movements.⁶¹ The Forestry Commission, for example, predicts that by 2050 birch - often a staple of reclaimed land - is likely to be unsuitable for planting and that ash will have replaced beech as the most suitable broadleaf species across much of southern England.⁶² The recent appearance of ash die-back disease in southern England, itself a possible consequence of climate change induced species movement, does however underline how difficult it is to make such predictions. Even where the composition of the tree canopy of woodlands remains unchanged, the composition, structure and character of the ground flora may change significantly. There has already been a natural spread of new species such as the tree bumblebee, which has now colonised as far north as Scotland, the ivy bumblebee, which reached north Worcestershire in the summer of 2013, and the small red-eyed damselfly into Britain from continental Europe. However it should be noted that in the long term the distribution of species will not in itself automatically track changes in the climate; many species are poor dispersers, prevented from

⁶⁰ *Making Space for Nature: A review of England's Wildlife Sites and Ecological Network* Chaired by Professor Sir John Lawton CBE FRS

⁶¹ *Making Space for Nature: A review of England's Wildlife Sites and Ecological Network* Chaired by Professor Sir John Lawton CBE FRS

⁶² Forestry Commission: Modelling the impacts of climate change on tree growth - future species suitability

dispersing by hostile barriers in the environment, or other essential components of their environment, needed for food or breeding, fail to keep pace with climate change.⁶³

- **Seasonal events in spring and summer are occurring earlier:** There is evidence of oak trees leafing 3 weeks earlier than 50 years ago, with the flight time of moths and butterflies, egg-laying dates for birds, and first spawning of amphibians also occurring earlier. These effects, however, differ by species and could disrupt crucial links between co-dependent species, such as a mismatch between peak caterpillar abundance and food needs of nesting woodland birds and between flowering times and pollinator emergence.
- **Species habitat preferences are altering:** For example the silver-spotted skipper butterfly has begun to breed in a wider range of grassland.
- **Sea-level rise:** has already led to loss of intertidal habitat.
- **More extreme weather events:** In woodlands, drought has changed the composition of tree species and major storm damage to woodlands may also be increasing in frequency.
- **Changes to ecosystem processes are inevitable:** as average climatic conditions change, and the weather becomes more unpredictable. More summer droughts threaten essential hydrological processes, and this may cause serious disruption and degradation of important wetlands.

4.28. The Lawton Review recommends that to maximise the capacity of our wildlife to cope with climate change we need to establish an ecological network that is as robust and resilient as possible to current conditions.

4.29. The Minerals Local Plan can guide the restoration of mineral workings to provide a unique opportunity to create habitats that are more resilient to climate change and to link existing sites and corridors to aid the dispersal of species.

4.30. The Lawton Review sets out the following principles to underpin action to achieve biodiversity conservation in a changing climate:

- “1. Conserve existing biodiversity
 - 1a. Conserve Protected Areas and other high-quality wildlife habitats
 - 1b. Conserve range and ecological variability of habitats and species
2. Reduce sources of harm not linked to climate change
3. Develop ecologically resilient and varied landscapes
 - 3a. Conserve and enhance local variation within sites and habitats

⁶³ *Making Space for Nature: A review of England's Wildlife Sites and Ecological Network*
Chaired by Professor Sir John Lawton CBE FRS

- 3b. Make space for the natural development of rivers and coasts
- 4. Establish ecological networks through habitat protection, restoration and creation
- 5. Make sound decisions based on analysis
 - 5a. Thoroughly analyse causes of change
 - 5b. Respond to changing conservation priorities
- 6. Integrate adaptation and mitigation measures into conservation management, planning and practice”

4.31. These principles should be considered when developing the approach to restoration in the Minerals Local Plan.

Conclusions and recommendations for the Minerals Local Plan

4.32. The restoration of mineral workings can provide a unique opportunity to create habitats that are more resilient to climate change and to link existing sites and corridors to aid the dispersal of species. The Minerals Local Plan should consider how the principles of "more, bigger, better and joined" proposed as part of the Lawton Review can be implemented through mineral site restoration.