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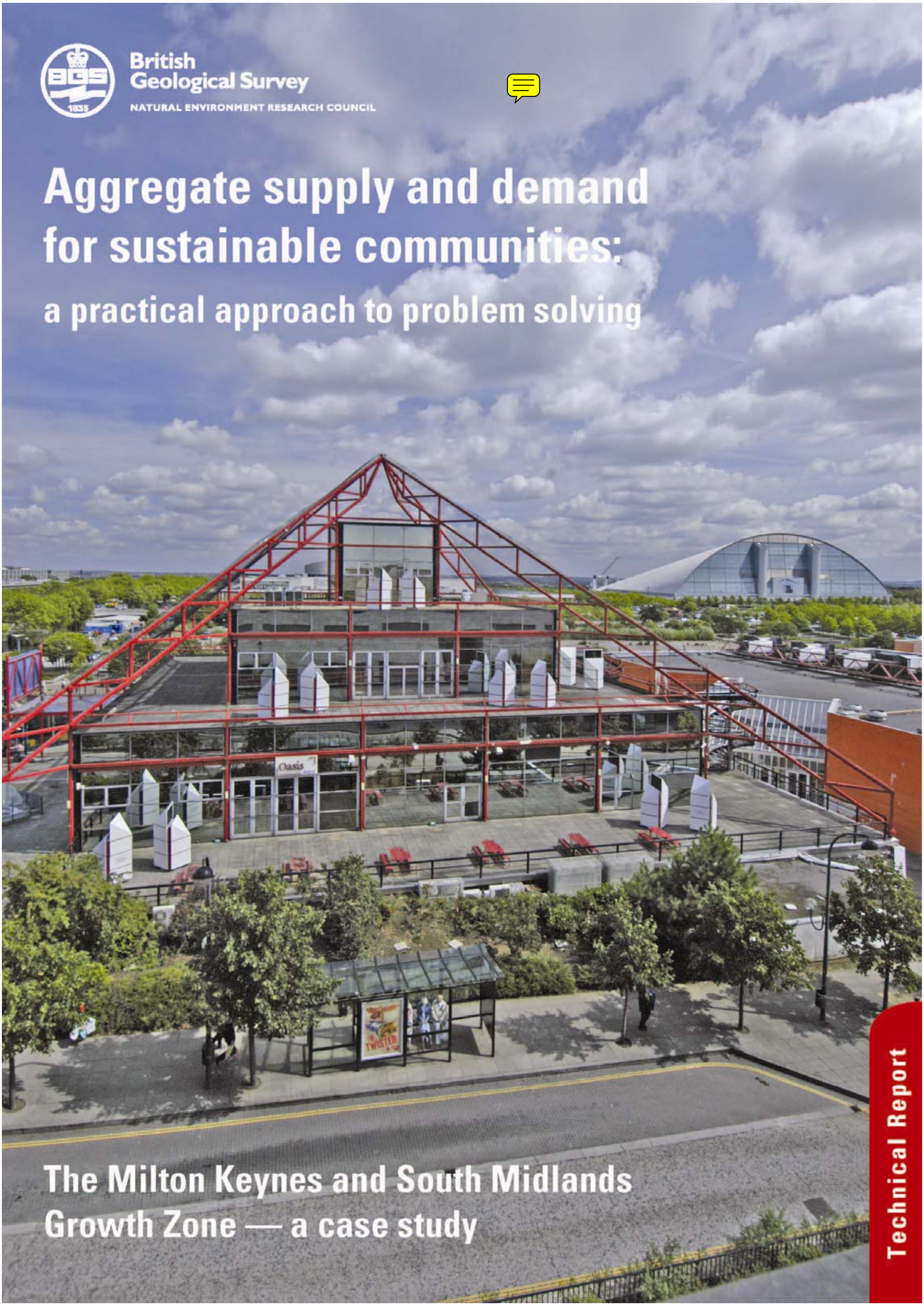
Aggregate supply and demand for sustainable communities:

a practical approach to problem solving



The Milton Keynes and South Midlands Growth Zone — a case study

Technical Report

BRITISH GEOLOGICAL SURVEY

GEOLOGY AND LANDSCAPE SOUTHERN BRITAIN PROGRAMME

COMMISSIONED REPORT CR/07/042N

Aggregate supply and demand for sustainable communities: a practical approach to problem solving.

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Milton Keynes.

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Foreword

This report is the published product of a 30 month study by the British Geological Survey (BGS), the National Stone Centre (NSC) and CG Down Planning Consultants. The project was funded by the Sustainable Land-Won and Marine Dredged Aggregate Minerals Programme (SAMP) established under the Aggregate Levy Sustainability Fund (ALSF). The Mineral Industry Research Organisation (MIRO), on behalf of the Office of Deputy Prime Minister (ODPM), manages this programme. The research falls within the scope of *Theme b -environmental assessment and aggregates.*

A 20 page detailed Executive Summary is available, summarising the results of this technical report.

Acknowledgements

A large number of individuals from local government and industry have contributed to the project. Their assistance has been received at all stages of the study. In addition to the collection of data, many individuals have freely given their advice, and provided the local knowledge so important to this project. Of the many individuals who have contributed to the project we would particularly like to thank the following:

Mr Gareth Jenkins, Ian Farmer Associates, for ensuring the borehole drilling was undertaken in a timely manner with minimal disruption to landowners.

All the landowners who allowed the borehole drilling to take place and who without their cooperation the drilling would not have been possible.

Thanks are due to Mr Andrew Bloodworth, Manager of the BGS Economic Minerals Programme Manager, for reviewing the report.

Finally the authors would like to thank all those who participated during the Project Workshop (January 30th 2007) and who contributed to the revision and development of the work reported here.

Abbreviations

ALSF	Aggregate Levy Sustainability Fund
BGS	British Geological Survey
EERA	East of England Regional Assembly
EERAWP	East England Aggregate Working Party
EMAWP	East Midlands Aggregate Working Party
EMRA	East Midlands Regional Assembly
MIRO	Mineral Industry Research Organisation
MKSMGZ	Milton Keynes South Midlands Growth Zone
NSC	National Stone Centre
ODPM	Office of Deputy Prime Minister
PSA	Particle Size Analysis
SAMP	Sustainable Land-Won and Marine Dredged Aggregate Minerals Programme
SEERA	South East and England Regional Assembly
SEERAWP	South East England Aggregate Working Party
SOBI	Single Onshore Borehole Index
SRA	Sub-Regional Apportionment (of regional guidelines for aggregate provision)

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1 Summary

The Regional Planning Guidance for the South East (RPG9, 2001) first identified the Milton Keynes and South Midlands (MKSM) Growth Zone. The Sustainable Communities Plan, (ODPM, 2003) which addressed the housing shortage in England by promoting a sustainable pattern of development, identified potential for up to 370,000 new homes within the Growth Zone by 2031. The Milton Keynes & South Midlands Sub-Regional Strategy (2005) provides an analysis of areas with potential for development within the Growth Zone, considering factors such as employment, transport links and utilities. This study identifies aggregate resources in, and close to, the MKSM Growth Zone, a fundamental requirement in the development of housing and infrastructure. It includes a detailed analysis of the evolution of minerals planning policies (the first ever undertaken) in the area and an examination of past, present and future demand. The study also demonstrates a method that can be utilised in future Growth Zone studies.

1.1 THE PLANNING CONTEXT

Proposed levels of growth in the MKSM Growth Zone are set to match the peaks of the 1980s. These growth levels are envisaged to persist for at least 16 and up to 26 years. Most sand and gravel producing counties in the Growth Zone are expected to be able to provide for the higher levels of demand. The areas that have no tradition of sand and gravel production, or which currently produce smaller amounts, are nevertheless also subject to significant growth. At the heart of the Growth Zone, Northamptonshire appears unlikely to be able respond to higher levels of aggregate demand.

In addition to addressing planning issues related to aggregate supply, there are options for reducing demand for primary aggregate through sustainable practices such as: using modern methods of production and high housing density; maximising the use of alternative aggregates. Despite these measures, it is unlikely that existing supplies will be sufficient to provide for anticipated demand. Additional action might include encouraging development of non-traditional aggregate resources within the Growth Zone such as glaciofluvial deposits, limestone and ironstone and/or importing more primary aggregate from remote areas.

This study has assessed the aggregate resources in the Growth Zone and makes recommendations based on the findings.

1.2 AGGREGATE RESOURCES

River terrace deposits are the most reliable aggregate resource within the MKSM Growth Zone. Despite intensive extraction of sand and gravel, considerable resources remain within the terraces of the principal rivers, the Nene, Great Ouse and Ivel, although planning considerations may limit continued working. In contrast, the terrace deposits of the upper reaches of the rivers Welland and Avon do not contain significant resources. Interpretation of geological data supported by a small but carefully focussed borehole drilling programme indicates that glaciofluvial deposits in the south of the project in north Buckinghamshire may contain potential resource. However, it is suggested that more research is required to investigate this potential resource further.

1.3 FUTURE PROVISIONS

The study concludes that difficulties may arise where one element of national policy – in this case, establishing 'growth zones' – is pursued without a clear consideration of all the factors (such as the availability of construction minerals, land, water and services) which govern its successful delivery within environmental and sustainability constraints.

The MKSM Growth Zone will be supplied with aggregate minerals, probably through a mix of sources, including local and remote production of newly dug material. What seems unavoidable is that the proportion of aggregate supplied from outside the area will need to increase significantly. This calls into question whether the supply of minerals to the MKSM Growth Zone can be achieved in a truly sustainable fashion.

1.4 RECOMMENDATIONS

1. Aggregate resources in the MKSM Growth Zone are depleted, therefore safeguarding of the remaining local resource will be critical in ensuring the sustainable development of housing and infrastructure into the future. Policies to encourage a critical examination of options for prior extraction if mineral-bearing land is to be developed will be particularly important in the MKSM Growth Zone, where the aggregate resource is in demand but depleted and where there will be intense pressure to develop land. The aggregates footprint of all significant elements within the Growth Zone should be monitored and reported regularly.

2. Further research to investigate the potential resource in the glaciofluvial deposits in the south of the Project Area. The sheets of glaciofluvial sand and gravels near Buckingham are suggested as a focus for investigation using a relatively small and targeting project drilling programme. Some Jurassic limestone formations may provide aggregate of useful quality but further investigation of their properties will be needed.

3. A critical examination of the existing transport infrastructure and the potential to develop this further to provide sustainable transport options for imported aggregate. This should include an analysis of existing rail freight capacity on relevant routes, safeguarding existing rail depots, identifying locations for additional depots and considering novel transport both water transport options and the potential to develop routes to import material from areas not currently serving the MKSM Growth Zone.

2 Introduction

This report describes the results of a 30 month research project entitled '*Aggregate supply and demand for sustainable communities: a practical approach to problem solving*'. The research was carried out by a consortium led by the British Geological Survey (BGS). The other project partners were Ian Thomas of the National Stone Centre (NSC) and Karen Down of C G Down Planning Consultants (CGD). The geological study, management of the drilling programme, analysis of resource in the Project Area, environmental sensitivity analysis and the production and editing of the Technical Report and Executive Summary has been carried out by BGS. The historical, planning and supply/demand analysis has been researched jointly by the NSC and CGD.

The project was funded by the Sustainable Land-Won and Marine Dredged Aggregate Minerals Programme established under the Aggregate Levy Sustainability Fund (ALSF). The Mineral Industry Research Organisation (MIRO), on behalf of the Office of Deputy Prime Minister (ODPM), manages this programme. The research falls within the scope of *Theme b -environmental assessment and aggregates.*

2.1 PROJECT BACKGROUND

The Milton Keynes and South Midlands (MKSM) Growth Zone was first identified by the Regional Planning Guidance for the South East (RPG9, 2001). The Sustainable Communities Plan, published by the former ODPM in 2003, to help address the acute housing shortage in England by promoting a sustainable pattern of development, identified potential for up to 370,000 new homes within the Growth Zone by 2031. The Milton Keynes & South Midlands Sub-Regional Strategy (2005) provides a detailed analysis of areas with potential for development within the Growth Zone and considers factors including employment, transport links and utilities. This study will assess the implications for aggregate supply to support the proposed growth, an important issue that has previously been given little consideration. Many of the issues analysed by this study will be the same as in other designated Growth Zones and it is envisages that this study can be used as a basis for future research in these areas.

The need to address the increasingly difficult aggregates supply situation in the south of the East Midlands has been apparent since the late 1980s but was brought to the fore in the sub-regional apportionment exercise carried out by EMAWP in 2003. Coincident with this process, the Government recommended the development of a major Growth Area centred on Milton Keynes and the South Midlands but it became clear that little consideration had been given to the implications for aggregates supply. In response to the situation this study, which stems from a proposal initiated by the National Stone Centre, was undertaken by a partnership comprising the British Geological Survey, the National Stone Centre and CG Down Consultants.

2.2 THE GROWTH ZONES

The Government's Sustainable Communities Plan (ODPM, 2003) identifies four potential major growth zones in the wider South East in order to meet the requirements of sustainable communities. These are the general area of Milton Keynes and the South Midlands, London-Stansted-Cambridge, Ashford, and the Thames Gateway. The aim of the Sustainable Communities Plan is to create new and expanded communities within these areas. This will involve the building of thousands of new homes along with new and improved infrastructure and regeneration measures. These developments are likely to create an increase in the demand for aggregates but, as yet, no estimates appear to have been made nor have the implications of supply been considered.

The Milton Keynes and South Midlands (MKSM) Sub-Region was chosen as the focus of this project because, in addition to its status as a Growth Area, it encompasses areas in which the supply of aggregates has been a particularly long-standing sustainability issue. However, the methodologies are likely to be highly applicable to other sub-regions. The Milton Keynes and South Midlands Sub-Regional Strategy (EERA, EMRA & SEERA, 2003) includes the administrative areas of Milton Keynes, Northamptonshire and Bedfordshire and Luton (Figure 1). Each of these sub-areas will need to ensure an adequate supply of aggregate in order to fulfil the aims of the sustainable communities plan.

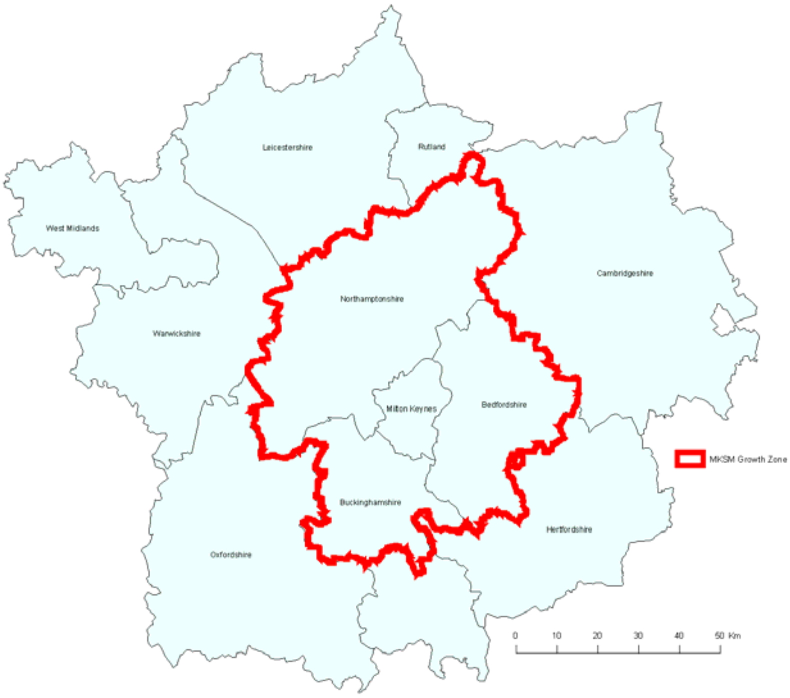


Figure 1 The Milton Keynes South Midlands Growth Zone

2.3 EXISTING SUB-REGIONAL SUPPLY SITUATION

Available evidence suggests that the area designated as the Milton Keynes & South Midlands Growth Zone is part of a larger supply-demand system which embraces much of the Midlands and south England. In general, hard rocks are drawn from the southern Pennines, Midlands and Mendip, whereas sand and gravel is sourced more locally. The hard rock elements are well established and can be relatively easily isolated.

However, the dynamics of sand and gravel supply are more locally based and generally more complex. From a short distance south of the Trent Valley, most of the sand and gravel supply is typified by a combination of sourcing within a 25 mile radius and a series of southward cascading systems as far south as the Thames Valley. The area of particular concern lies in the north half of this zone, i.e. from South Leicestershire to North Bedfordshire/North Buckinghamshire. This includes Northamptonshire, which has an acute shortage of permitted reserves of aggregate and thus poses a challenge for the area to meet its future allocations.

The supply of aggregates in Northamptonshire has been a longstanding issue having been highlighted by the East Midlands Aggregate Working Party (EMAWP) from the 1980s onwards and echoed in a report by the British Geological Survey (Harris, 1993). Typically, the life of Northamptonshire sand and gravel permitted reserves is 2-4 years, well below the original 10 year and more recent 7-year landbank stipulated by Mineral Planning Statement 1 (MPS1). Although the Jurassic oolitic limestone landbank is generally longer, this material is porous and weak and has limited application as an aggregate. A significant proportion of the permitted reserves is also “inherited” from ironstone consents. There have been several assertions made concerning the supply in Northamptonshire.

- There is a policy aim to minimise working in the Nene Valley due to changes in the character of the valley, through extensive sand and gravel extraction, from a floodplain meadow to a wetland.
- Northamptonshire County Council’s response to that situation has been to attempt to direct future sand and gravel extraction to the glacial gravels in the northwest of the county.
- Levels of extraction have not been as great as anticipated. The reasons for this were not clear, although the extent and character of these deposits was poorly known.
- Similarly there was no immediate logic to the almost total absence of workings in the eastern part of the Nene and along most of the Welland Valley.

This study aims to objectively investigate these issues.

2.4 DEFINING THE PROJECT AREA

Whereas the MKSM Growth Zone defines the limits for assessment of demand for aggregates, the area for which supply needs to be considered is larger. It is clear, that certain types of aggregates, particularly for more demanding uses, cannot be met from the immediately surrounding area. In order to contain the study within manageable and robust limits, it was necessary to define two broad zones:

The key “**demand zone**” coincides broadly with the Milton Keynes – South Midlands Growth Zone itself.

The “**supply zone**” assumes that areas essentially to the south of Milton Keynes will draw upon “traditional” local sand and gravel sources e.g. Vale of St Albans, and that flows from hard rock sources will be maintained. However the main resource area to be examined in detail was defined as an area from Milton Keynes running through Northamptonshire into southern Leicestershire. The case against extending the study into neighbouring areas e.g. Warwickshire and Rutland, was determined early in the project. Historically, the supply issue in this area rests with sand and gravel and not crushed rock aggregate. Crushed rock was included in the initial review, but the focus of the project will be on sand and gravel resources. In general crushed rock imports were eliminated from the supply/demand balance at an early stage. Figure 2 shows the limit of the Project Area compared to the MKSM Growth Zone and Figure 3 shows the infrastructure in the Project Area. The Project Area is larger as it includes the supply and demand zones. Figure 4 shows the regional flow patterns for sand and gravel and crushed rock in England and Wales.

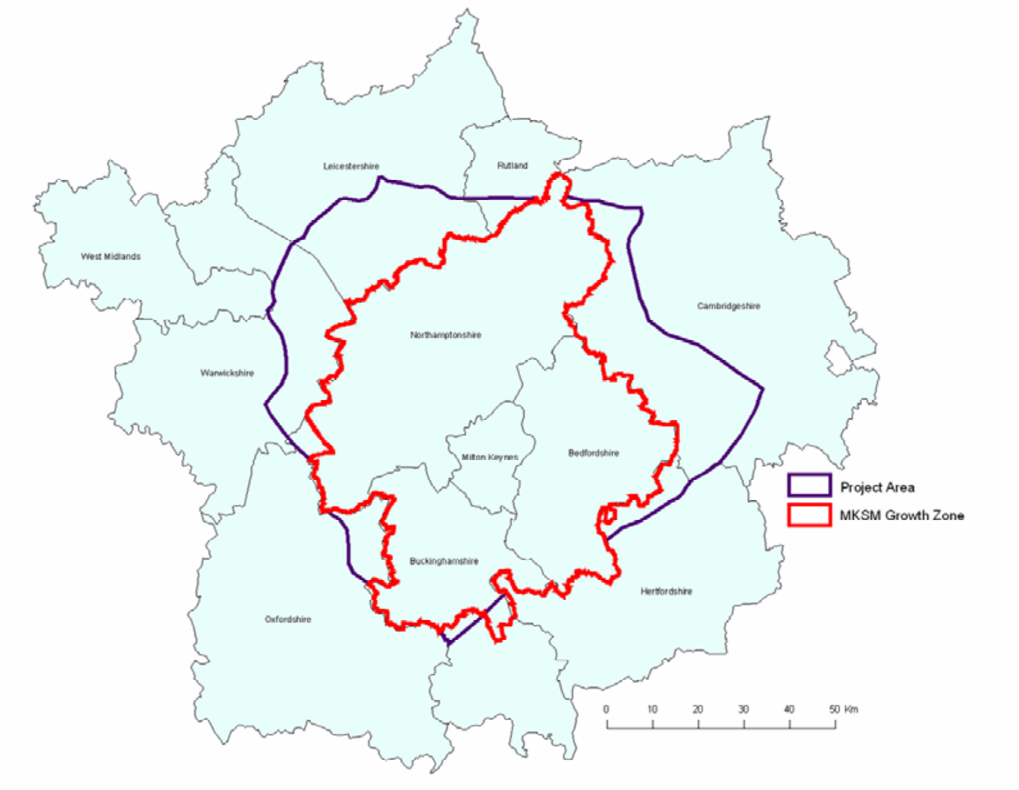


Figure 2 The Project Area compared to the MKSM Growth Zone

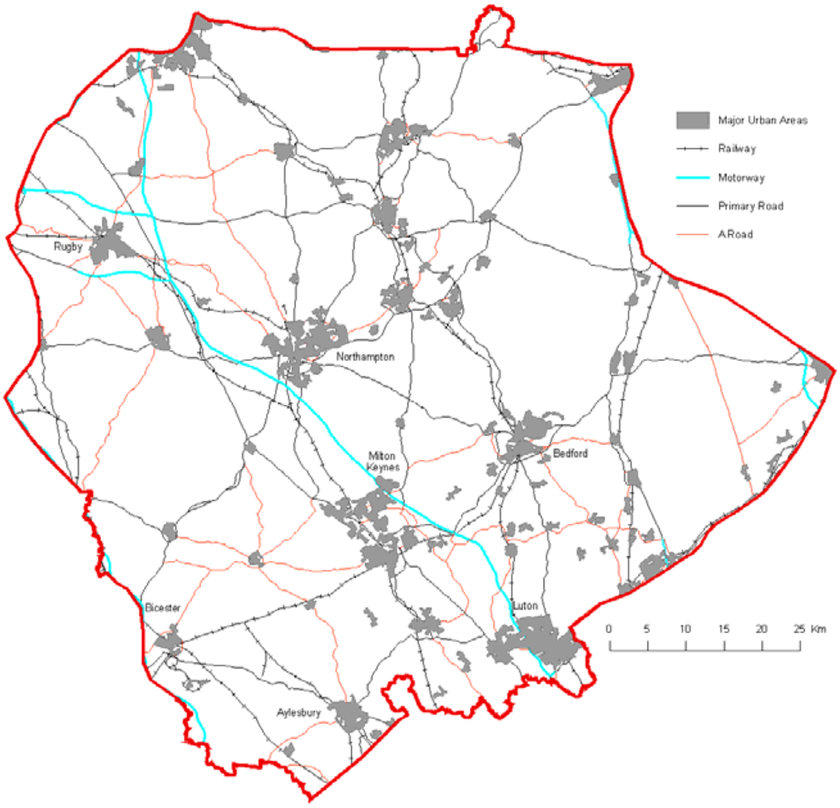


Figure 3 Infrastructure in the Project Area

Both reproduced in Appendix 5 at A3.

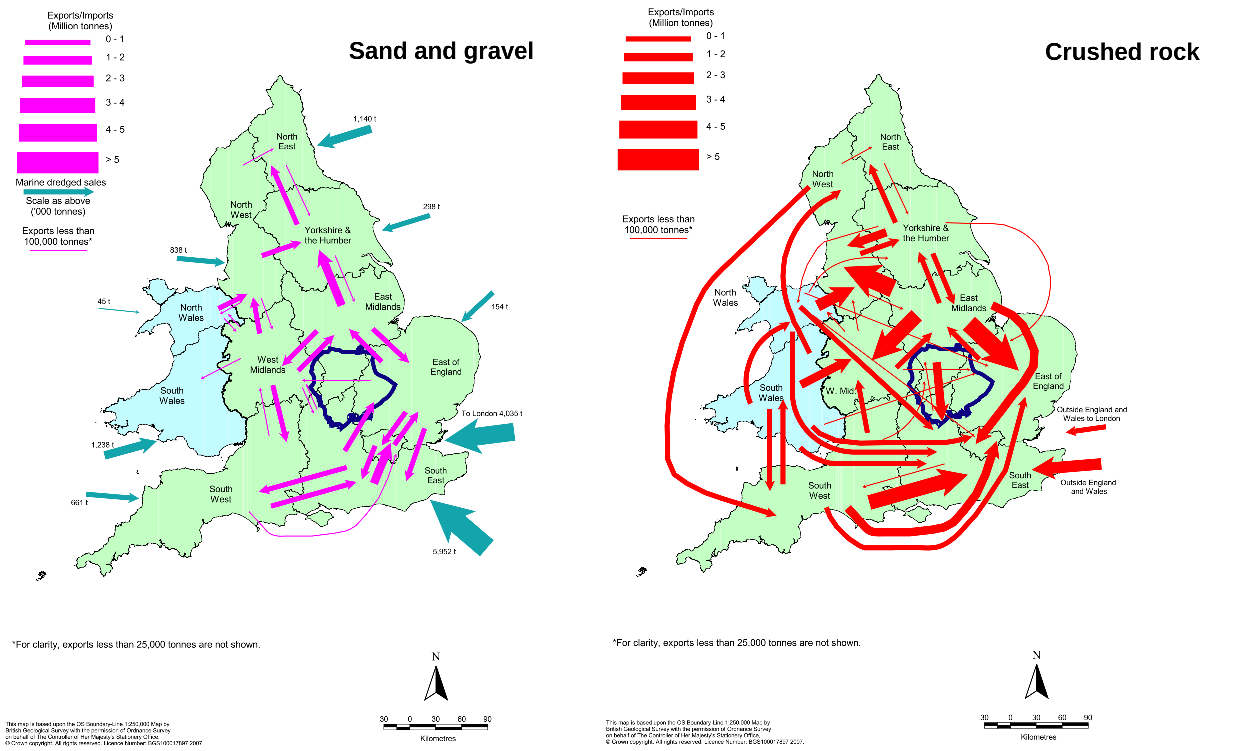


Figure 4 AM 2005 regional flows for sand and gravel and crushed rock exports for England and Wales

Notes 1. Dark blue outline is the Project Area. 2. Source AM 2005 (CLG, 2007)

Reproduced in Appendix 5 at A3.

2.5 METHODOLOGY

The main objective of this project is to assess aggregate resource availability for the MKSM Growth Zone, including a review of aggregate supply and demand and planning issues. Based on this analyse the study aims to determine the aggregate resource implications of the Growth Zone proposals and establish a method for identifying resources to supply sustainable communities in designated growth areas in the future.

The project objectives meets the general aims of the ALSF and the Sustainable Land-Won and Marine Dredged Aggregate Minerals Programme in that it aims to minimise the environmental effects of quarrying through identifying the most sustainable options for aggregate supply. The project aims to provide new and up-to-date information in an accessible format. The project was split into three phases:

Phase 1: A sub regional analysis for supply and demand

This phase included a desk study, data collection and consultation with stakeholders within the Project Area. An important part of the project was the development of a GIS to host the data and to aid analysis. Planning, environmental sensitivity and aggregate resources information was collated and analysed in order to determine the key influences over the distribution of aggregate workings in the Project Area. These included proximity to and scale of markets/demand, a comparison of markets past, present and future, other access factors, availability of other materials, the distribution and knowledge of resources - particularly of quality, quantity, distribution, and land ownership or control.

Research focused on Quaternary sand and gravel resources within the Project Area, however, bedrock aggregate (crushed rock and sand and gravel) resources were also assessed. Phase 1 is covered by the following Chapters within this report;

Chapter 3: Past patterns of supply and demand

Chapter 4: Analysis of planning information

Chapter 5: Building sustainable communities

Chapter 6: Aggregate resources: existing information for the Project Area

Chapter 7: Aggregate resources: updating information and refining knowledge

Phase 2: Borehole drilling programme

Phase 2 continued to focus on sand and gravel resources within the Project Area. This Phase involved a detailed assessment of sand and gravel resources by supplementing existing data with data newly acquired data from a carefully designed programme of borehole drilling and geological interpretation. The objectives for this phase were as follows:

- To carefully target new borehole sites based on a modern understanding of the Quaternary geology gained in phase 1.
- To use the new borehole and particle size data to gain further detailed information on composition, grading, thickness, overburden-mineral ratios and concealed resources.

Phase 2 is covered by:

Chapter 8: Borehole drilling programme

Chapter 9: Assessment of potential aggregate resources in superficial deposits

Phase 3: Synthesis of supply & demand and key drivers

Following the findings of Phases 1 and 2 a more detailed appraisal of the aggregate supply patterns in those areas of the Growth Zone that appeared to face a potential shortage in locally available aggregate supplies was undertaken. In particular past and current supplies to Northamptonshire, Milton Keynes and North Buckinghamshire were examined in the light of findings from the geological drilling programme in order to assess the future potential of the area to contribute towards the supply of sustainable aggregate to these parts of the Growth Zone. The appraisal takes into account the earlier findings that there is likely to be a modest reduction in intensity of use through modern methods of construction and higher density development and assumes that secondary and recycled aggregate contributions to demand will continue at approximately current levels.

Phase 3 is covered by:

Chapter 10: Future resource availability & demand in the Growth Zone.

3 Past patterns of supply and demand

A detailed analysis of past patterns of supply and demand within the MKSM Growth Zone can be found in Appendix 1. The Growth Zone relates to three regions and a number of MPAs, which complicated the analysis and refinement of data on aggregate production, construction, flows of materials and usage. The key findings drawn from this analysis are outlined below.

3.1 GROWTH ZONE PROPOSALS

The development envisaged in the growth zone is substantial. It will place significant and sustained demand on raw materials, including aggregates, in order to achieve this level of growth.

3.2 PAST PATTERNS OF DEVELOPMENT 1940S TO 1990S

The Project Area has been subjected to significant growth in the past. The designation of New Towns has lead to concentrations of growth of a scale not seen in many other areas. The growth in housing has lead to demand for supporting infrastructure which has been provided. The location of the area close to important transport corridors linking London and the South East with much of the rest of the county has only added to the intensity of growth in the area.

3.3 PAST PATTERNS OF DEVELOPMENT – MINERAL RESOURCES

Ironstone, brick and cement manufacture were the three primary industries which led the nineteenth and twentieth century growth in the Project Area. The growth of these industries in turn led to urban expansion and an associated growth in infrastructure. The raw materials for this construction were mostly local sand and gravel from the Nene Valley.

Walls made from Fletton bricks were widespread and with the introduction of the railway network Welsh slate became a popular choice of roofing. However, local brick and tile works were very common, especially on large building projects.

Modern construction now relies on a range of materials for construction which are often cheaper than traditional materials, not just in their production, but also in terms of labour costs during construction. For example, large lightweight blocks are used in the construction of load-bearing walls.

3.4 NATIONAL TRENDS IN AGGREGATE SUPPLY AND CONSUMPTION

Demand for aggregate since the Second World War has increased. Relative contributions from sand and gravel and crushed rock have changed markedly over the period with rock now providing a significantly greater proportion than was the case in the 1950s.

National housing completions are at levels at, or slightly below, those seen immediately after the war. However, throughout most of the period from the early 1950s to the late 1970s levels of house building were at least 50% and at times over 100% above these levels. There is a loose correlation between aggregate sales and housing completions but there is evidence of a multitude of contributory factors.

3.5 PROJECT AREA TRENDS IN AGGREGATE SUPPLY AND CONSUMPTION

Trends in the Project Area reflect well the national trend of increasing aggregate production, the peaks in production of the late 1980s and the increasing importance of crushed rock.

Sand and gravel production in the Project Area was stronger between the late 1970s and mid to late 1980s. Rock production failed to mirror the national rises in production seen during the late 1960s; and rock sales in the Project Area have remained stronger since the late 1990s.

Housing trends have been similar to those seen nationally, except during the 1970s with the influence of the New Towns in the area. There is some correlation between sand and gravel production and housing completions, but since 1982 the links are not so transparent.

3.6 OTHER CONSTRUCTION ACTIVITY

The area has experienced significant construction activity including an ambitious road building programme since the Second World War.

During the 1970s, the overall influence of the New Towns resulted in growth above national levels and at the same time sand and gravel sales were stronger than those seen nationally. The Project Area has thus already experienced significant growth in all types of construction. This appears to have been sustained by local sand and gravel supplies, supplemented by imports from neighbouring areas and crushed rock imports from further away. The ability of the area to sustain further significant growth from the same aggregate sources is a key issue which this study seeks to address.

3.7 SECONDARY AND RECYCLED

The data available on secondary and recycled aggregate are variable and not completely reliable. Ultimately it may therefore be necessary to require statutory returns to be made, in a similar way to those made for primary aggregate production, if a more robust understanding of the contribution made towards total aggregate demand by recycled and secondary materials is to be obtained.

It is clear that secondary and recycled aggregates may be expected to continue to make an important contribution towards meeting total aggregate demand both within the Growth Zone and on a national scale. However, the 2003 survey supports earlier surveys which suggest that the potential for increasing the current level of contribution appears to be limited. In the Project Area itself, the high proportion of relatively recent buildings and small percentage of inherited heavy industry, suggests that the potential for recycling construction and demolition waste for aggregate will be less than the national average.

4 Analysis of planning information

An in depth review of the evolution of local policy framework for each of the regions can be found in Appendix 3 & 4. The key findings drawn from this review are outlined below.

4.1 EVOLUTION OF NATIONAL AGGREGATES POLICY FRAMEWORK

The minerals policy framework for aggregates has evolved from general guidance based mainly on areas of known aggregate resource into a much more structured framework which attempts to anticipate demand and make provision for supply whilst striking a balance between the need for aggregate and the need to protect environmental assets and socio-economic wellbeing. The landbank system supports this by providing a mechanism to make planned provision for future supply based on demand estimates and other material considerations. It also allows for monitoring of whether provision is likely to be adequate. Areas where future supply is not secured display low or diminishing landbanks, as in the case of Northamptonshire. As far as we are aware, this is the first time the changes in minerals policies have been analysed over time. This work has identified a useful developmental progression which will be applicable to other areas.

4.2 EVOLUTION OF LOCAL POLICY

In general the local policy framework has, like national policy, become far more structured and precise and now aims to provide certainty and predictability through the plan-led system. This can be used not only to make provision for aggregates but also to manage the supply through monitoring and review. However, sound policy must be informed by good baseline data and knowledge. Where this is not available the success of resultant policy may be limited. For example in the case of Northamptonshire which has attempted to shift aggregate extraction away from the Nene Valley and into areas of glacial deposits.

4.2.1 Leicestershire

Although the latest documents are at a consultation stage it is clear that there is no expectation that Leicestershire will be unable to meet anticipated demand for aggregates up to at least 2021**.**

4.2.2 Northamptonshire

Overall it seems clear that at the time of the 1983 Topic paper Northamptonshire accepted that most sand and gravel extraction for the foreseeable future would be in the Nene Valley, provided it was not within areas already protected under Structure Plan policy for their landscape quality. These included the Upper Nene Valley, from just south of Thrapston. Certainly there was no reference to the Nene Valley being inundated with workings at this time. The Welland Valley was also protected for its landscape quality which, coupled with earlier references in Leicestershire County Council documents to the mineral being of poor quality, helps to account for the lack of any significant working within it.

By the time the Minerals Local Plan 1991-2006 was in preparation there had been a significant shift in policy with the County Council aiming to reduce reliance on sand and gravel reserves in the Nene Valley. However, whilst this overall aim did not alter between the deposit draft and the adopted plan it is important to note that it was thwarted by insufficient information regarding the ability of the glacial resource to substitute for the river valley materials.

In terms of the current situation the outcome of the public inquiry into the Northamptonshire Minerals Local Plan 2001-2016 and the resulting changes introduced in the adopted plan have lead to a shortfall in sand and gravel provision over the plan period. This is despite an acknowledgement that the current SRA does not make specific allowance for the demands of the MKSM Growth Zone. Although a more rigorous analysis of the suitability of other sites is expected to take place as part of the imminent preparation of a Minerals and Waste Development Framework, until it is confirmed that these sites can be brought forward without unacceptable environmental consequences there must remain some doubt as to whether Northamptonshire will be unable to make provision for current demand for sand and gravel. These doubts only serve to strengthen the concerns regarding the likely availability of sustainable resources to meet anticipated future demand.

Further, the landbank of permitted sand and gravel reserves is and for many years has been depleted. Although difficult to prove it is likely, in view of the continued growth that has taken place in Northamptonshire, that the shortfall in the landbank of permitted sand and gravel reserves has lead to a greater dependence on imports to the county. The demand for local supplies ought therefore to be very high. Intuitively one would expect under such circumstances that the minerals industry would be quick to take up allocated sites in order to supply the local market. However, this has not been the case. The reasons for this are not altogether clear. However, the lack of geological information available over much of the county, particularly in those areas underlain by glacial deposits, may have acted as a deterrent. If the landbank remains depleted this could have serious implications for the supply of sand and gravel from Northamptonshire to the Growth Zone, particularly if the level of demand was to rise rapidly. A consequence of this would be pressure either to import more sand and gravel from the surrounding areas or to increase the levels of crushed rock being imported to the Growth Zone.

4.2.3 Buckinghamshire

Overall Buckinghamshire appears, on the basis of existing data, to have little potential to contribute towards meeting the demand for aggregate that will arise from the MKSM Growth Zone. Aylesbury itself is allocated for significant growth but aggregate to support this development is likely to need to be imported from outside the County. The reopening of the rail aggregate depot could be environmentally beneficial if this proved to be the case.

4.2.4 Milton Keynes

As a result of the changes introduced in the adopted plan, Milton Keynes has made provision in its plan to meet expected demand throughout the plan period and for a seven year landbank to remain at the end of the plan period, taking provision to 2018. However, Milton Keynes which is a relatively small producer of sand and gravel and in recent years has had a landbank of under 7 years of permitted reserves, has clearly had to accept compromises in order to make this provision and if demand rises significantly difficulties may arise meeting this in the longer term.

4.2.5 Bedfordshire

Overall Bedfordshire has made provision for sufficient aggregate to meet the requirements of the sub-regional apportionment. However, given past patterns of supply and demand, it is possible that the buoyant landbank could mask a potential shortage of concreting sand and gravel. The need for further allocations of concreting sand and gravel is to be investigated by the County. Nevertheless, it appears that Bedfordshire would be able to identify additional potential reserves to make up any identified shortfall in supply.

4.2.6 Cambridgeshire and Peterborough

Until such time as the Minerals and Waste Development Framework is adopted it is difficult to assess how future aggregate provision in Cambridgeshire is likely to affect the MKSM Growth Zone. However, what is clear is that in terms of making appropriate provision towards regional demand there is little doubt that Cambridgeshire is well placed to be able to fulfil its commitments and historic movements of material from Cambridgeshire into the growth zone might reasonably be expected to continue.

5 Building sustainable communities

Sustainability is intended to be at the heart of the Growth Zone proposals and it is helpful to consider the consequences of this for the Project Area. Essentially there are three main areas in which this can be achieved:

- by the overall approach to development,
- the detailed design of buildings, and the
- safeguarding and prior extraction of resources to avoid loss e.g. through poor initial planning leading to sterilisation; ensuring that 'high' quality aggregates are reserved for high specification end uses

These issues are now considered in more detail.

5.1 APPROACH TO DEVELOPMENT

At a national level, having identified in The Communities Plan the severe shortfall in the level of new houses being built, the government, in April 2003, set up a review of housing supply to look more closely at the reasons for and consequences of the shortage. The review was led by Kate Barker and its terms of reference were as follows:

- conduct a review of issues underlying the lack of supply and responsiveness of housing in the UK

In particular consider:

- the role of competition, capacity, technology and finance of the house building industry; and
- the interaction of these factors with the planning system and the Government's sustainable development objectives.

An Interim Report was published in December 2003. This argued that a weak response to demand for housing had been one of the factors underlying the volatility in the housing market, but that in addition to the costs of volatility, there was a set of adverse consequences resulting from the long-term upward trend in house prices. These struck at the heart of the economic health of the country, both in terms of individuals and the economy as a whole. In particular, the wealth gap between home owners and others was widening and labour mobility was restricted, resulting in an overall cost in terms of economic welfare from the restriction in supply. Set against this, the report recognised that there were important benefits in terms of reduced urban sprawl and the retention of open greenfield land.

The final report, "Review of Housing Supply, Delivering stability: Securing our future housing needs" (The Barker Review Final Report) was published in March 2004. Its overall objectives were:

- to achieve improvements in housing affordability in the open market sector;
- a more stable housing market;
- location of housing supply which supports patterns of economic development; and
- an adequate supply of publicly-funded housing for those that need it.

In essence the review found that in order to achieve these objectives nationally, it would be necessary to build an additional 120,000 private sector homes per annum which would reduce the upward trend in real house prices to 1.1% (equivalent to the average trend rate of house price growth for Europe). This approximates to a doubling of current private sector house building levels, which are around 125,000 per annum. Moreover, an increase in supply of social housing of 17,000 homes each year was believed to be required to meet the needs among the flow of new households. A further 9,000 homes would be needed to start to accommodate those already in need but not provided for. An additional 23,000 social homes per annum would represent a more than doubling of the current annual provision, which is around 21,000 units.

Set against this was the recognition that house building on this scale would not come without environmental costs. Although the Barker Review did not attempt to assess these costs it made clear that choices had to be made between meeting social and economic need, and avoiding the adverse environmental consequences of doing so.

In order to understand better the environmental costs of building the extra homes (1.4 million in total) which the Barker Review proposed, the government commissioned consultants to assess and produce a report into the environmental implications. The report, entitled “Study into the Environmental Impacts of Increasing the Supply of Housing in the UK” was carried out by Entec and others and published in April 2004.

The study examined a wide range of environmental effects including effects on Green Belt and other protected land, demands on water supply and energy use and the impacts on local environmental quality and access to the countryside. In addition, and pertinent to this study, it examined the impacts of the construction process in terms of the UK demand for aggregates and looked at ways in which this demand could be reduced.

5.2 SUSTAINABLE DESIGN AND CONSTRUCTION

The Entec report identifies two key ways in which house construction might be made more sustainable through reducing the amount of aggregate used. Firstly, it suggests designing houses which make more efficient use of materials, including aggregate, and secondly, it suggests that a reduction could be achieved through increasing the density of developments in order to reduce the amount of aggregate used per unit in associated infrastructure.

Traditionally, sustainable construction was achieved by making use of locally derived materials. This avoided the need to transport over long distances. In addition it resulted in the development of local styles, making areas distinct from one another. Such local distinctiveness contributes to the character of an area and is important in creating a sense of place. Traditional building also makes use of renewable resources such as wood. However, it is no longer possible to continue building in the traditional way and keep pace with demand for new housing. The areas where housing is needed are not necessarily those which have ample supplies of building materials, resulting in the need to transport over long distances. In addition building in the recent past has not always made the best use of available land.

The concept of considering alternative methods of achieving sustainable construction is well established. The UK strategy for more sustainable construction, “Building a better quality of life”, published in 2000 sets out 10 key themes for action by the construction industry, which were designed to encourage the adoption of more sustainable practices in the industry. These themes included:

- design for minimum waste;
- lean construction (and minimise waste);
- minimise energy in construction and use; and
- respect people and the local environment.

Difficulties with efficiency and quality within the construction industry had previously been recognised by government and examined by the Construction Task Force under the chairmanship of Sir John Egan. The report of the Task Force, "Rethinking Construction" was presented in July 1998. One of the terms of reference was to look at improving the efficiency and quality of housing construction.

The Task Force identified promising developments in both public and private housing in the UK. In particular it was noted that good quality public housing, indistinguishable from the housing for sale that it is increasingly located alongside, was becoming commonplace.

The Task Force concluded that the main initial opportunities for improvements in house building performance existed within the social housing sector simply because most social housing is commissioned by a few major clients. Much of the scope for improved quality and efficiency comes from the standardisation of the product. Experience from abroad was identified as a way forward in the procurement of standardised, yet adaptable, quality housing, particularly in the social sector. For example, the Dutch Open Building approach offers a wide range of choices of internal fit-out, and modular industrialised housing systems, such as those used in Japan, can reduce the cost and time of construction and provide tight quality control. However, these may involve the use of highly processed, often hydrocarbon-based or other materials imported from abroad. In contrast, locally derived aggregates may be more sustainable, but as far as we are aware, no whole life comparative environmental cost studies have been undertaken

The Entec study examined in some detail the role of both design and density in respect of aggregate use. A number of scenarios based on a range of options for housing provision were considered against houses with various environmental ratings. The options for housing provision ranged from a baseline continuation of current completion rates by Region together with the additional dwellings associated with the Communities Plan, through to the most radical house building programme, based on the findings of the Barker Report (scenario 3), which comprised current RPG targets and Communities Plan dwellings plus an additional 139,000 dwellings per annum.

The environmental ratings of dwellings were based on EcoHomes ratings. EcoHomes is the Building Research Establishment's (BRE) Environmental Rating system for homes. It is independent, authoritative and based on many years of construction and environmental research carried out by the BRE, the construction industry and the government. It is updated annually to reflect changes in Building Regulations and best practice and provides a credible environmental labelling system for homes. EcoHomes ratings range from Pass to Excellent.

The baseline house type was assumed to be a typical new build 3 bedroom house, built using traditional construction methods. A low density development of 30 units per hectare was assumed. Two further categories assumed houses with EcoHomes ratings of "Very Good" and "Excellent". Finally, a high density category of 100 units per hectare, comprising 100% flats at 4-5 storeys was considered.

In terms of aggregate demand the study found that there was a relatively small change in aggregate use throughout the range of cases from baseline to EcoHomes "Excellent", due to a traditional structure being used. Only at the higher density were significant reductions seen.

In the worst-case scenario (baseline house type at 30 units per hectare and the number of dwellings assumed in scenario 3) the additional annual demand for aggregate would be about 18 million tonnes. This equates to about 10% of total quarried products used in the construction industry for 1998.

The Government has already embraced the concept of increasing density to improve sustainability. Planning Policy Guidance Note 3: Housing (2000) requires local authorities to encourage housing development at densities of between 30-50 dwellings per hectare in order to make more efficient use of land and to seek greater intensity of development at places with good public transport accessibility such as town centres (paragraph. 58).

In order to reduce dramatically the demand for aggregate the Entec report suggested two further avenues which should be explored:

- Increased use of recycled and waste materials in aggregates; and
- Choice of less traditional "Modern Methods of Construction", with less emphasis on aggregates. As 50% of the aggregate used in domestic applications represents external wall, the study considered that there were significant savings to be made.

The role of alternative aggregates is considered in more detail elsewhere in this document (Section 10.5.2).

The Entec report recommended that improved methods of construction, which are less resource intensive, should be actively promoted through the planning process to reduce environmental impact. It clarifies that this refers to those construction methods outside the traditional methods of construction currently specified in the national Specification for Houses in England and Wales, for example, pre-fabrication and timber frame versus brick and block.

In summary, a combination of the demand for more smaller dwelling units which are more suited to being provided in high density developments, coupled with an increased use of modern methods of construction will undoubtedly reduce the intensity of use of aggregate. However, it is not clear that the reductions achieved will be sufficient to offset the very significant increase in the number of homes and other infrastructure that is expected to be constructed within the Growth Zone over the next 25 years. Whilst the implementation of sustainable construction will therefore go some way towards tempering the increase in aggregate demand it cannot realistically be expected to do more than this.

5.2.1 Modern methods of construction

5.2.1.1 BACKGROUND

Prefabricated housing has been used in the UK during periods of high demand such as after the World Wars and during the slum clearances of the 1960s. In total about 1 million prefabricated homes were built during the 20th century. However, many were designed to be temporary. Problems arose over the quality of workmanship and materials, leading to a negative public attitude towards prefabrication. Nevertheless it has continued to be used in the UK in public buildings such as hospitals and schools and in housing in other countries. In recent years there have been technical improvements in prefabrication and the new term "modern methods of construction" (MMC) has been adopted to reflect this.

5.2.1.2 WHAT ARE MODERN METHODS OF CONSTRUCTION?

Typically MMC involves the manufacture of house parts off-site in a specially designed factory. A range of materials is used for MMC, the most common being wood, plasterboard, steel and concrete, although many houses built in the UK using MMC have a brick outer layer and so look like traditional houses. The two main products of MMC are:

- **Panels –** including ready made walls, floors and roofs. These are transported to the site and assembled quickly, often within a day. Some panels have wiring and plumbing already inside them, making construction even faster.
- **Modules –** ready made rooms, which can be pieced together to make a whole house or flat, but are used more frequently for bathrooms or kitchens, where all the fittings are added in the factory.

MMC can also include innovative site-based methods such as the use of concrete moulds.

Many of the benefits of using MMC for housing are as yet unproven in Britain. However, the government and manufacturers suggest that the main advantages are:

- **Economic –** houses typically have fewer defects and can be built more quickly.
- **Environmental –** houses can be more energy efficient, may involve less transport of materials and may produce less waste.
- **Social –** there may be fewer accidents associated with construction and less disruption to neighbours during the construction period.

Although the majority of homes in the UK are still constructed using traditional methods the number of MMC houses has increased within the past few years. In part this has been due to demands for faster construction. The increase is likely to continue as a few large private house builders have recently invested in MMC factories. The National House Building Council has estimated that currently about 10% of new UK homes are built using timber frames and a further 5% using other MMC. This is equivalent to about 25,000 homes per annum.

The recent interest in MMC for house building is driven by a severe shortage in housing supply. Government is keen to address the shortfall and it is anticipated that dwellings built using MMC could play a role. The government has established initiatives to encourage the use of MMC, focussing on the social housing sector where it can have a greater degree of influence. Since 2004 the Housing Corporation, the social housing regulator for England and Wales, has required a quarter of new houses it funds to be built using MMC. This is equivalent to about 5,000 houses per annum or 3% of new UK housing. The Millennium Communities (the first being Greenwich Millennium Village), overseen by English Partnerships, are also using MMC. In addition some key worker homes in the south east are being built using MMC.

There are currently over 30 house building factories in the UK. A recent survey carried out for the Housing Forum found there is current industry capacity to produce over 30,000 MMC homes per annum. This would be sufficient to build about 17% of new homes, based on a building rate of 175,000 homes per annum.

An example of a recent factory is the Westbury Homes *Space4* factory which opened near Birmingham in 2001. The factory can produce up to 6,000 homes per annum although it is currently producing only a third of this figure. Timber frame panels are built on a production line and then erected on site by trained contractors. The panels comprise a layer of insulation, sandwiched by wood sheets. Similar panels have been used for house building in the US since the 1950s. The houses are usually finished with an outer layer of brick and hence look like traditionally built homes.

Redrow Homes have also introduced a range of affordable homes built using modern methods of construction. They are known as the Debut range and the first development has recently been completed in Rugby in the West Midlands, just outside the growth zone. The houses are based on lightweight steel frames with a durable cladding. The kitchens and bathrooms have modular interior fixtures and fittings which are constructed off site and the homes have communal heating and hot water systems.

It is clear that the contribution towards meeting new housing demand made by homes built using MMC is set to increase. There is encouragement for this at the national level and house builders appear to have accepted the challenge. Not only do there appear to be potential advantages in terms of the sustainable use of materials but MMC housing can be provided more rapidly than traditional homes, helping to meet the current significant demand.

5.3 SAFEGUARDING RESOURCES

Between the First and Second World War hundreds of square kilometres of gravel bearing land in the Thames Valley west of London was sterilised by development, mainly housing. The process continued after 1945. Today that area is heavily dependent upon aggregates imported from elsewhere, e.g. the Mendip Hills, to augment local sources. It is imperative to ensure that as far as possible, useful mineral resources are not sterilised by development, when building sustainable communities. Unless whole urban areas are subsequently demolished at the same time, those sterilised resources are “lost” forever.

It is fully recognised that there are serious logistical issues which have to be taken into account and demand extremely skilful pre- planning as well as a holistic approach. The most significant of these are that removal of deposits can leave voids which, being at or below the water table, became flooded. There is frequently a shortage of suitable fill material to reinstate buildable levels and that, even where this is feasible, it may not be possible to guarantee load bearing conditions to support subsequent construction. Phasing is another important consideration.

There are particularly bad examples where the main obstacle may have been down to local plans superseding earlier mineral plans. However, with the new generation of plans, some of these issues (and in particular Safeguarding/Consultation Areas) and placing environmental priorities at a higher point on the agenda, may provide access to a more suitable mechanism for prior extraction.

There is very little environmental logic, in terms of safeguarding resources – including energy, applying the proximity principle etc, to sterilising a suitable mineral resource at the point of development and substituting this for material which will have to be carried over increasingly long distances. Even where rail transport is used for the bulk of a journey, utilising road is almost inevitable. This single measure, if applied sensibly would be more environmentally sustainable and generate far less inconvenience to the generality of the population, than many of the initiatives currently being promoted.

The planners and developers are required to liaise more comprehensively, to plan ahead and to identify suitable means by which such a process can be implemented. Examples of good practice need to be more widely disseminated. In particular, opportunities to dovetail prior extraction with the projected creation of say water storage, flood water accommodation/ balancing areas, nature reserves/recreational areas/green spaces, should be built into plans at the outset. There were some good examples in the original Milton Keynes development. Modified and novel building techniques may also be applied more easily to development in such areas (e.g. a very large supermarket at Carlisle floats when the area becomes flooded).

There are many other ways by which aggregates resources can be optimised, such as using lower quality materials where they are available and fit for purpose, strictly controlling aggregate use and wastage on site, but these matters are largely of national or industry cultural significance and outside planning and development controls. However it is expected that they will make a more general contribution to sustainability, whereas prior extraction is an option only available in relation to specific development – of the type and scale which is now being proposed.

5.4 GOVERNMENT RESPONSE

Regarding the issue of the need to achieve sustainable development whilst addressing housing shortages, the Government published its response to the Barker Review (The Government’s Response to Kate Barker’s Review of Housing) which is informed by the findings of the Entec report in December 2005. In its response the Government acknowledges the need for significant additional housing of all types and in all areas. The response sets out a framework for delivering its goals based on new homes in sustainable communities. The framework establishes a long term vision which the Government hopes to realise through work with partners at all levels. Of significance to this study is the emphasis placed by Government on its Sustainable Communities Plan which identifies that nationally the four growth zones plus London have the potential to deliver an extra 200,000 homes above existing plan commitments by 2016. More than 25% of these homes are destined to be provided in the Milton Keynes South Midlands Growth Zone. In the light of Barker there will be considerable pressure to ensure that the predicted level of new housing is achieved.

5.5 IMPLICATIONS FOR AGGREGATE REQUIREMENTS

A detailed analysis of historical construction trends in the area was conducted. This was hampered at many points. Firstly, despite the significant levels of construction mainly during the building of the new towns from Corby in the late 1940s onwards, there was a remarkable lack of data. Secondly, such data as were readily available related only to housing completions from, at the earliest, mainly the mid 1970s. There was very little data on roads and virtually nothing comprehensive on non public/non-housing sectors. Finally, the whole series of local and regional reorganisation from the early 1970s onwards greatly frustrated efforts to produce reasonable runs of data on construction that could be matched with the generally excellent information on mineral production.

Given the qualifications attaching to the available statistics any attempt to gauge the significance of future growth in quantitative terms may be questioned. It may be necessary to review what precisely is being sought and perhaps to revisit some initial premises. At its most basic level, given the Growth Zone construction targets now proposed either an empirical approach could be adopted or standard multipliers of aggregates applied to the individual growth elements, based on other studies, for example X tonnes of aggregates are consumed in constructing the average dwelling; Y tonnes per unit length of “standard” dual carriageway.

However, this would only give information for these specific quantified elements, which are but a part of the whole growth spectrum and in doing so, would not include for example other infrastructure including minor roads, commercial development etc. Also, it would assume that the current uptake of aggregates per unit of construction remained constant – whereas these particular proposed communities are intended to have sustainability inbuilt and so might be expected to be using significantly lower proportions of materials per unit completed, than in the conventional buildings of the past.

Finally such an approach does not necessarily cast light upon one especially important aspect, namely the degree to which the growth now proposed compares with that experienced in the past and in particular that arising from the development of the new and expanded towns in the area between 1950 and 1992. In this respect, a parallel issue is the extent to which other areas of major development past and proposed in adjacent areas, have had and will have implications for the South Midlands area. The main concern here is Peterborough, and to a lesser extent, Cambridge-Stansted, a part of one of two other Growth Zones.

The imperfections in the statistical record emerge with more force when detailed examination at the study area level is attempted. There are also difficulties in applying uncritically national datasets, which are unlikely to have a relatively high degree of accuracy, to the study area. For reasons that are given below, these difficulties may be of little practical importance, but it is of assistance to explore them to illustrate the points of most relevance.

BGS estimates[1] that between 1955 and 2004, the value of all construction in Great Britain, at constant 2000 prices, rose from £29.2 billion to £80.6 billion, including several peaks and troughs along the way. The consumption of natural (“primary”) aggregates measured as tonnes per £1000 of construction output grew from 3.0 tonnes in 1955 to a peak of 4.6 tonnes in 1975, since when it has declined so that by 2004 the figure was below that 49 years earlier, 2.7 tonnes. Put another way, the “intensity” of primary aggregate use first increased, peaked and has then diminished.

The explanations for that will include in particular the greater use of secondary and recycled aggregates, changes in building techniques allowing greater economy in aggregate consumption, greater specificity of aggregate types and hence cost and an incentive to economise, cultural awareness of non-renewable resources, and so on.

[1] United Kingdom Minerals Yearbook 2005

The Department of Trade & Industry statistics[2] of "Contractor's Output" suggest that, at constant (2000) prices, between 1993 and 2003 total output rose from £58.4 billion to £75.3 billion. Of those figures, in broad terms new work accounted for 55% of output and repairs and maintenance about 45%. Also, of total construction output, new housing accounted for about 15%.

A widely used "rule of thumb" is that the average new house requires about 50 tonnes of aggregate to build it[3].

Applying these national figures to the Project Area produces a series of interesting comparisons. For this exercise, only aggregate sales within the Growth Zone (Northamptonshire, Bedfordshire, Buckinghamshire and Milton Keynes) have been included (Figure 5). Whilst this ignores imports, there is no reliable data available that could reasonably be included, and in any case imports will, to some extent, be offset by exports. Leicestershire has been excluded because the majority of its production is from outside the Project Area. The whole of Buckinghamshire has been included because it is not possible to split figures to sub-county level.

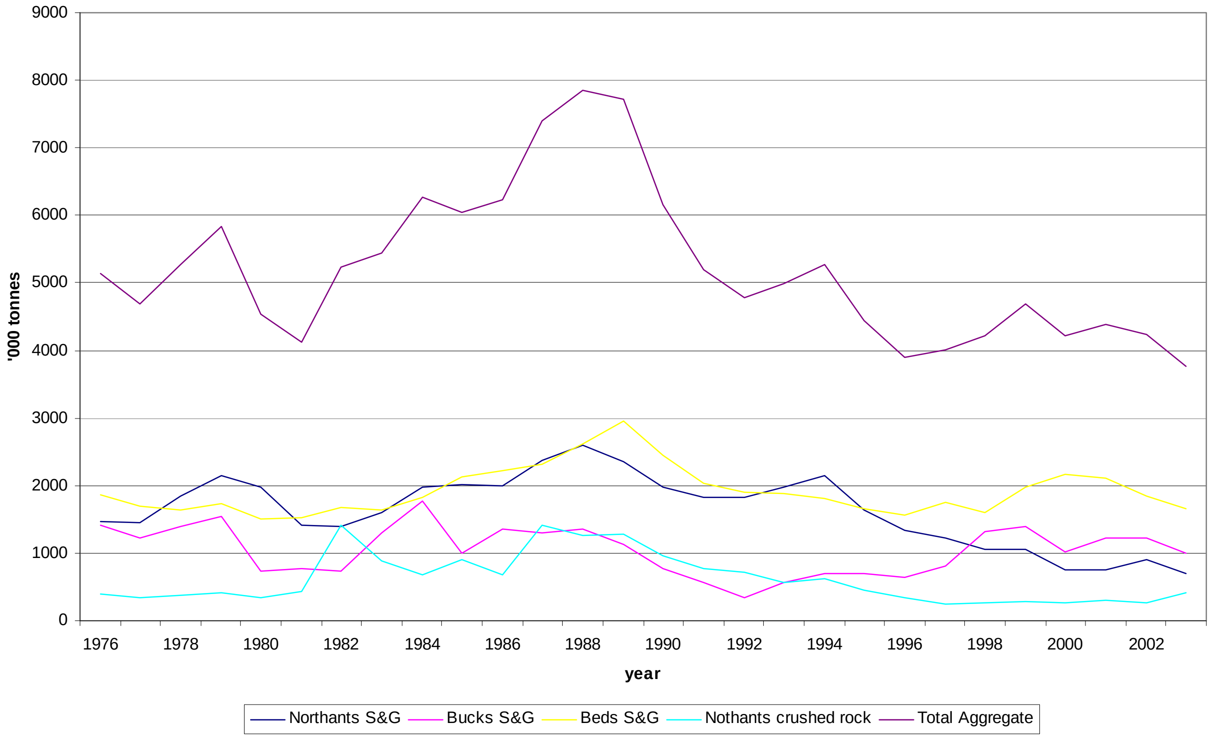


Figure 5 Aggregate sales in the Growth Zone

(Sources: BGS; UK Minerals Year Book; RAWP; Department of Environment)

If each house requires about 50 tonnes of aggregates, then with a total new house build averaging about 7500 units per annum since 1992 some 375,000 tonnes of aggregate per annum was required. Given that production in the growth zone counties was around 4.4 million tonnes per annum, the implication is that aggregate consumption directly in housing was around 8.5% by tonnage of the total.

It is possible to generate a simple measure within the Growth Zone alone (Figure 6), by relating aggregate consumption to house building, in effect, using housing numbers as a surrogate measure of all construction activity. This is not unreasonable as all housing construction generates much other construction as well and, in the absence of housing construction, little or no other construction would take place. Certainly there will be lags in the response of the rates of

[2] Construction Statistics Annual 2004, table 2.5
[3] Quarry Products Association

non-housing construction to the rates of housing construction but, overall, there should be broad consistency.

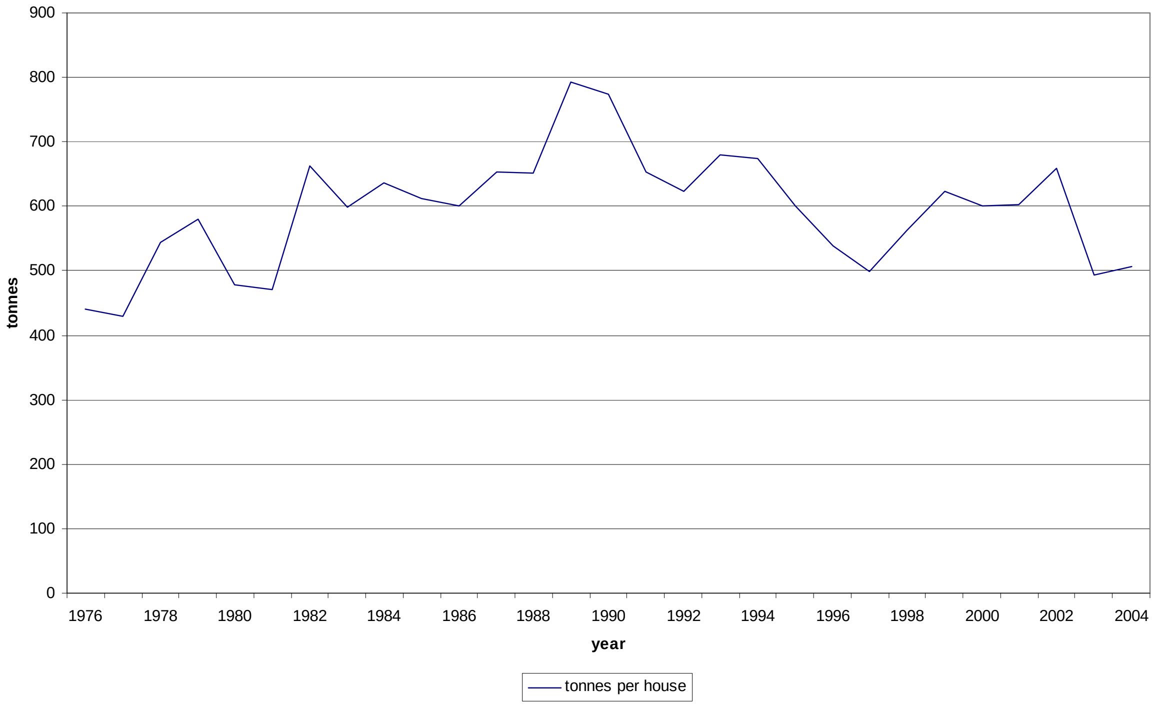


Figure 6 Variations in the relationship between aggregate consumption and house construction

(Sources: BGS; UK Minerals Year Book; RAWP; Department of Environment; County Councils in the study area)

The figures show that in the late 1970s (when adequate figures commence), on average for each house constructed in the Growth Area just over 400 tonnes of aggregate was locally produced. This increased consistently to 1989 when almost 800 tonnes were produced per house, since when the figure has fallen and roughly stabilised at around 500-600 tonnes. The implication of this is that during periods of most intensive house building, the amount of total aggregate needed per house rises. This is logical since intensive house building is generally accompanied by the construction of directly related supporting infrastructure as opposed to more piecemeal development, that is intensive housing construction must almost inevitably take place on larger new sites (as opposed to sporadic smaller infill sites) and hence require new primary infrastructure, the infrastructure requirements will tend to be greater during intensive period of construction than during quieter periods.

From this, one theme stands out clearly. In the growth area, in the peak construction years (for which adequate figures are available) of the late 1980s/early 1990s, 10,000-12,000 houses were constructed and each required, together with its infrastructure, on average the production of around 650 tonnes of aggregate, rising to almost 800 tonnes of aggregates in the years immediately following (this figure is based on sales for the whole of Buckinghamshire but ignores imports from Leicestershire and Cambridgeshire).

The scenarios for future expansion in the Growth Area assume an average of 10,600 houses for the next 16 years, with possible continued growth at similar levels for a further 10 years. In other words, the average future construction is proposed to equal the historic peaks of construction witnessed locally, and clearly peak future construction will exceed historic peaks. Given that aggregate consumption per house, when similar numbers were constructed, was around 650 tonnes but rose to almost 800 tonnes, presumably as supporting infrastructure was provided, the implication is that up to 2021 the growth area will require an average of just over 7.5 million tonnes per annum (a sales figure only previously achieved in the Growth Zone between 1988 and 1989 – Figure 5), and peak supplies much in excess of that. Notwithstanding that the growth zone is and is expected to continue to be reliant on imports from neighbouring areas, to postulate that the levels of construction and raw material supplies seen in the 1980s "boom years" will, over the next sixteen years and possibly well beyond, become the average, is to raise very serious questions of future supply of sustainable resources.

Figure 7 shows the flows of sand/gravel and crushed rock in 1997 into the Project Area. This year was selected as the latest available from which inter-county data was available. The survey in 2001 only carried information at intra-regional level. That for 2005 will show flows between sub regions (in some instances, counties).

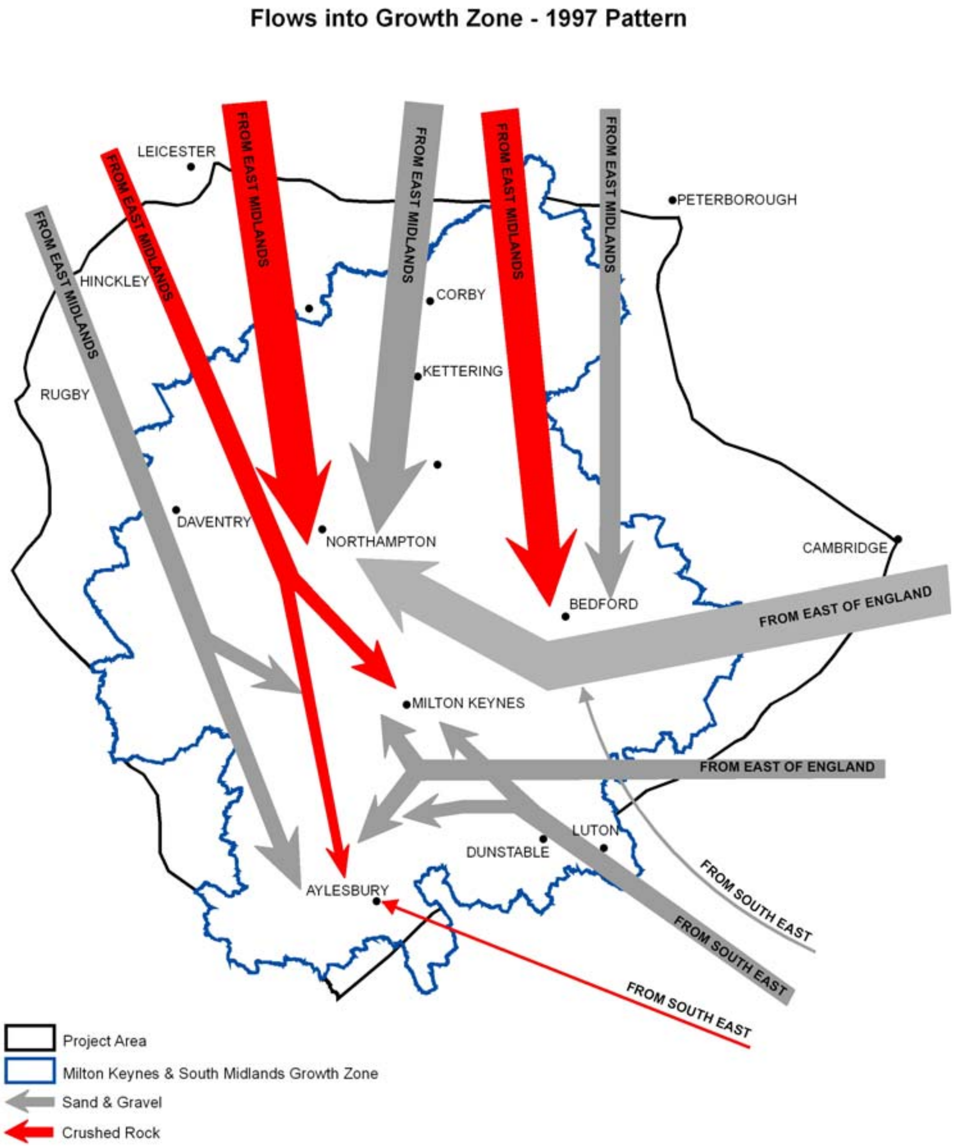


Figure 7 Indicative flows of aggregate into the Growth Zone

Reproduced in Appendix 5 at A3.

5.6 KEY FINDINGS - BUILDING SUSTAINABLE COMMUNITIES

- The level of growth proposed for the Growth Zone is equal to the high levels of growth seen during the mid to late1980s. However, and most significantly, it is envisaged that this will be sustained for a period of at least 16 and up to 26 years, as opposed to the much shorter period seen previously. In order to supply the amounts of aggregate needed to sustain this level of economic growth, it will be necessary to maximise sustainable supplies whilst minimising demand.

The following offer a range of potential options:

- Employ modern methods of construction and high levels of housing density to reduce the amount of aggregate used per house.
- Identify and exploit significant amounts of alternative aggregate (secondary and recycled aggregate). However, the opportunities for this, as generally identified at national level in the Capita Symonds Report, and in the light of the relatively new building stock in the Growth Zone, are believed to be limited;
- Continue to exploit traditional, mainly alluvial, resources within the study area whilst maintaining current proportions of imports. However, ultimately this must necessitate compromising current environmental standards.
- Ensure that all known suitable aggregate deposits in the area are adequately safeguarded and that the potential for extraction of mineral prior to development is assessed, properly programmed and required at the development plan stage.
- Exploit non-traditional aggregate resources within the Growth Zone such as glacial, as opposed to terrace, sands and gravels and limestone and ironstone. This study has improved knowledge with regard to alternative sand and gravel resource. However, there still remains an insufficient understanding regarding the quality and quantity of much of the rest of this material and so it is unknown whether it is suitable for wide ranging aggregate use.
- Using sustainable transport options to import more primary aggregate from other areas. However, there is the risk of “exporting” the effects of quarrying to other areas and simultaneously increasing the impacts of transportation;

Whilst all of these actions would go some way towards resolving the potential gap between supply and demand, alone they could not be expected to provide a complete solution. In some cases the consequences of a particular option may be deemed unacceptable. What is clear is that unless a combination of approaches is employed there are likely to be severe difficulties in making provision for the anticipated level of construction in the MKSM Growth Zone. Significant research has already been undertaken into the potential of a number of the above options. However, this study is the first to consider in detail the potential of alternative aggregate resources within the Growth Zone area. Clearly this is an area of study that demands a more detailed appraisal. The present approach to Sub-regional Apportionments deserves review as this cannot adequately take into account the scale of growth here, dissipated as it is to parts of three separate regions.

5.6.1 Further research

The initial findings of this project pointed clearly to two areas which required more detailed consideration:

Northamptonshire and Milton Keynes

Northamptonshire and Milton Keynes, which are both at the centre of the Growth Zone, already face a level of demand which intuitively must far outstrip supply. This situation is complicated by the fact that areas in Northamptonshire identified through the Local Plan process for future extraction have not been brought forward to make up the identified shortfall. A key explanation for this has been that reliance is being placed on deposits of unknown extent and quality, the glacials. This project has sought to improve knowledge of whether these areas contain mineral which is viable or of no economic importance in order to help determine the extent to which the difficulties facing Northamptonshire and by implication, Milton Keynes and the Growth Zone can be resolved utilising local supplies.

North Buckinghamshire

North Buckinghamshire, which has never been a significant producer of aggregate is nevertheless expected to undergo significant future growth (Aylesbury). It is acknowledged that Aylesbury has already undergone significant growth but whether further growth can be achieved in a sustainable way is unclear. It has no obviously sustainable local supply of aggregate and currently no sustainable transport mechanism for aggregate import.

These particular areas have therefore been considered in greater detail in this report.

6 Aggregate resources: existing information for the Project Area

Recent BGS geological resurveying of large parts of the Project Area, has provided a good understanding of the regional geology. Mapping at a scale of 1:10k of the geological sheets of Leicester, Kettering, Wellingborough, Biggleswade, Bedford, Leighton Buzzard and Buckingham has been completed within the last 10 years. The information gained from this work, and other available information listed below, has been drawn upon in the following overview of the geology of the Project Area.

The types of available information utilised in this study include:

- BGS Mineral resources county maps for area
- Mineral Assessment Reports
- BGS Borehole Geology database and existing borehole data
- BGS geological maps, brief explanations, memoirs and other publications
- Peer-reviewed publications

6.1 THE GEOLOGY OF THE MILTON KEYNES AND SOUTH MIDLANDS GROWTH ZONE AND BEDROCK AGGREGATE RESOURCES

An initial overview of the geology in the MKSM Growth Zone is given below, based on a desk study which utilised BGS Mineral Assessment Reports, geological maps, mineral resource "County" maps and memoirs and existing borehole data.

6.2 BEDROCK GEOLOGY

6.2.1 Overview

The following account gives a very general background to the bedrock geology of the region. Further details of those formations which have potential as a resource for sand and gravel or crushed aggregate are given in **Bedrock Aggregate Resources** (Section 6.2.3).

The Bedrock geology of the Project Area broadly encompasses rocks ranging in age from Triassic to Cretaceous. These strata dip at a low angle (<1°) to the southeast so progressively younger formations outcrop from west to east.

The oldest strata outcropping in the sub region form the Triassic **Mercia Mudstone Group,** a several hundred metre thick sequence of mainly red-brown mudstone with local occurrences of green-grey dolomitic siltstone, gypsum and anhydrite. The overlying and comparatively very thin (about 12 m) **Penarth Group** consists of grey mudstone, siltstone and thin beds of limestone and sandstone. This is succeeded by the Lower Jurassic **Lias Group** which includes the Blue Lias Formation, Charmouth Mudstone Formation, Dyrham Formation, Marlstone Rock Formation and Whitby Mudstone Formation. These mainly consist of several hundred metres of mudstones but the basal Blue Lias Formation includes interbedded limestones. The Dyrham Formation is notably silty to finely sandy with thin sandstone beds at some levels, and the Marlstone Rock Formation is a persistent unit between 1 and 7 m thick of sandy ferru-ooidal limestone and ferruginous and calcareous sandstone, with subordinate ferruginous mudstone.

The succeeding **Inferior Oolite Group** of Middle Jurassic age, crops out in a diagonal belt across the centre of the Growth Area and includes a varied sequence of ironstone, limestone and mudstone some of which represents a potential resource. The outcrop of the **Northampton Sand Formation** is continuous across the centre of the sub region through Northamptonshire, Leicestershire. Through most of the region, it mainly comprises greenish grey variably sandy, berthierine-ooidal and sideritic ironstone beds, which formerly rendered it (up to 1980) of great economic importance as a source of ore for steel making in this region, where it was known as the Northampton Sand Ironstone. The Northampton Sand Formation generally ranges from about 5 to 9 m in thickness along the outcrop, locally thickening in south Northamptonshire to perhaps 23 m. Eastward and southward it thins rapidly and is absent along much of the Nene valley and the Great Ouse valley. In the northeastern part of the sub region, the Northampton Sand is overlain by the mudstone **Grantham Formation** and the **Lincolnshire Limestone Formation** comprising ooidal and bioclastic limestone, but these formations are absent elsewhere.

The Inferior Oolite is succeeded by the **Great Oolite Group**, which encompasses the **White Limestone Formation** consisting of peloidal and ooidal limestone but is present only in the extreme southeast of the area**;** the mudstone dominated **Rutland Formation;** the **Blisworth Limestone Formation** comprising bioclastic, ooidal and peloidal limestone, and which is the approximate lateral equivalent of the **White Limestone;** the **Blisworth Clay Formation** consisting of mudstone**;** and the rubbly, shelly limestone of the **Cornbrash Formation**.

The very thick **Ancholme Group,** comprising the Kellaways, Oxford, WestWalton, and Amphill formations, all of which consist principally of mudstone, overlies the Inferior Oolite Group. It is in turn overlain by the Lower Cretaceous **Woburn Sandstone Formation** which is best seen in quarries around Leighton Buzzard, immediately south of the region, where it can be informally subdivided into a thick lower interval of fine and medium-grained sandstone, and a thinner upper interval of coarse-grained, poorly sorted sand. Conspicuous cross bedding, seen especially in the higher part of the Woburn Sandstone, is characteristic of sandwaves that form in strongly current-swept seaways. Mudstone of the **Gault Formation** follows and this is succeeded by the **Chalk Group**, of which only the lower, marly, **Grey Chalk** subgroup is present in the area.

6.2.2 Estimation of unsterilised aggregate resources in the bedrock

The detailed assessment of bedrock aggregate resources is outside the remit of this study as the potential for bedrock formations of the area to provide a resource for high quality construction aggregate is considered to be low. However, feedback from stakeholders indicated that a straightforward desk study similar to that undertaken by BGS for the South Eastern England Regional Assembly (Benham et al. 2006) was desirable.

Accordingly a variety of disparate datasets were drawn upon and interpreted by an expert resource geologist employing local and regional knowledge. These datasets included the East Midlands, Eastern England and South East Regional Minerals GIS, DiGMap50 (the digital geological map of Great Britain), the BGS Superficial deposits digital thickness map, BGS geological maps, memoirs, sheet explanations and other relevant BGS publications and to a small extent the BGS Borehole database.

The principal potential resources for the Growth Area are Middle Jurassic limestone of the Inferior Oolite and Great Oolite groups and the sand of the Lower Cretaceous Woburn Sand.

Volume estimates were derived from simplistic calculations based largely on expert judgement rather than statistical analysis of thickness data. This is because the quality of the resources did not justify a detailed study that included the interpretation of numerous borehole records, the population of a database and 3D modelling. However, area calculations are accurate.

No account has been taken of potentially unworkable parts of the resources where vertical and lateral variation is complex. Overestimates of resource volume are probable in such circumstances.

For estimating mean thicknesses of resources in bedrock formations it has been assumed that the geometry of the deposits beneath their outcrop is prism-shaped. In addition, a maximum practical working depth of 25 m has been adopted. No allowance has been made for the influence of topography, and the effect of geological structure (e.g. faulting) on volume estimates has been ignored, as they would require detailed 3D modelling to resolve.

Generally, estimates of volume exclude potential resources beneath (down-dip) overburden, except for those concealed by superficial deposits. In the latter case, potential resources beneath more than 10 metres of superficial deposits have been excluded.

Mineral resources may be sterilised by other planning features, in particular urban areas and major transport links, environmental assets and, for the purposes of this study, past and present mineral planning permissions. GIS was used to identify those resource areas sterilised by these factors. Only those resources not sterilised by urban areas, transport links and mineral planning permissions were included in the assessment. Major transport links were extracted as lines or vectors from the Ordnance Survey 1:250,000 Strategi dataset and included motorways, A-roads and railways. These vectors were buffered (Table 1) to take into account their polygonal footprint over the resource. Volume and area data moderated by a range of environmental asset indices were calculated (Table 1 and 2).

6.2.3 Bedrock aggregate resources in the Project Area

The main potential crushed aggregate resources lie within the limestone formations of the Middle Jurassic Inferior Oolite and Great Oolite Groups. The sole potential resource for bedrock (soft) sand is the Lower Cretaceous Woburn Sands. For the purposes of this study, a maximum working thickness of 25 m has been assumed and no account has been taken of any limitations to extraction that may be imposed by the presence of groundwater. Estimated volumes and tonnages for a range of environmental sensitivities are given in Tables 1 to 4.

The **Lincolnshire Limestone Formation** (Inferior Oolite Group) crops out in the northeast of the study area. It has two units: the Lower Lincolnshire Limestone, which commonly comprises fine-grained, sandy, bioclastic, ooidal limestone and the Upper Lincolnshire Limestone, which typically consists of cross-bedded ooidal limestone. In the Growth Area the formation averages about 6 metres in thickness but the Upper Lincolnshire Limestone has channelled deeply and irregularly into and, locally, through the Lower Lincolnshire Limestone resulting in considerable variation in thickness. The Lincolnshire Limestone generally has low strength and poor resistance to frost so that its use is limited to construction fill and sub-base roadstone. However, southwest of Stamford, in the extreme northeast of the subregion, the sandy basal unit known as the Collyweston ‘Slate’ might possess qualities that present a potentially wider range of uses. As with many other bedrock formations of the subregion, superficial deposits partially conceal the Lincolnshire Limestone.

Limestones of the Great Oolite Group, of which the **White Limestone Formation** and its lateral equivalent the **Blisworth Limestone Formation** represent the best potential as a crushed aggregate resource, crop out across the centre of the study area from Buckinghamshire to Cambridgeshire. Thickness of the formations varies considerably but they average about 9 m thick west of Buckingham to about 5 m east of Milton Keynes. The strata become increasingly argillaceous (clayey) eastward along the outcrop so that potential resources are confined to the southwestern sector of the study area. The Blisworth Limestone comprises bedded bioclastic limestone, lime-mudstone and ooidal or peloidal limestone, with varying amounts of bioclasts.

Table 1 Estimated volumes of potential aggregate resources in limestone

Number of Environmental Assets		0	1	>1			0	1	>1
MPA	Resource Area Total (hectare)	Resource Area (hectare)	Resource Area (hectare)	Resource Area (hectare)	Mean thickness	Total Volume million m3	Volume million m3	Volume million m3	Volume million m3
Bedfordshire	119	43	76	0	5	6	2	4	0
Buckinghamshire	2681	2371	310	0	5	134	119	15	0
Cambridgeshire	571	203	327	41	6	34	12	20	2
Leicestershire	40	0	35	5	6	2	0	2	0
Milton Keynes	5237	3026	2050	161	5	262	151	103	8
Northamptonshire	6671	5263	1238	170	6	400	316	74	10
Oxfordshire	3164	2294	777	92	9	285	206	70	8
Rutland	203	197	6	0	6	12	12	0	0
Total	**18685**	**13396**	**4820**	**469**		**1136**	**818**	**288**	**29**

Table 2 Estimated tonnages of potential aggregate resources in limestone

Number of Environmental Assets		0	1	>1
MPA	Total Tonnage (Mt)	Tonnage (Mt)	Tonnage (Mt)	Tonnage (Mt)
Bedfordshire	15.6	5.2	10.4	0
Buckinghamshire	348.4	309.4	39	0
Cambridgeshire	88.4	31.2	52	5.2
Leicestershire	5.2	0	5.2	0
Milton Keynes	681.2	392.6	267.8	20.8
Northamptonshire	1040	821.6	192.4	26
Oxfordshire	741	535.6	182	20.8
Rutland	31.2	31.2	0	0
Total	2951	2126.8	748.8	72.8

The **Woburn Sands Formation** outcrops in a 5 km or so wide belt stretching from south of Milton Keynes to Cambridgeshire. It is devoid of gravel but is a valuable source of construction and asphalting sand. Locally, it contains high purity 'Silver Sands' that are used for specialised industrial applications. The formation ranges from 30 to 120 m in thickness but is usually between 30 and 60 m thick. It consists mainly of yellowish brown to greenish yellow, fine-to coarse-grained loosely cemented quartz sandstone or unconsolidated sand. The lateral and vertical distribution of grain size throughout the formation is not well known but it may be too fine-grained in the eastern part of the study area to be of value as a source of construction sand. The Woburn Sands is overlain to the south east by increasingly thick mudstones of the Gault Formation and parts of is also partially concealed beneath Superficial Deposits (largely glacigenic).

Table 3 Estimated volumes of potential resources in bedrock sand

Number of Environmental Assets		0	1	>1			0	1	>1
MPA	Resource Area Total (hectare)	Resource Area (hectare)	Resource Area (hectare)	Resource Area (hectare)	Mean thickness	Total Volume million m3	Volume million m3	Volume million m3	Volume million m3
Bedfordshire	12776	5548	6228	996	20	2555	1110	1246	199
Buckinghamshire	305	268	36	0	20	61	54	7	0
Cambridgeshire	1430	579	760	91	20	286	116	152	18
Leicestershire	0	0	0	0	0	0	0	0	0
Milton Keynes	160	97	63	0	20	32	19	13	0
Northamptonshire	0	0	0	0	0	0	0	0	0
Oxfordshire	0	0	0	0	0	0	0	0	0
Rutland	0	0	0	0	0	0	0	0	0
Warwickshire	0	0	0	0	0	0	0	0	0
West Midlands	0	0	0	0	0	0	0	0	0
Total	**14670**	**6492**	**7088**	**1087**		**2934**	**1298**	**1418**	**217**

Table 4 Estimated tonnages of potential resources in bedrock sand

Number of Environmental Assets		0	1	>1
MPA	Total Tonnage (Mt)	Tonnage (Mt)	Tonnage (Mt)	Tonnage (Mt)
Bedfordshire	4088	1776	1993.6	318.4
Buckinghamshire	97.6	86.4	11.2	0
Cambridgeshire	457.6	185.6	243.2	28.8
Leicestershire	0	0	0	0
Milton Keynes	51.2	30.4	20.8	0
Northamptonshire	0	0	0	0
Oxfordshire	0	0	0	0
Rutland	0	0	0	0
Warwickshire	0	0	0	0
West Midlands	0	0	0	0
Total	4694.4	2078.4	2268.8	347.2

6.3 SUPERFICIAL DEPOSITS

6.3.1 Overview

During the glacial phases of the Quaternary the Midlands was invaded by ice from several directions: from Wales in the West, the Pennines in the North, the Lake District and Irish Sea to the North West and the Vale of York and the North Sea Basin to the northeast. Ice sheets spread from these areas as temperatures dropped during glacial stages, coalescing and spreading southwards covering the Midlands as they grew. This led to extensive deposits of glacial sediments covering the area comprising glacial tills and discontinuous lenticular bodies of glaciofluvial sand and gravel which are found throughout the Project Area. Following glaciation several river systems were initiated. During successive cold stages, when they were large and fast flowing, these rivers deposited considerable quantities of sand and gravel in the region.

6.4 PRE-GLACIAL DEPOSITS

The oldest known superficial deposit within the project area is the **Milton Formation**, consisting of sands and pebbly sands of fluvial origin. The formation is pre-glacial and underlies all known glacial deposits in the area. The Milton Formation was deposited by two contemporaneous east-south-easterly draining rivers: the Milton River to the south, and the Brigstock River to the north (Belshaw, 2007).

The Milton Formation deposits are located close to the upper reaches of the Welland and Nene Valleys (near Wellingborough and Northampton in the centre of the project area). The formation lies directly on the Jurassic strata, and is capped by chalky till and glaciofluvial deposits. In areas where the till is absent around Denton, Yardley Hastings and Bozeat the Milton Formation outcrops at the surface (Barron et al., 2006). The deposits fill a narrow channel around 30km long, 1.5km wide and up to 13m deep, stretching from near Watford Gap in the north-west to Bozeat, south-east of Northampton. The sediment structures and the orientation of the channel demonstrate that the river flowed in an east-south-easterly direction.

Simultaneously, another river flowed to the east-southeast near Rockingham Forest, depositing sands very similar to those found in the south. These pebbly sands are deposited in a line through the villages of Hallaton, Rockingham, Brigstock and Thrapston.

Pre-glacial fluvial deposits known as the Bagington Formation occur in the northwest of the sub-region. They are the deposits of an ancient River Soar. The Bagington Formation is not described in any detail as it lies outside the area of resource assessment.

6.4.1 Milton Malsor Member of the Milton Formation

The Milton Formation consists of thin horizontal beds of light brown sand and gravel, which are interrupted by small curving channels displaying cut and fill structures (Belshaw et al., 2005). These characteristics suggest they were deposited in a braided stream environment. The Milton Formation is thought to be late Pliocene to early Pleistocene in age. The gravel of the formation consists of Jurassic limestone and ironstone, both of which were derived from the local area, picked up by the river as it flowed through the region. Analysis suggests (Belshaw *et al.*, 2005) that the sand was derived from the Triassic Sherwood Sandstone of Staffordshire. The sand is clean with a strongly modal distribution at the medium size of 0.25mm and consists of rounded grains of quartz (Belshaw et al., 2005).

6.4.2 Courteenhall Member of the Milton Formation

The Courteenhall Member of the Milton Formation is exposed near the village of Collingtree. The stratigraphic position is the same as the comparably widespread Milton Malsor member, overlying the solid geology and capped by glacial till. The differences are in the direction of flow suggested by the deposit; more chaotic sediments compared to the well ordered Milton Malsor Member and the presence of floral and faunal material. The deposits consist of muddy gravels passing upwards to cleaner pebbly sands, all of which are interspersed with lenses of silt and clay and organic material (Belshaw et al., 2004). The Courteenhall Member is therefore assumed to be reworked sediments from the Milton Malsor Member, deposited in a channel which cut through the main Milton Malsor Member at right angles, flowing northwards.

6.4.3 Yardley Hastings Member of the Milton Formation

The Yardley Hastings Member of the Milton Formation is confined to a relatively small area, to the North of Yardley Chase. It is composed of sands of the similar to those in the Milton Malsor Member, but contains clasts which are larger and more angular (Phillips, 1982 (Belshaw et al., 2004). The flow direction is the same as that of the Milton Malsor Member, south-southeast. The current consensus on the deposition of this separate member is that it is the remnants of contemporary left bank tributaries of the Milton River.

6.4.4 The Milton Formation as a source of aggregate

The Milton Malsor member of the Milton Formation has been a major source of soft sand for building since the nineteenth century and small pits have worked the Courteenhall and Yardley Hasting Members since at least the 1890s. A new pit extracting Milton Formation sand and gravel has recently opened at Bozeat.

6.5 QUATERNARY TILLS

Three tills have been mapped in the project area: an upper till that is correlated with the Oadby Till, a distinctive middle till that has been named the Bozeat Till (Barron et al., 2006), and finally the older underlying Thrussington Till.

The **Oadby Till** is typical of what used to be known as the 'Chalky Boulder Clay' of central and eastern England and forms a continuous blanket across the project area. It is thought to have been deposited during the Anglian Glaciation some 430,000 years ago, but some authors consider it to date from a later glaciation. The till is an olive-grey to dark grey diamicton that weathers to yellowish brown and comprises silty clay with abundant clasts of chalk, flint, Jurassic limestone, sandstone and ironstone, quartz, quartzite, and Carboniferous limestone and sandstone. Other more exotic clasts have also been recorded including dolerite, tuff, schist, and gneiss. The silt and clay content of the till is derived almost wholly from Jurassic mudstone formations. The till is commonly up to 25 m thick but is locally much thicker in buried subglacial valleys.

The **Bozeat Till** is a dark bluish grey diamicton consisting of silty clay with clasts mainly of Jurassic limestone and ironstone, some quartz and quartzite, derived Jurassic fossils, rare flint and, very rarely, chalk. It occurs in a discontinuous belt across the west of the project area, occurring extensively in the Wellingborough, Buckingham and Towcester districts where a thickness of over 24 metres, including sizable rafts of Jurassic strata has been encountered.

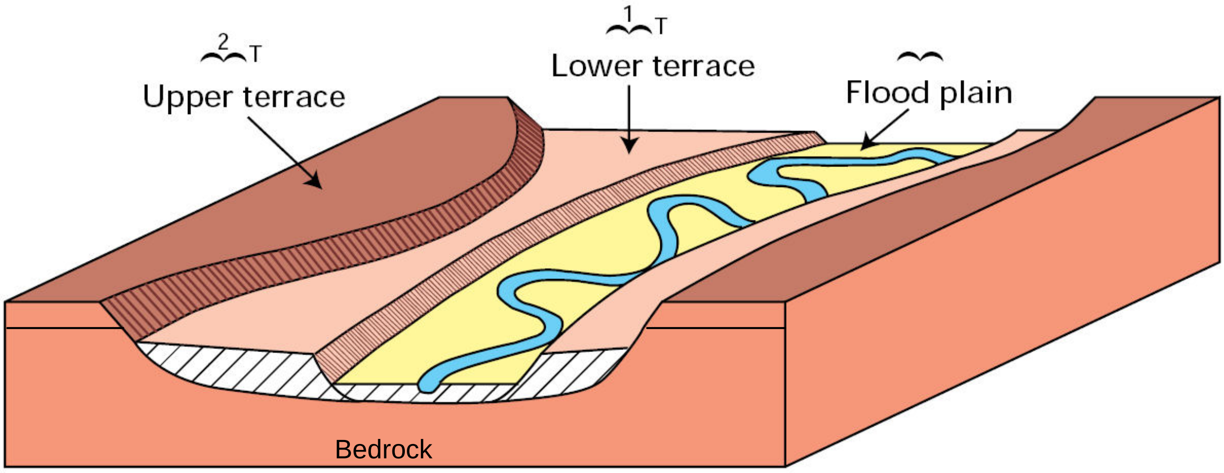
The **Thrussington Till**, brownish grey clay underlying the Oadby Till, is confined to the North of the project area, existing in isolated pockets. The Thrussington Till is thought to have been deposited during the Anglian Glaciation. It contains Carboniferous clasts, derived from north-west England, suggesting the ice moved southwards across England. In comparison to the younger tills, the Thrussington Till is rich in locally derived Triassic clasts.

6.6 GLACIOFLUVIAL SAND AND GRAVELS

Glaciofluvial deposits, comprising sand and gravel with clasts of Jurassic limestone, sandstone and ironstone, flint, quartz, quartzite and chalk, lie beneath, within and upon the till with which they are intimately associated. For example, extensive glacial outwash deposits that form in front of the advancing glacier are found beneath associated tills. Lenses of sands and gravels within the tills can be due to glaciofluvial ice contact deposits, and those above the associated till can be deposited by meltwaters of the glacier as it retreated. Glaciolacustrine clays can also be found in the project area, around Milton Keynes, with varve like repetitive laminations, originating from glacial lakes. Extensive sheet-like bodies of sand and gravel (sandar) are present within the glacial sequence around Rugby and Coventry (where they are known as the Wigston and Dunsmore members) and to the south-west of Milton Keynes. These represent the outwash deposits from the margins of the ice sheet. Elsewhere, small lenticular bodies of sand and gravel occur randomly throughout the glacial sequence. They are probably deposits of meltwater streams that flowed beneath, within and upon the ice sheet.

6.7 RIVER TERRACE DEPOSITS

River terraces are found either flanking the river valleys or beneath the floodplain. They can exist as single features, but can also form part of a "staircase" of terraces up the valley sides, as shown in Figure 8 below. If the terrace is formed due to a meander in the river's course, then it can be an unpaired terrace, with no correlating terrace at the same height on the valleyside opposite. If it formed by a period of rapid incision by the river into the valley floor, they can form "paired terraces", with terraces at the same height on either side of the valley. River terraces can be erosional, cutting into the bedrock. They can also represent a period of aggradation before down cutting, in other words, deposition of fluvial sediment on a pre-existing floodplain. When this is the case, as with both the River Nene and River Ouse and their associated tributaries, for example, it results in the formation of terraces, consisting of fluvial sand and gravel. Both these river systems have a staircase of three terraces, representing 3 cycles of incision and migration of the river, episodes of down cutting interspersed with aggradational phases. The higher terraces are believed to be the older features, with the lowest terraces being the youngest (Bridgland, 2000). The lowest terrace deposit is mapped as the First Terrace, the next highest as the Second Terrace and so on.



McMillan and Powell, 1999, modified from Clowes and Comfort, 1982

Figure 8 An example river terrace cross-section with recommended BGS drift symbols

6.7.1 The Nene Valley Formation

The 1st terrace of the River Nene terrace deposits, the **Ecton Member**, provides an important source of sand and gravel aggregate in the region, and the majority of workings in this area are in this deposit. The deposit is continuous beneath the alluvium within the river valley, and has a maximum thickness of 4.5m. Some reserves do remain but the deposit has been exploited along the length of the valley.

The second terrace is the **Grendon Member**, which is typically more clayey than the Ecton Member, thus is unlikely to provide a workable resource. It is not as extensive as the Ecton Member, and is up to 7.6m thick (Barron et al., 2006).

The third, oldest river terrace is the **Orton Longueville Member**, which is up to 5m thick.

6.7.2 The Ouse Valley Formation

The **Ouse Valley Formation** includes three river terrace deposits although it has not always been possible to differentiate them. The surface of the lowest terrace, the **Felmersham Member**, is between 0.6 m and 2 m above the floodplain. It comprises planar-bedded sand and gravel about 3 m thick in which the gravel fraction is composed mainly of flint and limestone with quartzite, sandstone, chalk, ironstone and chert.

In a former pit near Radwell [TL006586] a fossiliferous sandy silt infilling of a channel cut into the Felmersham Member, the **Radwell Member**, containing various organic material. The Radwell Member is overlain by a further metre of sand and gravel. It seems probable that both the Felmersham and Radwell members were deposited during the early Devensian stage about 80,000 years ago.

The surface of the ‘second’ terrace underlain by the **Stoke Goldington Member** lies between 5 and 7 m above the floodplain and is up to 8 m thick (Bowen, 1999). The composition of the gravel is similar to that of the Felmersham Member but with a significantly higher proportion of chalk in the upper part of the terrace. At the type locality the terrace sequence, which underlies a single terrace surface, exhibits the potential complexity of river terrace deposition, since it includes several deposits of slightly different ages and climates. The highest terrace, the **Biddenham Member**, lies some 11 to 13 m above the floodplain and is underlain by sand and gravel up to 4 m thick and similar in composition to the younger terraces. As with the younger river terrace deposits the Biddenham Member is the result of multi-stage deposition that began late in the Anglian stage.

6.7.3 The Welland Valley formation

River terraces have been mapped along the Welland valley and its tributaries, but are not as extensive or contiunuos as those of the Nene and Ouse. Two terraces have been identified; RTD2 around 10 m and RTD1 around 2 m above the alluvium. The limited borehole information available suggests the river terrace deposits can be up to 5 m thick, but more commonly are less than 2 m. The borehole data indicates the deposits are mainly silty, occasionally sandy, clay, with little gravel, although downstream at Stamford gravel deposits comprising mainly ironstone and limestone with some flint have been recorded.

6.7.4 The Avon Valley formation

Five terraces have been recognised along the Avon Valley, consisting of fluviatile sand and gravels. The Avon Valley Formation deposits post-date the last major glaciation to extend into the area, as the drainage system is developed on tills laid down during the Anglian Glaciation, around half a million years ago. The five terraces are **Bretford Member** (RTD1), **Wasperton Member** (RTD2), **New Inn Member** (RTD3), **Cropthorne Member** (RTD4) and the oldest highest terrace is the **Pershore Member** (RTD5). In the project area the youngest two terraces are by far the most extensive.

6.8 ALLUVIUM

Alluvium, consisting mainly of silt, clay and peat, underlies the floodplains of all river valleys in the project area. In the larger rivers such as the Nene, Welland and Great Ouse the alluvium occupies channels cut into the lowest river terrace deposit. It is important to note that sand and gravel deposits commonly referred to as ‘sub-alluvial’ are in fact within the youngest river terrace deposit.

6.9 HEAD

Head is a heterogeneous deposit derived from mass movement down slope during periglacial conditions. The composition of Head is closely related to that of the uphill deposit that it is derived from by solifluction. Head is present as a veneer on most valley sides and on the floors of smaller valleys. Typically, it consists of stony, sandy clay and can be up to 3 m in thickness.

6.10 SUMMARY

The bedrock of the Project Area comprises Triassic, Jurassic and Createous strata. It is overlain by deposits known as the Milton Formation that predate the glacial deposits of the region. The Milton Formation was laid down by fluvial action and is be found near the upper reaches of the Welland and Nene valleys. Disposed stratigraphically above this formation are the three main tills of the region, the Oadby, Bozeat and Thrussington tills. The Oadby till is a chalky till forming a continuous blanket over most of the Project Area. The Bozeat till forms a belt across the west of Project Area and is a dark bluish silty clay. The underlying Thrussington till, brownish grey clay, is only found in the north of the Project Area as isolated pockets underlying the Oadby till. Glaciofluvial deposits are widespread across the Project Area, often inter-bedded with the tills. In the four river valleys of the region, the Nene, Great Ouse, Welland, Avon and their larger tributaries river terrace deposits are found either flanking the valley sides or beneath floodplain. Alluvium (present day river deposits) is found on the floor of these valleys and Head, from mass movement down slope during periglacial conditions, occurs on the slopes across in the Project Area.

6.11 KEY FINDINGS – AGGREGATE RESOURCES IN BEDROCK AND SUPERFICIAL DEPOSITS

- Bedrock Geology - The principal potential aggregate resources for the Growth Area are Middle Jurassic limestone of the Inferior Oolite and Great Oolite groups and the sand of the Lower Cretaceous Woburn Sand.
- The most important aggregate resources in the Superficial deposits are, and have long been, the river terrace deposits of the principal rivers of the sub-region
- The glaciofluvial deposits within the region have also, in some areas more than others, been used as a source of aggregate.

7 Aggregate resources: updating information and refining knowledge.

This section updates and refines existing geological information about all resources in the project Project Area that are suitable for use as aggregates. Using:

- New and revised BGS geological maps
- Existing borehole data
- Mineral Assessment Reports (54, 60, 107, 114, 125)
- County Mineral Resource maps

This task has used ArcGIS as a tool to aid interrogation of the digital data held for the project area, something which previous studies have been unable to do. Existing borehole data will be reclassified to help build a more usable end product.

7.1 INTRODUCTION

Current 'County Mineral Resource' maps only show the extent of concealed resources within areas for which Mineral Assessment Reports are available and the parameters defining aggregate resources for the Mineral Assessment Reports may no longer be appropriate. New resource information is provided based on new and revised BGS geological maps, existing borehole data and Mineral Assessment Reports. The BGS itself has substantially increased its borehole record archive since the last assessments of bulk mineral resources in the region were carried out in the 1970s and 80s. Geological studies have shown that the composition, and therefore quality, of the sand and gravel deposits varies according to their origin. It follows that if their origin is known then their character and properties can, in part, be predicted. Existing geological maps differentiate only river terrace deposits whilst all other sand and gravel deposits in the region have been classified as "glaciofluvial deposits". Recent research suggests that this classification is too simplistic: "glaciofluvial deposits" probably includes deposits with a much wider range of origin and (implied) age. A project GIS has been constructed to help manipulate the spatial data. No fieldwork has been carried out as no new field data is required, for much of the project area has recently be resurveyed by BGS mapping geologists. The project focussed on the north of the Project Area as this is where most potential resources can be found. The Project Area is effectively the Demand Zone.

7.2 TOWCESTER BOREHOLE PILOT STUDY

The Towcester sheet (BGS sheet 202) was chosen as a pilot area to;

1) Compare 3D modelling software (GSI3d) and Geographical Information Systems (ArcGIS), with an aim of identifying the most useful package to aid interpretation of the borehole data and identify locations for new project boreholes
2) Verify the method of borehole selection and data input and interpretation and insure that it identifies all potential resource deposits.

Boreholes were selected using the rules outlined in section 7.3 and BGS geologists interpreted and input the borehole data, also outlined in section 7.3. These rules were found to be very successful and identified all resources within the area; therefore they were used to select the boreholes for the whole of the Project Area.

GSI3d had strengths in the fact it was a 3D package, aimed at mapping deposits in 3 dimensions (see Figure 9 for an example cross section from the Towcester sheet). It was able to build up a 3d model of an area to enable interpretation of the deposits. Difficulties arose when the area was enlarged and discontinuous, lenticular bodies of glaciofluvial deposits, which were interbedded with till, had to be added to the model. This complexity of the deposits and the large Project Area led to GSI3d being set aside for this project and ArcGIS being utilised for the rest of the projects digital geological interpretation.

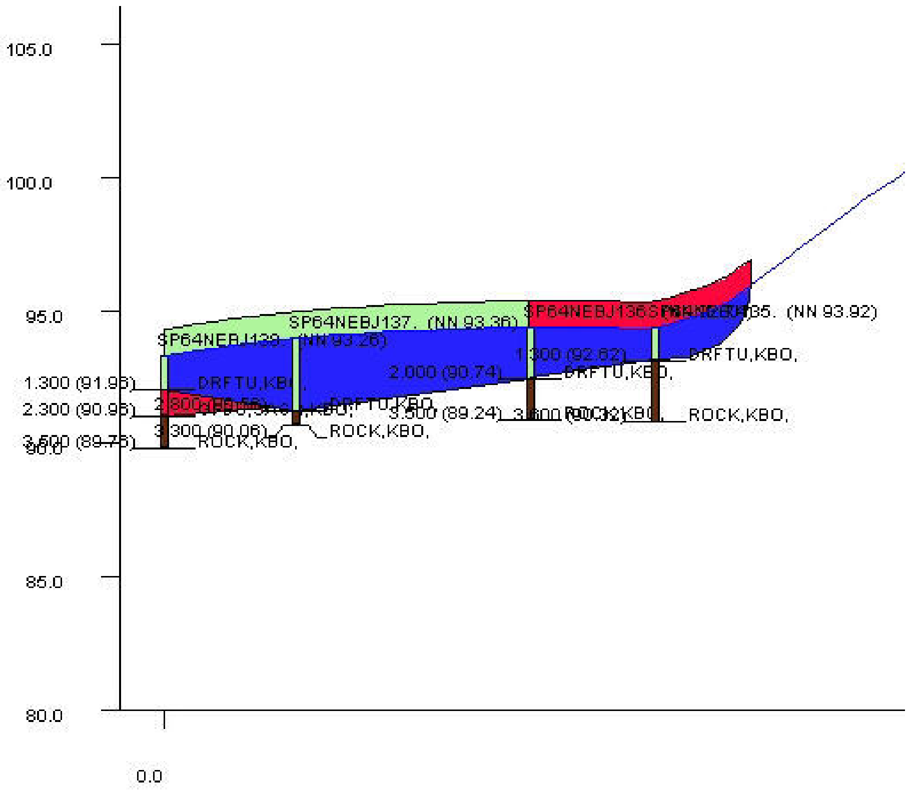


Figure 9 An example cross -section compiled using GSI3d and utilising data from borehole logs and BGS mapped surface geology

7.3 REFINING THE EXISTING GEOLOGICAL INFORMATION

A Geographical Information System (GIS) was utilised to display, manipulate and interrogate the various spatial data that was used during this phase the project. Table 5 lists the data layers used in this task. The existing SOBI (Single Onshore Borehole Index) data layer contains point data, providing the location of existing boreholes, and links to the BoGe (Borehole Geology) database that contains borehole data for existing boreholes. The existing borehole data was not in a usable format to allow manipulation to identify the required potential resource, overburden and waste.

Table 5 GIS data layers used

Data layer	**Brief description**	**Source**
SOBI (Single Onshore Borehole Index)	Index of all boreholes registered at BGS	BGS
Digital Geological maps	'DigMap' digital geological maps at 1:250k to 1:10k scale	BGS
Administrative Boundaries	County Council boundaries	Ordnance Survey
Mineral Assessment Reports database	BGS database of the borehole data collected for the Mineral Assessment reports	BGS

The total number of boreholes identified within the project area was approximately 64000. This included very shallow boreholes, those with very little data or a source of unknown reliability. Such a large number of boreholes was beyond the scope of this project, so a subset of boreholes was identified for coding and addition to the BoGe database. These would then be used by the project team to identify existing resources and potential areas for new boreholes. The GIS was used as a tool to identify the relevant boreholes by applying the following rules:

- Borehole is to be deeper than 1m
- Borehole is within a 250m buffer zone of a mapped sand body OR within a 500m gridcell containing a sand body
- Are not Mineral Assessment Report boreholes

Mineral Assessment Report boreholes were discounted at this stage as their existing entries into the BoGe database were in a known usable format.

This subset contained approximately 9000 boreholes. These boreholes were then assessed by geologists, who aimed at entering approximately 1 in 3 of them into the BoGe database. The aim was to enter data from the selected boreholes in order to provide a representative spread of data across the project area. For example, the deepest, most informative borehole was to be used in a cluster of closely grouped boreholes.

The coding scheme used when inputting the borehole data into the BoGe database is outlined below.

BoGe Lithology code field:

The boreholes should be coded in terms of:

- DRFTU = overburden: unwanted material overlying the sand and gravel
- SAGR = where the log records sand and gravel
- SANDU = where the log records sand
- GRAV = where the log specifically records gravel
- NATD = waste: unwanted material within or below sand and gravel units (Natural Superficial deposit (Undifferentiated))

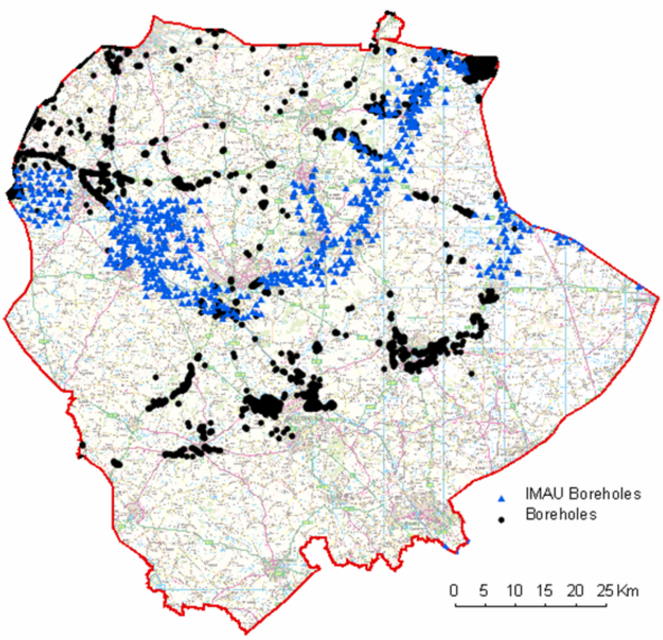
Examples:

Input as	When borehole log records (code)	When borehole log records (full name)
DRFTU or NATD	MGR	Made ground
	SOIL	Soil
	ALV	Alluvium
	GLLMP	Glaciolacustrine Deposits, Middle Pleistocene
	HEAD	Head
	PEAT	Peat
	TILMP	Till, Middle Pleistocene
	TUFA	Tufa
SAGR, GRAV or SANDU	GFD(U)	Glaciofluvial Deposits
	RTD1	First Terrace
	RTD2	Second Terrace
	RTDU	River Terrace Deposits, undifferentiated

The following rules were followed when entering the borehole data into the BoGe database:

- Include any resource with only SMALL clay and/or silt component
- Disregard any resource with MEDIUM / LARGE clay and/or silt component, recording it as DRFTU or NATD (as appropriate).
- If the resource contains deleterious material such as chalk fragments note this in the Unit Description field.
- Overburden and waste thicknesses of less than 0.1m are to be disregarded (i.e. included in the adjacent sand and gravel unit).
- Sand and gravel thicknesses of less than 0.1m are to be disregarded (i.e. included in waste or overburden).
- Boreholes with no sand and gravel in the superficial deposits should still be coded, as DRFTU.
- Record superficial interpretation down to Rock Head (RH) and record solid below rock head as ROCK.
- Always record Total Depth (TD) of borehole. If TD = RH, record as TD.
- Always include the project code of BR (Aggregates for Sustainable Communities: Bulk Resource) when adding a borehole to the Borehole Geology database.
- *Lithostratigraphy code field:* Classify sand and gravel deposits as Glaciofluvial deposits undifferentiated (GFDU) or River Terrace Deposits undifferentiated (RTDU) to aid correlation. For boreholes logs in which this has not been classified (because it is concealed) inspect the geological map (DigMap) and make a judgement based on this and geological knowledge. Judgements are to be made using the same criteria where there are more than one sand and gravel unit in the borehole.

The total number of boreholes coded within the project area was 2428. The Mineral Assessment Report boreholes (809) were then added to the subset and an algorithm was used to convert the lithology classifications into overburden, mineral and waste. This produced a total of 3237 (Figure 10) boreholes to be used in the following analysis work.



Key.

Yellow dots: Mineral Assessment Report boreholes.

Blue circles: Subset of existing borehole data from other sources.

Red line: MKSM Growth Zone.

Black line: Project Area

Reproduced in Appendix 5 at A3.

Figure 10 Existing boreholes in the Project Area

7.3.1 Lessons learnt

When coding, NATD was used for waste deposits both in-between and below sand and gravel units. For analysis of borehole data, it would have been useful to differentiate between the two. This is because NATD below all sand and gravel units does not affect the aggregate above. However, NATD between the top sand and gravel unit and a lower sand and gavel unit is above the lower unit and will affect its' potential use as a resource. When assessing percentages of units in a borehole, a large amount of NATD can make the percentage of resource lower. It would have been useful to assess just overburden, resource, and waste above the lowest resource, as the waste below is not important when assessing the potential use of resource above. Using a different code, such as NATA Natural Superficial deposit (Above) and NATB Natural Superficial deposit (Below) would have been useful.

7.4 ANALYSIS OF THE EXISTING GEOLOGICAL INFORMATION

Once the borehole data was in a usable digital format, the GIS was utilised to analyse the data by various methods.

7.4.1 Borehole Statistics

Utilising the tools within the GIS allowed easy analysis of the borehole data. Table 6 provides a summary of the number of boreholes with a deposit present, the minimum and maximum thickness of the deposit within the area and the mean average thickness. The table enables an overview of the data and allows a quick assessment of which areas have an abundance of boreholes, and where the thickest resources are within the project area.

Table 6 Data for the selected project boreholes, separated by administrative areas

Adminstrative Area	Overburden thickness (m)	Resource thickness (m)	Waste thickness (m)	Rockhead depth (m)
Project Area				
Count	3237	3237	3237	3237
Min	0	0	0	0
Max	49.5	30.09	58.43	63.42
Mean	4.18	1.37	0.1	3.49
Northamptonshire				
Count	1084	1084	1084	1084
Min	0	0	0	0
Max	32.77	24.38	58.43	63.42
Mean	5.32	1.36	0.12	5.14
Milton Keynes				
Count	544	544	544	544
Min	0	0	0	0
Max	16	10.82	3.9	14
Mean	2.83	0.83	0.03	1.95
Peterborough				
Count	452	452	452	452
Min	0	0	0	0
Max	7.31	9.6	2.29	12.43
Mean	2.03	1.26	0.04	2.69
Bedfordshire				
Count	378	378	378	378
Min	0	0	0	0
Max	14.35	10.35	6.71	51.54
Mean	2.51	1.1	0.04	2.87
Warwickshire				
Count	362	362	362	362
Min	0	0	0	0
Max	49.5	30.09	14.42	61.26
Mean	7.13	1.78	0.13	2.79
Leicestershire				
Count	185	185	185	185
Min	0	0	0	0
Max	24	24.07	28.8	36.57
Mean	4	3.35	0.41	3
Cambridgeshire				
Count	137	137	137	137
Min	0	0	0	0
Max	25	9.7	12.2	18.7
Mean	3.64	1.24	0.1	2.95
Buckinghamshire				
Count	74	74	74	74
Min	0	0	0	0
Max	34.8	21.95	3.2	34.8
Mean	6.72	1.14	0.05	4.91
Oxfordshire				
Count	16	16	16	16
Min	0.2	0	0	0
Max	4.4	2.1	0	4.6
Mean	1.88	0.23	0	0.89
Rutland				
Count	5	5	5	5
Min	1.05	0	0	0
Max	4	0.25	0	4
Mean	2.43	0.05	0	1.47

7.4.2 Interpolation methods

In the evaluation of borehole data and seeking locations for the new boreholes a series of spatial analysis techniques were tested including a range of interpolation methods. These methods use the known data points to create a continuous (prediction) surface. Care should be taken using these results however as they are based on the borehole data and do not take into consideration other factors e.g. the underlying geology. The results of this predictive method should not therefore be taken in isolation but included simply as a factor in the development of a strategy in the citing the new boreholes.

7.4.2.1 INVERSE DISTANCE WEIGHTING

This deterministic interpolation method assigns values to a location based on the surrounding measured values from the original data points and utilizes a mathematical formula which assigns a weighting based on distance i.e. actual data points closest to the unknown geographic location are given greater significance than those further away. The resulting map predicts most likely areas for boreholes (Figure 11 in Appendix 6).

Figure 11 Inverse Distance Weighting information for the borehole data

7.4.2.2 NATURAL NEIGHBOUR

Interpolates a surface from the known data points in a similar way to inverse distance weighting and produces very similar results (Figure 12 in Appendix 6).

Figure 12 Natural Neighbour information for the borehole data

7.4.3 Nearest Neighbour

Average nearest neighbour measures distance between each feature and its nearest neighbour using this information to see if the distribution of points is random or forms a clustered pattern. As there are a number of constraining features in the original location of boreholes in the project area, the geology for example, this would lead us to expect clustered rather than random distribution. This suggested pattern was supported by the analysis of the borehole data.

7.4.4 Volumes of potential resource

As a trial run to assess potential methods of calculating volume of aggregate, a section of river gravels on the Great Ouse from Milton Keynes to Huntingdon was selected and a resource block defined. The block was divided into four distinct areas and the River Terrace deposits were extracted from the superficial deposits. The total area of these deposits was then calculated within each section of the resource block.

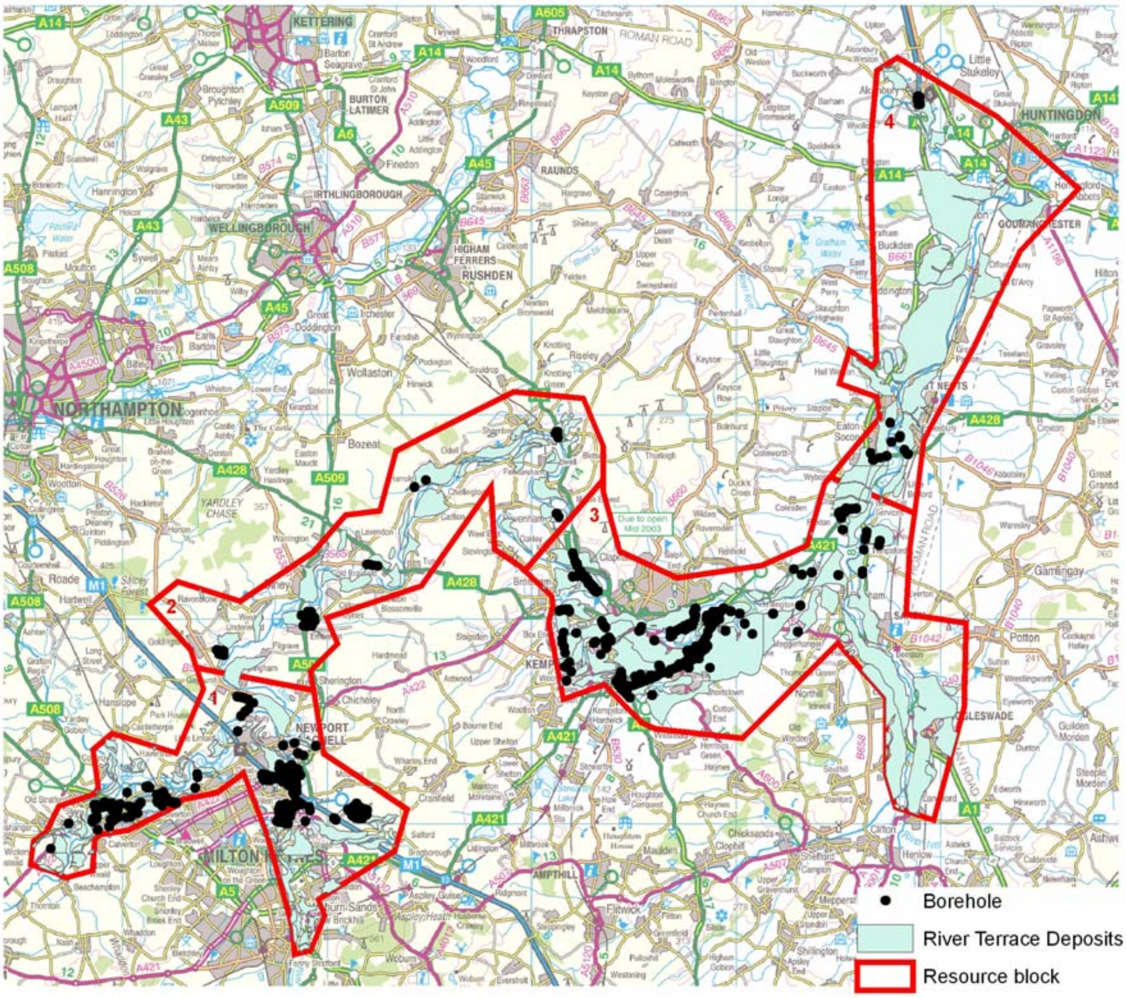


Figure 13 Demonstration of the method of calculating potential resource volume

The boreholes that fell within these resources were selected and the average depth of resource was calculated. This value was then used to give a generalised estimate of the volume of resource within the selected resource block.

Example Block 1 (Figure 13)

Area of River Terrace Gravel	21620000m^2
Boreholes	
Number of Boreholes in Block 1	209
Average depth of resource	2.16m
Approximate volume	21620000 x 2.16 = 46699200 m^3

This method would provide a very rough estimation of volume of resource, although it takes no account of geological variation the large number of data points within the test area should enhance the results obtained.

7.5 DISPLAYING THE BOREHOLE DATA

7.5.1 Density of boreholes

A density map of the boreholes was created taking the locations and showing their distribution through the project area. The density map was generated by establishing the number of boreholes in each cell of a 1km raster grid however an examination of the raw data points would have produced a similar outcome.

7.5.2 Borehole Data

Pie and stacked charts were used to illustrate the relationship between depth of the borehole and the amount of Overburden, Resource and Waste found within the borehole.

Each borehole was coded according to set criteria to assess the amount of each of the three material types.

For example:

New Inn Farm Illston on the Hill borehole (SK70SW BJ85 472120 0300070)

Total Depth	24.69m
Overburden	0.23m
Resource	9.67m
Waste	2.75m
Rock Head	12.65m

7.5.2.1 Pie Charts

To illustrate the content of the individual boreholes proportional pie charts were selected. These display the depth of the borehole as the radius of the pie resulting in larger circles for deeper boreholes. The ratio or proportions represented by each category i.e. overburden, resource & waste are based on the down borehole length of each type (See Figure 14 in Appendix 6).

Figure 14 Pie charts indicating borehole content

The strength of this analysis was to give a visual representation to the borehole data not only in relation to their spatial location which could be seen in the borehole density described previously but to establish the content highlighting areas with high resource content and allowing exclusion of areas with little or no resource present.

Figure 15 An example of a proportional pie chart illustrating the content of an individual borehole

7.5.2.2 Stacked Charts

Once analysis of the new borehole data had been carried out a series of stacked charts were created. These were similar to pie charts used previously illustrating the relationship between depth of the borehole i.e. the height of the stack and the amount of Overburden, Resource and Waste found within the borehole. This type of visual representation was found to be easier to understand.

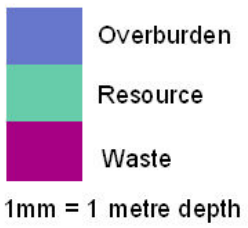


Figure 16 An example of a stacked pie chart illustrating the depth of overburden, mineral and waste in an individual borehole

7.5.3 Overburden to Mineral ratio

The use of GIS and detailed borehole information enables manipulation of the data to allow an assessment of the overburden mineral ratio of all the inputted boreholes. These values are shown in Table 7, by number per administrative area.

Table 7 Mineral overburden ratios for each administrative area within the Project Area

Region	1:1	2:1	3:1
Northampton	231	317	353
Warwick	97	117	126
Bedford	124	163	179
Buckinghamshire	10	13	13
Milton Keynes	134	170	187
Cambridge	48	56	60
Leicester	78	96	104
Rutland	0	0	0
Oxford	1	2	2
Peterborough	166	209	232
TOTAL	**889**	**1143**	**1256**

7.6 KEY FINDINGS - ANALYSIS OF EXISTING GEOLOGICAL INFORMATION

Various methods were used to analyse the existing borehole data. These include:

- A Pilot Area was identified and used as a test area for inputting borehole data
- Building the borehole database of thousands of interpreted borehole logs was a major undertaking that stretched the project resources.
- GSI3d, a 3D geological modelling package, was used as a tool to build an understanding of the deposits, but had difficulties dealing with lenticular deposits.
- GIS proved the most successful analytical tool.
- The BGS Borehole Geology database was utilised to interpret the existing borehole data efficiently and make it readily available for further analysis
- Various interpolation methods were used to view the existing borehole data, including Inverse Distance Weighting and Natural Neighbour.
- Crude calculations of the volume of resource available were trialled.
- Various ways of displaying the data were attempted, including displaying the mineral, resource and waste borehole data as pie and stacked charts.

8 Borehole drilling programme

8.1 INTRODUCTION TO DRILLING PROGRAMME

The first phase of the project collated and analysed existing resource information and identified areas with limited detailed data. The aim of the borehole drilling programme was to collect samples and to gain detailed information on the composition, quality, thickness, and overburden to mineral ratio of resources. It focussed on areas of potential resource with limited numbers of boreholes and areas with with little grain size or composition data. Potential resources investigated included: river terrace deposits, glacial and pre-glacial deposits, concealed resources and those outcropping at the surface. Following an assessment to identify suitable drilling locations, 48 boreholes were drilled during summer 2006. They mostly fell into three main groups: in the north of the project area near Market Harborough; to the east of the project area near Bedford and to the south near Milton Keynes. 115 particle size analyses (PSA) were performed on potential resources from 29 boreholes. The results of this drilling programme have been collated with the existing data to gain a complete overview.

8.2 ENVIRONMENTAL SENSITIVITY AND THE BOREHOLE DRILLING PROGRAMME

Environmental sensitivity has been mapped, by the BGS, for England, Scotland and Wales and the area pertaining to the Project Area was selected from this dataset (Figure 17). An overview of the technique and further details about the assets used are provided in Box 1 and Table 8. Generally, the Project Area has low environmental sensitivity. The maximum number of assets in any given hectare is five. This compares to a maximum of 11 nationally (Figure 18). There are important major assets in the Project Area including parts of the Chilterns AONB and a Community Forest (Forest of Marston Vale). There are also many other assets that will need to be considered in terms of aggregates supply for the sustainable communities.

Environmental sensitivity was used to guide the borehole drilling programme. The environmental sensitivity map allowed the least sensitive locations to be selected for drilling. This saved time and costs in terms of ease of access to land.

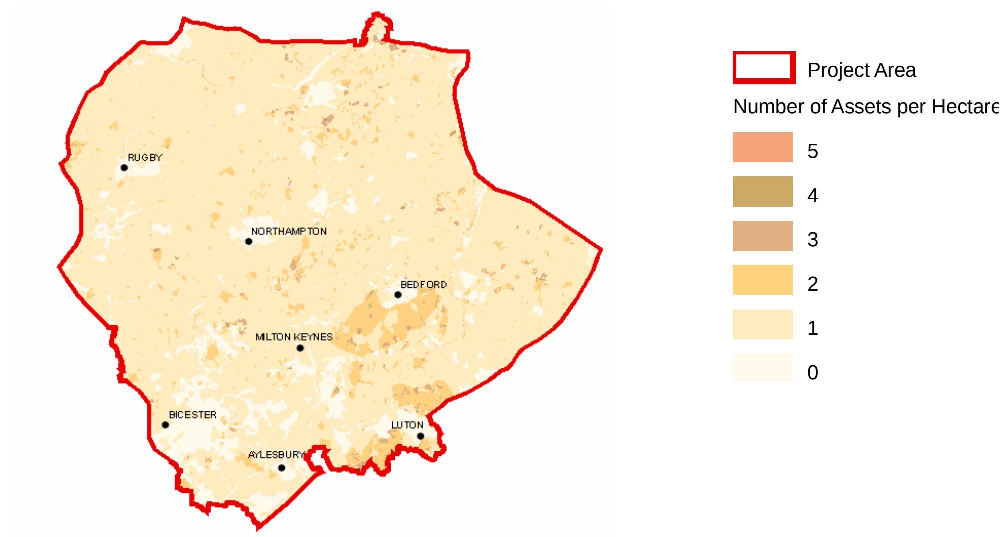


Figure 17 Environmental sensitivity for the Project Area using all assets

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Table 8 Environmental and cultural assets used to derive environmental sensitivity map

Asset name (listed alphabetically)	Asset type	Present in Project Area?	Area (hectares)
Ancient woodland	Landscape conservation	Yes	14,878
Agricultural Land Classification Grades 1, 2 or 3	Agricultural land	Yes	242,700
Area of Outstanding Natural Beauty	Landscape conservation	Yes	10,650
Community Forest	Landscape conservation	Yes	15,889
Doorstep Green	Landscape conservation	Yes	*
Heritage Coast	Landscape conservation	No	
Historic Parks and Gardens	Heritage & cultural conservation	Yes	15,073
Local Nature Reserve	Nature conservation	Yes	681
Millennium Green	Landscape conservation	Yes	*
National Forest	Landscape conservation	No	
National Park	Landscape conservation	No	
National Nature Reserve	Nature conservation	Yes	519
Ramsar	Nature conservation	No	
RSPB reserve	Nature conservation	Yes	101
RSPB Important Bird Areas	Nature conservation	No	
Special Area of Conservation	Nature conservation	Yes	428
Special Protection Area	Nature conservation	No	
Scheduled Ancient Monument	Heritage & cultural conservation	Yes	*
Site of Special Scientific Interest	Nature conservation	Yes	8,092
Woodland Trust site	Landscape conservation	Yes	648
World Heritage Sites	Heritage & cultural conservation	No	

*Point data only therefore no area available

8.2.1 Environmental sensitivity and local assets

Individual county councils do hold their own local level asset data and archaeological records. However, it is difficult to incorporate these data into the environmental sensitivity map for the Project Area. This is because each county council has different data and in some cases the datasets may have the same name but have been designated under different criteria. It is therefore not possible to directly compare the datasets. However, it would be possible, due to the flexible nature of the environmental sensitivity technique, at a county level to modify the environmental sensitivity map to include local data.

Box 1 Overview of the environmental sensitivity technique

Overview of the environmental sensitivity technique

Environmental sensitivity mapping provides a strategic overview of the environmental and cultural assets in a region. It is a technique that was developed, by the BGS, to integrate numerous datasets into a single composite layer in a GIS. It uses a transparent methodology to provide the user with an easy to understand visual overview of these assets. Environmental sensitivity mapping is a rapid, objective and straightforward method of identifying areas which may be particularly sensitive to development.

This technique has a number of applications in land-use planning for minerals and other forms of development. It may be used both to aid and explain decision-making.

The method is based on the number of environmental or cultural assets at a given location. It is analogous to a density map, whereby the higher the number of environmental and cultural assets in an area, the darker the colour on the map. Within a GIS, it is possible to weight or score different assets depending on their importance or significance. The environmental sensitivity map can then be based on the total score, rather than the total number of assets. The user can obtain a list of all environmental and cultural assets at a particular location by simply clicking on the area of interest. For further details on the methodology see Steadman *et al.*, (2004) and Steadman et al., (2005) or

http://www.bgs.ac.uk/mineralsuk/envsens/home.html

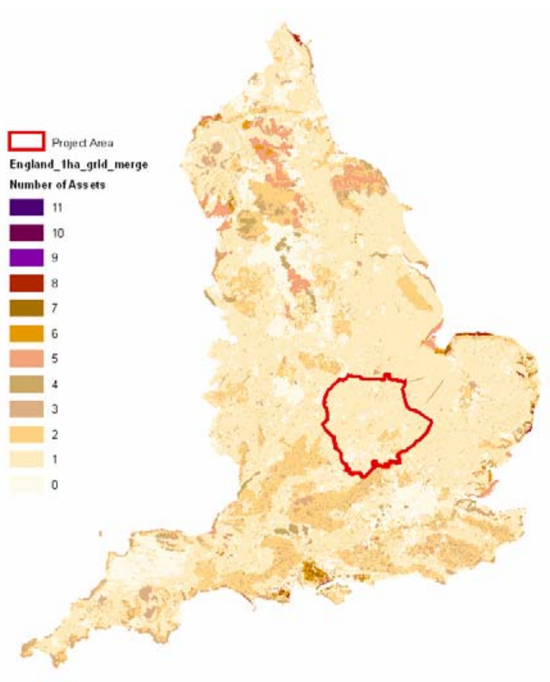

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Figure 18 Environmental sensitivity for England showing the Project Area

Assets and constraints

The assets used to create the environmental sensitivity map are listed in Table 8 (note some of these assets do not exist in the Project Area). In planning many of these assets are often referred to as 'constraints'. However, they are not treated as constraints in the environmental sensitivity technique. The presence of an asset at a particular location does not necessary preclude development, but it will certainly need to be considered in any planning decisions. The map used interactively in a GIS provides an index of all the assets at a particular location. This information can be used in conjunction with other information such as who owns the data so that a quick list of all stakeholders can be easily generated for a particular location.

Limitations

As can be seen from Table 8, there is a heavy bias in the data used toward landscape and nature conservation type assets. This is due to the availability of digital data. Only those datasets that are consistently available are included. This means that the data tends to be limited to national and regional datasets, though some local datasets are available nationally, such as Local Nature Reserves.

8.2.2 Key findings - Environmental sensitivity

- Generally the Project Area has low environmental sensitivity. The maximum number of assets in any given hectare is five (Figure 17). This compares to a maximum of 11 nationally (Figure 18).
- Local asset data is difficult to incorporate in the environmental sensitivity due to the variability between different county councils in terms of digital availability and designation criteria.

8.3 PLANNING THE BOREHOLE DRILLING PROGRAMME

The locations of the project boreholes were selected considering a number of factors, including environmental sensitivity, interrogated using GIS. Table 9 list the data layers utilised and Table 10 describes the interpretation process.

Table 9 Data layers

Data layer	Brief description	Source
The project boreholes	A subset of the SOBI (Single Onshore Borehole Index), an index of all boreholes registered at BGS	BGS
Superficial Geology	'DigMap' digital geology map at 1:50k scale	BGS
BRITPITS	Polygons outlining pits and coloured by their status (active, ceased, dormant, restored, tipping, yet to begin)	BGS
Planning Permissions	Polygon dataset illustrating areas granted planning permission	Mineral Planning Officers
Bedrock Geology	'DigMap' digital geology map at 1:50k scale	BGS
Mineral resources	Mineral resources of potential economic potential	BGS
Environmental sensitivity	Shows density of environmental assets	BGS
Environmental assets	International, national and local environmental features.	Various see section 7
Airport buffer zones	13 km radius buffer zone around all airports	BGS
Topography	OS settlements, towns and cities	Ordnance Survey
Administrative Boundaries	County Council boundaries	Ordnance Survey

Table 10 Interpretation layers

Data layer	Brief description	Source
Initial Drilling Areas	Initial areas highlighted by geologists as being potential resource areas, based on GIS layers and borehole data, and requiring further investigation	BGS project staff
Pot_res_no_drilling	Areas highlighted by geologists as being potential resource areas, based on GIS layers, requiring no further investigation as existing boreholes provide reliable data.	BGS project staff
Non_res_areas	Areas highlighted by geologists as areas that appeared to have potential resource based on DigMap, but existing boreholes prove this as highly unlikely, so drilling not advised	BGS project staff
Refined drilling Areas	Initial Drilling areas layer cropped by various	BGS project

	"influential" layers, as detailed in the text below	staff
Preferred_drilling_locations_wide	These are polygons chosen by the project geologists to represent a group of polygons, which were initially one polygon before refinement. Only the most suitable polygons were chosen. (38).	BGS project staff
Preferred drilling_locations_accurate	Small areas of the Preferred_drilling_locations_wide polygons, showing the optimum place(s) to drill within that polygons, chosen by the geologist based on factors such as elevation, geological data, access, location of houses etc. (49).	BGS project staff

8.4 SITE IDENTIFICATION AND LOCATION

The project GIS was used as a tool to manipulate the data available and identify suitable sites for the boreholes. The project GIS displayed the data layers listed in Table 10. The method of identifying borehole locations is outlined below.

Areas (polygons) in which to focus the search on were identified by geologists, based on an up-to-date understanding of the Quaternary stratigraphy of the area, the mapped superficial geology and existing borehole data. The main deposits targeted, to gain information on their thickness, grading, presence and distribution are listed below:

a. River Terrace Deposits
b. Glaciofluvial Deposits
c. Pre-glacial Deposits
d. Potential resources (glaciofluvial and pre-glacial) beneath overburden

Due to the detailed and reliable borehole data and particle size analysis carried out within earlier Mineral Assessment Report areas, this step automatically excluded those from the potential sites.

The polygons were then clipped as outlined below and shown in Figure 19.

1) Shows all the potential resource polygons as identified by geologists, clipped by the Mineral Assessment Report areas.
2) The potential resource polygons were then clipped by the urban settlements layer.
3) The polygons were then clipped by all areas with existing planning permissions.
4) Finally, the polygons were clipped by areas with an environmental sensitivity of more than 1, producing the final green polygons.

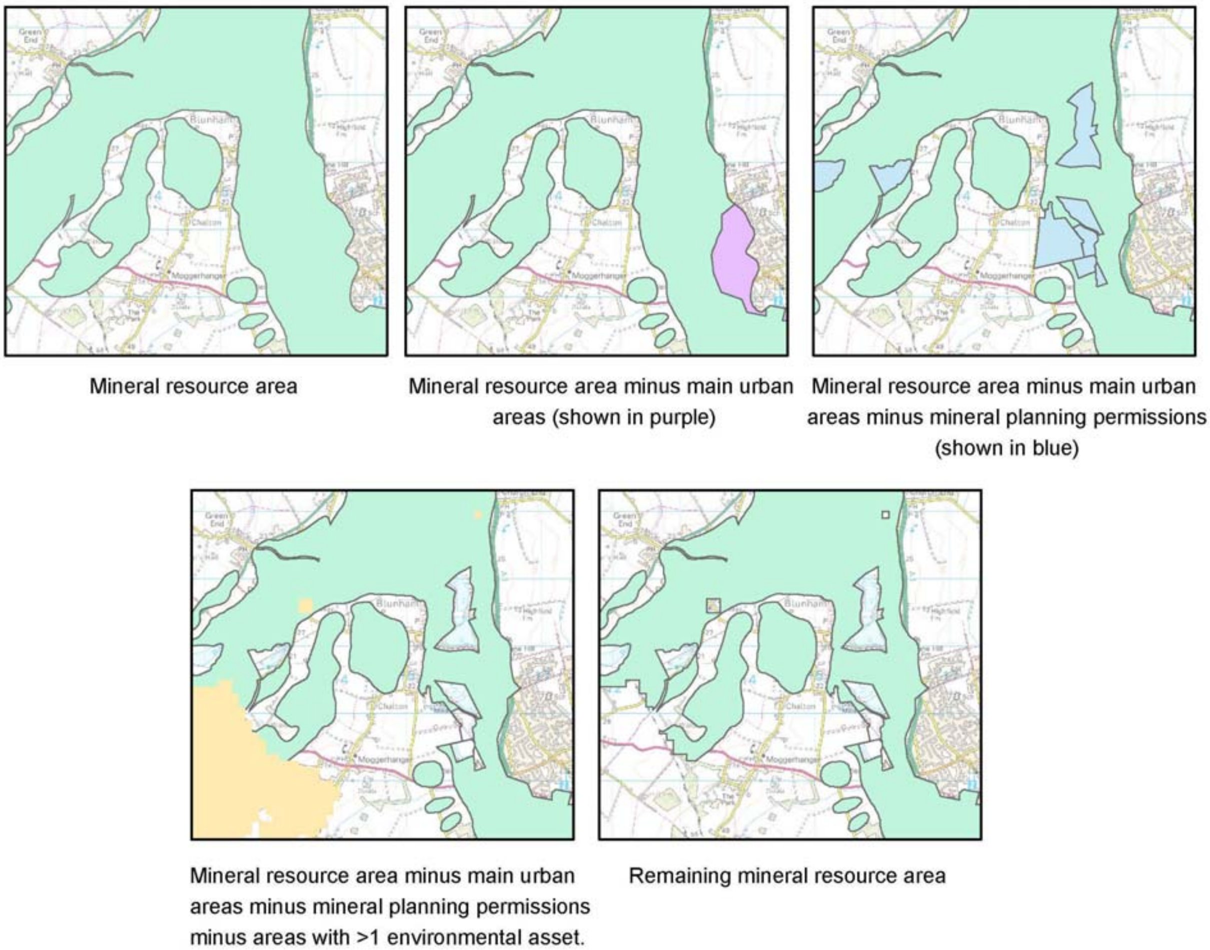

Figure 19 Clipping of the resource polygons

Of the remaining polygons, the geologist manually chose which to target. This decision was made based on a number of parameters, such as reassessment of the borehole data, the type of deposit at surface and the size of the polygon. Finally, of the final 38 chosen polygons, the geologist highlighted the optimum areas within them to drill. This was based on:

1) Elevation (mostly favouring higher elevation as this provides potential to reveal thicker Quaternary deposits)
2) Existing borehole data (where any existing boreholes are within the polygon and the data they provide)
3) Access (roads and tracks)
4) Settlements (as far from farms and villages as possible due to noise pollution).

Geologists identified a total of 49 optimum borehole locations within the final 38 polygons.

8.4.1 Services and Access

The landowners for each of the 49 optimum sites were approached, and access was gained for 43 boreholes. Five boreholes were re-drilled close to original borehole sites, giving the final total of 48. Whilst gaining written confirmation from the landowners, service checks were carried out on each of the sites with the service providers listed in Table 11.

Table 11 Service providers in the Project Area

Service	Provider
Water & sewerage	Anglian Water and Severn Trent Water
Electricity	Central Networks and EDF
Gas	National Grid
Telephone	BT
Private pipelines & cables	Landowner
High Voltage Electricity	National Grid
Pipeline and fibre optic cable ducts.	Linesearch (Esso Petroleum Co Ltd, Mainline Pipelines Ltd, Government Pipelines and Storage System, Manchester Jetline Ltd, BP, ConocoPhillips (UK) Ltd, Total UK, BP TSEP, Shell UK Ltd, Sabic UK Petrochemicals, BT GEO Network, E-on UK Plc).

The project area spanned numerous service provider areas as shown in Table 10.3. Many boreholes were located along the boundaries of different providers; therefore both providers were contacted for service checks. If any services were close by, the service providers produced maps of the borehole location highlighting any services. When there were no services in proximity to the borehole, most providers simply supplied written confirmation. A number of the sites required a visit from a service provider due to the proximity of pipelines to the proposed boreholes; therefore once services were marked out on the ground, and work remained outside a recommended distance, the drilling commenced.

Following a tender action, Ian Farmer Associates won the contract to undertake the project drilling programme. Drilling commenced on 11th July 2006.

8.5 BOREHOLE DRILLING

The sampling and initial logs were completed by the onsite drillers (Plate 1). They were provided with guidelines and were supervised by qualified staff. There also had regular contact with BGS geologists.

8.5.1 Sampling & logging

The sampling was carried out following the guidelines below:

- Bulk samples of resource (sand / sand and gravel) to be collected every 2m. Resource from a 2m length is to be collected and mixed in a large metal tray. This is then sub-sampled to provide a 10kg bulk sample per 2m length.
- Mixing and sampling every 2m of the resource stops with every change in lithology and sampling started again for the following lithology.
- For non resource, small samples are to be collected every 1m (Plate 2).
- The maximum depth of the borehole is 25m
- If bedrock is reached before a depth of 25m, one sample of the bedrock is collected and drilling stops.
- If no resource is revealed by the borehole, drilling is to cease at a depth of 18.7m.
- U100 (undisturbed) samples of the clays to be collected as instructed by BGS geologists.

The small non-resource samples and the U100 samples of the clays were carried out to support BGS research into the glacial deposits of the region, including provenance studies and investigation of the mechanical properties of glacial clays. Building a knowledge of the stratigraphy of the project area will aid the understanding of extent and continuity of potential resources.

Plate 1 The shell and auger percussion drilling rig, drilling one of the Project boreholes

Plate 2 Small non-resource samples collected by the drillers on site

The instruction that drilling should stop if no resource is reached by 18.7m is based on the maximum 3:1 overburden to mineral ratio allowed for the project. Any sand and gravel recorded between 18.7 and 25 m depth would lie outside this limit and not constitute a resource. The maximum depth of 25m was chosen as this is considered to be the maximum depth that companies would quarry.

8.6 LABORATORY ANALYSIS AND RESULTS

Particle Size Analysis (PSA) was carried out on all potential resource samples collected. The analysis was carried out by Ian Farmer Associates in their laboratories in Harpenden, Hertfordshire, during October 2006. In total, 100 samples were analysed from 27 of the 48 boreholes drilled. The composition of the samples was assessed by onsite drillers and BGS geologists.

8.7 RESULTS AND ASSESSMENT

The logs for the project boreholes, plus a short geological assessment of each, can be found in Appendix 5. The Particle Size Analysis (PSA) results are also summarised in Appendix 5 and Table 12. An overall assessment of each deposit type and region is given below. A map showing the borehole locations is shown (Figure 20).

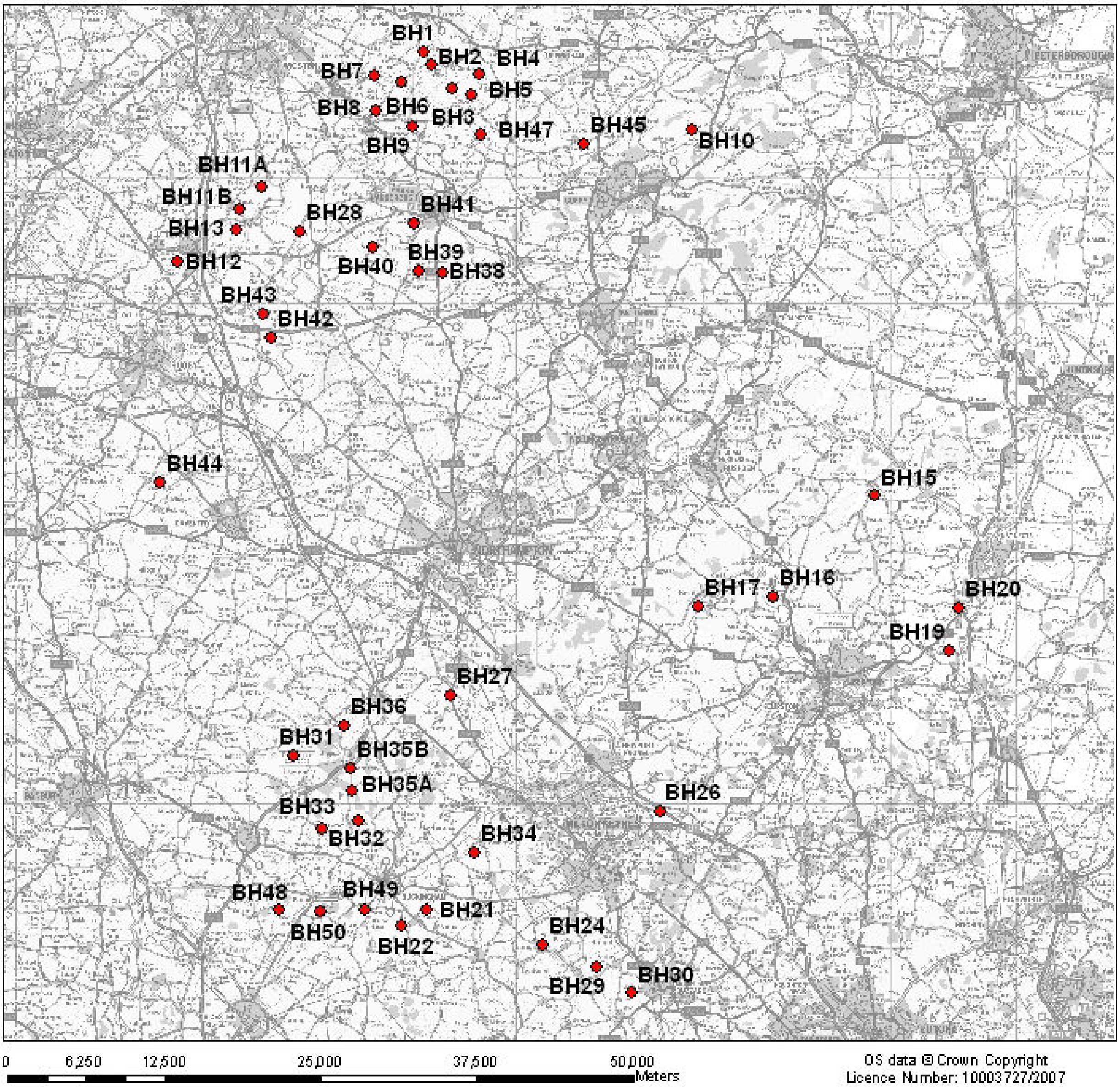

Figure 20 The locations of the project boreholes drilled in the summer of 2006

Reproduced in Appendix 5 at A3.

8.7.1 Glaciofluvial deposits in the North of the Project Area

The glaciofluvial sand and gravels in the North of the Project Area are not as widespread as shown on the geological maps, with 7 of the 17 boreholes encountering no potential resource.

The thickest deposit of potential resource (16m) was identified in BH13, near the village of Kimcote, east of Lutterworth.

Only BH12 (5.3m), BH12a (8.5m), BH13 (16m) and BH28 (2.5m) identified thick deposits of potential resource. All other potential resource deposits were less than 1.6m thick.

Fines (silt and clay) content for most of the potential resource samples were above 15%, except BH5 (11%), BH11b (6%) and BH28 (3%).

8.7.2 Glaciofluvial deposits in the South of the Project Area

In the south of the Project Area, all the potential resource deposits identified by the drilling programme have an overburden to mineral ratio of around 1:1.

The thickness of the potential resource recovered in the boreholes is consistently around 10m. This is much thicker than the glaciofluvial deposits identified in the North of the project area, which average around 4m.

All of the 6 boreholes identified glaciofluvial deposits, compared to only 10 of the 17 drilled in the North of the project area.

Fines content was variable within the potential resource. The highest content (46%) was in a sample at the base of BH21, just above the mudstone bedrock.

8.7.3 Glaciofluvial deposits in the West of the Project Area

Except for BH36, all potential resource found had an overburden to mineral ratio of more than 3:1.

The thickest deposit was found in BH36 (8m thick). It had variable fines content and an overburden to mineral ratio of 0.25:1.

2 of the 6 boreholes identified no potential resource

8.7.4 Sandur deposits

The sandur mapped as glaciofluvial deposits near Buckingham has a complex relationship with the till, with the deposits overlying, underlying and interdigitating with the till. It is thought to be an extensive outwash sandur, which has subsequently been buried beneath advancing ice.

Silt/clay content within the sandur deposits varied between 6% and 21%,

Of the main potential resources identified, the overburden to mineral ratios were 0:1, 1:1, 3.3:1 and 2.4:1.

The thicknesses of the identified potential resource deposits were 6.4m, 7m, 2.6m and 4m.

3 of the 4 boreholes identified potential resource.

8.7.5 River Terrace Deposits of the middle reaches of the Ouse (and tributaries)

All boreholes were drilled in areas mapped as river terrace deposits. However, only 3 of the 5 identified terrace deposits, with 2 encountering only till. This suggests that in places the terrace features could have been cut into till or bedrock and no terrace deposits were actually laid down. Alternatively, the terrace deposits could since have been eroded, perhaps leaving pockets within undulations in the till surface. Further research is required to build a better understanding of the river terraces of the middle reaches of the River Ouse.

As would be expected with river terrace deposits, all potential resource found had an overburden to mineral ratio of better than 0.5:1.

The maximum thickness of potential resource was identified in BH19 (3.254m). The 2 other boreholes, BH17 and BH17, both revealed deposits approximately 2m thick.

8.7.6 River Terrace Deposits of the Upper reaches of the Ouse (and tributaries)

The upper reaches of the Ouse, west of Milton Keynes, have not been worked extensively and have few planning permissions, compared with those to the east, close to Milton Keynes. The following boreholes aimed at investigating the reasons for this contrast.

Nether of the 2 boreholes drilled on these river terrace deposits of the upper reaches of the Ouse identified the river terrace sand and gravels. This suggests that the river terrace deposits are not as extensive as mapped. This could be due to the terrace features cutting into till or bedrock and no terrace deposits were actually laid down. Alternatively, the terrace deposits could since have been eroded, perhaps leaving pockets within undulations in the till surface.

8.7.7 River Terrace Deposits of the upper reaches of the River Ise

The upper reaches of the River Ise, west of Kettering, is an area of potential resource previously unworked with no existing planning permissions. BH38 and BH39 were drilled to investigate the reasons for this.

Nether of the 2 boreholes drilled on these river terrace deposits identified the river terrace sand and gravels. This suggests that the river terrace deposits are not as extensive as mapped. This could be due to the terrace features cutting into till or bedrock and therefore no terrace deposits were actually laid down. Alternatively, the terrace deposits could have been eroded since deposition, perhaps leaving pockets within undulations in the till surface.

8.7.8 River Terrace Deposits of the Welland Valley

None of the 3 boreholes drilled on the river terrace deposits of the Welland proved river terrace sand and gravels. This suggests, as with the valleys of the Ouse and Ise, that the river terrace deposits are not as extensive as mapped. This could be due to the terrace features cutting into till or bedrock and therefore no terrace deposits were actually laid down. Alternatively, the terrace deposits could have been eroded since deposition, perhaps leaving pockets within undulations in the till surface.

8.7.9 River Terrace Deposits in the Avon and Leam Valleys

The river terrace deposits of the Avon Valley, within the Project Area near the towns of Rugby and Coventry, is an area of potential resource previously unworked with a small number of existing planning permissions. BH43 and BH44 were drilled to investigate the reasons for this.

No River Terrace Deposits were identified by the 2 boreholes drilled into the river terrace deposits of the Rivers Avon and Leam. The lack of river terrace deposits could be due to 2 reasons; the terrace feature could have been cut into till or bedrock and no terrace deposits were laid down, or the terrace deposits have since been eroded, perhaps leaving pockets within undulations in the till surface.

8.7.10 Pre-glacial deposits in the Project Area

No boreholes were drilled in the Milton Formation pre-glacial deposits as these areas were investigated by earlier mineral assessment surveys.

Table 12 Summary of project borehole data and particle size analysis results

Borehole	Grid Reference X	Grid Reference Y	Type of geology being investigated	No. of PSA tests	Silt/clay content of all samples (%)	Potential resource silt/clay mean %	Overburden to mineral ratio
1	472716	300209	North GFD	0			
1a	472671	300188	North GFD	1	15	15	2.7:1
2	473166	299104	North GFD	0			
3	474849	297156	North GFD	1	27	27	4.8:1
4	477047	298357	North GFD	0			
5	476370	296733	North GFD	1	11	11	11:1
6	470954	297821	North GFD	0			
7	468628	298200	North GFD	0			
8	468900	295446	North GFD	1	26	26	1.3:1
9	471681	294153	North GFD	0			
10	494064	293968	North GFD	1	16	16	2.2:1
11a	459662	289360	North GFD	0			
11b	457864	287578	North GFD	1	6	6	9:1
12	452989	283358	North GFD	4	23,12,17,20	18	0.5:1
12b	452994	283355	North GFD	4	14,24,18,23	20	0.02:1
13	457670	285948	North GFD	4	23,10,6,14	13	0.36:1
15	508655	264647	Mid Ouse RTD	0			
16	500540	256444	Mid Ouse RTD	1	1	1	0.5:1
17	494600	255833	Mid Ouse RTD	1	20	20	0.4:1
19	514506	252390	Mid Ouse RTD	2	3,1	2	0.2:1
20	515393	255674	Mid Ouse RTD	0			
21	472811	231526	South GFDU	9	42,23,12,25,4,15,15,3,46	20	0.6:1
22	470805	230351	Upper Ouse	0			
24	482221	228824	South GFDU	6	Upper: 20,26 Lower:13,14,15,16	Upper:23 Lower:14	Upper: 0.3:1 Lower: 0.8:1
27	474764	248675	Upper Ouse RTD	1	82	82	
28	462659	285760	North GFD	1	3	3	4.5:1
29	486437	226987	South GFDU	5	4,3,3,3,7	4	0.5:1
29a	486207	226850	South GFDU	10	21,7,1,4,6,11,8,5, 10,72	6.5	0.2:1
30	489256	224939	South GFDU	4	26,9,22,9	13	2.1:1
30a	489256	224939	South GFDU	2	10,9	9	1.5:1
31	462338	244008	West GFDU	4	53,51,28,61	28	8:1
32	464479	238097	West GFDU	0			
32a	464493	238099	West GFDU	4	18,2,19,17	14	3:1
33	467392	238683	West GFDU	2	12,15	13	3.2:1
34	467498	236081	Sandur	10	Upper:20,22,19,24,12 Lower:12,18,2,10,2	Upper:19 Lower: 9	Upper: 0.01:1 Lower: 0.8:1
35a	466899	241082	West GFDU	0			
35b	466773	242966	West GFDU	0			
36	466240	246311	West GFDU	13	21,24,19,29,21,11,18,18,12,16,18,10,22	18	0.25:1
38	474077	282537	Upper Ise RTD	0			
39	472265	282673	Upper Ise RTD	0			
40	468570	284508	Welland RTD	0			
41	472093	286494	Welland RTD	0			
43	459712	279238	Avon RTD	0			
44	451514	265708	Leam RTD	0			
47	477135	293513	Welland RTD	0			
48	460509	231156	Sandur	0			
49	467945	231661	Sandur	2	12,7	9	3.3:1
50	464538	231344	Sandur	5	14,4,6,3,5	6.4	2.4:1

8.8 LOGPLOT BOREHOLE LOGS

Borehole logs for the new project boreholes have been created using LogPlot2005 (RockWare Inc.) to display the recorded deposit depths, sample data and the interpretation of overburden, mineral and waste. The resource column on the borehole logs have been block coloured as a rough guide to mineral, resource and waste. Due to limitations in the software, it should be noted that this is as a visual aid only. These borehole logs are displayed in Appendix 5 of this report.

8.9 LESSONS LEARNT

The method of borehole site identification worked well. The use of a GIS was fundamental and allowed interrogation of the data that would not have been possible using paper maps.

The main issue concerning borehole location arose when attempting to access the land. On some occasions the borehole sites were relocated slightly following discussion with landowners. This would be worth considering in the future. For example, if a farmer has crops in the field, they will not approve drilling in the centre of it. However, drilling at the edge of the field, near the entrance, is much less likely to cause problems. This issue may also be resolved in certain circumstances by drilling at different times of the year when crops are not planted in the area to be drilled.

The drilling of 48 boreholes took a huge amount of organisation, and relied upon good regular communication with the drilling company. The amount of time taken in arranging the logistics of a large drilling programme should not be underestimated.

8.10 KEY FINDINGS

In the North of the project area, the glaciofluvial deposits are not as widespread as shown on the geological maps, with just under half of the boreholes not encountering sand and gravel deposits. Only four of the boreholes identified deposits of potential resource thicker than 2.5m. Most of the boreholes drilled in the west of the project area identified glaciofluvial deposits with an overburden to mineral ratio of more than 3:1. The thickest deposit was 8m thick. Two of the 6 boreholes drilled in the west of the project area identified no potential resource. In the south of the project area, the glaciofluvial deposits identified have a mineral to overburden ratio of around 1:1. The thicknesses of the potential resources proved in the boreholes were consistently around 10m. This is much thicker than the sands and gravels identified in the North and west of the project area. All of the southern boreholes identified glaciofluvial deposits suggesting they are more widespread than in the north and west of the project area.

Three of the four boreholes drilled into the sandur deposit identified potential resource with thicknesses between 2.6m and 7m. Silt/clay content within the sandur deposits varied between 6% and 21%. Of the main potential resources identified, the overburden to mineral ratios were between 0:1 and 3.3:1.

Only 3 of the 7 boreholes drilled in the Ouse valley river terrace deposits identified terrace deposits. This suggests that in places the terrace features have been cut into till or bedrock and no terrace deposits were actually laid down. All potential resource found had an overburden to mineral ratio of better than 0.5:1. The maximum thickness of potential resource identified was 3.3m. None of the boreholes drilled on the river terrace deposits of the Ise, Welland and Avon Valleys proved river terrace sand and gravels.

Overall, the project boreholes suggest the glaciofluvial deposits in the south of the Project Area, and the sandur deposit west of Buckingham, could contain significant potential resource. However, because the targeted drilling programme carried out for this project was relatively small, it is suggested that more research is required to investigate this further. The boreholes drilled for the IMAU drilling programme in the 1980s suggest that the pre-glacial deposits of the Milton Formation could also be a potentially large source of aggregate.

9 Assessment of potential aggregate resources in Superficial deposits

9.1 INTRODUCTION

The area originally identified for assessment in the project proposal was restricted to south-eastern Leicestershire and northern Northamptonshire. However, at the commencement of the project it was agreed by the project staff that the study area would be greatly enlarged to encompass an area bounded by the Milton Keynes and South Midlands Growth Area and a 25 mile wide buffer zone around the sub-region (Figure 2). Bedfordshire south of the River Ouse and Buckinghamshire south of the Chilterns escarpment were excluded from the assessment of resources because it was considered that the flow of sand and gravel extracted from these areas would be to the south, away from the Growth Area. Initially, a borehole database was populated and other resource related information collated for the area. New boreholes were drilled in the northern and southwestern sectors of the study area where existing data were sparse. A wealth of data, including Mineral Assessment Reports and the borehole data acquired during their compilation, was already available for the central tract of the area extending from Warwickshire through Northamptonshire to Peterborough and Cambridgeshire. Later in the project it became apparent that the study area was too large to be adequately assessed with the resources available (originally intended to be sufficient only for the northern part of the study area). Much of the area of Warwickshire that falls within the study area is well served by earlier Mineral Assessment Reports. Project resources limited the population of the borehole database to the northern part of Buckinghamshire falling within the study area. Accordingly, these areas were excluded from the final resource assessment, together with Leicestershire west of Lutterworth. Nevertheless, the area remaining for assessment is still substantially larger than was defined in the project proposal and certainly adequate to test the suitability of the methodology.

9.2 ASSESSMENT OBJECTIVES

The principal objective was to identify potential resources at the indicated level as defined by McKelvey (Figure 21). Participants at stakeholders meetings, including mineral planning officers and members of the minerals industry, were asked to assist in defining potential resource for the purposes of this project. Feedback indicated that potential resources should contain a proportion of gravel, not be excessively clayey (i.e. a fines content of less than 20%), and have a minimum thickness of 1 metre. Planners accepted that the definition should include deposits where the ratio of overburden to ‘mineral’ is better than 3:1, while industry preferred a ratio of 1:1. All agreed that the maximum depth of the resource should not exceed 25 metres. These were the parameters adopted for this project. In order to satisfy both planners and industry, potential resources at overburden to mineral ratios of both 3:1 and 1:1 were to be assessed. Conveniently, this definition of potential resource is very similar to that used for the earlier BGS Mineral Assessment Reports thereby making their findings compatible with the output from this project.

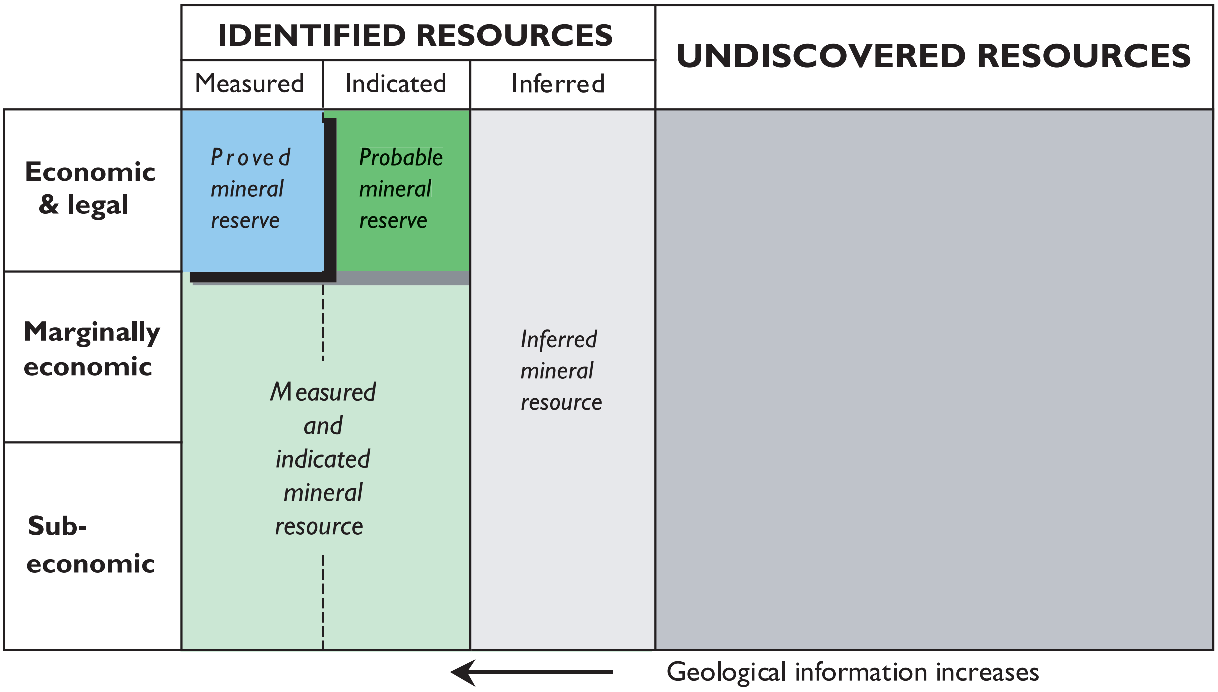

Figure 21 A classification of mineral resources and reserves

After McKelvey, 1972

9.3 METHODOLOGY

The new borehole data was interpreted and entered into the borehole database according to the parameters described in Section 8.4 and used for the existing borehole records. GIS (ESRI ArcGIS) methods were then employed to analyse the data for assessment of potential resources as defined above. Following initial analysis maps were plotted showing the geology, existing resource information from BGS Regional Mineral Resource Maps. Borehole locations were colour-coded to show those which proved overburden to mineral ratios of 3:1, 1:1, or no mineral present. A geologist then used their expert knowledge to interpret the information thus presented to delineate areas containing potential resources. These areas were digitised and incorporated as layers in the project GIS. A new GIS analysis was carried out in order to calculate areas, mean thicknesses and volumes of the potential resources. The methodology employed is described in Section 7.4.4 and is similar to that used for the BGS Mineral Assessment Report Series. The project GIS included layers containing mineral planning permissions, environmental assets (greater than 1) and urban areas. An additional layer was created to include major roads and railways, each with a narrow buffer around them: features such as these effectively sterilise any potential resources that they have been constructed on, or in. Using GIS, the areas of potential resources identified by the geologist were 'clipped' (subtracted) where they were intersected by the features in these layers (as shown in Figure 19). The resultant areas are considered to realistically delineate 'unsterilised' resources for the purposes of this project. However, the method is sufficiently flexible to accommodate a range of alternative factors.

9.4 PRESENTATION OF THE RESULTS

A great advantage of GIS is that many different types of output are possible. This report presents a selection designed to meet the preferences of stakeholders (see above).

The original intention had been to define arbitrary resource blocks as a convenient way to package the resource data. Feedback from participants of stakeholder meetings suggested that their preference was for the data to be presented for each of the parts of Mineral Planning Authority areas that fall within the study area: this approach has been adopted. However, for practical reasons, Northamptonshire was divided into three sub blocks. As a refinement, the potential resources of each block have been classified by deposit type (River Terrace Deposits, Glaciofluvial Deposits and Milton Formation) as each has significantly different characteristics.

The potential aggregate resources within these blocks are described briefly below. Maps showing the extent of the potential resources in each MPA are presented in Figures 22 to 29. Tables 13 and 14 contain quantitative data on potential resources in each deposit type, listed by MPA. Tonnages were calculated using a density value for dry sand and gravel of 1.65 (source www.simetrics.com: bulk commodities and materials). Figures are for total areas of potential resources lying outside mineral extraction permissions and for these areas adjusted for environmental assets, urban areas and buffered major transport links. However, alternative figures for different combinations of these factors can easily be calculated.

9.5 LIMITATIONS OF THE METHODOLOGY

The principal drawback of this method of assessment is the uneven spread of existing borehole data, which tends to be concentrated along roads and in urban areas. In rural areas they are rather sparse or even completely absent. This means that resource volume calculations were sometimes based on a small number of unevenly spaced boreholes. In a few cases where borehole data was scant, thicknesses had to be estimated (for example, for River Terrace Deposits in Buckinghamshire), and in southern Northamptonshire the paucity of data and the discontinuous nature of the Glaciofluvial deposits precluded meaningful assessment. The 48 boreholes drilled for this project were insufficient to overcome this problem as they were spread out across a very large area. In view of these shortcomings it is questionable whether this assessment adequately satisfies McKelvey's requirements for indicated resources (Figure 21).

9.6 ADVANTAGES

The methodology did succeed in confirming the absence of extensive concealed resources in the glaciofluvial deposits of southeast Leicestershire, northern Northamptonshire and Bedfordshire. It demonstrated the virtual absence of potential aggregate resources in the valleys of the rivers Avon and Welland (within Leicestershire, Northamptonshire and Rutland). The pre-glacial Milton Formation was assessed separately from Glaciofluvial deposits by reanalysing Mineral Assessment Report borehole data and northern Buckinghamshire was identified as a target area for future detailed assessment.

9.7 RESOURCE BLOCK DESCRIPTIONS

9.7.1 South-eastern Leicestershire

This area includes Leicestershire south of Leicester and east of a line between Narborough and Lutterworth. Potential sand and gravel resources lie within River Terrace Deposits, Glaciofluvial Deposits and the Wigston and Dunsmore members (formerly the Wolston Sand and Gravel and Dunsmore Gravel).

River Terrace Deposits

These lie within the valleys of the rivers Soar, Sence (a tributary of the Soar) Welland and Avon (Figure 23). Those in the Soar and its tributary the Sence are the most extensive. They consist mainly of flint and quartzite gravel averaging 2.4 m in thickness. The ratio of overburden to potential resource is 1:1 or better in the River Terrace Deposits of the Soar Valley. This is also the case for the lower part of the Sence but above South Wigston the ratio decreases to better than 3:1. The upper reaches of the Sence do not appear to contain significant potential resources. The upper reaches of both the Avon and the Welland appear to be largely devoid of potential aggregate resources. Examination of existing borehole records and the results of borehole drilling carried out for this project show that the river deposits comprise mainly clay, silt and peat. Any sand and gravel present rarely exceeds 1 metre in thickness although a stretch of the Welland valley in the extreme south-eastern corner of the area contains sand and gravel with a mean thickness of 4.6 metres. Investigations carried out for this project suggest that the actual extent of River Terrace Deposits is probably more restricted than that shown on the published geological maps. Where potential aggregate resources do occur the variably clayey gravel tends to comprise mainly limestone, with subordinate flint and ironstone, reflecting the bedrock geology of the terrain over which these rivers flow.

Glaciofluvial deposits

Potential aggregate resources within these deposits are very limited and likely to be of poor and variable quality. The geological map shows a scattering of small outcrops of Glaciofluvial deposits mostly to the west of Uppingham and in the Avon valley near South Kilworth. This project investigated the possibility that these outcrops, which mostly lie on the flanks of valleys, might represents the exposed parts of more extensive glaciofluvial deposits that may be concealed beneath overburden of glacial till. However, examination of existing borehole records and the results of a limited borehole survey carried out for this project show that either the sand and gravel deposits do not extend far beneath overburden or that the thickness of overburden rapidly becomes excessive. Moreover, the glaciofluvial deposits are commonly very variable in character and thickness and are commonly clayey or very clayey sand and gravelly sand. The composition of the sand and gravel reflects that of the glacial till from which it has been derived. Flint is the main component but limestone and chalk are also present. Chalk content is notably variable, and forms a significant proportion of the gravel at some localities. The mean thickness of 5.5 metres given for these deposits in Table 13 is probably misleadingly high as it is based on fewer borehole records than there are outcrops of glaciofluvial deposits.

Wigston and Dunsmore members

The Wigston and Dunsmore members of this area represent the eastern extremity of more extensive deposits lying to the west of Lutterworth (outside the assessed area). These deposits are the sand and gravel outwash from an ice sheet and occur as more-or-less continuous sheet-like bodies above and within layers of till. These layers have been dissected by streams and rivers with the result that the sand and gravel deposits are for the most part exposed on valley sides. Nevertheless, the overburden to mineral ratio is commonly at least 1:1.

9.7.2 Rutland

Potential aggregate resources are confined to River Terrace Deposits of the Welland Valley (Figure 23). Few useful records of boreholes exist for these deposits and significant potential resources occur only in the extreme south of the area where they are contiguous with potential resources in the neighbouring MPA areas. As in Leicestershire, the sand and gravel of the Welland river terrace deposits consist principally of limestone derived from Jurassic formations with subordinate ironstone and flint.

9.7.3 Northamptonshire

Potential sand and gravel resources occur within the pre-glacial Milton Formation, Glaciofluvial Deposits and River Terrace Deposits. Resources in the River Terrace Deposits are described by catchment as for other MPA areas, but for ease of presentation the county has been divided into three blocks for Glaciofluvial deposits, lettered A, B and C (Figures 24, 25 and 26).

River Terrace Deposits

The upper reaches of both the Avon and the Welland appear to be largely devoid of potential aggregate resources (Figure 24). Investigations carried out for this project suggest that the actual extent of River Terrace Deposits is probably more restricted than that shown on the published geological maps. Examination of existing borehole records and the results of borehole drilling carried out for this project show that the river deposits comprise mainly clay, silt and peat. Any sand and gravel present rarely exceeds 1 metre in thickness. However, borehole records indicate that a short stretch of the Welland to the north west of Corby may contain potential sand and gravel resources averaging 3.6 metres in thickness with a favourable overburden to resource ratio. As in neighbouring areas, the sand and gravel of the Welland river terrace deposits consist principally of limestone derived from Jurassic formations with subordinate ironstone and flint.

The River Terrace Deposits of the Nene Valley have been extensively worked for sand and gravel, but still represent a potential resource. However, possible future extraction may be limited by local planning considerations. These deposits have been the subject of several detailed assessments by the British Geological Survey. The river terrace deposits have a mean thickness of about 3 metres and, for much of their extent, a favourable overburden to resource ratio. According to BGS mineral assessment reports, the composition of the gravel fraction comprises mainly ironstone and flint, though locally limestone is a significant component. The proportion of gravel commonly exceeds sand. Fines content is usually less than 10% although locally it may reach 20%. Project boreholes sited on River Terrace Deposits mapped in the headwaters of the River Ise to the west of Kettering proved no potential resources there.

Northamptonshire includes a short stretch of the River Ouse along its southern boundary with Buckinghamshire and Milton Keynes, near Cosgrove and Old Stratford. The river terrace deposits have a mean thickness of 2.5 metres but there are few borehole records so this figure is not wholly reliable. The gravel fraction of the deposits is composed mainly of flint and limestone with quartzite, sandstone, chalk, ironstone and chert.

Glaciofluvial Deposits Block A

Potential resources in these deposits are extremely limited. They are confined to a narrow discontinuous strip between Brigstock and Thrapston (Figure 24). However, although they have been mapped as Glaciofluvial deposits according to Belshaw (2005) they may actually be deposits of a pre-glacial Brigstock River, similar to the Milton formation, with gravel composed entirely of locally derived limestone and ironstone.

Glaciofluvial Deposits Block B

Quite extensive potential resources are indicated within the Daventry-West Haddon-Northampton triangle (Figure 25). Their existence and extent has been known in detail since a Mineral Assessment Report was published in 1982. This report merely updates the effects of permissions and environmental assets on the volume of potential resources that remain unsterilised (as defined for this report) and identifies areas where the overburden to mineral ratio is 1:1 or better. Like other glaciofluvial deposits of the sub-region these are locally quite clayey but, unlike most other such deposits they are notably gravelly. They are consistently thick, up to

18 metres or even 24 metres in places, although these figures may include an element of undifferentiated Milton Formation. Elsewhere in the block, glaciofluvial deposits occur in scattered, isolated spreads: they are not extensively continuous beneath the glacial till.

Milton Formation Block B

The occurrence of Milton Formation deposits has been identified by participants in the stakeholder meeting as an attractive source of aggregate. Geological maps do not differentiate the formation from 'glacial sand and gravel'. Potential aggregate resources in the pre-glacial Milton Formation remain in the Watford Gap area, near Nether Heyford and at Milton Malsor (Figure 25) where they average 4.8 metres in thickness. They are for the most part slightly gravelly sand in which the gravel is composed largely of locally derived limestone and ironstone, while the medium-grained sand is comparatively far travelled having been derived from the Triassic Sherwood Sandstone Group. The area of Milton Formation shown on Figure 25 may include some overlying Glaciofluvial deposits.

Glaciofluvial Deposits Block C

No attempt has been made to assess potential aggregate resources in this block and, although glaciofluvial deposits are quite extensive, they are not shown on the map of the resource block (Figure 26). This is because the number and spread of boreholes penetrating the deposits is so sparse and outcrops of deposits so scattered that any assessment would be meaningless. Of the two project boreholes drilled in the south of the block, one (BH36) proved 8 m of clayey very sandy gravel while the other (Borehole 31) encountered a thin layer of very clayey sand gravel beneath prohibitive overburden. In the absence of other useful data no conclusions can be drawn from this information. This is a good example of where the methodology adopted for this report can fail.

9.7.4 Peterborough

River Terrace Deposits

Potential aggregate resources remain in the River Nene west of Peterborough despite a long history of extraction, although future extraction may be limited by local planning considerations. No new investigations of the deposits were carried out for this report other than calculating the mean thickness from existing boreholes of 1.7 metres and 3 metres for respective overburden ratios of 3:1 and 1:1, and taking into account the 'sterilising' effect of permissions and environmental sensitivity. Information from Mineral Assessment reports indicates that the majority of potential aggregate resources will occur within the deposits beneath the First Terrace. They typically consist of sandy gravel with less than 10% 'fines' and the gravel is commonly composed mainly of flint and limestone with subordinate ironstone and quartzite.

Glaciofluvial Deposits

No significant Glaciofluvial deposits occur within the area.

9.7.5 Cambridgeshire

River Terrace Deposits

The valley of the River Ouse between St Neots and Huntingdon contains potential aggregate resources in the River Terrace Deposits with a mean thickness of 3.1 metres (Figure 27). However, the area has a long and intensive history of aggregate extraction and extensive planning permissions. A Mineral Assessment Report (MAR) for the area was published in 1980.

No new investigations were carried out for this report beyond recalculating the area and volume of the resources with due consideration of planning permissions and environmental assets. According to the MAR the deposits commonly comprise sandy gravel and gravel (with gravel generally exceeding 40%), in which the gravel is composed mainly of flint and with subordinate quartz, quartzite, sandstone, limestone and some ironstone.

Potential resources also occur in the valley of the River Nene in the northwest of the county. They are almost certainly very similar in grading and composition to those in the adjacent Peterborough MPA.

Glaciofluvial Deposits

These are of very limited extent and are probably too small and scattered to be considered of economic value. Outcrops around Keyston, Bythorn and Molesworth may in fact be in part pre-glacial deposits of the Brigstock River mentioned for Northamptonshire Block A above, but nothing is known of their composition.

9.7.6 Bedfordshire

River Terrace Deposits

The river terrace deposits of the Great Ouse and its large tributary, the River Ivel contain considerable potential aggregate resources with a mean thickness of 3 metres (Figure 28). Three of the project boreholes drilled in First and Second Terrace deposits proved gravel and gravelly sand between 2 m and 3.2 m thick but a fourth, sited on Third Terrace proved only till on bedrock. The gravel fraction is composed mainly of flint and with subordinate quartz, quartzite, sandstone, limestone and some ironstone. Small quantities of potential resource also occur within river terrace deposits of an unnamed tributary of the River Ouse

Glaciofluvial Deposits

As mentioned above glaciofluvial deposits in the southern half of the county were not assessed. The northern part of the county contains a few isolated occurrences of Glaciofluvial deposits most of which have an overburden to mineral ratio of 1:1 or better and a mean thickness of 4.5 m (Figure 28). Although they are sufficiently extensive to represent a potential resource, their composition or grading characteristics are not known.

9.7.7 Milton Keynes

River Terrace Deposits

Potential aggregate resources occur in the River Terrace Deposits of the Great Ouse and its tributary the River Ouzel (Figure 29). Although these deposits have been extensively worked around Milton Keynes, significant potential resources remain in the lower terrace deposits of the Great Ouse downstream from Milton Keynes with mean thicknesses of 2.9 metres and 2.3 m for overburden to mineral ratios of respectively 1:1 and 3:1. No project boreholes were drilled in this section of the river, but by analogy with deposits downstream, they are likely to consist of gravel and sandy gravel. Observations by field geologists show that the composition of gravel fraction consists mainly of flint and quartzite with subordinate limestone. Potential resources are contained only within the lowest two terraces of both the Great Ouse and Ouzel.

Glaciofluvial deposits

In the Milton Keynes area these deposits are very limited in extent and many of the outcrops are too small to be of economic interest. The most extensive occur along the valley of the great Ouse north of Milton Keynes where they have been exploited in the past (Figure 29). Small spreads emerging from beneath till at North Crawley are probably of poor quality: clayey and perhaps with chalk in the gravel fraction. There is very little borehole data available so the thickness of the deposits has been estimated at 1.3 metres.

9.7.8 Buckinghamshire

River Terrace Deposits

There is virtually no borehole data for the Great Ouse and its tributary Padbury Brook but by analogy with the downstream Ouse potential resources may be expected to occur within the lower terraces. A geologist estimated the likely extent and thickness of the potential resources and any calculations are therefore necessarily inaccurate. Composition and grading are expected to be similar to the deposits of the Ouse elsewhere.

Glaciofluvial deposits

Extensive Glaciofluvial deposits occur in northern Buckinghamshire where sheet-like bodies of sand and gravel (sandar) are either sandwiched between till sheets or resting upon the uppermost till (Figure 29). The Glaciofluvial deposits are sand and gravel outwash from the margin of the Anglian ice that once straddled the area. The stratigraphical relationships of the deposits are complex and the existing borehole data was sparse. Nevertheless, the area was predicted to contain substantial potential resources so 15 project boreholes were drilled in the area. The results were rather mixed. Eight boreholes proved potential resources, of the remainder some proved sand and gravel that was too thin or beneath prohibitive overburden and some proved only till. The boreholes located to the east and southeast of Buckingham proved the thickest deposits of between 7 and 13 metres. Several boreholes encountered two beds of sand and gravel separated by a layer of till: the lower sand and gravel tended to be thicker and sandier. The deposits were extremely variable in composition ranging from clayey sand through very clayey gravelly sand to sandy gravel, sometimes within the same borehole. The gravel fraction was mainly composed of flint but chalk was also present in some boreholes. Despite the variability of the deposits in the area, the Glaciofluvial deposits of north Buckinghamshire appear to offer considerable potential aggregate resources that warrant further detailed assessment.

9.7.9 Key findings – Assessment of aggregate resources

Methodology

- GIS analysis is an excellent and flexible tool for analysing resource data
- The distribution and quality of pre-existing borehole data was not ideal and this inevitably affected the accuracy of the tonnage calculations. It seems there is no substitute for detailed assessment surveys involving the drilling of numerous evenly spaced boreholes.
- However, the methodology proved an effective means for identifying target areas for such detailed assessments.

Aggregate resources in the MKSM Growth Zone

- River Terrace Deposits are the most reliable potential aggregate resource.
- Despite intensive extraction of sand and gravel from the river terrace deposits, considerable potential aggregate resources remain within those of the main rivers: Nene, Great Ouse and Ivel, although planning considerations may limit continued working.

- The terrace deposits of the Rivers Welland and Upper Avon (Northamptonshire and Leicestershire) do not contain significant potential resources.
- The Glaciofluvial deposits and Milton Formation of west central Northamptonshire contain considerable resources although their quality is lower and less predictable than those in River Terrace Deposits

The Glaciofluvial deposits of northern Buckinghamshire, particularly in the area to the east of Buckingham, contain considerable though variable resources and should be the subject of detailed investigation

The following figures are reproduced at A3 size in Appendix 5, because of the detail they contain..

Figure 22 Bedrock aggregate resources

Figure 23 Superficial sand and gravel resources: Leicestershire and Rutland (part)

Figure 24 Superficial sand and gravel resources: Northamptonshire - Resource Block A

Figure 25 Superficial sand and gravel resources: Northamptonshire - Resource Block B

Figure 26 Superficial sand and gravel resources: Northamptonshire - Resource Block C

Figure 27 Superficial sand and gravel resources: Cambridgeshire and Peterborough (part)

Figure 28 Superficial sand and gravel resources: Bedfordshire

Figure 29 Superficial sand and gravel resources: Buckinghamshire (part) and Milton Keynes

				Resource area (ha)		Resource volume (million m3)		Resource tonnage (Mt)	
Mineral Planning Authority (or part thereof)	**Sub block**	**Overburden to resource ratio (equal or better than)**	**Resource mean thickness (m)**	**Unsterilised and <2 Environmental Assets**	**Total (exc. permissions)**	**Unsterilised and <2 Environmental Assets**	**Total (exc. permissions)**	**Unsterilised and <2 Environmental Assets**	**Total (exc. permissions)**
Leicestershire		3:1	0.7	119.9	195.9	0.8	1.4	1.4	2.3
		1:1	5.5	1083.2	2398.3	59.6	131.9	98.3	217.6
Buckinghamshire		3:1	1.6	1182.6	2025.4	18.9	32.4	31.2	53.5
		1:1	2.9	2628.3	5192.4	76.2	150.6	125.8	248.5
Bedfordshire		3:1	2.5	20.2	20.4	0.5	0.5	0.8	0.8
		1:1	4.5	238.0	294.6	10.7	13.3	17.7	21.9
Cambridgeshire		1:1	6.1	46.5	151.4	2.8	9.2	4.7	15.2
Milton Keynes		1:1	*1.3*	53.5	92.9	0.7	1.2	1.1	2.0
Northamptonshire	A	3:1	2.8	53.25	129.48	1.5	3.6	2.5	6.0
	A	1:1	3.4	110.98	186.72	3.8	6.3	6.2	10.5
	B	3:1	2.5	126.15	172.25	3.2	4.3	5.2	7.1
	B	1:1	3.5	2759.4	4530.74	96.6	158.6	159.4	261.7
	Milton Formation	1:1	4.8	461.81	962.09	22.2	46.2	36.6	76.2
Totals				8883.9	16352.5	297.5	559.5	490.8	923.2

Table 13 Glaciofluvial deposits volume and tonnage data

Figures in italics are estimates

				Resource area (ha)		Resource volume (million m3)		Resource tonnage (Mt)	
Mineral Planning Authority (or part thereof)	**River catchment**	**Overburden to resource ratio (equal or better than)**	**Resource mean thickness (m)**	**Unsterilised and <2 Environmental Assets**	**Total (exc. permissions)**	**Unsterilised and <2 Environmental Assets**	**Total (exc. permissions)**	**Unsterilised and <2 Environmental Assets**	**Total (exc. permissions)**
Leicestershire	Avon	1:1	1.7	20.1	22.9	0.3	0.4	0.5	0.6
	Welland	1:1	4.6	226.6	240.4	10.4	11.0	17.1	18.1
	Soar/Sence	1:1	1.6	337.5	608.8	5.4	9.7	8.9	16.1
	Sence	3:1	2.4	118.0	118.0	2.8	2.8	4.7	4.7
Rutland	Welland	1:1	2.6	20.7	20.7	0.5	0.5	0.9	0.9
Peterborough	Nene	3:1	1.7	40.7	70.5	0.7	1.2	1.1	2.0
	Nene	1:1	3.0	622.6	1022.0	18.7	30.7	30.8	50.6
Buckinghamshire	Padbury Brook	1:1	*1.5*	633.4	650.5	9.5	9.8	15.7	16.1
	Great Ouse	1:1	*1.5*	101.7	104.5	1.5	1.6	2.5	2.6
Bedfordshire	Ouzel	1:1	2.0	20.9	55.3	0.4	1.1	0.7	1.8
	(Ouzel tributary)	1:1	*1.5*	66.8	86.3	1.0	1.3	1.7	2.1
	Ivel	1:1	3.0	1422.1	2252.1	42.7	67.6	70.4	111.5
	Great Ouse	1:1	3.0	3397.6	5129.3	100.2	151.3	165.4	249.7
Cambridgeshire	Great Ouse	1:1	3.1	1676.6	3538.5	52.5	110.8	86.6	182.7
	Nene	3:1	2.9	27.2	28.4	0.8	0.8	1.3	1.4
	Nene	1:1	3.8	376.6	482.0	14.3	18.3	23.6	30.2
Milton Keynes	Great Ouse	3:1	2.3	347.4	563.2	8.0	13.0	13.2	21.4
	Great Ouse	1:1	2.9	947.4	1569.9	27.5	45.5	45.3	75.1
	Ouzel	3:1	*1.0*	8.2	27.0	0.1	0.3	0.1	0.4
	Ouzel	1:1	2.4	238.7	487.3	5.7	11.7	9.5	19.3
Northamptonshire	Welland	1:1	3.6	254.1	265.6	9.1	9.6	15.1	15.8
	Nene	3:1	2.0	80.7	83.1	1.6	1.6	2.6	2.7
	Nene	1:1	3.2	4170.2	5001.6	133.4	160.1	220.2	264.1
	Ouse	1:1	2.5	177.1	286.6	4.5	7.2	7.4	11.9
Totals				15332.7	22714.5	451.6	667.7	745.2	1101.8

Table 14 River Terrace Deposits volume and tonnage data

Figures in italics are estimates

10 Future resource availability & demand in the Growth Zone

The main findings of the project are outlined in chapters 1 to 9 of this report. This research has highlighted an area within the Growth Zone facing a potential shortage of locally available aggregate supplies and this chapter is a detailed appraisal of the supply patterns in this area. This area has been designated the Focus Area (Figure 30).

The past and current supplies to Northamptonshire, Milton Keynes and North Buckinghamshire will be examined in the light of findings from the geological drilling programme in order to assess the future potential of the area to contribute towards the supply of sustainable aggregate to these parts of the Growth Zone. The appraisal will take into account the earlier findings that suggest that there is likely to be a modest reduction in intensity of use through modern methods of construction and higher density development, and will assume that secondary and recycled aggregate contributions to demand will continue at approximately current levels.

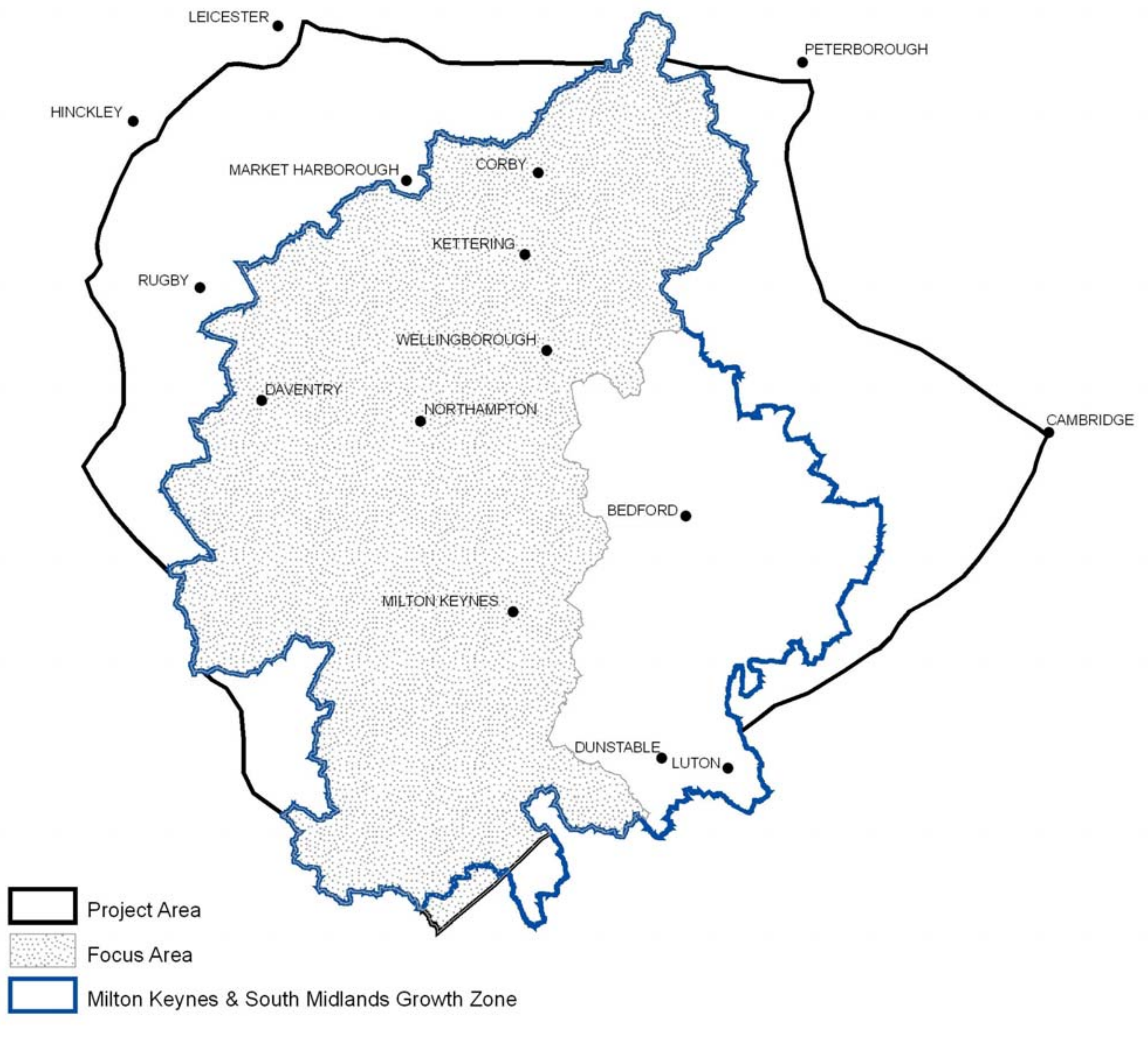

Figure 30 The extent of the Focus Area in relation to the Project Area and Growth Zone

Analysis of the supply of aggregates from past and current quarries within the Focus Area discloses a contrasting pattern of:

- increasing stress as supply opportunities diminish in some formerly prolific parts of the Project Area, such as the Nene Valley of Northamptonshire, and
- continuing low or nil supply from other areas, such as the glacial area and Welland Valley.

These issues are considered below.

10.1 OPPORTUNITIES FROM THE FOCUS AREA

10.1.1 Past patterns - Northamptonshire

The effect of diminishing supply opportunities in the Nene Valley shows most clearly in the analysis of planning permissions granted in the Nene Valley, between Northampton and Thrapston. First, it will be observed that planning permissions have been granted along virtually the entire length of the river valley, with only trivial gaps other than a short unpermitted stretch south of Thrapston. Second, analysing these permissions by the decade in which they were granted illustrates the following features:

- Permissions granted up to 1969 were few and far between, occupying very small areas of land.
- Between 1970 and 1989 there was a major change in both pattern and size of permission. Areas permitted extended beyond the immediate “riparian” locations of earlier decades, into areas more remote from the course of the river itself. Also, the areas of land involved were substantially larger than previously.
- Since then, while a few large permissions have been granted, generally filling in the main remaining gaps in the exploitation corridor, an increasing number of permissions have been for minor extensions to earlier workings.

This spatial pattern is consistent with known levels of production. From the early 1960s Northamptonshire consistently produced well in excess of 1Mt sand and gravel per annum with levels exceeding 2Mt in 1973, 1975, 1979, 1985, 1987-1989 and 1994. However, from 1995 onwards levels of production fell and have been below 1Mt each year since 2000. This downturn roughly coincides with the County Council adopting policies to minimise further exploitation of the Nene Valley but it is unclear whether this was the driver or whether a general economic downturn was responsible. However, what is clear is that since the early 1990s, when landbanks were first expressed in years of supply, the sand and gravel landbank has been very low at 3 years or under.

The general pattern of mineral working is that the best quality areas of deposit, and those which are most able to secure planning permission, tend to be worked first. As those are exhausted, deposits of lesser quality and those more difficult of access are exploited. Finally, as significant deposits approach exhaustion, attention turns to more minor operations, recovering odd pockets of mineral not previously available for ownership, economic or planning reasons.

Whilst it is not certain that this generic pattern is demonstrated in the Nene Valley, the geography of the grant of permissions is consistent.

10.1.2 Past pattern - Milton Keynes

A second example is the River Great Ouse between Milton Keynes and Olney, where a similar pattern is displayed, but at an earlier stage. Currently there are fewer permitted areas, with more extensive gaps between them.

In terms of dates, the permissions in Milton Keynes were predominantly granted during the 1960s, 1970s and 1980s and thus coincide with the main development of the new town. Very little was permitted during the 1990s and although several sites have been permitted more recently they have all been relatively small and the landbank for the area has been under 7 years at least since 2002 when it was first calculated separately from Buckinghamshire (although still shown combined in published documents).

In terms of production levels the area has been a modest producer of sand and gravel owing to its relatively small size. Its share of Buckinghamshire's average 1 – 1.3Mt production (with which it is normally combined to protect confidentiality) has in recent years been only about 10%.

10.1.3 Past patterns - North Buckinghamshire

To complete the picture, traditionally North Buckinghamshire which has no major sources of alluvial sand and gravel has produced very little aggregate, mainly owing to the perceived lack of economically viable mineral.

10.1.4 Key findings - Past patterns

There is a very consistent narrative. Exploitation overall has followed the "easiest first" principle, and today's forward planning difficulties faced by different planning authorities are at least partly explained by the stage in the full exploitation sequence that has been reached. Thus Milton Keynes, at a slightly earlier stage than Northamptonshire, may be slightly more able to identify future deposits and meet its landbank requirements. In Buckinghamshire the north of the county is not ruled out but consistent with the past approach neither is it relied upon to contribute towards demand.

Overall the three stages may be expressed in terms of an evolution of areas of mineral exploitation as follows:

- **Juvenile**, where only random permissions have been granted and there are no plan allocations. Such area may progress to the other stages but only if the mineral resource is available.
- **Intermediate**, where the pattern of workings is more extensive and probably has become plan led. Extensions to existing sites will generally predominate. There will be further opportunities for future working. These may be identified through a mixture of constraints and allocations.
- **Mature**, where the area is mostly worked out and very few opportunities for further exploitation remain. Future workings will generally be smaller "gap filling" sites. Where larger sites do exist they may have been previously unavailable.

10.2 IDENTIFIED FUTURE SUPPLIES

10.2.1 Northamptonshire

Turning to the future, in Northamptonshire sand and gravel is currently worked at 5 sites: Earl's Barton and Thrapston (Nene Valley); Bozeat (south of the Nene Valley); Bugbrooke (Milton Formation); and Passenham (Great Ouse Valley – the most recently permitted extension is across the county boundary into Milton Keynes). Allocated sites identified in the adopted Minerals Plan are: an extension at Earl's Barton (application for 1.4Mt, of total 4Mt, currently being considered by the County Council); Dodford (near Daventry, 2Mt of glacial sand and gravel); and

Collingtree (south of Northampton, 1.1Mt of Milton [soft] Sand). A further 10 sites are identified for potential future working subject to further consideration of their suitability.

In addition limestone is worked for aggregate at three sites (Pury End, Duddington and Pitsford) and limey sandstone is worked at one site at Harlestone with permitted reserves totalling in the region of 2Mt. According to the Northamptonshire Minerals Local Plan, May 2006 a further 20Mt is available in old mineral permission sites, originally permitted for ironstone working but where the limestone forms an overlying stratum. The Minerals Local Plan identifies one allocation, an extension to the Duddington site which would yield at least 3Mt.

10.2.2 Milton Keynes

In the case of Milton Keynes, there are currently three sand and gravel sites with planning permission: Caldecote Farm (Ouzel Valley), Manor Farm (Great Ouse Valley) and Calverton (Great Ouse Valley; extension to Passenham in Northamptonshire). These three sites enable the requirement of the sub-regional apportionment for the plan period (including a landbank beyond the plan) to be met. The adopted Local Plan resists further sites being released unless there is a proven need to meet a shortfall in the sub-regional apportionment. Much of the remaining sand and gravel deposit is identified as an Area of Search from which sites could potentially come forward. However, taking account of past levels of production, they are unlikely to amount to major new supplies.

10.2.3 Key findings - Identified supplies

To summarise, traditionally won aggregate sources within the Focus Area are becoming ever more difficult to identify and where they exist they are increasingly constrained by a desire to protect the local environment, in particular the river valleys.

10.3 SUPPLIES FROM OTHER AREAS WITHIN THE FOCUS AREA

The opposite of the intense supply areas identified above is displayed in the northwest, east, southeast and southwest of the Focus Area (Figure 30). Taking each in turn, the main features are:

- **Northwest**. A swathe of land from Daventry via Rugby to Market Harborough and Corby, including the Welland Valley has almost no planning permissions granted for aggregates. This is despite Corby and Daventry, in particular, experiencing substantial growth. In Corby's case the presence of Lincolnshire Limestone produced as a by-product of ironstone working may be a contributory factor. However, Daventry which has witnessed substantial and ongoing growth since the 1980s has no obvious alternative sources.
- **East**. Similarly, few or no aggregates permissions have been granted in the east of the Focus Area. Here the explanation is that although some sand and gravel resources appear to exist, much more attractive areas are located just beyond the Focus Area boundary in Bedfordshire (around Bedford and Sandy), Cambridgeshire (between St Neots and Huntingdon) and Peterborough. These will have supported the growth of the main centres of development (Bedford, Peterborough, Huntingdon and Cambridge) which are themselves outside the Focus Area and, with the exception of Bedford, outside the area of the Milton Keynes South Midlands Growth Zone.
- **Southeast and Southwest including North Buckinghamshire**. Here planning permissions for aggregates are almost entirely restricted to sand deposits around Leighton Buzzard (Bedfordshire) which are also extensively worked and highly valued as industrial sands rather than for aggregate materials apart from a limited use (about 0.5Mtpa.) in mortars. Traditionally North Buckinghamshire, which has no major sources of alluvial sand and gravel has produced very little aggregate, mainly owing to the perceived lack of economically viable mineral.

There are currently no active aggregate sites in North Buckinghamshire and no specific allocations are identified in the adopted Buckinghamshire Minerals Local Plan for this area. Supplies for development in Aylesbury are therefore likely to have come largely from beyond the Focus Area. Other large towns within the Growth Zone, such as Leighton Buzzard, Dunstable and Luton are likely to have drawn supplies predominantly from Bedfordshire but also from outside the Project Area e.g. Hertfordshire.

However, uniting all these areas is the underlying explanation that few or no high quality conventional aggregate resources have been identified in these areas. With the exception of the Welland and other river valleys which have been protected, in none of these areas is there evidence (for example through planning refusals) that restrictive planning policies, or fundamental inadequacies in infrastructure, have prevented the exploitation of existing suitable deposits. An analysis of borehole data for these areas undertaken for this project (Chapter 9) have generally confirmed the received wisdom that over much of the Focus Area, including the Welland Valley and the glacial areas, it is simply the case, that deposits considered to be economically viable are absent or otherwise unworkable. However, some potentially workable deposits have been identified in the pre-glacial Milton Formation. These are discussed in more detail under the consideration of future supplies.

10.4 ESTABLISHED IMPORTS FROM OUTSIDE THE FOCUS AREA

The above analysis implies that several areas of major development activity over the last fifty years cannot have relied upon their own local resources, because such resources did not exist. Therefore, transfers from better endowed areas within the Project Area, or imports from outside the Project Area, must have occurred.

Statistics for import/export of aggregates remain one of the “Cinderellas” of mineral planning. While general patterns can be detected, there is low precision in detail because, as compared with production and sales (i.e. statutorily required), the destination is less easily defined and measurable and therefore less attention is devoted to securing accurate quantified information. Specific limitations include much data being available only to regional level and where it has been collected to county level, much is confidential.

10.4.1 Crushed Rock

The absence of hard rock aggregate within the Project Area, other than in the extreme North West, around Leicester, is well established. Further, active rail import depots in Northampton, Milton Keynes (with a second recently permitted but not yet operational) and Bedford provide evidence that significant quantities of aggregate are imported to the area. Although statistical data is sparse, it can be established from the four yearly Aggregates Monitoring surveys carried out by the Regional Aggregates Working Parties on behalf of central government that at least since the 1970s (when the earliest data is available) Northamptonshire, Buckinghamshire, Milton Keynes and Bedfordshire have all been importers of crushed rock. In the case of Northamptonshire the majority of import is derived from the East Midlands and accounts for well in excess of 50% of the crushed rock consumed within the county. Buckinghamshire and Milton Keynes which produce no crushed rock also import from the East Midlands, However, larger quantities, which are probably destined for the south of Buckinghamshire, outside the Project Area, originate in other areas, probably the South West. Bedfordshire also imports crushed rock from the East Midlands but also from other areas. Some is thought to be imported, via ports in the South East, from areas outside England.

In recent years, new or substantially redeveloped hard rock quarries have invested in new or enhanced rail links and equipment, suggesting that rail hauled transport, which is supported nationally as a more sustainable form of transport than road haulage, is not only well established but likely to grow. Modern developments, notably the self-discharging train, also mean that the need for "traditional" rail depots with a high degree of infrastructure which has historically constrained their location may become less relevant in the future. Instead, all that is required can be an area of open ground along a rail siding, a loading shovel and a temporary office and weighbridge. With adequate dust suppression and suitable lighting aggregates can now be unloaded almost anywhere. Off-site road infrastructure and sensitive nearby land uses, of course, remain important constraints.

Much rail transport is directed towards London and the South East, but is also able to serve other areas where there is a local need, such as in the Growth Zone where indigenous hard rock is not available. Should the need arise, the safeguarded former aggregate rail deport in Aylesbury could be re-opened, to provide for a more sustainable means of importing aggregate to support the expected growth in the town.

The future of the Growth Zone as a continuing importer of crushed rock aggregate therefore appears certain and it would be reasonable to suppose that levels of import can and will rise unless other factors intervene.

10.4.2 Sand and Gravel

Turning to imports of sand and gravel, traditionally these are more local and road transport has been the usual option; although at one time sand and gravel was imported by rail from Elvaston in the Trent Valley to Milton Keynes and the Northampton area. Some cross boundary movement is to be expected since quarries will supply to the surrounding area regardless of county or regional boundaries. However, in the case of Northamptonshire the statistics, imperfect as they are, appear to show a trend of increasing proportions of imports compared with consumption of locally produced material. During the 1980s consumption of imports appears to have amounted to less than half that of material of home origin. By comparison, by the late 1990s consumption of imports appeared to roughly equal that of home produced material. The statistics also indicate that while imports from elsewhere in the East Midlands have always been significant, those from the East of England have tended to rise over time.

An analysis of imports to Milton Keynes and that part of Buckinghamshire which lies within the Project Area and the Focus Zone is more difficult owing to the inability to disaggregate imports between the two areas or the different parts of Buckinghamshire. However, suffice it to say that imports of sand and gravel make an important contribution towards total consumption and those deriving from the East Midlands and East of England, are more likely to have supplied Milton Keynes and North Buckinghamshire simply because it is to these areas (at least before recent regional re-organisation) that they are most proximate. This assumption is supported in the case of imports from the East Midlands since that region does not export any sand and gravel by rail.

It therefore appears that over time the Focus Area has slowly become more reliant on imports of sand and gravel. That other areas are better placed to supply the needs of the Focus Area appears inescapable. The geological findings of this study have served to demonstrate this with greater force. However, if still greater reliance is to be placed on imports in the future, through dwindling supplies in the local area and increased demand in order to meet the aspirations of the Growth Zone proposals, it is important to consider whether transportation could (and should) be made more sustainable, rather than continue to rely heavily on road haulage. The environmental implications for the sensitivity of the supply area and those areas within the transport corridors are also key issues.

10.5 FUTURE PROVISION

Thus the supply of minerals to support the anticipated growth in the Growth Zone is not likely to be achieved solely in traditional ways. Indeed, as sustainability issues become of ever greater importance, the first question to ask is more likely to be “how can the requirement for minerals be minimised?” rather than “how much can be secured as cheaply as possible?” which would have been the question in the past. Economic supply remains, of course, a key issue, but one that is leavened with other considerations.

This situation is not unlike that seen in the South East where parts of the region appear to be suffering acute shortages of locally derived material, although in that case, throughout the region as a whole, recent research has indicated (Benham *et al.,* 2006) that the potential resource is significantly greater than had been thought.

It is intended to explore the future on the basis that, as national policy increasingly says, traditional aggregates supply options should only be promoted when all others have been exhausted. Accordingly, the assessment proceeds as follows, on the basis of the apparent sustainability of each prescription:

10.5.1 Minimising aggregate requirements

The earlier analyses (5 Building Sustainable Communities) concluded that the intensity of aggregate consumption – that is, the amount of aggregate required per unit of output – was likely to decrease in the future, due to the evolution of building techniques, in particular prefabrication and the use of novel materials. As the quest for reduced carbon emissions from built development gains momentum, it is highly likely that the amount of development contemplated will continue to demand less new aggregate. Other policy developments, for example the focus on sustainable urban drainage systems and promotion of biodiversity, will tend to promote “soft” as opposed to “hard” landscape and drainage solutions and, hence, offer further potential diminution in the amount of new aggregate required for some types of infrastructure.

However, there is probably an irreducible minimum, primarily due to structural imperatives, below which aggregate requirements cannot go, unless more fundamental changes occur. So long as roads, paths, houses, commercial, railway, services and similar constructions are built roughly along the lines they are today, then there must come a point of diminishing returns in the pursuit of aggregates economy. Drastic changes – building houses solely out of plastic, or wattle-and-daub, for example, or entirely of renewables or abandoning motorised transport – would obviously have a dramatic effect in reducing aggregate requirements, but no such fundamental changes can be anticipated.

On a very small scale, some interesting substitutions have been achieved – for example, recycled rubber for playground surfacing, or recycled glass as a non-skid material – but these are small scale and no matter how widely adopted are unlikely to make a significant quantitative inroad into the requirements for natural aggregates. Within the realms of the possible, therefore, a continuing modest decrease in the requirement for aggregates per unit of construction is the best that can be anticipated through better design and enhanced on site monitoring and control.

10.5.2 Use of recycled materials

As discussed earlier, the increased use of recycled materials, mainly CDW, is a recent and welcome feature of recorded aggregates supply, although it has always been an important aspect of construction. In 2005 there were fourteen sites in Northamptonshire processing CDW and a further site in Milton Keynes is identified in the SEERAWP Annual Report for 2004. There were no known sites in North Buckinghamshire but a number of sites operate in Bedfordshire, reprocessing bricks and rail ballast as well as CDW.

The main difficulty is, firstly, the indifferent statistical base which makes it hard to define either absolute amounts or relative trends. Secondly, such evidence as there is suggests that the potential for increasing the current contribution appears to be limited. The current estimate for the growth zone is 1.5 Mtpa recycled aggregate, equivalent to 15% of total aggregates supply.

However, increasing production of recycled aggregates is constrained by the fact that they arise predominantly from demolition. Demolition of a building will never be 100% efficient in terms of recovering every tonne of aggregate originally used in its construction; and even if everything could be recovered, it is likely to be in a condition that prevents 100% reuse. Therefore, even to stand still, the inevitable routines of maintenance and replacement must consume some new aggregate. An area that is experiencing net growth may also be demolishing and recycling, but the quantum of aggregate demand due to growth must always exceed the available recycled aggregate. Furthermore, the building stock of the area concerned is generally newer than the average urban setting, implying that rather less CDEW will be forthcoming than in a typical conurbation when expressed in per capita terms.

Nonetheless, it was identified earlier that growth within the Focus Area must have been sustained to some degree by imported aggregates in one form or another. It is those locations that might benefit most from serious attempts to maximise recovery of aggregates from demolition and their reuse. While that should be a universal policy prescription, these areas might benefit most from it, by reducing the unsustainability of transporting imported materials.

Therefore, as with improving the intensity of aggregate usage, recycling must likewise have a practical maximum limitation and experience diminishing returns as that is approached.

It should be noted here that there is little or no evidence of widespread import/export of recycled aggregates. Indeed, traditionally demolition materials were (and often still are) recycled on the demolition site in the ground preparation for the new structure. There is no suggestion that new major sources of recycled or other alternative materials, within or beyond the Project Area, will arise in the near future. Hence, the contribution of recycled materials will probably continue at roughly current levels and will be predominantly quite local.

10.5.3 Existing primary aggregate resources within the Project Area

The findings of this study confirm earlier concerns that the ability to continue to rely upon traditional sand and gravel resources within the Project Area seems clearly to be diminishing. The Nene Valley south of Stanwick is largely worked out and whether the area has the environmental capacity to tolerate much more working is open to question, even if further resources were to be identified. The north east section of the Nene Valley, the Great Ouse and other river valleys have potential additional supply capacity but they all represent attractive landscapes and the need for the mineral must be balanced against the sometimes dramatic changes inflicted on the landscape as a result of aggregate extraction. As identified above (4.2 Evolution of local policy) at the present time both the Northamptonshire and the Milton Keynes Minerals Local Plans identify the river valleys as areas worthy of protection. In the case of Northamptonshire rigorous protection against the effects of mineral development is given to all river valleys, including that section of the Nene in the north east of the county between Stanwick and Wansford which has been subject to much less intensive working in the past. In Milton Keynes, mineral extraction is generally resisted in the locally defined Area of Attractive Landscape (including the valley of the River Great Ouse) unless the need outweighed any detriment to the landscape quality. Therefore, although short term provision is or is likely to be secured from traditional alluvial resources within the Project Area, simply viewed in terms of the intensity of planning permissions required, beyond the current minerals local plan horizon the situation becomes more speculative.

Of those project boreholes investigating glaciofluvial sands and gravels, the potential resources discovered were much thicker in the South compared to those in the North and West of the Project Area. All of the southern project boreholes identified glaciofluvial sand and gravels, unlike those in the North and West, suggesting they are more widespread in the South, in the areas to the South and West of Milton Keynes. Demonstrating potential resource thicknesses of up to 7m, the sandur deposit West of Buckingham was identified as a source of potential aggregate. Under half of the boreholes drilled in the Ouse River terrace deposits identified sand

and gravel terrace deposits. In comparison, none of the boreholes drilled on the river terrace deposits of the Ise, Welland and Avon Valleys identified the river terrace sand and gravels. The existing boreholes drilled for the IMAU drilling programme, suggest that the pre-glacial deposits of the Milton Formation could also be a potentially large source of sand. Overall, there are areas with potential for aggregate extraction, but the opportunities are limited considering the growth anticipated in the region.

It therefore appears essential that alternative ways of providing sustainable aggregate supplies to the Growth Zone are brought forward as a matter of some urgency if the anticipated growth is to be delivered in a sustainable way and at an acceptable environmental cost.

10.5.4 New primary aggregate resources

As identified above, there is very little high quality, and limited amounts of low quality, hard rock aggregate resource within the Growth Zone. Discounting the concentrations of sand and gravel in the major river valleys, little or no viable sand and gravel resources; or, at the least, none that has been found viable in the last sixty years.

Whilst it is not the case that the detailed near-surface geology of the Project Area is fully known, those local studies that have been undertaken, including the programme of drilling and borehole analysis undertaken for this project have tended to confirm that no major sand and gravel (or hard rock) deposits capable of influencing the supply picture significantly have been overlooked.

Therefore, the question to be considered here is whether any other strata are capable of yielding alternative aggregate materials capable of substituting in uses other than bulk fill.

Of the potential strata, the most immediately apparent are the strata of the Lincolnshire Limestone, which are known geologically in some detail through having being removed as part of the overburden during opencast ironstone mining. Although worked in a few instances (notably for building stone and lime burning), in ironstone mining these limestones were purely waste.

The decline and extinction of large-scale ironstone mining left several extensive anomalous old planning permissions in Northamptonshire, where the right to win and work was not explicitly limited to the underlying ironstone. In these cases, limestone quarries have continued in operation at a few locations near Northampton, Kettering and Corby. Currently one site at Pitsford is active while a number of others are inactive but could re-open since modern planning conditions have been approved. In addition there are two other active limestone quarries (Pury End and Duddington) and one (Harlestone) where sandstone is worked as aggregate. Overall Northamptonshire has a permitted reserve of some 23Mt which at recent rates of production represents a landbank of over 50 years. Given the considerable extent of these permitted reserves, the limited actual production may be indicative of practical difficulties.

There is insufficient detailed knowledge of the physical properties of the limestones contained in such old mining permissions to be able to say with any confidence what contribution they might offer to wider aggregate supplies. Indeed, the County Council has allocated in its Minerals Local Plan a further 3Mt of limestone elsewhere in the county which is understood to be of a suitable quality, in part because of the uncertainty regarding the quality of existing permitted reserves.

Another possibility is the ironstones themselves. The Northampton Sand Formation has offered traditional building stones for centuries and these are responsible for the character of many settlements across the north of the Project Area. However, these strata are markedly bedded and there is, apparently, insufficient detailed knowledge of their physical properties to be able to say whether they would be capable of functioning as anything more than specialist building stones, or bulk fill. One point against them is that, by the end of the nineteenth century, most near-surface ironstone was exhausted, and much deeper strip mining, beneath the Lincolnshire Limestone, had begun. That form of excavation was immensely disruptive environmentally, and economically could only be accepted so long as the ironstone had a high value as an iron-making raw material. Once cheaper overseas iron ores were imported in quantity, British iron ore mining could not be maintained. There is, therefore, thought to be little or no prospect of ironstone working supplying viable aggregates, whether the environmental impacts of using them could be tolerated or not.

What is particularly telling, when considering these alternatives, is that industry has not so far taken any of them up in a significant way. Indeed, there appears to be a general reluctance to use these materials on the basis of their quality. While that will be, to some extent, because better traditional resources are still just available and hence the commercial need for new resources is not yet sufficiently urgent, the industry has often shown itself perfectly capable of long sight and, had any natural alternatives shown promise, it would be surprising if at least some development had not been promoted, or at least positions staked out.

Nevertheless, in terms of sustainability, it would be prudent to investigate the potential of these other materials to determine exactly what role they might be able to play in contributing towards sustainable aggregate supplies to the Growth Zone in general and the Focus Area in particular.

10.5.5 Import from outside the Project Area

This option is placed at the bottom of the nominal sustainability ladder. Fundamentally, it amounts to exporting pollution, transferring the environmental impact from the communities that benefit from the proposed growth, to those that experience the disamenity of quarrying and mineral transport. One should not over-state the disadvantages; at the supply end there are economic advantages, and of course national life is based ultimately upon a matrix of different “winners and losers” in terms of such basics as reservoirs, power stations, ports, communications, and so on.

Of more immediate concern is the sustainability of hauling many millions of tonnes of relatively low-value commodity long distances around the country. As shown above, that has always happened, and successive mineral policy documents have at least given it tacit support, if not positively promoted it for the last few decades. Given an uneven distribution of geological resources about the UK, let alone the Project Area, it is no doubt inevitable.

Moreover, in a free market, architects and engineers will tend to specify, and builders will tend to procure, the resources they require from where they prefer. In a risk-averse society there will be a tendency to over specify (within a reasonable cost range) both quality and quantity. Aggregates are usually the lowest cost component material, which would suggest a tendency to skew specifications towards a higher grade and level of usage of aggregates than might be necessary. Even the free granting of planning permissions for novel aggregate rocks – if one could imagine that – would be ineffective if the perceived fundamentals of stone quality were not right. This might be addressed if the overall costs (environmental, social and economic) were taken fully into account at the design stage.

Therefore, it would appear that the proper approach to planning the supply of aggregates to the Growth Zone, and in particular the Focus Area, cannot avoid making continued provision for imports of both hard rock and sand and gravel. In the case of hard rock, existing levels may be expected to increase. This might be possible using existing import facilities and supplementing them with additional depots in locations where the need to import large quantities of aggregate occurs. In the case of sand and gravel a positive step towards securing sustainable supplies in the longer term would be to investigate opportunities to move materials by methods other than road such as rail and water. This might open up opportunities to source material from areas that do not traditionally export to the Growth Zone, thus spreading the environmental cost. However, this must come with the proviso that rail transport can be a twin edged sword, being environmentally favourable in terms of carbon footprint but potentially resulting in the greater exploitation of more environmentally sensitive areas such as National Parks.

10.6 KEY FINDINGS – FUTURE RESOURCE AVAILABILITY & DEMAND IN THE GROWTH ZONE

The study has been essentially a process of elimination to confirm or otherwise generally held views of the dynamics of the supply/demand market within the Project Area.

The research shows that the Growth Zone will give rise to a sustained average construction demand in the Project Area, throughout its development, equal to the peak demand of the 1980s/1990s. There will inevitably be peaks above that average. The extent to which this is translated into aggregate demand is conditioned by several factors.

The results of the research, taken overall, have suggested that there are few available remaining resources of traditional aggregates, namely sand and gravel within the Focus Area. Even in the absence of the Growth Zone proposal, mineral planning would soon need to address the issue of alternatives. The Growth Zone plans can only hasten that depletion and hence the decisions upon how to provide for alternative supplies. The fact that the past fifteen years have been ones of decreasing demand may have provided a false sense of security: the full impact of what was predicted during the 1980s in terms of the effects of diminishing supply has not so far materialised with such force. The Growth Zone will place an almost unprecedented demand pressure on the area and thus a close consideration by high level policymakers, including government, of the fundamental issues of how this is to be met from sustainable supplies is perhaps already overdue.

The findings of this research project suggest that there is no single strategy available. The geological drilling and analysis conducted as part of the project tends to confirm the more instinctive industry view that there are no major undiscovered sand and gravel deposits available. It cannot be confirmed without further research to what degree the Lincolnshire Limestone could substitute for other aggregates. However, it does not appear likely that it would be of sufficient quality to provide an acceptable substitute for more demanding specifications. Still less do the ironstones, appear to offer much potential; certainly not over the timescale envisaged. Neither do there appear to be any major deposits of other hard rocks capable of being substitutes. Although quality information is sadly lacking, and should be gathered and appropriate tests carried out and made public as part of any future study, there is no current evidence to suggest that optimism in that respect would be justified.

What is also discouraging is that there is some reason to expect that the supply available from recycled aggregates may have peaked. At the very least, there is no evidence that significant increases can be anticipated.

There is also no evidence that reduced intensity of aggregate usage or artificial aggregates can make more than a minor contribution to the total demand.

Therefore, while policy ought to promote recycling and economy of usage, the quantum of demand must, it would appear, be satisfied predominantly by import. Policy therefore must ensure that acceptable locations for receipt of imports, and onward redistribution, are made available at appropriate locations.

The final conclusion to emerge from this study is the difficulties that might arise where one element of national policy – in this case, establishing certain Growth Zones – is pursued without consideration of all the factors that govern its delivery successfully and within environmental and sustainability constraints. It may well be the case that this Growth Zone is, in land use planning terms, relatively unconstrained by high-order protective policies. But, if the area contains insufficient, or no, other essentials for the policy to succeed – minerals, water, services, etc – or else no obvious means of remedying deficiencies in a sustainable fashion can be perceived, then it calls into question the reality of the concept.

This is not to say that the Growth Zone cannot be supplied with minerals. It can be, and no doubt will be, but by a mix of local and remote production of newly dug mineral, the latter transported from only partially defined sources via undetermined routes and modes, with a 15-20% contribution from recycled aggregates and, with luck, a couple of percent contribution via economies in usage.

11 Recommendations

11.1 MKSM GROWTH ZONE RECOMMENDATIONS

1. Aggregate resources in the MKSM Growth Zone are depleted, therefore safeguarding of the remaining local resource will be critical in ensuring the sustainable development of housing and infrastructure into the future. Policies to encourage a critical examination of options for prior extraction if mineral-bearing land is to be developed will be particularly important in the MKSM Growth Zone, where the aggregate resource is in demand but limited and where there will be intense pressure to develop land. The aggregates footprint of all significant development elements within the Growth Zone should be monitored and reported regularly.

2. Further research to investigate the potential resource in the glaciofluvial deposits in the south of the Project Area. The sheets of glaciofluvial sand and gravels near Buckingham are suggested as a focus for investigation using a relatively small and targeting project drilling programme. Some Jurassic limestone formations may provide aggregate of useful quality but further investigation of their properties will be needed.

3. A critical examination of the existing transport infrastructure and the potential to develop this further to provide sustainable transport options for imported aggregate. This should include an analysis of existing rail freight capacity on relevant routes, safeguarding existing rail depots, identifying locations for additional depots and considering novel transport both water transport options and the potential to develop routes to import material from areas not currently serving the MKSM Growth Zone.

11.2 NATIONAL RECOMMENDATIONS

1. Further research into the extent to which lower grade natural aggregates such as softer crushed rock can meet demand in physical terms. This should include the possibility of stabilising and strengthening such materials.

2. Research to establish a better understanding of alternative aggregate occurrences and distribution. In particular, the quantitative monitoring of the arising and usage of secondary and recycled aggregates at anything below regional level is poor: it should become a statutory requirement to report such data.

3. In order to assess potential demand a series of benchmarks need to be established, for example:
   a. units of aggregate consumed by each dwelling unit (*sensu stricto*)
   b. units of aggregate generated by each dwelling unit expressed as a general multiplier
   c. units of aggregate consumed by commercial units (e.g. per unit of floor area) large road schemes, etc.

4. An assessment of the aggregates footprint should be an essential requirement of every proposed construction project or more general plan proposal (e.g. Growth Zones) above a defined level, as part of the plan monitoring/SEA processes.

5. Critically examine the greater potential for prior extraction and integration of other extraction planned, to provide terrain suitable for other desirable related planning

initiatives, such as landfill, water storage, recreation, geo/bio conservation, water features/facilities, to avoid sterilising the aggregate resources.

6. Accept that in forward planning for aggregates there will often be a limit to the level of geological evidence available. Thus, when considering potential future sites put forward through Minerals Development Frameworks it may be necessary to accept a less robust evidence base than would be the case for a built development site, for example. The precise level of evidence required for any particular location should be decided on a case by case basis but if complete geological certainty is required, which can only be possible through a comprehensive drilling programme, there is a danger that sites will fail to meet the stringent tests of certainty and hence will not be adopted as allocations.

7. The established mechanism for calculating Sub Regional Apportionments should be reviewed and moved more towards a demand response rather than, as at present, simply reinforcing traditional supply patterns. In particular, at a local level, it must become more responsive to major development proposals. [Note: This point was raised at a stakeholders' workshop after this study was largely completed, so its possible outcomes have not been examined herein. Nevertheless, it is considered a valuable contribution and one that might be given future consideration.]

12 Glossary

Aggregate	Granular or particulate material, either naturally occurring (sand and gravel) or produced by crushing (crushed rock) which, when brought together in a bound (with cement, lime or bitumen) or unbound condition, is used in construction to form part or whole of a building or civil engineering structure. Also referred to as 'construction aggregates' and used mainly as concrete, mortar, roadstone, asphalt or drainage courses, or for use as constructional fill or railway ballast.
Aggregate Mineral	Naturally-occurring material suitable for aggregate uses. For example, sand and gravel, crushed rock and stone.
Alluvium	A general term for clay, silt, sand, gravel. Unconsolidated detrital material deposited by a river, stream or other body of running water as a sorted or semi-sorted sediment in the bed of the stream or on its floodplain or delta, or as a cone or a fan at the base of a mountain slope.
Primary Aggregate	Aggregate produced from naturally-occurring mineral deposits and used for the first time.
Secondary Aggregate	Aggregate which originates as a waste of other quarrying and mining operations, or from industrial processes (e.g. colliery waste or minestone, blastfurnace slag, power station ash, china clay sand, slate waste, demolition/construction wastes including road planings), but excluding chalk and clay/shale worked primarily for aggregate purposes.
Recycled Aggregate	Aggregate derived from both construction waste, for example damaged bricks, and demolition waste, such as broken concrete, brickwork and masonry.
Borrow pit	A site for the extraction of aggregate minerals over a limited period, for exclusive use in a specific construction project, which will usually be close to or contiguous with the site.
Brownfield site	Land previously developed for urban, industrial, military or infrastructure purposes or which has been damaged by previous use.
Construction fill	Fill material that will bear loads (e.g. in suitably designed embankments) as distinct from landfill to occupy voids and not specially intended to bear loads.
Diamicton	A deposit with particle sizes varying from clay to boulder size. For example, a till deposit is often a diamicton.
Fluvial deposit	Sedimentary deposits consisting of material transported by, suspended in, and laid down by a river or stream.
Glacial	An extended length of time during which earth's glaciers expanded widely.
Glacial deposit	Sediments which have been removed and transported by a glacier.
Glaciofluvial deposit	Sand and gravel deposited by meltwater streams flowing from wasting glacier ice; typical landforms include terraces and outwash (sandar) plains.

Greenfield site	Land previously in agriculture or non-urban/industrial use or which has not been damaged by a previous use.
Head	Poorly sorted and poorly stratified, angular rock debris and/or clayey hill wash and soil creep, mantling a hill slope and deposited by solifluction and gelifluction processes.
Hoggin	A term mainly applied in southern England for 'as raised' clayey sand and gravel, used as dug for constructional fill for low-grade purposes, paths etc. ('A natural deposit of stony sand and gravel containing a small admixture of clay which is sufficient to hold the mass together without affecting the interlocking properties of the coarser particles.' Mineral Dossier on Sand and Gravel. Mineral Resources Consultative Committee, 1970).
Interglacial	A long distinct period of warmer conditions between glacials when the Earth's glaciers have shrunk to a smaller size.
Interstadial	Short lived period of warming during a glacial phase.
Landbank	A stock of planning permissions for the winning and working of minerals. It is composed of the sum of all permitted reserves at active and inactive sites at a given point in time, and for a given area.
MPA	Mineral Planning Authority, responsible for planning control over mineral working within its area.
MPG	Minerals Planning Guidance.
MPS	Mineral Planning Statement
Mt	Million tonnes (i.e. Megatonne)
Quaternary	The most recent geological period, spanning the last two million years or so of the earth's history, extending up to present day. The Quaternary is characterised by numerous glacial-interglacial cycles, and on several occasions during this period much of the UK has been covered by glaciers.
QPA	Quarry Products Association, the trade association which represents some 120 quarry operators, who together account for more then 90% of the quarried aggregate materials in Great Britain.
RAWP	Regional Aggregates Working Party
River terrace	A bench-like feature running along a valley side, roughly parallel with the valley walls. Most terraces form when a river's erosional capacity increases so that it cuts down through its floodplain. Many river valleys have been subject to alternating phases of aggradation and dissection such that a series of terraces has developed. These are cut and fill terraces, formed as erosion alternates with deposition. Two similar terraces on each side of a river are paired terraces. These occur at times of elevation of the land surface or when down cutting is greater than lateral erosion. Unpaired terraces usually form when lateral erosion dominates.
Sandur, Sandar (pl.)	Stratified detritus of coalescing outwash fans, mainly sand and gravel removed or washed out from a glacier by meltwater streams and

	deposited in front of or beyond the margin of an active glacier on the outwash plain.
SAC	Special Areas of Conservation designated in accordance with European Directive 92/43/EEC, adopted 21st May 1992, to provide measures to conserve natural habitats and associated wild fauna and flora. The directive is commonly known as the 'Habitats Directive.' SACs, together with SPAs (see below), will form part of 'Natura 2000,' a European wide network of areas of special nature conservation interest. SACs are also SSSIs.
SPA	Special Protection Areas designated in accordance with European Directive 79/409/EEC, adopted 2nd April 1979, to provide measures to conserve wild birds, their eggs and their habitats. This directive is commonly known as the 'Birds Directive.' SPAs are also SSSIs.
SSSI	Site of Special Scientific Interest designated by English Nature or the Countryside Council for Wales in accordance with the Wildlife and Countryside Act 1981 so as to conserve areas of special interest for their flora, fauna, geological or geomorphological interest.
Stadial	Short cold episodes during which local ice advances occur.
Till	The unsorted sediment deposited directly below a glacier, which exhibits a wide range of particle sizes, from fine clay to rock fragments and boulders. The lithological character of the till depends on the geology of the region the glacier has travelled over. A now out-of-date term for glacial till is boulder clay; inexact as till does not always contain boulders.
Unallocated sales	Sales of primary aggregate where the destination is unknown.

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14 Appendix 1: Analysis of past supply & demand

This is a review of the historic patterns surrounding supply and demand of resources in the Project Area, and determines the aggregate resource implications of the Growth Zone proposals.

The section is divided into the following sub-sections:

- **Growth Zone proposals**

  This sub-section provides brief details of the Milton Keynes South Midlands (MKSM) Growth Zone proposals which give an overview of the level of development envisaged for the area up to and beyond 2021.

- **Past patterns of development**

  This sets out a broad overview of post war development in the area to provide background regarding the area of study and to place into context the development envisaged under the Growth Zone proposals. It includes a brief assessment of the contribution that the geology of the area has historically made to its economic development.

- **Trends in national supply and consumption of aggregate and construction**

  This sub-section analyses the national patterns of supply and consumption of aggregate over time. It compares sales of aggregate with levels of house building and other major developments which are taken as a surrogate for overall consumption of aggregate. It considers a very wide range of possible methods of assessing past and future demand.

- **Trends in the Project Area supply and consumption of aggregate and construction**

  This sub-section analyses the local patterns of supply and consumption of aggregate over time in the Project Area. It compares sales of aggregate with levels of house building and other major developments which are taken as a surrogate for overall consumption of aggregate. It considers a very wide range of possible methods of assessing past and future demand.

- **Other construction activity**

  This sub-section provides a qualitative analysis of demand for aggregate from construction other than housing such as road construction, construction of commercial and industrial buildings and other major projects.

- **Secondary and recycled aggregates**

  This sub-section gives brief information on the more recent contribution that secondary and recycled aggregate has made towards satisfying demand. It attempts to assess the level of alternative aggregate which is currently being used in the Project Area.

14.1 GROWTH ZONE PROPOSALS

Regional Planning Guidance 9 (RPG9, 2001) for the South East England first identified a number of areas for potential Growth Zones in the “wider” South East. These were as follows:

- Milton Keynes – South Midlands (MKSM)
- London – Stansted - Cambridge
- Ashford
- Thames Gateway

The Milton Keynes South Midlands (MKSM) Growth Zone was formally identified in February 2003, when the Office of the Deputy Prime Minister published the Sustainable Communities Plan (ODPM, 2003) which set out a programme of action to tackle housing shortages in the UK. In particular it recognised that while demand for new housing was growing, new house building had actually fallen to a post war low of around 140,000 units per annum.

The Communities Plan promoted an increase in and speedier supply of, affordable housing, tackling issues related to skills, deprivation and urban renewal, making better use of land and improving infrastructure/transport.

All the Growth Zones were identified as "Sustainable Communities", an important policy element being that they should be "developed sustainably" in terms of design, land use, impact on the environment etc. Whereas many of the contributory factors have been considered from an architectural, social planning or urban planning perspective, little attention appears to have been paid in the initial studies to the basic requirements and sourcing of materials to support this growth, including national resources such as aggregates and water supply.

The MKSM Sub-Regional Strategy was adopted in March 2005. It relates to the period 2001-2031 and incorporates alterations to the Regional Spatial Strategies for the East Midlands, East of England and South East. Its intention is to provide guidance on the scale, location, and timing of development; the associated transport, employment and social infrastructure required; and the delivery mechanism over a shorter timescale needed to achieve the Government's vision of sustainable growth in the sub-region.

The Strategy sets out the locations for and intended patterns of future growth. These are summarised in Box 2. The objectives of the Sub-Regional Strategy include ensuring high standards of design and sustainable construction, protecting environmental assets, planning reductions in the need to travel, the regeneration of deprived areas and the recycling of land.

Box 2 Locations for intended patterns of growth

Box 2 Locations for intended patterns of growth
Aylesbury – concentrate on strengthening/extending the existing county town.
Bedford/Kempston/northern Marston Vale – economic regeneration and growth, urban renaissance, selective development in N. Marston vale.
Corby/Kettering/Wellingborough – all to grow, but to retain identities. At Corby, regeneration of town centre. Kettering/Wellingborough - management of town growth/sustainable job creation.
Luton/Dunstable/Houghton Regis/Leighton Linslade – build up the main towns to produce robust economies by general regeneration in the urban areas and, maximising links to London/South East. Leighton Linslade will absorb some of the growth previously allocated to these other areas, to strengthen their links with Milton Keynes.
Milton Keynes – capitalise on the town as a mature regional centre by substantial development of central area and support for growth in major development areas (NB: one of the responses to earlier proposals was the lack of focal urban centre in the Growth Zone).
Northampton – combined general growth as a regional centre; town centre renaissance.

In general, there will be an emphasis on reusing brownfield sites, high quality housing in sustainable locations, attracting quality jobs and building commensurate social infrastructure, reduced need for reliance on private cars (by improved public transport).

14.1.1 Growth - housing

Table 15 shows the levels of new housing proposed, which have been provisionally revised in places, notably for Northampton, through draft Regional Spatial Strategy.

"Current policies" refers to those already carried in regional planning documents prior to the inception of the Growth Zone. Some further housing development will take place elsewhere in the Sub-Region outside the key growth towns, but at a much lower scale, to be determined in Local Development Documents.

Table 15. Housing proposed for the MKSM Growth Towns to 2031

Area	Current policies	Sub-Regional Strategy additions	To 2021	2021-31
Aylesbury	7,750	7,250	15,000	8,500
Bedford, Kempson & Northern Marston Vale	19,500	Nil	19,500	10,000
Corby, Kettering & Wellingborough	14,900	19,200	34,100	28,000
Luton/Dunstable & Houghton Regis (with Leighton Linslade)	8,750	17,550	26,300	15,400
Milton Keynes	27,150	17,750	44,900	23,700
Northampton	28,100	3,400	31,500	17,500
MKSM Growth Zone Total	106,150	63,650	171,300	103,100

Source: MKSM Sub-Regional Strategy, March 2005 & Draft East Midlands Regional Plan, Part 2: Milton Keynes and S Midlands Sub-regional stategy, additional consultation, December 2006.

The figures for 2021-31 shown in Table 15 are "without commitment" but represent the minimum needed to achieve those set out in the "Barker Review" (see Chapter 5). It would be reasonable to assume that there will be no diminution in housing growth post 2021.

The Sub-Regional Strategy acknowledges that a step change in the magnitude of growth required to achieve the level of housing provision identified will not be achieved immediately. Instead the projected building programme becomes more intensive towards the end of the main growth period. However, the rate of growth is not the same for all areas as is seen in Table 16.

Table 16 Phasing of housing growth in the Growth Zone

Administrative Area	Average annual rate of house production				
	2001-06	2006-11	2011-16	2016-21	Total dwellings 2001-21
Milton Keynes	1,580	3,000	2,200	2,200	44,900
Aylesbury (urban area)	480	760	880	880	15,000
Corby	560	680	1,060	1,060	16,800
Daventry	540	540	540	540	10,800
E. Northants	520	520	420	420	9,400
Kettering	550	810	630	630	13,100
Northampton	1,300	1,450	1,775	1,775	31,500
S. Northants	330	330	330	330	6,600
Wellingborough	595	595	685	685	12,800
Bedford/Kempston/ N.Marston Vale	750	1,050	1,050	1,050	19,500
Luton/Dunstable/ Houghton Regis	700	1,300	1,600	1,660	26,300
TOTAL	7,905	11,035	11,170	11,230	206,700

Source: Milton Keynes & South Midlands Sub-Regional Strategy, 2005

14.1.2 Growth - employment

As shown in Table 17 below, the Strategy also puts forward desired levels of employment for each part of the Growth Zone by 2021 but these are not set against existing rates in the same areas (so growth levels are not apparent). Just as important, details of the sectors of employment are not given. However, it is evident from statements elsewhere in the document that the employment strategy will promote particularly "high value knowledge-based sectors", but otherwise the majority will be involved in services of various types - "creative industries", food/drink, logistics, community infrastructure and tourism (paragraph 35).

Table 17 Desired levels of employment for areas within the Growth Zone

Area	New jobs to 2021
Aylesbury Vale	12,690
Bedford/Mid Beds	22,400
Corby/Kettering/Wellingborough/E. Northants	43,800
Luton/S. Beds	12,600
Milton Keynes	44,900
Northampton/S.Northants/Daventry	37,200

(NB: the above relate to District Council/Unitary authority areas which enclose the representative key parts of the Growth Zone).

14.1.3 Growth - transport

The strategy for transport focuses upon sustainable modes, major improvements to public transport capacity and highway improvements. The new and improvement schemes (Table 18) concentrate upon links between major urban centres in and beyond the region, the Haven Ports and national airports. All these relate to "improvements", except where otherwise stated in brackets.

In a more detailed later section of the strategy document, passing reference is made to major expansion in passenger numbers at Luton Airport, but notes that physical development proposals await consideration.

Table 18 Transport schemes to 2031

Transport schemes to 2031
East/west public rail transport as far east as Bedford
A14 inc. M1/M6 junction
A45
A421
A428 – east/west route
West coast main rail line (via Northamptonshire/MK)(modernisation)
Midland mainline/Thames link 2002 (enhancement)
M1 (widening)
Dunstable northern bypass (new)
A418
A4146

Source: Milton Keynes & South Midlands Sub-Regional Strategy, 2005

14.1.4 Growth – aggregate resources

The Strategy interprets for its own area, the aims of the Sustainable Communities Report as "key requirements". Features of particular relevance to this project include:

- Minimising the use of resources (including land) by the built development
- An urban fabric/buildings which can minimise the use of energy, water and other natural resources, facilitate reduction of, recycling and sustainable management of waste"
- Provide a "mix of decent homes"
- Provide a "sense of place"

It points out that although these are covered by national and regional guidance, "it is important that every aspect of the Growth Area strategy is focussed upon delivering them".

However, the Strategy fails to refer to the materials resource implications of this growth. In particular no mention is given to the aggregate resources that would be required for this growth. It does not recognise the strategic role of the existing providers of aggregate resources in the Growth Zone (nationally significant in the case of the brick industry). For example, only a passing reference is made to "primary Industries (Agriculture and Forestry)" – there being very little of the latter in the whole area. It is however implied that the need for increased water supply will have to be met largely from outside the Growth Zone.

In addition, no reference is made to the potential impact of the proposed development upon the environmental quality of areas outside the Growth Zone e.g. by sourcing materials (including aggregates) from elsewhere and possibly from more sensitive locations. Reference is made later in the Strategy to sustainable design of new buildings, master planning and managing development.

The remainder of the strategy contains details of how the proposals relate to very specific areas, including an indication of how development will be phased over time and geographically.

14.1.5 Key findings – Growth Zone proposals

- It is clear that the level of development envisaged in the Growth Zone is substantial and that significant and sustained demand will be placed on raw materials, including aggregates, in order to achieve the desired level of growth.
- Demand for aggregates in the Growth Zone could possibly have an impact outside the Growth Zone due to sourcing materials from elsewhere.
- Growth Zone proposals fail to refer to where the raw materials to sustain the proposed growth will be supplied from.

14.2 PAST PATTERNS OF DEVELOPMENT

Although this project has focused on a quantitative analysis of development in the Project Area it is considered that a qualitative/narrative approach is helpful as a precursor to a more empirical analysis, for example in providing a means of focussing upon key factors or indicators. Therefore a review of past patterns of development in the Project Area has been undertaken. In order to set the scene, this review is taken back to the 1940s, as the World War II marked a significant continuity break, after which, a series of major trends can be identified, some of which have persisted, but many of which have not. Boxes 3 to 8 outline past patterns of development through the decades from the 1940s to the 1990s in the Growth Zone and Project Area. These demonstrate that the area has had a very long history of major development. The mineral resources that sustained these developments are also summarised in Box 9.

14.2.1 Past patterns of development the 1940s

Box 3 The 1940s

World War II witnessed a step change, a reversal and shortly afterwards, a further step change in construction and the economy in general. Whereas this area is perhaps not exceptional in displaying these trends, it should be remembered that some important national industries already had a firm footing in the area, notably: "Fletton" brick making around Calvert, Bedford and Peterborough based on energy saving advantages of the Oxford Clay; boots and shoes in Northampton and some neighbouring towns; car and commercial vehicle production at Luton/Dunstable (originally in part stemming from the Luton hat industry); specialist textiles; the railway works at Bletchley; silica sands production around Leighton Buzzard; and cement along the Chiltern foothills. Many of the small towns in the area had engineering works, having origins which related to agriculture, the Northamptonshire iron and steel works or to serving the Midlands and London with specialist goods.

Plate 3 Extraction of Oxford clay at Beeby's L.B. Pit, Fletton, for the brickmaking industry of the 1940s.

Very significant from a number of standpoints, Northamptonshire together with south Leicestershire and Rutland had strategically important sources of iron ore, supporting not only several local works but others in the East and West Midlands. By far the largest of these was Corby, the main modern development being inaugurated in 1934. By 1939, in addition to the works itself, 2250 houses had been built for workers, Eyebrook reservoir had been completed (1938) and the works was apparently producing 1.0-1.4 mt per annum of blast furnace slag as a by product of pig iron.

As a related aside, ironstone extraction itself underwent radical changes in the War in production technique and scale, which set a pattern persisting into the 1970s and also had far reaching implications for aggregates production and planning in Northamptonshire and Rutland. The large scale availability of by-product blast furnace slag, in an area lacking particularly hard rocks, found a ready market for road surfacing materials.

Just outside the Growth Zone, to the north but partly in the Project Area igneous rock quarrying, engineering and coal mining were mainstays in Leicestershire.

Box 3 The 1940s

…continued

Plate 4 Extraction of ironstone during the 1940s at Wellingborough No. 5 Pit, near Finedon village

As one would expect, these industries were diverted to major war work in the 1940s, with iron/steel production, cement and vehicle output, generally peaking in about 1943, only to fall back (despite post war reconstruction) on account of post war austerity measures and the need to concentrate efforts on raising foreign currency through exports.

Clearly military construction was at an exceptionally high level and this included significant numbers of airfields, many converted from grass to concrete runways by 1943, with the demand to sustain the increasing loadings posed by larger aircraft. Whereas a number of these were constructed in this area, far more were built just outside the area immediately to the east and north east in East Anglia and Lincolnshire and doubtless called upon resources from this area. The airfield construction programme was considered to be the largest construction initiative since the building of Victorian railways. By far the largest number of airfields were constructed in 1943 with c20 operational in 1940-45 in Northamptonshire and South Leicestershire/Rutland alone. There were a similar number of airfields in North Buckinghamshire and Bedfordshire, but these included a significant number which by 1945, remained as grass fields.

These sites were to have a further role as a source of secondary aggregates when the land was reinstated at the end of their lives. There were also major building, expansions in other areas such as defence lines and Bletchley Park.

14.2.2 Past patterns of development the 1950s

Box 4 The 1950s

Although still predominantly rural in overall landuse terms, by 1950 unlike other “rural areas” of England, the area also had a substantial industrial base and that founded upon the iron industry in Northamptonshire had been active for a century. The A1, A5 and A6 with the East Coast mainline, the Midland, Great Central and West Coast mainline rail routes, served the area. There were no significant east-west routes.

The post war housing boom made great calls on all materials, but in particular, underpinned major expansion of the relatively low cost brick making units in this area, where considerable economies of scale could be gained at a time when fuel supplies were under pressure. The whole of the Fletton brick industry was confined entirely to the Oxford Clay located in the area under review (if one includes Peterborough).

Iron

The main iron making centre operating in Northamptonshire after the 1930s was Corby. Apart from being the only major iron and steel works in the Project Area, Corby was also the only one to make methodical use of slag as secondary aggregate. The basic slag plant (latterly operated by Fisons) had been installed at least as early as 1935 and took molten slag directly for processing to aggregates. Shanks & McEwan operated a second slag plant from about the same date.

These plants did not rely upon large slag stockpiles so that, once already-processed material was used up, they closed about two years after iron and steel making ceased in April 1980.

Only three other iron works operated post-war: Cransley (closed 1957); Kettering (closed 1959); and Wellingborough (closed 1963). Their small scale meant that only limited slag stockpiles had been created and mostly this material was reused for on-site reconstruction. On a still smaller scale, at the various nineteenth-century ironworks - such as Finedon (closed 1891), Hunsbury Hill (closed 1921), Irthlingborough (closed 1925), and Islip (closed 1942) - slag banks were occasionally recovered for many years after closure. For example, Finedon slag bank was recovered progressively over the period 1891 to 1925, for use as railway ballast.

Plate 5 The first section of the M1 was built in the Project Area in 1958/9

Other construction

- Active RAF airfields in the northern half of the area had fallen to five by 1955 (and then to two, ten years later, both of which are still operational).
- However over the next 30 years or so a number were converted to related uses including civilian flying, other military requirements or non-flying civilian uses. In the Cold War period (1950s) a number of airfields were considerably extended and strengthened to accommodate RAF “V” bombers and the USAF (Bruntingthorpe, Wittering, Thurleigh, Cottesmore).
- The M1 was built in record time through the area in 1958/9.
- The large Pitsford Reservoir was completed near Northampton in 1956.
- Many branch railway lines, especially those running east/west were being run down and closed in the 1950s.

14.2.3 Past patterns of development the 1960s

Box 5 The 1960s

Plate 6 Sand and gravel extraction during 1968 at Broughton Quarry, near Milton Keynes village.

By the mid-late 1960s Corby works had transferred much of its steel output from open hearth to basic oxygen processes and blastfurnace slag output was probably running at about 0.5-0.6 Mtpa.

By 1965 expansion of the following towns was underway via Town Development schemes under the Town Development Act 1952: Wellingbrough, Bletchley, Aylesbury, Houghton Regis. In addition in adjacent areas, Banbury, Letchworth, St Neots and Huntingdon were undergoing similar development (Bletchley was yet to be absorbed within the much larger Milton Keynes New Town only at this stage proposed). Also designated or under consideration were Town Development schemes for Luton, Northampton and Daventry and just outside the Growth Zone, Peterborough.

Milton Keynes was formally designated in 1967 and serious construction began in c. 1971. Also in 1967, Peterborough was designated and in the following year Northampton was accorded New Town status.

The final tranche of rail closures took place in 1963-69 following the "Beeching Axe" (1963); this included almost all remaining branch lines in the area and the Great Central mainline.

Major road schemes completed during the 1960s included the M1 between Crick and Kegworth, the Baldock bypass (now part of the A1(M)) and along the eastern edge of the area, the A1 was converted to dual carriageway.

The large Grafham Water reservoir project, just over the Cambridgeshire border, was completed in 1966.

14.2.4 Past patterns of development the 1970s

Box 6 The 1970s

Plate 7 Today the large 1970s rectangular shopping centre (to the left) is overshadowed by modern constructions.

In Milton Keynes today, the modern constructions The Point (centre) and Xscape (to the right) overshadow the large 1970s rectangular shopping centre (to the left).

The 1970s saw the main period of development for Milton Keynes, Northampton and the expanded towns in the area. In Milton Keynes around 20,000 houses were built, with associated road building, major industrial and commercial floorspace was constructed and the 93,000m^2 shopping centre was completed.

By 1970 some 22 brickworks were operating, only two of which had been developed since World War II. By the late 1970s, the rapid decline in construction and particularly housing, had forced this number down to 12.

Rutland Water, one of Britain's largest post war reservoirs was under construction throughout the early 1970s and completed in 1977.

14.2.5 Past patterns of development the 1980s

Box 7 The 1980s

Corby Iron and Steel works closed in 1980, resulting in not only in a local economic downturn but also a sudden decline in the availability of blast furnace slag for secondary aggregate uses in the area. By the end of the decade only very small quantities were being produced from the remaining stockpiles.

A number of major road schemes took place notably the A5 dualling around Milton Keynes, major rebuilding/resurfacing works to the M1 and improvements to the A43 in Northamptonshire.

Development related to the then proposed A14 took place in Wellingborough, Kettering and Market Harborough.

Magna Park, a very large distribution complex, was commenced near Lutterworth, Leicestershire.

Plate 8 Dragline working of the Jurassic iron ore in Corby

14.2.6 Past patterns of development the 1990s

Box 8 The 1990s

The A14, linking the M1 and the A1 through Northamptonshire was opened in 1994, marking the end of a long phase of major road construction in the county.

The Daventry International Rail Freight Terminal (DIRFT) with associated warehouses and roads was developed as was the Rail Hub at Corby, a similar type of development.

Just after the millennium the Rockingham Motor Speedway was developed just outside Corby.

Plate 9 Typical road layout in Milton Keynes

Towards the end of the 1990s the Highways Agency announced four major trunk road schemes in Northamptonshire. These were the A6 Rothwell/Desborough bypass, A6 Rushden/Higham Ferrers bypass, A43 Silverstone bypass and A43 Whitfield Turn to Brackley Hatch improvements. The County Council was also pursuing two village bypass schemes on the A428 at Crick and West Haddon. However, these developments did not commence until after 2000.

14.2.7 Key findings - Past patterns of development

- The Project Area has been subjected to significant growth in the past. The designation of New Towns has lead to concentrations of growth of a scale not seen in many other areas.
- The growth in housing, in part accounted for by demand brought about by industry, has lead to demand for supporting infrastructure which has been provided.
- The location of the area close to important transport corridors linking London and the South East with much of the rest of the county has only added to the intensity of growth in the area.

14.2.8 Past patterns of development – Mineral resources

Box 9 Mineral resources

The three main primary industries which led the nineteenth and twentieth century growth of the Project Area from agriculture to industry were

1. ironstone for local and remote iron making,
2. brick manufacture
3. cement manufacture.

Ironstone was won from Liassic strata of which in the Project Area the Northampton Sand and Marlstone ores were the most important, spanning the northern part of the present Project Area. The industry began in the 1850s and ceased in 1980, having prompted growth of many towns and villages, notably Wellingborough, Kettering and Corby.

Brick manufacture on a large scale – the Fletton industry – was based upon the belt of Oxford Clay traversing the centre of the Project Area. Commencing in the 1980s, unlike iron ore it remains a major primary industry.

Cement was manufactured either from Liassic limestone (overlying the ironstone beds) in the north of the Project Area, or from the Middle and Lower Chalk horizons spanning the southern part of the Project Area. Although no active cement works remain within the Project Area, three cement works (Ketton, Barrington and Rugby) remain in operation not far away.

All three primary industries, and a host of secondary ones, generated a growing demand for labour and hence urban expansion, housing and other infrastructure. The first two industries attracted a large influx of population from other areas of the UK, then Europe and the Commonwealth. The materials to construct this expansion were predominantly local sand and gravel: the majority of which was derived from the river valley of the Nene.

A **"sense of place"** is seen today as something to be created by design. Up to the 1850s that was not always so. Characteristic local architectural features arose automatically, from the use of natural, local, raw materials and the inability to transport economically alternative materials from any great distance. However, the Project Area historically embraced a variety of raw material characteristics and hence architectural styles were diverse, from the use of ironstone and oolitic limestone building stones across the northern and eastern areas of the Project Area, with stone 'slate' roofing, to the clay-based brick and tile constructions further south and east.

Plate 10 Northampton Town Hall constructed of a locally derived Lincolnshire Limestone

The development of a national railway network from the 1850s allowed long distance transport of competing building materials. Welsh slate roofing upon Fletton brick walls became widespread for much new construction within the second half of that century, throughout England.

Local brick and tile works were never entirely superceded but those two materials became ever more common, especially on large building projects.

The dominance of the Fletton industry remains today, but on a reduced scale. By the 1970s, just three brickworks in Bedfordshire/Buckinghamshire produced over a billion bricks annually, 20% of all UK brick production. At that time, overall, London Brick, which owned the whole of the Fletton brick industry, accounted for some 41% of the UK brick market. On the other hand, the use of slate, other than, occasionally, Spanish slate, has almost died out. In place of local, and indeed non-local but still 'natural', raw materials has come increased reliance upon a range of modern materials, such as plastic, glass, aluminium, concrete, steel reinforcing, manufactured lightweight building blocks, fibre tiles, plastic-coated steel sheets, and similar. These have risen to prominence in part because they are intrinsically cheaper, but also because they may economise on construction labour costs. Civil engineering structures bear no relationship either structurally or aesthetically to those of a century before. Small structures, and dwellings, may appear superficially similar, but the traditional (or imitation traditional) materials are often no more than skins.

Even though the Project Area remains a principal source of bricks for the UK, this does not necessarily mean that products manufactured here are also used here. The demand from architects for particular aesthetic qualities in building materials creates a nation-wide demand even for local products

14.2.9 Key findings - Past patterns of development – Geological resources

- Ironstone and brick and cement manufacture were the three primary industries which led the nineteenth and twentieth century growth in the Project Area. The growth of these industries in turn led to urban expansion and an associated growth in infrastructure. The raw materials for this construction were mostly local sand and gravel from the Nene Valley.
- Walls made from Fletton bricks were widespread and with the introduction of rail Welsh slate became a popular choice of roofing. However, local brick and tile works were very common, especially on large building projects.
- Modern construction now relies on a range of natural materials for construction which are often cheaper than traditional materials, not just in their production, but also in terms of labour costs during construction. For example, large lightweight blocks.

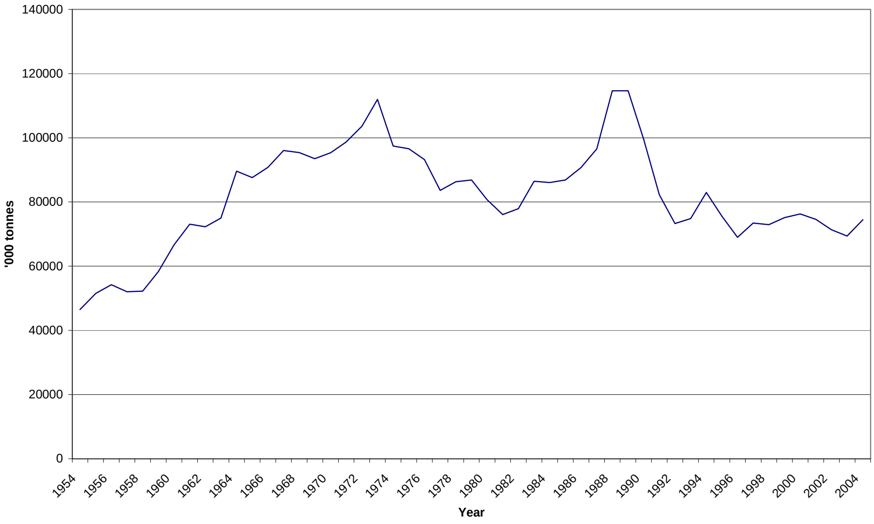
14.3 NATIONAL TRENDS IN SUPPLY AND CONSUMPTION OF AGGREGATE AND CONSTRUCTION

One of the aims of this project was to assemble consistent data sets of historic trends in aggregate production and construction activity, both at national and local level in order to assess the ramifications of projected future growth in the Project Area. Aggregate sales data for the past 30 years or thereabouts was collected from two main sources, the surveys conducted by the Regional Aggregates Working Parties (RAWPs) and data from the central government AMRI surveys. Earlier data was taken from published government statistics contained in the "Sand and Gravel Production" and "Production of Aggregates in Great Britain" series. Assessment of consumption is based on data collected by the RAWPs every 4 years. A number of difficulties have been encountered, mainly owing to the lack of consistent data over much of the period since the Second World War. The difficulties encountered are reviewed in greater detail at the end of Appendix 1. Nevertheless, within the constraints of the available data, it has been possible to assess past trends at both national and local level and to draw some important conclusions.

This analysis examines the trends in aggregate sales since the Second World War and compares them, with construction trends, in particular house building, road construction and other major infrastructure projects. Firstly, an analysis is made of national aggregates sales and house building.

14.3.1 Aggregates

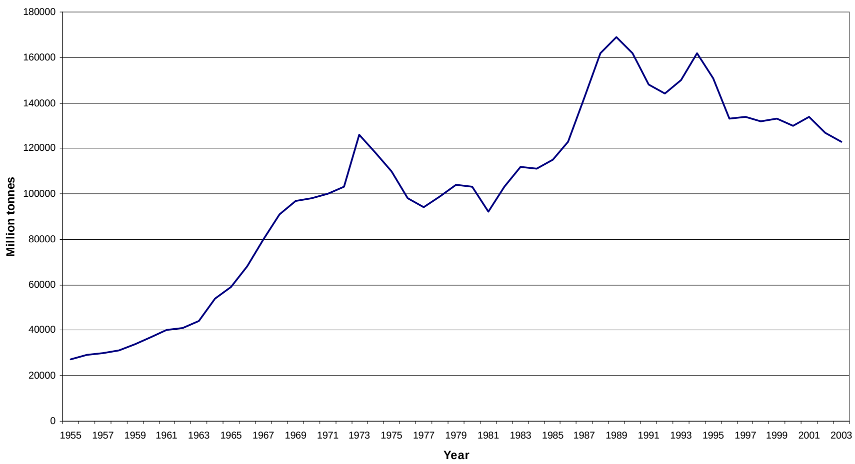
After the Second World War sand and gravel sales in England rose steadily from around 45Mt in the early 1950s to a peak of almost 112Mt in 1973 (Figure 31). Sales then fell steadily during the 1970s, reaching a low of 76Mt in 1981. The 1980s saw steady increases in production, reaching a peak at the end of the decade of almost 115Mt, the highest levels on record. However, over the next three years sales plummeted to 73Mt in 1992, briefly rising again to almost 83Mt in 1994 before falling again to 69Mt in 1996. Since the mid 1990s sales of sand and gravel have been fairly steady, showing a slight upward trend but remaining well under 80Mt per annum.



Source UK Minerals Yearbook 2004

Figure 31 Sand and gravel sales England 1954- 2004 (including marine)

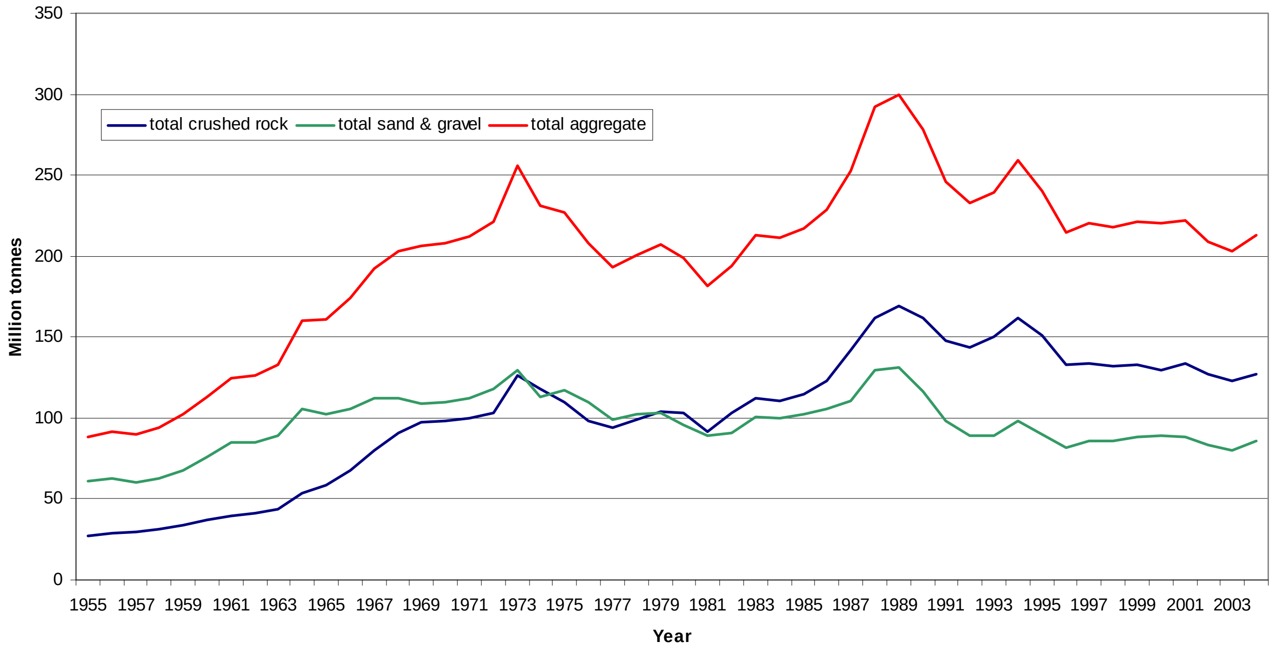
The estimated consumption of crushed rock (sandstone, igneous rock and limestone – including dolomite) in Great Britain which in this context provides an adequate estimate of production rose steadily after the Second World War from around 25Mt per annum, until it reached a peak of some 126Mt in the early 1970s. Estimated consumption then fell sharply, to a low of around 94Mt at the end of the decade. It rose again during the 1980s and peaked at just under 170Mt in 1989. A sharp fall was briefly reversed in 1994 but since that time crushed rock consumption has followed a downward trend, steadying at just over 130 Mt per annum during the late 1990s before rising briefly then falling to under 125 Mt per annum by 2003 (Figure 32).



Source UK Minerals Yearbook 2004

Figure 32 Great Britain estimated consumption of crushed rock 1955 -2003

Although sand and gravel output increased substantially during the 1950s and 1960s increases in the output of hard rock aggregates were proportionally greater. During the early 1950s sand and gravel accounted for approximately 70% of aggregate production. However, between 1950 and 1970 sand and gravel production in the UK increased by about 180% whereas crushed rock increased by about 275%. By the early 1970s contributions towards aggregate supplies from crushed rock and sand and gravel were roughly equal. This situation continued until the early 1980s when crushed rock contributions increased in relation to sand and gravel. The gap continued to widen until the mid 1990s. Since the late 1990s there has been a fairly steady relationship with crushed rock meeting approximately 60% of demand for aggregates (Figure 33).



Source UKMYB 2004

Figure 33 Great Britain aggregate production between 1955 and 2003

14.3.2 Housing

Between 1951 and 1954 housing completions in the United Kingdom rose from about 200,000 per annum to over 350,000 per annum before falling to just under 280,000 completions in 1958. Completions then remained at around 300,000 per annum until 1964 when a sharp rise, to 380,000 took place. The number of completions continued to rise, reaching a peak of 425,000 in 1968 as part of Harold Wilson's National Plan (target 0.5 million). After that time house building fell dramatically to well under 200,000 dwellings in 1982. With the exception of a short period of increased activity in the mid to late 1970s the fall was steady throughout the period. During the mid-1980s house building recovered slightly, to reach a level of 242,000 completions in 1988, before falling again to under 200,000 completions per annum throughout the 1990s and into the 21st century (Figure 34).

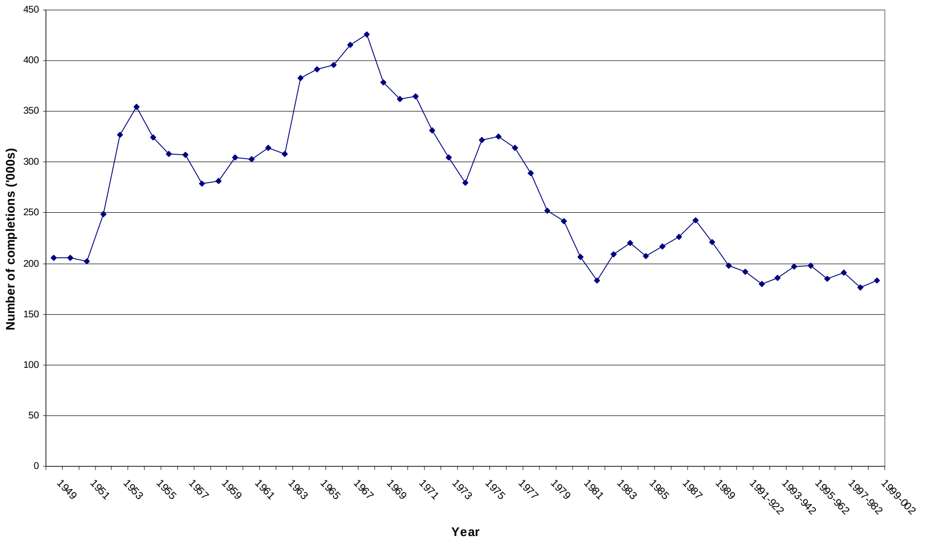


Figure 34 National Housing completions

The trends in demand for sand and gravel do not show a close correlation with house building between the early 1950s and the late 1960s other than an overall upward trend. Within this period, the 1950s saw sand and gravel sales rise steadily while levels of house building fell between 1954 and 1958. It was not until 1964 that a sharp increase in housing completions was seen, which does correlate with an increase in sand and gravel sales. After 1968 housing completions fell, while demand for sand and gravel continued to rise for a further five years. Although there was a fall in sand and gravel demand during the 1970s this did not reflect the significant drop in house building. During the 1980s and early 1990s demand for sand and gravel and housing completions show a closer correlation, with rising trends during the 1980s giving way to falls during the early 1990s. However, increases in sand and gravel sales during the late 1980s appear too great to be accounted for only by increased house building but may in part be due to the development of other infrastructure to support new housing. Since 1992 both sand and gravel demand and house building have levelled out, the former showing a slightly increasing trend and the latter remaining on a plateau.

A clear correlation between crushed rock consumption and housing completions is difficult to establish. However, there does appear to be some relationship between the two insofar as increases in both were recorded during the 1980s following falls during the 1970s. After the late 1980s crushed rock consumption and housing completions both fell. There was a sharp rise in crushed rock consumption during 1994 which does not appear to be linked to housing completions which were relatively steady at the time.

14.3.3 Key findings - National trends

- The national picture indicates that overall, demand for aggregate since the Second World War has increased. However, levels of demand are currently running significantly below those seen during much of the 1960s, 70s and 80s.
- The relative contributions from sand and gravel and crushed rock have changed markedly over the period with rock now providing a significantly greater proportion than was the case in the 1950s.
- National housing completions are currently running at levels at or slightly below those seen immediately after the war. However, throughout most of the period from the early 1950s to the late 1970s levels of house building were at least 50% and at times over 100% above these levels.

- There appears to be a loose correlation between aggregate sales and housing completions but there are numerous anomalies suggesting that the overall picture is influenced by a multitude of contributory factors.

14.4 PROJECT AREA TRENDS IN SUPPLY AND CONSUMPTION OF AGGREGATE

The Project Area includes all of the Counties of Northamptonshire and Bedfordshire and the Unitary Authorities of Milton Keynes and Peterborough and part of the counties of Leicestershire, Cambridgeshire and Buckinghamshire (Figure 2). The adjacent counties of Warwickshire and Oxfordshire have been excluded from the review since although there is some movement of aggregate between these areas and the Growth Zone, available data shows that its contribution to the supply and demand pattern is not significant. Data have been collected relating to aggregate sales and house building within the area since the Second World War. Figures for sand and gravel are available from 1954. However, detailed data relating to crushed rock and housing are less readily available for the earlier years. In the case of crushed rock figures are available from about 1967 and for housing from around the early 1970s. However, this varies from authority to authority. Aggregate figures relate to whole counties and cannot be disaggregated. Hence, inevitably, they relate to areas not only within but beyond the boundaries of the Project Area.

14.4.1 Aggregates

Between 1954 and 1977 the trends in sand and gravel sales in and around the Project Area (including the whole of Leicestershire, Buckinghamshire and Cambridgeshire) mirror very closely the national picture (Figure 35). There were steady increases from 4.5Mt to 11.7Mt in 1973. Sales then fell to 8.8Mt in 1977. However, in 1979 there was a significant peak, with sales in the Project Area reaching 12.5Mt. This was accounted for by high levels of production across the area, rather than in any one part of it. The peak was not repeated nationally. Again during the mid 1980s there were strong sales in the Project Area, ranging between 11Mt and 12Mt per annum, which were not reflected across the country. Since the late 1980s trends in the Project Area have generally been similar to those seen across England. Sales have fallen and by 2000 had dipped below 8Mt per annum, a low not seen for a sustained period since the early 1960s. Thus, overall sales in the Project Area have followed the national pattern except during the period 1979 – 1988 during which time there was a relatively greater level of activity.

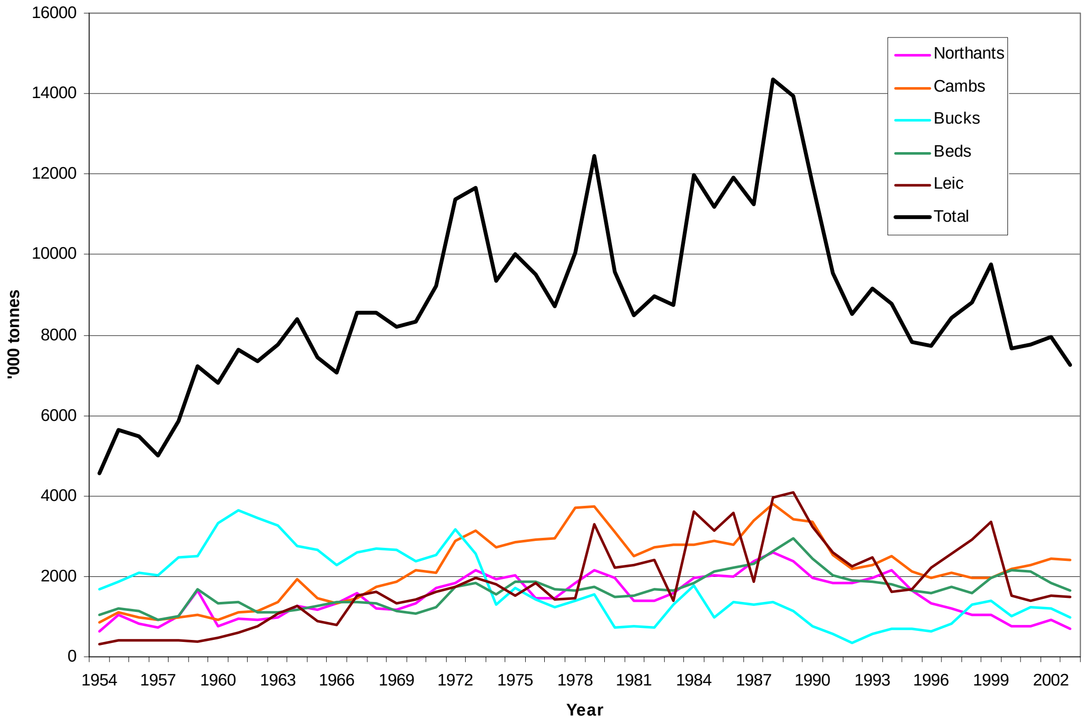


Figure 35 Sand and Gravel production in the Project Area

The data do appear to show a peak in consumption in Northamptonshire and Bedfordshire in 1989 and an earlier peak (1983) in Buckinghamshire and Milton Keynes. All counties in the Project Area show reliance on imports from other areas. In the case of Northamptonshire most sand and gravel imports are from Cambridgeshire and Bedfordshire. Bedfordshire imports sand and gravel from Northamptonshire but also from Hertfordshire and from the South East Region. Buckinghamshire and Milton Keynes import sand and gravel mainly from Bedfordshire but also from Hertfordshire and at one time by rail from Derbyshire.

The Project Area has traditionally been one of abundant local supplies of sand and gravel. Crushed rock, suitable for aggregate purposes, is hardly available locally. The closest major source of crushed rock is in Central Leicestershire which is just outside the Project Area. In 1993 17.5% (2.88Mt) of crushed rock produced in Leicestershire was exported to Northamptonshire. It has therefore made a significant contribution towards aggregate supply in the Growth Zone and its potential to influence supply patterns cannot therefore be ignored.

Crushed rock sales in the Project Area and Leicestershire were at around 6.5Mt per annum during the late 1960s and showed a slightly rising trend between 1967 and 1978 (Figure 36). However, it was not until 1982 that production levels began to increase more rapidly. They rose steadily to peak in 1990 at a level of just over 20Mt. Production fell sharply in 1991 to 17.6Mt before rising to just over 21Mt in 1994. Production then fell throughout much of the 1990s, reaching a low of 15.5Mt in 1998. This period was followed by steadily rising sales, which reached a peak of 19Mt in 2001. Since that time there has been a downward trend. Compared with the national picture, the trends in the Project Area and Leicestershire appear to differ markedly before about 1980. The sharp rise in production that occurred nationally during the late 1960s, culminating in the significant peak and subsequent fall in production in the early 1970s, did not occur at all in the Project Area or Leicestershire. Since 1980 the local trends have followed more closely those seen nationally, with the exception that much stronger and more sustained rising sales were seen in the Project Area and Leicestershire at the end of the 1990s. The explanation for this difference could in part be linked to changes to supply patterns brought about by amalgamations and rationalisations within the aggregates industry which locally resulted in a transfer of some production from the West to the East Midlands Region.

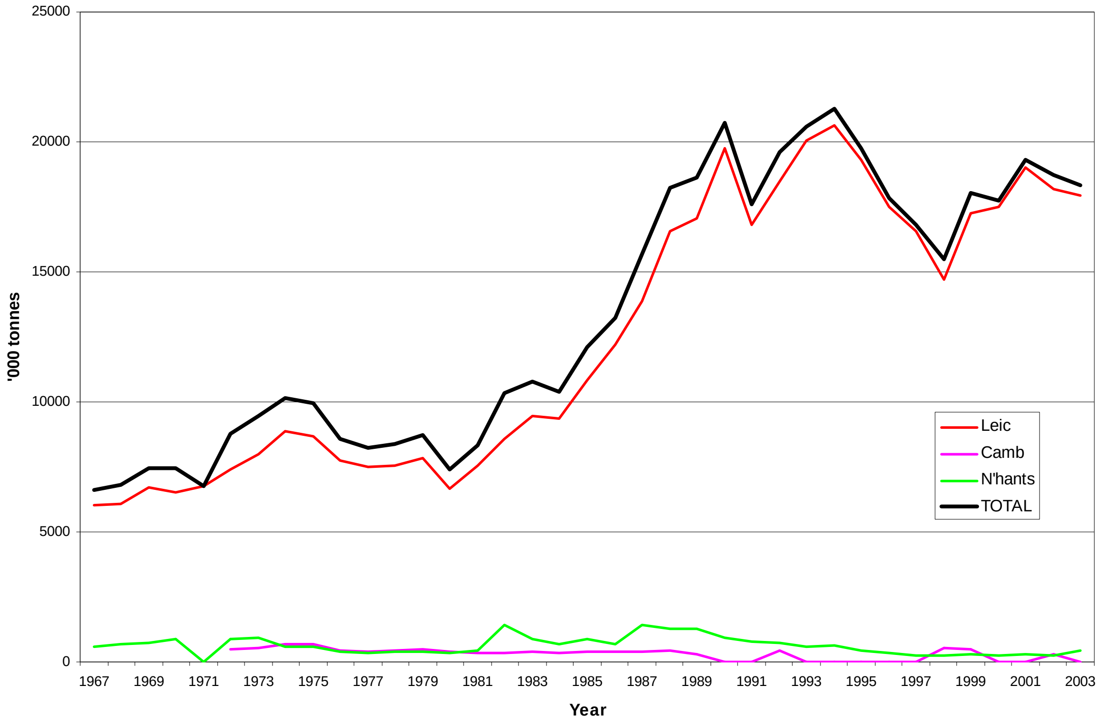


Figure 36 Crushed rock sales in the Project Area

Owing to the limited production of crushed rock for aggregate purposes within the Project Area all areas are reliant on imports. Although consumption data are not available in a consistent form, it is clear that the East Midlands supplies significant quantities of rock to the Northampton area. A further significant amount is imported by rail both to Bedfordshire, and Buckinghamshire and Milton Keynes. The origin of this is not fully known, although the main rail-served igneous rock quarries such as Bardon Hill and Mountsorrel, in Leicestershire are suppliers. Some imports are brought in by rail via the South East region and are therefore likely to originate in Scotland (Glensanda) or abroad. Small amounts of rock have also been imported sporadically from the South West and West Midlands Regions (SWRAWP, EMAWP annual reports).

A comparison of the relative increases in sand and gravel and crushed rock sales during the period 1967 to 2003 suggests that the growing importance of crushed rock in meeting aggregate demand that occurred nationally also occurred in and around the Project Area. By the early 1970s contributions towards aggregate supplies from crushed rock and sand and gravel were roughly equal, although in contrast to the national picture, sand and gravel production in and around the Project Area was significantly above rock production in three years during that decade. The state of equilibrium persisted in the area until the mid to late 1980s, slightly later than nationally, after which crushed rock contributions increased in relation to sand and gravel. The gap continued to widen until the mid 1990s. Since the late 1990s there has been a more steady relationship, with crushed rock meeting approximately 70% of demand for aggregates, a relatively greater proportion than seen nationally (Figure 37).

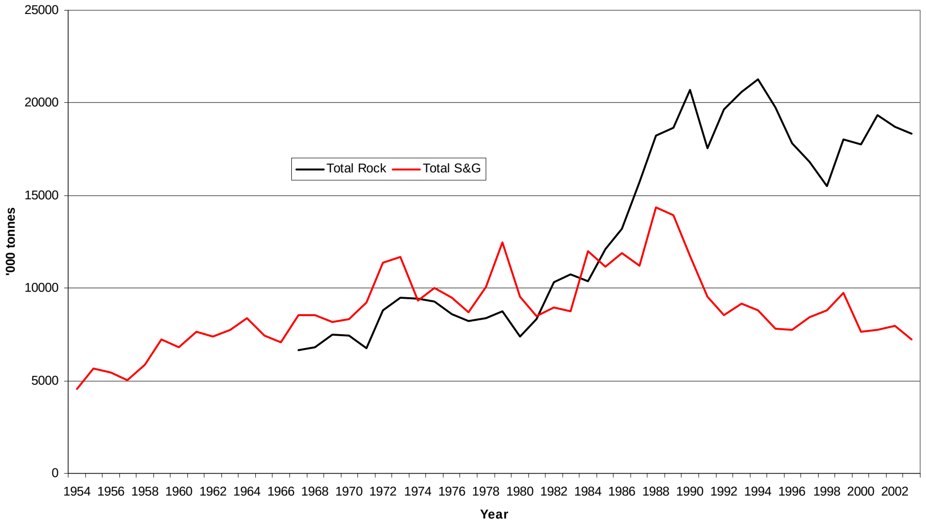


Figure 37 Crushed rock versus Sand and Gravel sales in the Project Area

14.4.2 Housing

Comprehensive data for housing completions in the Project Area are only available from 1976. However, from that time there is a strong correlation between the housing trends in the Project Area and those seen nationally. Generally, housing completions fell from around 13,639 in 1976 to under 10,000 in 1982. They then rose throughout much of the 1980s, reaching a peak of 13,619 in 1988 before falling again from 1989 onwards. Completions had levelled by 1993, thereafter remaining steady at around 8,000 per annum until 2001. In 2002 there was a slight drop to just over 7,000 completions (Figure 38).

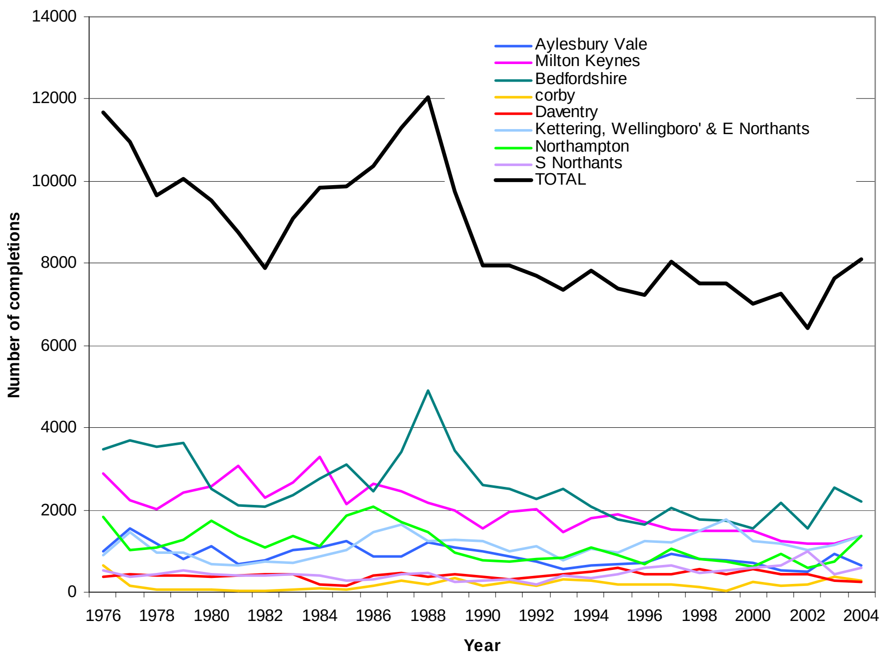


Figure 38 Housing completions in the Growth Zone

Lack of data prevents a detailed comparison of the trends before 1976. However, data for Peterborough and Milton Keynes, which are available from the early 1970s, show steady increases in completions during the early to mid 1970s. These run counter to the national picture, which shows a steady decrease in housing completions during much of the same period.

The key explanation for trends in housing completions in the Project Area differing from the national pattern is likely to be the influence of the New Towns. The area includes the New Towns of Corby (designated in 1950), Peterborough (1967), Northampton (1968) and the “new city” of Milton Keynes (1967) which was the UK’s largest “green field” project. The early 1970s corresponds with the period of early completions associated with both Peterborough and Milton Keynes New Towns. It is likely that these increases would have been mirrored in the case of Northampton. In contrast, Corby, having been designated almost 20 years previously, is likely to have expanded at an earlier date, but cannot be readily tracked.

Comparing housing completions and sand and gravel sales in the Project Area reveals that since 1982 there has been a fairly good correlation between the two. However, before 1982 this is not the case. In particular, the 1979 peak in sand and gravel sales is not reflected in housing completions, which were falling steadily at the time. This peak must therefore be attributable to some other cause. This could include events beyond the Project Area, given that the data include sales for areas outside its boundaries, such as South Buckinghamshire and Central and North Leicestershire. More generally, whilst housing completions fell steadily between 1976 and 1982, sand and gravel sales remained fairly steady (except in 1979) ranging between 8.5Mt and 10Mt per annum throughout the period.

Crushed rock sales in the Project Area and Leicestershire do not show a strong correlation with housing completions except during the period 1982 to 1988 during which time both rose steadily. However, after this time rock sales continued to rise until 1990 while housing completions fell rapidly until 1993 before reaching a plateau. Prior to 1982 rock sales had remained steady, with a very slightly rising trend, for over a decade. In contrast, housing completions fell steadily from 1976. The lack of correlation is not, however, surprising given that much of the rock produced in Leicestershire would not have been used within the Project Area.

14.4.3 Key findings - Trends in the Project Area for aggregates and housing

- Trends in the Project Area reflect well the national trend of increasing aggregate production, the peaks in production of the late 1980s and the increasing importance of crushed rock.
- There are marked differences: sand and gravel production in the Project Area was stronger between the late 1970s and mid to late 1980s; rock production failed to mirror the national rises in production seen during the late 1960s; and rock sales in the Project Area have remained stronger since the late 1990s.
- Housing trends in the Project Area have been similar to those seen nationally, except during the 1970s when the influence of the New Towns in the area was at its peak: current levels of housing completions are half those seen during the peak years and more than 50% lower than those seen throughout the period 1976 to 1988.
- Although there appears to be some correlation between sand and gravel production and housing completions since about 1982 the links are not completely convincing and there appears to be no real correlation between housing completions and crushed rock production at all.

14.5 OTHER CONSTRUCTION IN THE PROJECT AREA

House building, of course, only accounts for a proportion of construction activity. In addition road construction, construction of commercial and industrial buildings and other major projects and maintenance of existing infrastructure, place demands on aggregate supply. Reliable and consistent quantitative information relating to these activities is not available and so their effects on aggregate demand have been assessed in a more qualitative manner, incorporating statistical information where possible.

14.5.1 Road construction

Within the Project Area significant road building has taken place since the Second World War. Table 19 lists the major road construction projects in, and in close proximity to the area, together with approximate dates and the length of road involved.

Table 19 Major road construction projects in and close to the Project Area

Road	Date of construction	Approximate length of road (km)
M1 junction. 11 (Luton) to junction. 18 (Crick)	1958 - 1959	73.6
M45	1958 - 1959	28.2
M1 junction. 18 (Crick) to junction. 21 (Leicester)	Opened 1965	30.4
A1M junction. 8 – 10 (Baldock bypass)	Opened 1967	11.2
A1 dualling from junction. 8 (Stevenage) to junction. 17 (Peterborough)	1960s	76.8
M6 from M1 to junction. 2 (Anstey)	Opened 1971	17.6
Milton Keynes principal distributor road network	1970 – 1976	42.0
A45 dualling from M1 junction. 16 to Stanwick	1972 – 1976	34.4
M69	Opened 1976 - 77	25.6
M11 from Stanstead to Cambridge	Opened 1979 - 80	48.0
A5 dualling around Milton Keynes	Opened 1980	19.0
M1 Re-building	1980s	c. 75.0
A14 from M1 junction. 19 to Cambridge	Completed 1994	81.6
A1M junction. 14 (Alconbridge) to junction. 17 (Peterborough)	1996-1998	21.0
A43 dualling from M1 junction. 15 to Brackley	2002-2003	38.0

In addition to the above, many smaller road construction projects took place, together with the maintenance of existing roads. The building programme which was particularly intensive between the late 1950s and 1980 when over 350km of major road construction took place, would be expected to have placed significant demand on aggregate supplies in the Project Area. This is supported by a rising trend in sales during much of the period. Paradoxically however, between 1980 and the early 1990s little new road building occurred yet demand for sand and gravel rose throughout much of the period. Equally, during the 1990s the construction of the A14 and the upgrading of the A1 to motorway standard just south of Peterborough, both of which comprised major projects that might be expected to have affected aggregate demand, correspond with a period of lower sand and gravel sales. Thus, there is no clear correlation between road building and sand and gravel sales. However, in relation to sales of hard rock aggregate, it is probable that the strong sales of rock seen in Leicestershire during the early 1990s were at least in part due to the construction of the A14.

14.5.2 Commercial, industrial, retail and service industry development

It has been particularly difficult to identify reliable data for commercial, industrial, retail and service industry development. It is known that throughout the Project Area there has been significant development of this nature both in conjunction with new housing and in stand alone developments such as Magna Park near Lutterworth, the Daventry International Rail Freight Terminal (DIRFT), The Corby Rail Hub and Luton Airport. Some estimates of the level of construction activity can therefore be made in a qualitative manner.

However, much better information exists in the case of the development of Milton Keynes which probably represents the single most significant post war construction project in the Project Area. The information has been derived from the Annual Reports of the Milton Keynes Development Corporation (MKDC) and of necessity is presented in the form of a narrative.

The first annual report covers the financial year 1967/68. During the early years the main task of the MKDC was to acquire land. Therefore, although some development did take place during the late 1960s it was undertaken by agencies other than the MKDC. It is not until the annual report for 1970/71 that the completion of the first sections of city road and the commencement of 415,000 sq.ft. of industrial development are reported. By April 1972, 375,000 sq.ft. of industrial development had been completed, a further 170,000 sq.ft. was under construction and 180,000 sq.ft. of office development had been commenced. The seventh report, for 1973/74 reported that total completions of industrial and warehouse development on corporation land now exceeded 1.1 million sq.ft. and that a further 540,000 sq.ft was under construction. In 1974/75 an additional 700,000 sq.ft of industrial space and over 200,000 sq.ft of office accommodation were completed. Work on the major shopping centre (93,000 m^2) and the commercial complexes in Central Milton Keynes also commenced around this time. The ninth annual report covering 1975/76, reports the opening of six middle schools, a total of 29,000m^2 of industrial and warehouse completions and major progress on the shopping centre during the year. The following year a further four schools opened and the shopping centre was reported as being 60% complete, it was opened in August 1979.

This account is a demonstration of the phenomenal level of growth that took place in Milton Keynes during the 1970s. Major development was also taking place in the New Towns of Peterborough and Northampton as well as in Bedfordshire and other larger towns across the Project Area. However, attempts to correlate this growth with aggregate demand have proved to be unsatisfactory. Between 1970 and 1980 demand for sand and gravel increased only slightly and although there were peaks during the decade they were separated by years of unexceptional demand. During the same period rock sales initially rose but then dipped until by 1980 they were barely higher than they had been a decade before.

14.5.3 Key findings - Other construction activity

- The area has experienced significant construction activity including an ambitious road building programme since the Second World War.
- During the 1970s, the overall influence of the New Towns resulted in growth above national levels and at the same time sand and gravel sales were stronger than those seen nationally.
- The Project Area has thus already experienced significant growth in all types of construction. This appears to have been sustained by local sand and gravel supplies, supplemented by imports from neighbouring areas and crushed rock imports from further away.
- The ability of the area to sustain further significant growth from the same aggregate sources is a key issue which this study seeks to address.

14.6 SECONDARY AND RECYCLED AGGREGATE

The contribution of secondary and recycled aggregate (see Box 10 for definitions) towards satisfying total demand is seen as, in policy terms, an important factor. In the early years of the 2000's it accounted for about 23% of the construction aggregates used in Great Britain, with recycled aggregate representing 18% (WRAP, 2003, data sources from Planning Research by ODPM for 2001). The ability of these materials to substitute for primary aggregate, whilst having limitations should not be under estimated, they represent a significant and sustainable source of material and an understanding of their dynamics is helpful.

Box 10 Definitions of secondary and recycles aggregate

Definitions of secondary and recycled aggregate
Secondary aggregate Aggregate which originates as a waste of other quarrying and mining operations, or from industrial processes (e.g. colliery waste or minestone, blastfurnace slag, power station ash, china clay sand, slate waste, demolition/construction wastes including road planings), but excluding chalk and clay/shale worked primarily for aggregate purposes.
Recycled aggregate Aggregate derived from both construction waste, for example damaged bricks, and demolition waste, such as broken concrete, brickwork and masonry.

Throughout the Project Area traditional sources of secondary aggregate such as blast furnace slag have been lost following the decline of industries such as the steel industry and these are very unlikely to be replaced. At one time, Pulverised Fuel Ash (PFA) produced in the Trent Valley power stations was being produced at such an increasingly high rate that large volumes were being railed to Bedfordshire but not for aggregate usage. Output has since greatly declined.

However, the contribution made by recycled aggregate from construction and demolition waste and other sources has grown steadily over the past decade and it is likely that scope for further modest increases exists. The most recently published national survey of construction and demolition waste was carried out in 2003 (Capita Symonds, 2003). A more recent survey of 2005 arisings has been undertaken but the final report was not available in time to be taken into account here. The 2003 survey found that the estimate for production of recycled aggregate throughout England had risen from 36.47Mt in 2001 to 39.60Mt in 2003. Information provided by respondents suggested that although modest, the growth was real. Table 20 shows regional estimates for the production of recycled aggregate and soil in England in 2003.

Because the survey assessed arisings to the regional level it is difficult to assess arisings in the Project Area itself as the latter covers three regions (East Midlands, East of England and South East). However, an amalgamation of the figures for the three regions shows that 14.32Mt ± 14-17% of recycled aggregate was produced. In addition 2.04Mt ± 19-23% of recycled soil was produced. All this was reused.

Table 20 Regional estimates for the production of recycled aggregate and soil in England in 2003 (million tonnes)

Region	Recycled aggregate	Recycled soil	Total recycled aggregate and soil
North West	4.52 ± 13%	0.70 ± 19%	5.21 ± 12%
North East	2.27 ± 13%	0.33 ± 18%	2.61 ± 12%
Yorkshire & the Humber	4.44 ± 14%	0.64 ± 19%	5.08 ± 13%
West Midlands	4.29 ± 13%	0.65 ± 18%	4.94 ± 12%
East Midlands	4.26 ± 14%	0.62 ± 19%	4.88 ± 12%
East of England	5.24 ± 17%	0.72 ± 23%	5.96 ± 15%
South East	4.82 ± 14%	0.70 ± 19%	5.52 ± 12%
London	5.28 ± 18%	0.86 ± 25%	6.15 ± 16%
South West	4.47 ± 17%	0.62 ± 23%	5.09 ± 15%
England	39.60 ± 13%	5.85 ± 18%	45.45 ± 10%

Source: Survey of Arisings and Use of Construction, Demolition and Excavation Waste as Aggregate in England in 2003

The survey also assessed the level of re-use of construction, demolition and excavation waste (CDEW) in England (Table 21). Very little evidence was found of hard C&D waste which could be recycled into aggregate being landfilled as waste, and only very modest tonnages were identified being used in landfills in an unprocessed form (and then it was mainly for site engineering). The table below shows regional estimates for use/disposal of CDEW in England in 2003. Of the remaining CDEW available in the three regions included in the Project Area it is estimated that 3.46Mt was used for landfill engineering and restoration, 6.64Mt was used for backfilling quarry voids, 6.19Mt was used at "exempt" sites and 5.08Mt was disposed of as waste at landfill sites.

Table 21 Regional estimates for use/disposal of CDEW in England in 2003 (million tonnes)

Region	Recycled as aggregate and soil	Used for landfill engineering or restoration	Used to backfill quarry voids	Used at Para. 9 & 19 sites	Disposed of as waste at landfills	Total CDEW
North West	5.21	0.92	1.00	2.89	1.09	11.11
North East	2.61	0.26	0.81	0.84	0.36	4.88
Yorkshire & the Humber	5.08	0.55	2.57	2.75	0.89	11.84
West Midlands	4.94	0.54	1.14	0.78	0.73	8.13
East Midlands	4.88	0.84	1.84	1.10	1.22	9.88
East of England	5.96	0.63	2.06	2.18	1.79	12.62
South East	5.52	1.99	2.74	2.91	2.07	15.23
London	6.15	0.05	0.29	0.58	0.17	7.24
South West	5.09	0.67	0.96	2.41	0.87	10.00
England	45.45	6.45	13.41	16.43	9.19	90.93
Bands (90% confidence)	± 10%	± 31%	±26%	±38%	±19%	±10%

Source: Survey of Arisings and Use of Construction, Demolition and Excavation Waste as Aggregate in England in 2003

Although figures for arisings in the Growth Zone are not available it is possible, using the survey figures and population estimates for each of the three regions and for the Growth Zone, to estimate the amount of recycled aggregate one might expect to have been produced. The estimates are somewhat crude, being based on production figures that are themselves estimates, but they provide a way in which an approximate figure for recycled aggregate production in the Growth Zone can be reached.

Firstly, the quantity of recycled aggregate is divided by the population estimate for each region. This provides a figure for the amount of recycled aggregate produced per capita head of population. The results of the calculation are shown in Table 22.

Table 22 Estimates of recycled aggregate produced per capita.

Region	Recycled aggregate (Million tonnes)	Population in 2001 (million)	Recycled aggregate per head of population (tonnes)
East Midlands	4.26 +- 14%	4.1	1.04
East of England	5.24 +- 17%	5.4	0.97
South East	4.82 +- 14%	8.0	0.6

It was assumed that an average of the three regional figures would be appropriate to provide an estimated figure for recycled aggregate production per head of populations in the growth zone. However, the level of recycled aggregate produced in the South East Region per head of population is significantly lower than in either of the other two regions. Reasons for this are likely to be linked to the special characteristics of the south east, which appear to apply less to that part of the South East Region that lies within the Growth Zone (Bedfordshire, Milton Keynes and Aylesbury Vale). These areas appear to have more in common with the neighbouring areas of the East Midlands and East of England. It is therefore considered likely that the levels of recycling will also reflect those of the two northern most neighbouring regions rather than those seen in the South East Region as a whole. For this reason an average of the two figures for recycled aggregate production per head of population in the East Midlands and East of England were used. This figure is 1.005 tonnes per head of population which, given that the calculation can be no more than a rough estimate, has been rounded to 1 tonne.

Population estimates for the growth zone, which are based on the findings of the 2001 census, are shown in Table 23.

Table 23 Estimates of population for the Growth Zone

Area of Growth Zone	Population (2001)
Northamptonshire	629,676
Bedfordshire	381,572
Milton Keynes	207,063
Luton	184,000
Aylesbury Vale, Buckinghamshire	165,749
TOTAL	1,568,060

It might therefore be expected that the level of recycled aggregate production in the growth zone would currently be about 1.57mt per annum. This level would represent a contribution of about 15% to current overall levels of aggregate production in the growth zone, slightly below the 18% estimate based on application of GB figures to the local population.

As stated above, it is considered (WRAP, 2003) that some opportunity exists to increase the amount of recycled aggregate being produced. The following measures are likely to assist in enabling such increases to be achieved:

- a network of recycling plants in urban areas
- more encouragement to establish recycling facilities at quarries and landfills
- requirements, through the planning system, to audit resources on new developments
- local authorities to have sustainable procurement policies

All of these are being promoted by local authorities and the Regional Assemblies both through the planning system and the wider sustainability agenda.

In addition it is important that more complete information is obtained on the level of recycled and secondary aggregate production and sales. It is clear from the 2003 survey that only a proportion of those involved in the industry are willing to provide data voluntarily.

14.6.1 Key findings - Secondary and recycled aggregate

- The data available are variable and not completely reliable.
- Ultimately it may therefore be necessary to require statutory returns to be made, in a similar way to those made for primary aggregate production, if a more robust understanding of the contribution made towards total aggregate demand by recycled and secondary materials is to be obtained.
- It is clear that secondary and recycled aggregates may be expected to continue to make an important contribution towards meeting total aggregate demand both within the Growth Zone and on a national scale. However, the 2003 survey supports earlier surveys which suggest that the potential for increasing the current level of contribution appears to be limited.

14.7 SUPPLY AND DEMAND: AVAILABLE STATISTICS AND DATA LIMITATIONS

14.7.1 Statistical resources and their difficulties

Despite the fact that aggregates provision in England and Wales at regional level has been monitored for 30 years [4] and regular government regional targets are set which are in turn sub-regionally apportioned (mainly to Mineral Planning Authorities), the assessment of future requirements from within the Growth Zone is particularly problematic, mainly because it embraces parts of three regions (which before April 2001 fell within two regions) and at a detailed level, covers a mix of whole or part MPA areas. Even if perfect datasets existed for all MPA areas, disaggregating them to create a new series applicable specifically to the Project Area would be problematic. In fact, in all these cases, the historic databases vary not only across the area geographically, but also over time.

Furthermore the South Midlands Growth Zone also has few sections or boundaries that can be readily defined by "aggregates market watersheds".

In particular, although the primary aggregates production ("arisings") database is varied, it can be reassembled in most cases to produce reasonable historic series of information covering a considerable period, albeit by utilizing informed estimates in a few cases e.g. where figures in

1. The Regional Aggregates Working Parties (RAWPs) were established in the 1970s and play a major role in data collection and monitoring. Their findings inform future Government guidelines on aggregate provision and are used by Mineral Planning Authorities to formulate plans and policies which reflect national and regional need.

the past were grouped to protect confidentiality. Sand and gravel production data are available at England and county level from 1954, but crushed rock is only available at county level from 1967.

In contrast, the data available for the demand end of the equation is extremely imperfect. Even the most consistent of indicators, namely housing statistics, are not available in sufficiently consistent or detailed form at a local level for the whole period under review. There is a certain irony here as housing provision has always been a major planning function and housing completions for example are theoretically a very easily measured (and largely undisputed) output, which is gathered simultaneously by various agencies for various purposes. In contrast, mineral production, by its very nature, is so transient that if records are not recorded at the time, there is little prospect of reconstructing the data later. Furthermore, the information on minerals is highly specialist in nature and the original data are derived from many originators (i.e. individual producers). (Notwithstanding these challenges, there is a substantial body of bulk minerals data – in some cases as far back as the 1890s).

Housing data at a local level seems to be available only from around 1970. National level figures are available back to 1949 but these are for the United Kingdom as a whole.

Information on overall construction activity has been unavailable in any consistent statistical form; therefore a more qualitative approach to major construction activity, such as road building, major industrial and commercial development and other major infrastructure projects, within the Project Area has been attempted. This is particularly so in the case of other indicators such as road completions and major improvements.

It is still less easy to establish a regular series and for other consuming sectors, e.g. industry, commercial, civic, retail, military, non-road communications, where there are no meaningful series at local level covering a reasonable time span. Whereas with growing regional awareness and function, there is greater consciousness of the need to gather data for and present general economic indicators, where these exist, not only are they difficult to compare between regions, they usually only relate to recent years, and to whole regions (i.e. not sub regions). They cannot therefore be reassembled to relate to the Growth Zone. Furthermore, the readjustments to the definition of “East Anglia/East of England and South East/new South East/London” create further discontinuity problems.

In this connection, although there is considerable variation in the data on sales destinations collected by the RAWPs since 1973 (with some at county; some at regional level, missing data etc), overall, it is possible to produce a general picture of flows and hence consumption. Otherwise data on imports and exports are exceptionally poor and often no more than anecdotal. Furthermore it is not always possible to presume that the differences between production and consumption figures in fact represent net export/import, rather than imperfect recording.

Consequently, the equation

production – exports + imports = consumption

which ought to be a justifiable assumption, in reality is often unsolvable.

Virtually no data was available for tonnages of secondary/recycled aggregates.

14.7.2 Data Assimilation and Statistical Appraisal

Given the review set out above, it will be appreciated that, from an early stage, it was acknowledged that the statistical series relating to both construction output and aggregate production/sales were inconsistent in a number of respects e.g.:

1. Many agencies only “admitted” to the availability of those series, to which they had access in electronic form (older paper records had often been destroyed).

2. Whereas the strenuous attempts we and others made to augment electronic data with paper-based records (e.g. from County Archives, LPA files) met with reasonable levels of success, in many instances, at best, details were typically only identified as far back as the mid 1970s (one suspects to the point of, or a little after the major 1973 local government reorganisation).
3. The categories of construction output available for any combination of geographical areas (even national) are (a) grossly inconsistent (b) far from cover the whole spectrum of construction work e.g. commercial and non-road/non-housing data is particularly poorly served and even within sectors such as roads, there is little uniformity in say new construction/maintenance data.
4. Over the period under review, the area concerned has experienced tremendous changes in government boundaries at district/county/unitary/regional levels and responsibilities.
5. The Project Area (i.e. MKSM), plus selected conventional supply areas in several instances – especially in Leicestershire, is not contiguous with local authority boundaries and so, even if data series were available for the latter, adjustments would have had to be made.
6. Structural/conceptual changes in data collection for aggregates occurred during the period notably from county based tonnages, in the 1960s to cubic measures or acreages for "Gravel Regions/Service Areas" then, from the early/mid 1970s, reverting to county (old then new defined boundaries)/tonnage data. Sometimes there was some series overlap which assisted correlation.

Nonetheless, it was considered essential to assess the historic levels of demand, and considerable effort was directed to seeking, building up and analysing conventional statistical series. The prime aim was to gauge the levels of demand over the last c.50 years and to indicate (even in broad terms) the relative significance of the present MKSM growth zone proposals in the context of past experience.

It was recognised that care would be needed to ensure true comparability, e.g. in terms of the composition of construction load, technical changes and in particular, when assessing developments leading to either reduced levels of consumption per £unit of construction spend or diversion from primary to secondary/recycled sourcing. Overall, without pretending to a statistical precision that would clearly not be justified, it is considered that the key data informing the conclusions of the study are broadly indicative of quantity and not solely qualitative.

14.8 APPENDIX 1 SUMMARY OF KEY FINDINGS –ANALYSIS OF SUPPLY AND DEMAND

Appendix 1 Key findings: Analysis of supply and demand

Growth Zone proposals

- Development envisaged in the growth zone is substantial
- Significant and sustained demand will be placed on raw materials, including aggregates, in order to achieve this level of growth.

Past patterns of development 1940s to 1990s

- The Project Area has been subjected to significant growth in the past. The designation of New Towns has lead to concentrations of growth of a scale not seen in many other areas.
- The growth in housing has lead to demand for supporting infrastructure which has been provided.
- The location of the area close to important transport corridors linking London and the South East with much of the rest of the county has only added to the intensity of growth in the area.

Past patterns of development – economic geological resources

- Ironstone and brick and cement manufacture were the three primary industries which led the nineteenth and twentieth century growth in the Project Area. The growth of these industries in turn led to urban expansion and an associated growth in infrastructure. The raw materials for this construction were mostly local sand and gravel from the Nene Valley.
- Walls made from Fletton bricks were widespread and with the introduction of rail Welsh slate became a popular choice of roofing. However, local brick and tile works were very common, especially on large building projects.
- Modern construction now relies on a range of natural materials for construction which are often cheaper than traditional materials, not just in their production, but also in terms of labour costs during construction. For example, large lightweight blocks.

National trends in aggregate supply and consumption

- Demand for aggregate since the Second World War has increased.
- Relative contributions from sand and gravel and crushed rock have changed markedly over the period with rock now providing a significantly greater proportion than was the case in the 1950s.
- National housing completions are at levels at, or slightly below, those seen immediately after the war. However, throughout most of the period from the early 1950s to the late 1970s levels of house building were at least 50% and at times over 100% above these levels.
- There is a loose correlation between aggregate sales and housing completions but there is evidence of a multitude of contributory factors.

Project Area trends in aggregate supply and consumption

- Trends in the Project Area reflect well the national trend of increasing aggregate production, the peaks in production of the late 1980s and the increasing importance of crushed rock.
- Sand and gravel production in the Project Area was stronger between the late 1970s and mid to late 1980s.
- Rock production failed to mirror the national rises in production seen during the late 1960s; and rock sales in the Project Area have remained stronger since the late 1990s.
- Housing trends have been similar to those seen nationally, except during the 1970s with the influence of the New Towns in the area
- There is some correlation between sand and gravel production and housing completions, but since 1982 the links are not entirely convincing.

continued

continued

Appendix 1 Key findings: Analysis of supply and demand

Other construction activity

- The area has experienced significant construction activity including an ambitious road building programme since the Second World War.
- During the 1970s, the overall influence of the New Towns resulted in growth above national levels and at the same time sand and gravel sales were stronger than those seen nationally.
- The Project Area has thus already experienced significant growth in all types of construction. This appears to have been sustained by local sand and gravel supplies, supplemented by imports from neighbouring areas and crushed rock imports from further away.
- The ability of the area to sustain further significant growth from the same aggregate sources is a key issue which this study seeks to address.

Secondary and recycled

- The data available are variable and not completely reliable.
- Ultimately it may therefore be necessary to require statutory returns to be made, in a similar way to those made for primary aggregate production, if a more robust understanding of the contribution made towards total aggregate demand by recycled and secondary materials is to be obtained.
- It is clear that secondary and recycled aggregates may be expected to continue to make an important contribution towards meeting total aggregate demand both within the Growth Zone and on a national scale. However, the 2003 survey supports earlier surveys which suggest that the potential for increasing the current level of contribution appears to be limited.

15 Appendix 2: Alternative approaches to establishing demand patterns

In order to address some of the identified drawbacks apparent with conventional statistical sources (in particular the lack of consistent information on non-road/non-housing construction and, to a lesser extent secondary/recycled data), a number of alternative approaches were considered, particularly involving comparison of different "mapped" data sets. The pros and cons are summarised below. Clearly in some instances they may have potential but in general, they are expensive and not comprehensive or could not be delivered within the time and cost budget available.

15.1 SATELLITE IMAGING:

- systems available – various – tweaked for different land uses
- cost - some free/interpretation expensive
- frequency of survey – good but no coverage for early period
- definition – early ones poor; later v. good
- practicality of digital analysis/comparison - unsure but probably difficult
- other advantages/problems – maybe difficult to integrate/interpret

15.2 AERIAL PHOTOGRAPHY:

- availability - good
- costs – probably very high for whole area
- extent of coverage – generally good
- definition/resolution - mixed
- are they digitised – some are; most are not
- practicality of digital analysis/comparison – where available, probably good
- other advantages/problems – physical handling; a cheaper route might be collaboration with MPAs who may have access to such material but this could pose IPR and integration issues.

15.3 CONVENTIONAL CARTOGRAPHY:

- availability – generally good
- costs – generally expensive
- regularity of survey – good but early versions not usefully digitised
- extent of digitisation - good
- practicality of comparative analysis – probably difficult
- other advantages/problems – significant IPR issues

15.4 OTHER SOURCES:

Roads – information on major road construction completions (by mileage/carriageway) is available form the Highways Agency and specialist websites (especially for older schemes especially), but would require better information on aggregate consumption for different roads at the time in order to be meaningful

Airfields – specialist historic publications – e.g. "Action Stations" series and recent WRAP Report/Analysis.

Reservoirs – construction completion dates from Environment Agency/water companies/other historic sources (inc. websites) e.g. British Steel/Corus.

Major/distribution centres - district/unitary planning authorities; conventional or remote sensing/mapping, sector employment data, specialist commercial data sources.

Major retail centres - District/unitary planning authorities; conventional or remote mapping; sector employment data, specialist commercial data sources.

Residential **–** population statistics/census returns down to wards.

Industrial – district/unitary planning authorities; conventional/remote mapping; sector employment data.

Public Authority Construction – district/unitary planning authorities.

General Development

- Satellite images of light pollution
- Planning returns/statistics made for monitoring purposes (on applications)

15.5 GENERAL COMMENT

For almost all the above there is a lack of consistency at both local and regional levels, a lack of "series" data over time and a paucity of usable data before the "digital age".

16 Appendix 3: Detailed analysis of planning information

Throughout the post-war period, aggregates production has been increasingly subject to Town and Country Planning controls. Initially expressed predominantly via development control decisions at individual locations, the wider planning policy framework has become an increasingly significant driver in influencing the distribution of aggregates extraction and it is important to identify how this has shaped the past and present distribution of sand and gravel operations in the supply area. In addition to assessing the rationale for the location of past and present operations, gauging the reasons for the absence of workings in some areas is equally important.

The following chapter outlines the national and local policies applicable to the Project Area:

- National Policy and Guidance

  This sets out the broad policy framework within which aggregate planning has evolved. It considers the background to and the development of national guidelines on apportionments and the system of landbanks and provides information on the former for those regions included within the growth zone and the latter for Mineral Planning Authorities (MPAs) within the Growth Zone.

- Local Policy Framework

  Provides a detailed desk based review of the evolution of aggregates planning policy in MPA areas within the growth zone.

16.1 EVOLUTION OF NATIONAL POLICY AND GUIDANCE FOR AGGREGATES

Since 1948 planning permission has been required for the extraction of minerals. Permissions have been granted and withheld following consideration of planning applications in the context of a set of criteria designed to assess the acceptability of the proposal.

Some of the earliest guidelines available to local authorities in making decisions about the exploitation of aggregate mineral resources were provided by the reports prepared by the Waters, and in the 1970's the Stevens and Verney Committees.

The Advisory Committee on Sand and Gravel under the Chairmanship of Sir HAS Waters was appointed in 1946 "to make recommendations on future policy, for control under the Town and Country Planning Act of sand and gravel". The various area reports of this Committee were published between 1948 and the early 1950s. They sought to recommend allocations of land for sand and gravel working for fairly specific areas. However, although they raised awareness of issues and provided important input to the first round of country development plans, by the time the later reports were published, the recommendations were already being overtaken by events – many of the sites were already being worked. The reports and the later need to review their policy advice resulted in the establishment of seven Sand and Gravel Working Parties based largely on the Service Areas advocated by Waters in the southern and eastern England, the area then considered to be under greatest pressure. Some of these covered parts of the present Project Area. These Working Parties were later recast and absorbed into the Regional Aggregates Working Parties (RAWPs) (see below).

A memorandum on the Control of Mineral Working (the "Green Book") was produced by the Department of the Environment in1960. It provided detailed advice for both planning authorities and the mineral industry.

In February 1976, the Stevens Committee Report on "planning control of mineral workings" was published. It contained a comprehensive analysis of the effectiveness of existing minerals legislation and reviewed the machinery and staff required to control mineral workings effectively. The recommendations of the Stevens Committee formed the basis for much of the Town and Country Planning (Minerals) Act 1971.

An advisory committee was set up in 1972 under the chairmanship of Sir Ralph Verney to provide the Government with advice on the supply of aggregates to the construction industry. Its Report "Aggregates, the Way Ahead" was published in May 1976. The Report provided a comprehensive document on current and future aggregate production and distribution.

16.1.1 Guidelines for the provision of aggregates

It was the Verney report (see above) that influenced the strategic future direction of planning for aggregates provision: out of it came the first guidelines for the provision of aggregates in England and Wales which were published in 1982 (DOE Circular 21/82). These guidelines were prepared following the 1977 aggregates survey undertaken by the ten Regional Aggregates Working Parties (RAWPs) which were established during the early 1970s to monitor and commentate on the supply and demand for aggregates in their respective regions. The 1982 guidelines set out the likely supply patterns for each economic planning region for the period 1981-1991. Mineral planning authorities were asked to take the guidelines into account in preparing development plan documents and other policies for mineral working and when reaching decisions on applications relating to aggregates.

The 1982 guidelines were replaced in 1989 by the Guidelines for Aggregates Provision in England and Wales (MPG6). These revised guidelines were based on the 1985 aggregates survey carried out by the RAWPs, a collation of which was published in March 1988, coupled with forecasts of economic growth. They covered the period from 1986 to 2005 (2006 in the case of the South-East, although the reason for this is not clear).

The original MPG6 was cancelled in April 1994 when a revised document was published. The new MPG6 related only to England and provided guidelines for aggregates provision from 1992 to 2006. These were based on the 1989 aggregates survey carried out by the RAWPs, a national collation of which was published in 1991, and economic forecasts of future growth based on work carried out for the Government by ECOTEC and Cambridge Econometrics.

The most recent guidelines, which also apply only to England, were published in June 2003. They were based on the 2001 aggregates survey and further economic forecasting. They cover the period from 2001 to 2016.

Table 24 displays the regional guidelines for aggregates provision for each of the regions included in the Project Area and for England as a whole as set out in each of the guidelines. The figures relate only to land-won primary aggregate. In all cases they are based on assumptions relating to other sources of supply such as marine aggregate, imports and secondary and recycled material.

The guidelines were based primarily on past trends, coupled with predictions of future demand. Those published in 1982 were derived from a period of high but falling demand whilst those published in 1989 reflected a period of rising demand. The 1994 guidelines were based on high sales and continued rising demand. Thus throughout the period of the first three sets of guidelines a steadily rising demand trend is predicted and the guideline figures are seen to rise steadily. However, during the 1990s demand fell far short of the predictions and the 2003 guidelines therefore reflect a period of low, steady and slightly declining demand.

Table 24 Changes in the National and selected Regional Guidelines for Aggregates Provision In England between 1982 and 2003

(Figures in Million Tonnes)

Region		1982 guidelines (average annual figure)	1989 guidelines (average annual figure)	1994 guidelines (average annual figure)	2003 guidelines (average annual figure)
South East	Sand & gravel	25.2 – 33.5	31	28	13.25 [1] [4]
	Crushed rock	0.7 – 1.1	1.47	2	2.1875 [4]
	Total aggregate	**25.9 – 34.6**	**32.47**	**30**	**15.4375**
East Anglia	Sand & gravel	5.5 – 9.9	8.7	9	16 [3]
	Crushed rock	0.5 – 0.8	0.9	0.66	0.5 [3]
	Total aggregate	**6 – 10.7**	**9.6**	**9.66**	**16.5**
E. Midlands	Sand & gravel	8.6 – 12.6	13.5	14	10.3125
	Crushed rock	13.5 – 20.4	27.4	33.66	32.6875
	Total aggregate	**22.1 - 33**	**40.9**	**47.66**	**43**
Project Area Regions combined	Sand & gravel	39.3 – 56	53.2	51	39.5625
	Crushed rock	14.7 – 22.3	29.77	36.32	35.375
	Total aggregate	**54 – 78.3**	**82.97**	**87.32**	**74.9375**
England	Sand & gravel	62.4 – 85.5 [2]	83.4	80	66.75
	Crushed rock	61.1 – 85.4	102.87	126.66	101.125
	Total aggregate	**123.5 – 170.9**	**186.27**	**206.66**	**167.875**

1. figure includes London
2. figure includes marine sand and gravel in North-West
3. figure covers new East of England Region
4. figure covers new South-East Region

Changes between the latest 2003 guidelines for England and those published in 1994 show a fall of on average 19% in the land won supply of aggregates over the period of the guidelines. These reflect an overall fall in national demand for aggregates and also a substantial increase in the use of alternatives to primary aggregates (from 35Mt per annum to 57Mt per annum).

In the three regions covered by the Project Area the drop in anticipated demand for sand and gravel from primary land won sources is 22%. Notwithstanding that this is expected to be supplemented by other supply streams, and in particular secondary and recycled material, this is a significant reduction. The fall in anticipated demand for crushed rock is much smaller at only 3%.

The latest guidelines were published before the detailed growth zone proposals were known and therefore they have not been taken into account other than at a broad national level. The consequence of this is that, based on the past and anticipated future level of growth in the area, it appears that the current guidelines are unlikely to make sufficient provision for the level of growth that is anticipated.

The current guidelines are to be reviewed on an annual basis by CLG. They are updated using indicators of activity produced by Cambridge Economics and data from the RAWPs on landbanks and reserves. An early upward adjustment in the regional apportionments for the three regions covering the MKSM Growth Zone might therefore be anticipated here.

16.1.2 Landbanks

Following the publication of national guidelines, it is the task of the RAWPs to prepare a Rub-Regional Apportionment (SRA) of these regional figures, dividing them between the Mineral Planning Authorities (MPA) in the region. The SRA, once approved, is used by the MPAs in the preparation of Minerals Plans. The SRA, expressed as an annual figure, is used to provide a landbank (in years) of permitted reserves. This is achieved by dividing it by the total amount of permitted reserves in the MPA area. Separate landbanks are calculated for sand and gravel and crushed rock. The requirement to derive a sub-regional apportionment from the regional figure was introduced in MPG6 (1994). Prior to this the landbank was calculated for sand and gravel and separately for crushed rock by using the average of the last 3 years production for which figures were available and dividing this figure by the total permitted reserve for each aggregate type.

Tables 25 and 26 indicate landbanks from 1991-2004 (where available) in the counties of the Project Area. It is a useful guide as to whether the area has an adequate supply of permitted reserves. Advice in MPG6 currently suggests that MPAs should aim to keep a landbank of at least seven years for sand and gravel and a longer period for crushed rock.

Table 25 Sand and gravel landbanks in years

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Northants	3	3	3	3	2.04	3	1.77	2	3	2.3	2.18	1.82	1.45	3.24
Bedfordshire	21.5	21.1				20	18.6	20.2	19.1	18.1	15.6	13.6	15.5	15.3
Bucks (b)	5.6	9.6				18.9	17.4	16.2	16.4	15	16.3	16.4	14.5	8.5
Leicestershire	13	13	13	12	12.1	11.3	11.129	9	10	9.4	7.56	6.32	6.84	7.4
Cambridgeshire (c)	7.6		10.2	9.6			11.8	10.6	10.5	12.8	18.4	20.1	18.5	17.7

Table 26 Crushed rock landbanks in years

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Northants	3	3	3	3	4	5.4	1.04	34(a)	34(a)	34.6(a)	4.94	4.74	4.33	9.7
Bedfordshire	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bucks (b)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leicestershire	58	59	60	68	69	66.1	71.82	66	64	61.7	57.77	62.36	43.92	45.4
Cambridgeshire	26.9		21.9	18.9			8.4	7.8		18.5	14.9	15.7	15.5	14.3

(a) includes an estimated 31Mt permitted reserve of limestone associated with ironstone
(b) including Milton Keynes, except for 2002, 2003 and 2004 when MK landbank was separate and under 7 years but exact figure was not disclosed.
(c) including Peterborough

It is clear from the data that in general most areas have in the recent past maintained landbanks in line with the guidance set out in MPG6. However, this has not been the case in Northamptonshire where for over a decade aggregate landbanks have been significantly below the levels suggested in MPG6. It is known that prior to the formal calculation of landbanks it was recognised that permitted reserves of, in particular sand and gravel, were severely depleted in Northamptonshire and that both the County Council and the East Midlands Aggregates Working Party raised concerns about this during the early 1980s.

16.2 EVOLUTION OF LOCAL POLICY FRAMEWORK

The Town and Country Planning Act 1971 made provision for the preparation of two types of development plan: Structure Plans and Local Plans. The earliest local authority policies relating to mineral extraction were mostly contained in Structure Plans, many of which were adopted during the 1970s. However, these policies were intended to be strategic. They were normally restricted to general operational and land use policies and did not attempt to identify specific working areas. However, in some cases they did include general preclusions, such as from working mineral in designated areas of high landscape quality.

Most mineral planning authorities started to undertake surveys which were to inform the first Minerals Local Plans during the 1980s. In many cases the Minerals Local Plans themselves were not adopted until the 1990s.

The Planning and Compulsory Purchase Act 2004 introduced significant changes to the content, process of delivery and format of the Development Plan. In terms of content, the Regional Spatial Strategies which replace Regional Planning Guidance and Structure Plans became part of the statutory Development Plan, providing a strategic framework. At Local Authority level a series of Local Development Documents are to be prepared. These can either be Development Plan Documents or Supplementary Planning Documents. In the case of minerals and waste, the County Councils are to prepare Minerals and Waste Development Plan Documents. The Act requires Local Development Documents to have regard to national policies and guidance, the local authority's Community Strategy and to be in general conformity with the Regional Spatial Strategy.

However, although the mechanism for plan delivery has materially altered, the policy framework with respect to aggregates provision has not and so the general thrust of local aggregates planning policy is unlikely to change significantly as a result of the new system.

A brief review of the planning policy framework for the supply area has been undertaken to determine how this has influenced the distribution of sites. All counties within the Growth Zone are included plus Leicestershire and Cambridgeshire since they are significant exporters of aggregate to the growth zone. The adjacent counties of Warwickshire and Oxfordshire have been excluded from the review since, although there is some movement of aggregate between these areas and the Growth Zone, available data shows that its contribution to the supply and demand pattern is not significant.

This section considers the way in which local release policies have evolved by examining them over time. Survey reports, consultation documents and draft plans as well as adopted plans, since they all constitute material planning considerations and are all capable of having some influence over site distribution particularly since the timescales for the preparation of adopted plans are often protracted yet during this period decision making must continue. The detailed review for each can be found in Appendix 4.

16.2.1 Leicestershire

Leicestershire falls outside the MKSM Growth Zone but is an important exporter of aggregate, particularly crushed rock, to the area. The following policy documents have been reviewed. A detailed analysis of each policy document can be found in Appendix 4.

- Leicestershire County Council Report of Survey 1984
- Leicestershire Minerals Local Plan, May 1995
- Leicestershire and Rutland Minerals Local Plan, Monitoring and Key issues Report, March 2003
- Leicestershire Minerals Development Framework: Issues and Options Consultation, June 2005

- Leicestershire Minerals Development Framework, Core Strategy & Development Control Policies (preferred options) up to 2021, July 2006
- Leicestershire Minerals Development Framework, Site Allocation (preferred options) up to 2021, July 2006

16.2.1.1 KEY FINDINGS: LEICESTERSHIRE

Although the latest documents are at a consultation stage it is clear that there is no expectation that Leicestershire will be unable to meet anticipated demand for aggregates up to at least 2021.

16.2.2 Northamptonshire

Northamptonshire has traditionally been an important producer of sand and gravel, together with small amounts of crushed rock. However, for some years it has had a landbank of permitted sand and gravel reserves well below the seven years suggested in MPG6 and production is currently at its lowest level for 50 years. Its location, at the heart of the MKSM Growth Zone, means that its ability to supply significant quantities of sand and gravel in the future has important implications for the Growth Zone. The following policy documents have been reviews. A detailed analysis of each policy document can be found in Appendix 4.

- Sand and Gravel Topic Paper, March 1983
- Draft Revised Sand and Gravel Local Plan 1991-2006
- Draft Mineral Local Plan 1991-2006 (Part 2) – Limestone and Related Minerals
- Northamptonshire Minerals Local Plan 1991-2006 (Deposit Draft)
- Northamptonshire Minerals Local Plan 1991-2006
- Northamptonshire Mineral Local Plan 2001-2016 (Deposit Drafts)

In addition the following was also reviewed (see Appendix 4 for detailed review):

- Inspector's Reasoning and The Northamptonshire Minerals Local Plan 2001-2016

16.2.2.1 KEY FINDINGS: NORTHAMPTONSHIRE

Overall it seems clear that at the time of the 1983 Topic paper Northamptonshire accepted that most sand and gravel extraction for the foreseeable future would be in the Nene Valley, provided it was not within areas already protected under Structure Plan policy for their landscape quality. These included the Upper Nene Valley, from just south of Thrapston. Certainly there was no reference to the Nene Valley being inundated with workings at this time. The Welland Valley was also protected for its landscape quality which, coupled with earlier references in Leicestershire County Council documents to the mineral being of poor quality, helps to account for the lack of any significant working within it.

Although the overall thrust of the Minerals Local Plan (1991-2006) did not alter between the deposit draft and adopted versions (1991 -2006), it is important to note that the aim of the County Council to reduce reliance on sand and gravel reserves in the Nene Valley continued to be thwarted by insufficient information regarding the ability of the glacial resource to substitute for the river valley materials.

The outcome of the public inquiry into the Northamptonshire Minerals Local Plan 2001-2016 and the resulting changes introduced in the adopted plan have lead to a shortfall in sand and gravel provision over the plan period. This is despite an acknowledgement that the current SRA does not make specific allowance for the demands of the MKSM Growth

Zone. Although a more rigorous analysis of the suitability of other sites is expected to take place as part of the imminent preparation of a Minerals and Waste Development Framework, until it is confirmed that these sites can be brought forward without unacceptable environmental consequences there must remain some doubt as to whether Northamptonshire will be unable to make provision for current demand for sand and gravel. These doubts only serve to strengthen the concerns regarding the likely availability of sustainable resources to meet anticipated future demand.

Further, the landbank of permitted sand and gravel reserves is and for many years has been depleted. Although difficult to prove it is likely, in view of the continued growth that has taken place in Northamptonshire, that the shortfall in the landbank of permitted sand and gravel reserves has lead to a greater dependence on imports to the county. The demand for local supplies ought therefore to be very high. Intuitively one would expect under such circumstances that the minerals industry would be quick to take up allocated sites in order to supply the local market. However, this has not been the case. The reasons for this are not altogether clear. However, the lack of geological information available over much of the county, particularly in those areas underlain by glacial deposits, may have acted as a deterrent. If the landbank remains depleted this could have serious implications for the supply of sand and gravel from Northamptonshire to the Growth Zone, particularly if the level of demand was to rise rapidly. A consequence of this would be pressure either to import more sand and gravel from the surrounding areas or to increase the levels of crushed rock being imported to the Growth Zone.

16.2.3 Buckinghamshire

Buckinghamshire is separated into three distinct parts. To the north of the Chilterns Escarpment is Aylesbury Vale, a relatively sparsely populated rural area. To the south and east is the Chilterns Area of Outstanding Natural Beauty (AONB), underlain by chalk, and further south the much more densely populated areas of High Wycombe, Gerrards Cross and Beaconsfield. South Buckinghamshire is almost entirely underlain by sand and gravel. This has been heavily exploited to meet the demands of the local area and the adjacent parts of the south east. By contrast Aylesbury Vale has much less sand and gravel. That which occurs does so mainly in the river valleys associated with the Ouse Basin. Glacial Sand and Gravels, do occur but are variable in composition and likely to be of limited economic value. Published information on the pre-glacial deposits is extremely sparse.

For the purposes of this study, only that part of Buckinghamshire which lies to the north of the Chilterns escarpment is considered further since the area to the south plays little or no part in the supply of aggregates to the MKSM Growth Zone. The following policy documents have been reviewd. A detailed analysis of each policy document can be found in Appendix 4.

- Replacement Minerals Local Plan for Buckinghamshire, adopted 1995
- Review of the Replacement Minerals Local Plan for Buckinghamshire 1996 – 2006
- Review of the Replacement Minerals Local Plan for Buckinghamshire 1996 – 2006
- Buckinghamshire Minerals & Waste Local Plan, 2004-2016, adopted June 2006

16.2.3.1 KEY FINDINGS: BUCKINGHAMSHIRE

Overall Buckinghamshire appears, on the basis of existing data, to have little potential to contribute towards meeting the demand for aggregate that will arise from the MKSM Growth Zone. Aylesbury itself is allocated for significant growth but aggregate to support this development is likely to need to be imported from outside the County. The reopening of the rail aggregate depot could be environmentally beneficial if this proved to be the case.

16.2.4 Milton Keynes

Milton Keynes Council is in the process of preparing and adopting its own Minerals Local Plan. This is expected to be adopted during 2006. However, until the new plan is adopted the Minerals Local Plan for the area is the Replacement Minerals Local Plan for Buckinghamshire, 1995. This plan has been considered above insofar as it related to "New Buckinghamshire". It is considered below in the context of Milton Keynes. The following policy documents have been reviewed. A detailed analysis of each policy document can be found in Appendix 4.

- Replacement Minerals Local Plan for Buckinghamshire, adopted 1995
- Milton Keynes Minerals Local Plan 2001-2011, Second Deposit Version

In addition the following inspector's report following a Public inquiry in 2004 was reviewed:

- Inspectors Report 2005

16.2.4.1 KEY FINDINGS: MILTON KEYNES

As a result of the changes introduced in the adopted plan, Milton Keynes has made provision in its plan to meet expected demand throughout the plan period and for a seven year landbank to remain at the end of the plan period, taking provision to 2018. However, Milton Keynes which is a relatively small producer of sand and gravel and in recent years has had a landbank of under 7 years of permitted reserves, has clearly had to accept compromises in order to make this provision and if demand rises significantly difficulties may arise in meeting this in the longer term.

16.2.5 Bedfordshire

Prior to 1996 the policy framework for minerals planning was contained in the county Structure Plan (Alterations No.3) which was approved in February 1992. This document contained broad policies covering mineral extraction and restoration but no site specific proposals. The following policy documents have been reviewed. A detailed analysis of each policy document can be found in Appendix 4.

- Bedfordshire Minerals & Waste Local Plan, adopted 1996
- Bedfordshire & Luton Minerals & Waste Local Plan, adopted 2005

16.2.5.1 KEY FINDINGS: BEDFORDSHIRE

Overall Bedfordshire has made provision for sufficient aggregate to meet the requirements of the sub-regional apportionment. However, given past patterns of supply and demand, it is possible that the buoyant landbank could mask a potential shortage of concreting sand and gravel. The need for further allocations of concreting sand and gravel is to be investigated by the County. Nevertheless, it appears that Bedfordshire would be able to identify additional potential reserves to make up any identified shortfall in supply.

16.2.6 Cambridgeshire and Peterborough

Cambridgeshire is not within the Growth Zone but is close to it and is of importance because historically, significant quantities of sand and gravel have been exported from Cambridgeshire to Bedfordshire, Buckinghamshire and Northamptonshire. It is likely that exports to these areas will continue and additional demand may be generated as a result of the Growth Zone expansion. This could place particular pressure on Cambridgeshire reserves since they will also be called upon to supply the Cambridge Growth Zone. The following policy documents have been reviewed. A detailed analysis of each policy document can be found in Appendix 4.

- Cambridgeshire Aggregates (Minerals) Local Plan, 1991
- Cambridgeshire and Peterborough Minerals and Waste Development Plan (Issues and Options Paper) June 2005
- Cambridgeshire and Peterborough Minerals and Waste Development Plan (Preferred Options) November 2006

16.2.6.1 Key findings: Cambridgeshire and Peterborough

Until such time as the Minerals and Waste Development Framework is adopted it is difficult to assess how future aggregate provision in Cambridgeshire is likely to affect the MKSM Growth Zone. However, what is clear is that in terms of making appropriate provision towards regional demand there is little doubt that Cambridgeshire is well placed to be able to fulfil its commitments and historic movements of material from Cambridgeshire into the growth zone might reasonably be expected to continue.

16.3 LOCAL POLICY FRAMEWORK – SUMMARY

Overall it appears from the review of policy that in most areas the aggregate supply patterns of the past are likely to be sustained, at least in the short to medium term. However, the MKSM Growth Zone will place an additional burden on the traditional supply areas which are then vulnerable to potential supply problems in the future. This risk appears to be most acute in the cases of Northamptonshire, Milton Keynes and North Buckinghamshire where resources are either dwindling, constrained or have not been identified .

Whilst traditional imports of sand and gravel from Cambridgeshire and Leicestershire appear likely to be maintained it would be reasonable to assume that the level of these imports could not rise significantly without impacting negatively on the exporting area. Further, a heavy reliance on imports must cast doubt on the sustainability of the development proposed.

The Growth Zone is already reliant on imports of crushed rock. These supplies appear to be secure in the long term. There may also be potential to increase imports of crushed rock, particularly if rail aggregate depots are expanded or new sites brought forward. However, this would not come without some environmental cost to the exporting areas and again the sustainability of the development proposed is brought into question.

To conclude, the policy aim throughout the Project Area is to make provision for projected aggregate demand in accordance with the SRA. However, in the medium and long term some areas may have difficulty in identifying sufficient quantities of sand and gravel from known resources occurring in areas unrestricted by overriding environmental constraints to satisfy either this or any additional demand from the Growth Zone. The identification of alternative aggregate sources, both secondary and recycled, and primary, within the Growth Zone therefore appears an imperative if sustainable development is to be secured.

16.4 APPENDIX 3 SUMMARY OF KEY FINDINGS – ANALYSIS OF PLANNING INFORMATION

Appendix 3 Key findings: Analysis of planning information

Evolution of National aggregates policy framework

The policy framework for aggregates has evolved from general guidance based mainly on areas of known aggregate resource into a much more structured framework which attempts to anticipate demand and make provision for supply whilst striking a balance between the need for aggregate and the need to protect environmental assets and socio-economic wellbeing. The landbank system supports this by providing a mechanism to make planned provision for future supply based on demand estimates and other material considerations. It also allows for monitoring of whether provision is likely to be adequate. Areas where future supply is not secured display low or diminishing landbanks, as in the case of Northamptonshire.

Evolution of local policy

In general the local policy framework has, like national policy, become far more structured and precise and now aims to provide certainty and predictability through the plan-led system. This can be used not only make provision for aggregates but also to manage the supply through monitoring and review. However, sound policy must be informed by good baseline data and knowledge. Where this is not available the success of resultant policy may be limited. For example in the case of Northamptonshire which has attempted to shift aggregate extraction away from the Nene Valley and into areas of glacial deposits.

Leicestershire

Although the latest documents are at a consultation stage it is clear that there is no expectation that Leicestershire will be unable to meet anticipated demand for aggregates up to at least 2021**.**

Northamptonshire

Overall it seems clear that at the time of the 1983 Topic paper Northamptonshire accepted that most sand and gravel extraction for the foreseeable future would be in the Nene Valley, provided it was not within areas already protected under Structure Plan policy for their landscape quality. These included the Upper Nene Valley, from just south of Thrapston. Certainly there was no reference to the Nene Valley being inundated with workings at this time. The Welland Valley was also protected for its landscape quality which, coupled with earlier references in Leicestershire County Council documents to the mineral being of poor quality, helps to account for the lack of any significant working within it.

Although the overall thrust of the Minerals Local Plan (1991-2006) did not alter between the deposit draft and adopted versions (1991 -2006), it is important to note that the aim of the County Council to reduce reliance on sand and gravel reserves in the Nene Valley continued to be thwarted by insufficient information regarding the ability of the glacial resource to substitute for the river valley materials.

The outcome of the public inquiry into the Northamptonshire Minerals Local Plan 2001-2016 and the resulting changes introduced in the adopted plan have lead to a shortfall in sand and gravel provision over the plan period. This is despite an acknowledgement that the current SRA does not make specific allowance for the demands of the MKSM Growth Zone. Although a more rigorous analysis of the suitability of other sites is expected to take place as part of the imminent preparation of a Minerals and Waste Development Framework, until it is confirmed that these sites can be brought forward without unacceptable environmental consequences there must remain some doubt as to whether Northamptonshire will be unable to make provision for current demand for sand and gravel. These doubts only serve to strengthen the concerns regarding the likely availability of sustainable resources to meet anticipated future demand.

Further, the landbank of permitted sand and gravel reserves is and for many years has been depleted. Although difficult to prove it is likely, in view of the continued growth that has taken place in Northamptonshire, that the shortfall in the landbank of permitted sand and gravel reserves has lead to a greater dependence on imports to the county. The demand for local supplies ought therefore to be very high. Intuitively one would expect under such circumstances that the minerals industry would be quick to take up allocated sites in order to supply the local market. However, this has not been the case. The reasons for this are not altogether clear. However, the lack of geological information available over much of the county, particularly in those areas underlain by glacial deposits, may have acted as a deterrent. If the landbank remains depleted this could have serious implications for the supply of sand and gravel from Northamptonshire to the Growth Zone, particularly if the level of demand was to rise rapidly. A consequence of this would be pressure either to import more sand and gravel from the surrounding areas or to increase the levels of crushed rock being imported to the Growth Zone.

continued

continued

Appendix 3 Key findings: Analysis of planning information

Buckinghamshire

Overall Buckinghamshire appears, on the basis of existing data, to have little potential to contribute towards meeting the demand for aggregate that will arise from the MKSM Growth Zone. Aylesbury itself is allocated for significant growth but aggregate to support this development is likely to need to be imported from outside the County. The reopening of the rail aggregate depot could be environmentally beneficial if this proved to be the case.

Milton Keynes

As a result of the changes introduced in the adopted plan, Milton Keynes has made provision in its plan to meet expected demand throughout the plan period and for a seven year landbank to remain at the end of the plan period, taking provision to 2018. However, Milton Keynes which is a relatively small producer of sand and gravel and in recent years has had a landbank of under 7 years of permitted reserves, has clearly had to accept compromises in order to make this provision and if demand rises significantly difficulties may arise in meeting this in the longer term.

Bedfordshire

Overall Bedfordshire has made provision for sufficient aggregate to meet the requirements of the sub-regional apportionment. However, given past patterns of supply and demand, it is possible that the buoyant landbank could mask a potential shortage of concreting sand and gravel. The need for further allocations of concreting sand and gravel is to be investigated by the County. Nevertheless, it appears that Bedfordshire would be able to identify additional potential reserves to make up any identified shortfall in supply.

Cambridgeshire and Peterborough

Until such time as the Minerals and Waste Development Framework is adopted it is difficult to assess how future aggregate provision in Cambridgeshire is likely to affect the MKSM Growth Zone. However, what is clear is that in terms of making appropriate provision towards regional demand there is little doubt that Cambridgeshire is well placed to be able to fulfil its commitments and historic movements of material from Cambridgeshire into the growth zone might reasonably be expected to continue.

17 Appendix 4: Detailed local policy documents review

17.1 LEICESTERSHIRE

Leicestershire falls outside the MKSM Growth Zone but is an important exporter of aggregate, particularly crushed rock, to the area.

Leicestershire County Council published a Report of Survey in 1984, which was to inform the preparation of the first Minerals Local Plan for the county. This identified three permitted and active sand and gravel sites within the supply area: Shawell; Ashby Parva; and Husbands Bosworth. All three sites were formed on glacial deposits. The Report mentioned river terrace deposits within the supply area, notably in the valley of the River Welland but concluded that they were “unlikely to be of economic significance”. At the time of the Report the largest concentration of sand and gravel workings was to the north of Leicester with two other quarries located to the south-west of Leicester and one major site at Hemington, to the north west of Loughborough.

Leicestershire Minerals Local Plan, May 1995
The first Minerals Local Plan for Leicestershire was adopted in 1995 and remains in force. It identified extensions at all three sites within the supply area **(Policy 15)** sufficient to provide reserves at each until the end of the plan period (2006). The plan noted that Ashby Parva and Husbands Bosworth were unlikely to last as long as 2013 (the seven year landbank period beyond the end of the plan) without further extensions. Extensions to both sites were permitted in 2004. **Policy 16** of the plan identified three new sites. Of these only one, at North Kilworth, was within the supply area. The allocation was subject to highway improvements. This had not, at the time of writing, been brought forward although planning applications were made, most recently in 2004, but subsequently withdrawn. The application was expected to be refused as the need for the mineral did not outweigh environmental effects. **Policy 17** controlled working outside the allocated areas. Such working was not normally permitted unless it was for a limited extension to an existing site or it could be demonstrated that demand could not otherwise reasonably be met. Leicestershire has extensive **igneous rock deposits** to the north and to the south-west of Leicester. These are important to the Growth Zone. In 1993 17.5% (2.88 Mt) of production was **exported to Northamptonshire**. Owing to the high level of permitted reserves the Minerals Plan did not make any specific provision for future igneous rock production. Minerals and Waste Policy 6 of the Structure Plan indicates a presumption against new sites in favour of suitable extensions. **Limestone** is also worked in Leicestershire at a number of sites. **Policy 20** restricts new permissions to those intended to extend an existing operational quarry in order to ensure continuity of supply. During the early 1990s production was about 3.2Mt per annum but only about 50% of this was destined for aggregate uses.

Leicestershire and Rutland Minerals Local Plan, Monitoring and Key issues Report, March 2003
In March 2003 a Monitoring and Key Issues Report, intended to inform the review of the Mineral Local Plan, was published. An officer assessment of reserves estimated that the Ashby Parva site was nearing exhaustion. . The report identified that if no new application is received for North Kilworth, the future of the allocation would be considered as part of the plan review. The Report estimated that Leicestershire would have a landbank of 8-11+ years at the end of 2006 if all extensions and allocated new sites had been brought forward by then. It suggested that new allocations would be needed during the first part of the next plan period and anticipated that these would take the form of extensions at existing sites and replacements for worked out sites. In view of reduced demand over the past 5+ years the Report suggested strengthening the presumption against unallocated sites. There was also a desire to encourage recycling initiatives. The following Key Issues are raised:

Should additional areas be, as far as possible, extensions or should new sites provide the bulk of future supply?

Where should new sites be located and is it still relevant to include un-worked allocations at Shawell and North Kilworth?

Both issues could impact upon the future supply of sand and gravel from Leicestershire to the Growth Zone.

Of greater importance to the MKSM Growth Zone is the production of crushed rock (igneous rock) in Leicestershire which has continued to be exported in significant quantities to the area. The Report indicates that although there have been a number of significant developments affecting the provision of igneous rock in Leicestershire, ultimately resulting in a rationalisation of production with extraction being concentrated at four main sites, production levels, as a percentage of regional production, have been maintained and there is a substantial stock of permitted reserves in the county.

Limestone is also worked in Leicestershire and Rutland. During the early 1990s about 1.6Mt per annum was produced for aggregate purposes. Reserves equated to about 33 years production. Although of less strategic importance than igneous rock the level of production is nevertheless significant.

Leicestershire Minerals Development Framework: Issues and Options Consultation, June 2005

The Issues and Options Consultation was based on information contained in the earlier 2003 Monitoring and Key Issues Report. It was intended as the first formal stage in the process of reviewing the adopted Minerals Local Plan and creating the first new style Minerals Development Framework (MDF) for Leicestershire. Of note is the fact that this document and the proposed MDF cover only Leicestershire rather than being prepared jointly with Rutland as has been the case in the past. The document contains no policy since it is an options paper and simply aims to set out a background against which proposed policy direction can be considered. Figures for minerals sales, including aggregate sales, are updated to 2003. The calculations of need are based on the latest Sub-Regional Apportionment which was derived from the Regional Apportionment published in June 2003 by ODPM. The figure for limestone has been adjusted to take account of production in Rutland.

The document records that there are nine sand and gravel sites in the county, mainly working alluvial and river terrace deposits. However, glacial deposits are worked at several sites (including those within the supply area for the study). Igneous rock production is by far the most important in Leicestershire, accounting for over 70% of total mineral sales. It is worked at four large sites.

The document sets out options for the adequate but sustainable supply of minerals in Leicestershire. Only new sand and gravel supplies will need to be identified during the plan period and the document suggests a range of options for achieving this.

The document is of limited relevance to the study since it does not attempt to indicate a policy direction.

Leicestershire Minerals Development Framework, Core Strategy & Development Control Policies (preferred options) up to 2021, July 2006

Leicestershire Minerals Development Framework, Site Allocation (preferred options) up to 2021, July 2006

The above two preferred options documents were issued for consultation in July 2006. The Core Strategy and Development Control Policies document reflects national policy to maintain an adequate supply of aggregate minerals through sustainable minerals development to meet expected needs.

The document identifies that policy direction will be towards maximising recycling, including at temporary sites; favouring extensions to existing sites over new sites; and minimising road transport. These aims will be achieved through allocating preferred areas to meet the anticipated need and only permitting other sites if they meet certain criteria or are to fulfil an identified need.

The document identifies that there is no need to allocate further areas for igneous rock or limestone production but that 10.2 Mt of sand and gravel should be allocated to meet the anticipated need to 2021.

The Site Allocations document describes the site selection process which was based on a full, detailed assessment of all the sites put forward. Nine sites were put forward, including two existing allocations. In total 21.17Mt of sand and gravel was identified.

Following site assessment, preferred areas were identified at five sites: Brooksby; Cadeby; Husbands Bosworth; Lockington; and Shawell. All involve extensions to existing sites. In total they would yield about 12.18Mt, more than sufficient to meet anticipated need.

Four alternative sites were considered but not put forward due to lack of need and potential environmental effects.

These included one of the existing allocations at North Kilworth.

Leicestershire – Key finding

Although the latest documents are at a consultation stage it is clear that there is no expectation that Leicestershire will be unable to meet anticipated demand for aggregates up to at least 2021.

17.2 NORTHAMPTONSHIRE

Northamptonshire has traditionally been an important producer of sand and gravel, together with small amounts of crushed rock. However, for some years it has had a landbank of permitted sand and gravel reserves well below the seven years suggested in MPG6 and production is currently at its lowest level for 50 years. Its location, at the heart of the MKSM Growth Zone, means that its ability to supply significant quantities of sand and gravel in the future has important implications for the Growth Zone.

Sand and Gravel Topic Paper, March 1983
Northamptonshire published a draft Sand and Gravel Topic Paper in March 1983. This identified that at the end of 1982 there were 12 active sites in the county. Eight were located in the Nene Valley and three were located on glacial deposits elsewhere. Draft Policy SG3 stated that permission would not necessarily be given for areas shown on the proposals map but that extensions would generally be considered favourably (subject to various provisos). Paragraph 6.13 stated that although demand for sand and gravel up to 1996 would be met mainly from the Nene Valley there might be a need for small scale operations elsewhere in the county to meet local demand. Draft Policy SG5 contained a general presumption against working areas not specified on the proposals map. Exceptions would be considered where they were small scale and a need was justified. Proposals for extensions to existing sites in the Nene Valley at: Washlands, Northampton; Earls Barton; Ditchford/Higham Ferrers; Stanwick; Ringstead and Thrapston were identified, together with a small new site at Billing. Elsewhere extensions were identified at: Fawsley and Kislingbury. New sites were identified at Husbands Bosworth (as an extension to a site in Leicestershire) and Rothersthorpe. The Topic paper set out an extract from the Structure Plan policies relating to the recreational use of the canal and river system which stated that: "In the Nene Valley where agriculture cannot be reintroduced because of the high water table, an appropriate after-use will be established for sand and gravel workings." These included a range of water-based recreational activities including peace and quiet activities.

Northamptonshire - Key findings 1

Overall it seems clear that at this time Northamptonshire accepted that most sand and gravel extraction for the foreseeable future would be in the Nene Valley, provided it was not within areas already protected under Structure Plan policy for their landscape quality. These included the Upper Nene Valley, from just south of Thrapston. Certainly there was no reference to the Nene Valley being inundated with workings at this time. The Welland Valley was also protected for its landscape quality which, coupled with earlier references in Leicestershire County Council documents to the mineral being of poor quality, helps to account for the lack of any significant working within it.

Draft Revised Sand and Gravel Local Plan 1991-2006
In July 1991 Northamptonshire County Council published a Draft Revised Sand and Gravel Local Plan 1991 – 2006. At this time (March 1991) there were 11 active sand and gravel sites in the County. The majority were in the Nene Valley with only two relatively small sites, both working soft sand, operating in other areas. The landbank

stood at just under 4 years (9.2Mt).

It is clear from the plan objectives that Northamptonshire County Council was becoming concerned that the Nene Valley could not continue to provide the bulk of sand and gravel extraction in the county. The potential of the glacial gravels was highlighted but so too was the lack of information regarding the deposits. The plan aimed to maintain flexibility to allow additional (glacial) reserves to be incorporated during the plan period should reserve information become available. It was hoped at the time that Government or other research would be undertaken to provide more data. The plan encourages industry to explore the glacial deposits and expresses the hope that they may be able to make a “significant” contribution towards meeting demand.

Of the 23 proposed sites, 15 were in the Nene Valley, 2 in the Ouse Valley and 6 in the glacial deposits. The sites in the Nene Valley accounted for 78% of the proposed reserve.

One reason for this was that the County resisted any development in Special Landscape Areas (SLAs) (and other environmentally sensitive locations). This policy resulted in a number of potential sites in the glacial deposits being excluded from the draft plan proposals.

However, the County Council took the view that environmental protection was paramount, even though this resulted in them being unable to satisfy projected demand forecasts. The plan pointed out that supply difficulties in Northamptonshire had been highlighted in national guidelines for aggregates provision (Circular 21/82) as long ago as 1982.

In terms of the draft policy framework, there was a presumption in favour of allocated sites (SG1) and against those in other areas (SG3). Policy SG4 safeguarded proven and potential mineral reserves from other forms of development. Policy SG9 gave specific protection to the SLAs.

Draft Mineral Local Plan 1991-2006 (Part 2) – Limestone and Related Minerals

In April 1992 a companion document to the draft sand and gravel local plan was published. This considered limestone and related minerals and also covered the period 1991-2006. The plan identified four former ironstone sites where proposals for the extraction of the limestone only would be given favourable consideration, in addition to 13 permitted sites. However, there was no need to identify any new sites in the plan.

Northamptonshire Minerals Local Plan 1991-2006 (Deposit Draft)

The draft sand and gravel and limestone plans became amalgamated into a single Deposit Draft Northamptonshire Minerals Local Plan 1991-2006 which was placed on deposit in March 1993. The general thrust of this plan was fundamentally the same as that of the later adopted version. For this reason the draft is considered in some detail here with differences between it and the final plan being highlighted in the section below which deals with the adopted plan.

The document updated the earlier draft plans, taking into account Department of the Environment (DoE), industry and others concern that the draft sand and gravel plan failed to allocate sufficient resources to meet the forecast demand. The plan stated that there was considerable support for the policy to shift extraction away from the river valleys, even amongst the minerals industry. However, there was also concern that the glacial gravels were overly restricted by virtue of their location within or on the edge of the SLAs. The industry view was that some of these gravels could be extracted without causing significant permanent damage to the landscape and would therefore comply with Structure Plan policy. These representations were taken into account and as a result some of the proposed sites in the Deposit Draft Plan did fall within the SLAs.

The Deposit Draft Plan set out a number of plan objectives. These included protecting and enhancing the County’s landscape (with special reference being made in the supporting text to the SLAs) and various objectives aimed at protecting the river valleys, including reducing the amount of extraction in valleys already being worked and preventing extraction in currently unexploited valleys. To compensate for restricting extraction in these areas, encouragement was given to using glacial sand and gravels and alternative aggregates. Finally, there was a desire to reduce the level of exports of sand and gravel from the county and to safeguard mineral resources from sterilisation by other forms of development.

Sand and Gravel

Provision for future demand for sand and gravel was to be met predominantly from existing permissions and allocations in the plan. However, 2Mt was to come from windfalls and unallocated extensions. In addition an Area of Search was identified between Northampton and Kilsby which was to act as a fall-back should demand exceed the forecasts or allocated sites fail to come forward. Overall Draft Policy NMLP2 sought to make provision for the extraction of 40Mt of sand and gravel.

The Deposit Draft Plan anticipated that DoE research into the glacial deposits in the north and west of the county would take place during 1993/94. However, this did not happen.

Draft Policy NMLP4 identified 24 sites containing a total of about 29 Mt. Of these 11 were in the Nene Valley and contained about 57% of the resource; six were in the glacial sands and gravels and accounted for a further 20%; six sites contained soft sand and represented about 19% of the total resource; finally, three sites were identified in other river valleys and made up 4% of the available mineral.

By the time the draft plan was placed on deposit five of the allocated sites had been permitted. All were relatively small, containing 0.5Mt or less. One further site had been applied for.

Draft Policies NMLP5 and NMLP6 carried forward the presumption in favour of allocated sites contained in Policies SG1 and SG3 of the earlier Draft Sand and Gravel Local Plan.

Limestone

The Deposit Draft Plan reported that with the exception of a small number of controversial sites the draft limestone plan generated much less response that the draft sand and gravel plan.

The supply of limestone for aggregate in Northamptonshire comes from two sources: firstly from old mining permission areas permitted originally for ironstone; and secondly from more recent areas permitted for limestone working.

In considering the use of limestone as aggregate the Draft Plan highlighted the difficulties arising from the status of the old ironstone permissions in the County with regard to working the limestone as a mineral in its own right. At March 1993 there were 33 dormant limestone sites with economic limestone reserves and around five sites were actively being worked for limestone.

Draft Policy NMLP8 identified eight sites with planning permission for limestone working, together with three former ironstone sites that were being worked for limestone. These sites, together with extensions at two of the permitted sites were sufficient to provide for the extraction of 24Mt of limestone during the plan period; enough to meet the expected demand as set out in the sub-regional apportionment, derived from DoE Guidelines for the provision of aggregate.

Secondary & Recycled Aggregate

The Draft Minerals Local Plan contained a short chapter on secondary and recycled aggregates. It encouraged the use of alternative aggregates and identified demolition and construction wastes and asphalt road planings as being particularly significant in Northamptonshire. Draft Policy NMLP14 gave general encouragement to recycling initiatives, particularly those involving demolition and construction wastes and asphalt road planings, subject to the proposals complying with other policies contained in the Development Plan.

Environmental Protection

Chapter 11 of the Draft Plan considered the impact of mineral workings on the environment and set out a policy framework to protect interests of acknowledged importance. These included areas of important landscape. Draft Policy NMLP24 stated in respect of workings in the SLAs or the valleys of the rivers Ise or Tove: "Permission will not normally be granted unless the restoration proposals will result in no significant adverse permanent change in the landscape". It went on to say that " …proposals within the river valleys of the Nene and Great Ouse will be carefully considered and the County Council will seek, as far as possible, to exclude workings from such areas unless the local landscape importance can be safeguarded or satisfactorily reinstated".

Draft Policy NMLP29 encouraged the use of alternative methods of transport and supported the construction of new rail facilities. This was especially encouraged "where this is likely to assist in increasing the amount or proportion of aggregate imported into the county".

Northamptonshire Minerals Local Plan 1991-2006

Following a Public Inquiry the Northamptonshire Minerals Local Plan 1991-2006 was adopted in 1996. Significant changes from the Deposit Draft are set out below:

Policy NMLP2 made provision for the extraction of 36Mt of sand and gravel during the plan period 1991-2006, this is 4Mt less than was referred to in the Deposit Draft. The difference is explained by the time lag between the two versions of the plan during which time mineral continued to be worked.

Policy NMLP4 identified eleven sites containing in total 21.58Mt of sand and gravel. Five sites that had been listed in the draft plan had been granted planning permission since it was placed on deposit. The proposed sites made provision for 2.3Mt (11% in one site) from glacial deposits, 14.13 Mt (65% from four sites) from the Nene Valley, 4.93 Mt (23% from four sites) from soft sand deposits and 0.22Mt (1% from one site) from the Avon Valley. Compared with the deposit draft plan the percentage of provision from the Nene Valley had risen by 8% but the actual amount of sand and gravel had fallen by around 3Mt. The provision from glacial deposits had fallen by almost 10% or 3Mt, taking into account those sites which had been permitted since the deposit draft was issued.

Any shortfall in provision during the plan period (anticipated at around 4Mt) was expected to be made up from the Area of Search (Policy NMLP5) or exceptionally from other areas where proposed workings were small, or small extensions to existing sites.

In terms of limestone provision, the adopted Minerals Local Plan allowed for the extraction of 16Mt of crushed rock over the plan period. About 2.4Mt was in specifically permitted sites or old ironstone permissions that were being worked. One new site at Duddington containing 1.75Mt was proposed (Policy NMLP9). Additional provision was expected to be made through the review of Old Mineral Planning Permissions for ironstone. Policy NMLP13 prohibited further working of limestone for aggregate outside the proposed area.

With regard to Policy NMLP14, relating to recycled and secondary aggregates, there was no change from the draft policy.

Policy NMLP24 which protected the Special Landscape Areas and other areas of landscape importance had not changed materially from the deposit draft.

There were some changes to the section relating to transportation. The earlier references to assisting in increasing imports to the county were deleted. However, support for alternatives to road transport was retained through supporting text. Policy NMLP29 was amended to refer only to proposals needing to make satisfactory provision for access and road transport of mineral if they were to be acceptable.

Northamptonshire - Key findings 2

Although the overall thrust of the plan did not alter between the deposit draft and adopted versions, it is important to note that the aim of the County Council to reduce reliance on sand and gravel reserves in the Nene Valley continued to be thwarted by insufficient information regarding the ability of the glacial resource to substitute for the river valley materials.

Northamptonshire Mineral Local Plan 2001-2016 (Deposit Drafts)

Northamptonshire County Council undertook an initial consultation on key issues for the Local Plan during Autumn 2003. A first deposit draft plan was published in March 2004 and this was followed by a second deposit draft in October 2004. This latter document is considered below.The document sets out the new Sub-Regional Apportionment (SRA) for Northamptonshire for the period 2001-2016 which is contained in the SRA for the East Midlands Region, prepared by EMAWP. This is 15.5Mt of sand and gravel and 6.3Mt of crushed rock.

The draft plan confirms that the sub-regional strategy for the Milton Keynes South Midlands Growth Zone is contained in the draft revised RPG8 and, insofar as it affects Northamptonshire, in the Northamptonshire Minerals Local Plan.

The draft plan sets out production levels during the period covered by the previous plan. Between 1991 and 2002 sand and gravel production averaged 1.4Mt per annum, well below the SRA of 2.24Mt per annum. However, production was considerably higher at the beginning of the period, peaking at 2.3Mt in 1993. By 2000 it had fallen to below 1Mt per annum where it has remained. The draft plan states that the reserve position at the end of 2002 was 4.82Mt which equates to 5 years, based on the new SRA of 0.97Mt per annum. It is of note that even taking account of the lower SRA the landbank remained below the 7 year level recommended in MPG6. The plan states that most sand and gravel extraction between 1991 and 2001 was from the Nene Valley.

Crushed rock production was also well below the SRA during the previous plan period; under half based on annualised figures. Extraction was largely to the north of Northampton and in the north-east of the county.

The plan estimates that at least 10% of aggregate need in Northamptonshire is being met from secondary and recycled sources. However, no basis for this is provided.

The overall aim of the plan is considered to be to reduce extraction and consumption in favour of the more efficient use of minerals and the greater use of secondary and recycled materials. However, the continued need for primary mineral extraction, including in the Nene Valley, is recognised. The plan sets out a series of aims and objectives focussed on achieving the overall aim. Relevant objectives include:

•Increasing recycling facilities
•Increasing efficiency of use of minerals
•Reducing the amount of mineral extracted from the Nene Valley
•Increasing the amount of mineral extracted from glacial deposits

•Resisting extraction from other river valleys, specifically those of the Welland, Tove and Ise
•Resisting further extraction from the valley of the Great Ouse
The plan identifies a need to allocate 15.8Mt of sand and gravel in order to provide for demand during the plan period and beyond. This figure is in addition to the permitted reserve. Proposed sites are all acceptable in principle. Draft Policy 3 identifies: three sites in the glacial deposits containing a total of 5.25Mt; two sites in the Nene Valley containing 8.38Mt and two sites in the Milton Sands (soft sand) containing 2.18Mt.

As a proportion of total anticipated extraction the Nene Valley would therefore provide about 53%, demonstrating that Northamptonshire remains committed to achieving its aim of reducing reliance on the Nene Valley as a future supply of sand and gravel. However, for various reasons the potential shift in supply is not dramatic.

In terms of crushed rock provision, the plan states that the majority of that which is needed is already permitted. Nevertheless, draft Policy 5 allocates one area, a further extension at Duddington Quarry, and this would be expected to yield an additional 3Mt.

The plan promotes the increased use of secondary and recycled materials whilst recognising that processes involved in recycling can, like primary mineral extraction, be noisy, dusty and visually intrusive as well as having transportation implications. Twelve sites with planning permission for recycling are listed and draft Policy 9 supports additional sites in suitable locations. These are stated as being: mineral processing plants; construction sites; existing and disused railheads and wharves; waste management facilities; and industrial areas within the urban area.

Draft Policy 10 sets out in detail how important mineral deposits will be safeguarded from other development. Draft Policy 11 carries forward the safeguarding of railheads and wharves where they have the potential for mineral use (primary or secondary). The policy also supports the creation of new facilities where they will enable mineral to be transported by rail, barge or conveyor and this would result in an overall environmental benefit.

Other policies with implications for the principle of mineral extraction are draft Policy 14 which resists development unless restoration has no significant adverse impact on the landscape character context and draft Policy 19 which requires proposals to respect the local character and distinctiveness of the landscape both during operations and in restoration/afteruse proposals. Draft Policy 19 in part replaces draft Policy NMLP24 and it is of note that the specific reference to the Special Landscape Areas has been omitted, in line with the thrust of new government guidance contained in Planning Policy Statement 7: Sustainable Development in Rural Areas.

A Public Inquiry was held into the Draft Northamptonshire Minerals Local Plan during March and April 2005. The Inspector's report was published in October 2005. The County Council adopted a modified plan in May 2006. .

Inspector's Reasoning and The Northamptonshire Minerals Local Plan 2001-2016

The Draft Plan was subject to a significant number of objections. In terms of this study two themes are of key importance. Firstly, the concern expressed that the plan did not take into account new proposals for the Growth Zone and secondly that the site selection criteria were not sufficiently rigorous. Inter-linked with these was the debate focussing on the aim of the plan to shift extraction away from the Nene Valley and into the glacial deposits whilst at the same time protecting "unworked" river valleys, including parts of the Nene Valley, from exploitation.

The Inspector, whilst acknowledging that the plan should provide an adequate explanation, concluded that Northamptonshire County Council (NCC) could not vary the Sub-Regional Apportionment (SRA) in response to the Growth Zone proposals. This could only be done through a formal review of the SRAs at a regional level. Nevertheless, there was an acceptance that current provision may not be sufficient and this should be kept under review through the proper channels of plan monitoring. Consequently no special provision for the Growth Zone could be justified as part of this plan.

With regard to the proposed shift from working river valley deposits to working those in the glacial areas, the Inspector accepted this aim but questioned whether NCC was properly implementing its own locational strategy. In particular he noted that the Earl's Barton site in the Nene Valley was the single largest allocation and had been enlarged at the Second Deposit Draft stage of the plan. Whilst accepting that part of the site was allocated in the current Minerals Local Plan the extension, in particular, appeared to conflict with NCC aims and objectives.

The Inspector also raised concerns regarding the plan's altered approach to the Special Landscape Areas (SLAs). Whilst accepting the shift towards Landscape Character Assessment, as promoted in Planning Policy Statement 7: Sustainable Development in Rural Areas (PPS7), he noted that the current SLA designations which remain in district-wide Local Plans continue to be protected under Structure Plan policy. The Inspector concluded that the SLAs remained a material consideration in site selection and that this plan could not pre-empt their deletion.

Fundamental to the outcome of the plan was the Inspector's criticism of the site selection process. He was concerned by the apparently slim assessment of the sites and of NCCs assertion that they were merely allocated in principle. His chosen approach to this situation was to re-visit each site and assess whether it was broadly acceptable as a future site or whether it should be placed on a "reserve" list for more detailed consideration if allocated sites failed to come forward. He concluded that if this approach meant that the plan failed to meet the requirements of the SRA without undue environmental consequences this would be an appropriate message to send back to EMAWP and the RPB since it could then be used to inform the future revision of the guidelines contained in the June 2003 partial revision of MPG6.

As a result of the Inspector's findings NCC has provided an enhanced explanation of the relationship between the SRA, the Growth Zone proposals and the plan and has strengthened the protection of the river valleys by adding wording to Policy 12, relating to extensions and applications outside permitted and allocated areas which states that:

"The river valley areas of the Great Ouse, Ise, Tove, Welland and the Nene between Stanwick and Wansford will be subject to rigorous protection from the effects of mineral development".

With regard to the SLAs an explanatory paragraph has been inserted: acknowledging the presence of the SLAs; but highlighting the national move towards Landscape Character Assessment; confirming that this is supported by the Structure Plan; and stating that an assessment has been carried out in Northamptonshire and that this will be used as the driver for assessing proposals in respect of landscape impact in the future.

The most fundamental change to the plan has been the re-assessment of the proposed allocated sites for sand and gravel extraction. The seven sites proposed in the Second Deposit Draft have been reduced to three, with one of these, the Earls Barton West site in the Nene Valley, being reduced in extent. These sites comprise one in the glacial deposits expected to yield 2Mt, one in the Nene Valley with an expected yield of 4Mt and one in the Milton Sands (soft sand) containing 1.1Mt. In total the plan thus makes provision for an approximate yield of 7.1 Mt of which 1.1Mt is soft sand. This does not therefore meet the identified requirement of 15.8Mt.

The remaining four sites plus the deleted portion of the Earls Barton West site and five sites previously considered have been placed in a list of sites for further consideration. These have the potential to make up the shortfall but require further analysis of their appropriateness. This will be undertaken through the preparation of the Locations for Minerals Development Local Development Document which will form part of the Minerals and Waste Development Framework which NCC is committed to preparing.

In terms of crushed rock provision, no changes to the single allocation of an extension to Duddington Quarry were made.

Northamptonshire - Key findings 3

The outcome of the public inquiry into the Northamptonshire Minerals Local Plan 2001-2016 and the resulting changes introduced in the adopted plan have lead to a shortfall in sand and gravel provision over the plan period. This is despite an acknowledgement that the current SRA does not make specific allowance for the demands of the MKSM Growth Zone. Although a more rigorous analysis of the suitability of other sites is expected to take place as part of the imminent preparation of a Minerals and Waste Development Framework, until it is confirmed that these sites can be brought forward without

unacceptable environmental consequences there must remain some doubt as to whether Northamptonshire will be unable to make provision for current demand for sand and gravel. These doubts only serve to strengthen the concerns regarding the likely availability of sustainable resources to meet anticipated future demand.

Further, the landbank of permitted sand and gravel reserves is and for many years has been depleted. Although difficult to prove it is likely, in view of the continued growth that has taken place in Northamptonshire, that the shortfall in the landbank of permitted sand and gravel reserves has lead to a greater dependence on imports to the county. The demand for local supplies ought therefore to be very high. Intuitively one would expect under such circumstances that the minerals industry would be quick to take up allocated sites in order to supply the local market. However, this has not been the case. The reasons for this are not altogether clear. However, the lack of geological information available over much of the county, particularly in those areas underlain by glacial deposits, may have acted as a deterrent. If the landbank remains depleted this could have serious implications for the supply of sand and gravel from Northamptonshire to the Growth Zone, particularly if the level of demand was to rise rapidly. A consequence of this would be pressure either to import more sand and gravel from the surrounding areas or to increase the levels of crushed rock being imported to the Growth Zone.

17.3 BUCKINGHAMSHIRE

Buckinghamshire is separated into two distinct parts by the Chiltern escarpment. To the north of this divide is Aylesbury Vale, a relatively sparsely populated rural area. To the south and east is the Chilterns Area of Outstanding Natural Beauty (AONB), underlain by chalk, and beyond this the much more densely populated areas of High Wycombe, Gerrards Cross and Beaconsfield. South Buckinghamshire is almost entirely underlain by sand and gravel. This has been heavily exploited to meet the demands of the local area and the adjacent parts of the south east. By contrast Aylesbury Vale has much less sand and gravel. That which occurs does so mainly in the river valleys associated with the Ouse Basin. Glacial Sand and Gravels, do occur but are variable in composition and likely to be of limited economic value.

For the purposes of this study, only that part of Buckinghamshire which lies to the north of the Chilterns escarpment is considered further since the area to the south plays little or no part in the supply of aggregates to the MKSM Growth Zone.

Replacement Minerals Local Plan for Buckinghamshire, adopted 1995
At the time of this plan Buckinghamshire included Milton Keynes. However, for the purposes of this policy review those areas now in Milton Keynes will be considered under that MPA below. The plan identified only one active sand and gravel site in Aylesbury Vale. This was located to the north west of Leighton Buzzard. In addition one site working Greensand was identified near Great Brickhill. However, this sand is of exceptional quality and is used for special building and industrial needs. The County Council recognised that there was a shortage of knowledge relating to the sand and gravel resource in the North and Central areas, including Aylesbury Vale, and a number of appraisals were carried out during the 1980s by BGS on behalf of the County Council. These informed the plan review process. In general terms the reports indicated that outside the river terraces along the Ouse (much of which now falls within Milton Keynes) workable sand and gravel was confined to a few small areas. However, they did not determine the viability of the mapped deposits which are irregular. The Minerals Plan did not identify any Preferred Areas in the Aylesbury Vale area. Nevertheless, the area was included in a broad Area of Search since it was judged that applications to work deposits in this area could not be ruled out. Policy MLP3 supported working in the area provided applications met the criteria that had been used to define the Preferred Areas and were consistent with other policies in the plan. The plan provided information on rail depots for aggregates which were supported by Structure Plan policy. In 1987 there were four rail aggregate depots in Buckinghamshire. However, two of these (at Bletchely and Wolverton) now fall within Milton Keynes. A third was located in the south of the county. The fourth depot, located in Aylesbury,

had closed by the time the plan was adopted.

The plan did not address secondary and recycled aggregate production or use.

Review of the Replacement Minerals Local Plan for Buckinghamshire 1996 – 2006
The Review of the Replacement Minerals Local Plan for Buckinghamshire was adopted in 2000. The plan covers the area of "New Buckinghamshire" i.e. excluding Milton Keynes. The plan adopted the same approach as the previous one and identified Preferred Areas in the south of the county where detailed information was available. The Area of Search for sand and gravel covering the northern and central parts of the county, including Aylesbury Vale, was retained. The plan reports that approaches have been made to the County Council by mineral operators as to the possibility of working sand and gravel deposits in the Area of Search. However, at the time of plan adoption few, if any, of these inquiries had lead to formal planning applications. When BGS produced their Mineral Resource Information for Buckinghamshire and Milton Keynes, which was based on the planning position at 01/09/03, there were no active sand and gravel workings in Aylesbury Vale. The policy framework covering the Area of Search is contained primarily in Policy MLP5 which requires applications to extract sand and gravel deposits within the Area of Search to meet the criteria used to define Preferred Areas and be consistent with other relevant policies in the plan. The plan supports the transport of aggregate by rail and water, and the provision of rail aggregate depots where adequate environmental standards can be achieved (Policy MLP8). The fullest use of rail and water is encouraged by Policy MLP6. There is recognition that the Aylesbury area is particularly poorly served since the closure of the rail aggregates depot in the town. This remains as a safeguarded site in the plan (Policy MLP7) but there appears to be little expectation of its re-opening in the foreseeable future. The plan addresses the provision and use of secondary and recycled aggregates. There are no known sources of secondary aggregate within the county but recycling of demolition and construction waste takes place and further provision is supported. However, the Minerals Local Plan does not include any specific policies relating to recycled aggregate provision since these areas are considered to be adequately covered in the County Structure and Waste Local Plans (Policy WLP11).

Buckinghamshire Minerals & Waste Local Plan, 2004-2016, adopted June 2006
The recently adopted plan for Buckinghamshire broadly rolls forward the provisions contained in the previous plan. Specifically, the Area of Search covering Aylesbury Vale is retained (Policy 4) together with a policy (Policy 7) supporting the transport of aggregates by rail and water and safeguarding rail aggregates depots and wharves, including the former rail aggregates depot at Griffin Lane, Aylesbury and any new permanent facilities to be permitted in the future. Since the new plan covers both minerals and waste development, a new policy (Policy 6) supporting both temporary and permanent recycling activities, including for aggregate recycling, is included.

Buckinghamshire – Key findings

Overall Buckinghamshire appears, on the basis of existing data, to have little potential to contribute towards meeting the demand for aggregate that will arise from the MKSM Growth Zone. Aylesbury itself is allocated for significant growth but aggregate to support this development is likely to need to be imported from outside the County. The reopening of the rail aggregate depot could be environmentally beneficial if this proved to be the case.

17.4 MILTON KEYNES

Milton Keynes Council adopted its own Minerals Local Plan in April 2006. However, prior to that the Minerals Local Plan for the area was the Replacement Minerals Local Plan for Buckinghamshire, 1995. This plan has been considered above insofar as it related to "New Buckinghamshire". It is considered below in the context of Milton Keynes.

Milton Keynes Council is in the process of preparing and adopting its own Minerals Local Plan. This is expected to be adopted during 2006. However, until the new plan is adopted the Minerals Local Plan for the area is the Replacement Minerals Local Plan for Buckinghamshire, 1995. This plan has been considered above insofar as it related to "New Buckinghamshire". It is considered below in the context of Milton Keynes.

Replacement Minerals Local Plan for Buckinghamshire, adopted 1995
At the time of plan preparation there were two sand and gravel quarries in Milton Keynes. These were located just to the north east and north west of Newport Pagnell. The site to the north west, known as Mill Farm, was permitted on appeal in 1990. The plan did not identify any additional Preferred Areas in Milton Keynes. However, the generalised Area of Search which covered north and central Buckinghamshire and is described above applied to Milton Keynes. In addition there were two permitted aggregate rail depots; one at Bletchley and the other at Wolverton, to the north west of Central Milton Keynes. In 1984 a planning application was made for a new depot at Wolverton. Buckinghamshire County Council (the MPA at the time) resolved to grant permission subject to the completion of a legal agreement to restrict traffic movements. However, the application was withdrawn in 1992.

Milton Keynes Minerals Local Plan 2001-2011, Second Deposit Version
The Second Deposit Version of the Minerals Local Plan (MLP) was placed on deposit in February 2004. The principle aims of the Plan include: To make an appropriate contribution to meet local, regional and national needs for minerals; To protect the Areas of Attractive Landscape and minimise the adverse effects of mineral extraction on the Council's environmental resources; To safeguard deposits of potentially valuable minerals from sterilisation by other forms of development; To support and safeguard the use of rail and canal for the importation of aggregates; and To encourage greater use of secondary and recycled materials. Milton Keynes main production of aggregates has been from sand and gravel and currently no limestone extraction takes place within the area. The plan makes no specific reference to or provision for future limestone production. At the time the second deposit draft MLP was prepared it was anticipated that the shortfall in permitted reserves at the end of the plan period would be very small (0.015Mt). However, no account was taken of the need to make provision for a landbank beyond the plan period. The Council decided not to allocate any proposed sites but to rely on identifying an Area of Search that covered the entire council area and in which proposals would be considered if they met other relevant policies in the plan and an essential need for the mineral could be shown (Draft Policy MLP2). Of particular relevance was Draft Policy MLP12 which resisted extraction in the Area of Attractive Landscape (AAL), where it would result in detriment to the landscape quality of the area, unless it was outweighed by essential need. This policy was a significant constraint because much of the known and economically workable sand and gravel resource was in this area. The Draft MLP supported the use of secondary aggregate and aggregate recycling through Draft Policy MLP5. However, the Council considered that owing to the nature of Milton Keynes as a new town the contribution that aggregate recycling could make towards meeting regional requirements was likely to be limited. The Draft MLP also supported the provision of aggregates depots through Draft Policy MLP6. The plan noted that the South East Region is expected to require 300Mt of imports to meet the region's needs up to 2016.

A Public Inquiry into objections to the MLP was held during October 2004 and the Inspector's Report was published in February 2005. The Inspector concluded that the plan did not make sufficient provision for total aggregate production during the period of the plan, nor for a rolling seven-year landbank. He recommended that a specific site, a reserve site and a more relevant area of search should be identified in the plan. He concluded on the basis of present knowledge that extraction would probably have to be permitted within the AAL to meet landbank requirements during the plan period and production obligations up to 2016. This is because the majority of sand and gravel deposits in Milton Keynes are in the valley of the River Ouse which forms the core of the AAL to the north of the urban area. There is a smaller AAL to the south-east of the urban area but the mineral here is Greensand which is sought for its industrial uses and not widely used for aggregate purposes.

Recommendations to Cabinet arising from the Inspector's Report were agreed on 12 July 2005. Modifications to the Draft MLP were the subject of public consultation during November and December 2005. The main changes proposed affecting aggregate provision were:

A site at Passenham, outside the AAL, to be allocated as a proposed site in the plan

A site at Lathbury, within the AAL, to be identified as a specific site to come on stream if, and only if, Passenham is not granted permission

The Area of Search is to be revised so that all or part of the sand and gravel deposits shown on the Proposals Map are defined as the Area of Search

Additional potential sites at Ravenstone and Olney to be included (remain) in the Area of Search.

Following consideration of the consultation responses and officer recommendations the Council agreed on 14 March 2006 to adopt the plan subject to minor modifications which did not materially affect its content. The Milton Keynes Minerals Local Plan 2001-2011 was adopted on 28 April 2006.

The allocated site at Passenham was granted planning permission in 2005. It will yield approx 0.475 Mt. over a period of six years. Although the reserve is in Milton Keynes, the access to the site is through Northamptonshire and the site is, in effect, an extension to the Northamptonshire site known as Passenham.

Milton Keynes – Key findings

As a result of the changes introduced in the adopted plan, Milton Keynes has made provision in its plan to meet expected demand throughout the plan period and for a seven year landbank to remain at the end of the plan period, taking provision to 2018. However, Milton Keynes which is a relatively small producer of sand and gravel and in recent years has had a landbank of under 7 years of permitted reserves, has clearly had to accept compromises in order to make this provision and if demand rises significantly difficulties may arise in meeting this in the longer term.

17.5 BEDFORDSHIRE

Prior to 1996 the policy framework for minerals planning was contained in the county Structure Plan (Alterations No.3) which was approved in February 1992. This document contained broad policies covering mineral extraction and restoration but no site specific proposals.

Bedfordshire Minerals & Waste Local Plan, adopted 1996
The 1996 plan covered the period 1996-2006 and the "Old Bedfordshire" administrative area. It therefore included Luton, which has more recently become a Unitary Authority. Bedfordshire is a major producer of sand and gravel for aggregate purposes. At the time of the 1996 plan the annual apportionment figure for sand and gravel was 2.0Mt. Production was split into soft sand and concreting sand and gravel. The historic proportions were roughly 50:50. Bedfordshire took the view that separate landbanks should be maintained for these two types of aggregate. Soft sand reserves were well in excess of what was expected to be needed during the plan period and so no further allocations were proposed. For concreting sand and gravel three proposed sites were allocated. This followed a consideration of 20 alternative sites and a further six soft sand sites. The plan included a list of these sites and comments on their suitability for extraction. Constraints were identified. The proposed sites were considered to be the least damaging. In all cases the mineral was proven and the site was available during the plan period. The proposed sites, identified in Policy MW7, were as follows: • Land West of Willington (just to the east of Bedford): this site contained 2.8Mt of concreting sand and gravel and extended to some 202 hectares. The area was an extension to the existing Willington quarry and material was expected to be processed through the existing plant site.

• Salford (approx. 3 miles east of Milton Keynes): this site contained 1.01Mt of concreting sand and gravel and covered an area of 33.5 hectares. It was an extension to an existing quarry.

• Ivel Valley (East of A1 between Sandy and Biggleswade): this site contained about 650,000te of concreting sand and gravel in an area of 29.3 hectares. It was located in an area of existing workings and was expected to utilise an existing haul road and plant site.

In other areas of the county Policy MW8 allowed proposals for mineral extraction to be considered on their merits in the light of need, economic benefits and the environmental impact of working. The policy did not apply to building sand, presumably owing to the significant landbank already available.

Stone for aggregate was not being worked in Bedfordshire at the time of plan preparation and there was no expectation that it would be, hence there were no policies or allocations for this.

Other policies in the plan with direct relevance to the supply of aggregate included the following:

Policy MW10 – Alternative Mineral Sources: this policy supported the use of secondary aggregates and recycled material in principle and stated that permission would normally be granted for their import, reworking and processing.

Policy MW16 – Areas of Great Landscape Value: this policy restricted mineral operations in Areas of Great Landscape Value (AGLV) which would have an unacceptable effect on the character of the area. The AGLV were as follows:

•The Upper Ouse Valley – which contains river valley sand and gravel

•The Greensand Ridge – which contains soft sand

•The Chalk Hills of the Chilterns – which are not relevant to aggregate supply

Policy MW24 – Alternative Means of Transport: this policy states that wherever practicable and appropriate alternatives to road transport of mineral would be sought.

Policy MW26 – Rail Aggregate Depots: this policy safeguards facilities for rail served aggregates depots. At the time of plan preparation there were two active depots at Elstow south of Bedford and in Luton respectively. A second depot in Luton closed in 1993 but the site was safeguarded by the policy. The policy also supported the creation of a new facility in the Biggleswade/Sandy area subject to a demonstration of need and environmental considerations.

Bedfordshire & Luton Minerals & Waste Local Plan, adopted 2005

Between the adoption of the 1996 plan and the preparation of the current plan two significant administrative changes took place in Bedfordshire. Firstly, Luton became a unitary authority: this had little effect in terms of aggregate supply since the two areas have continued to work together in the preparation of the new plan. Secondly, in 2001 the regional planning framework changed for both Bedfordshire and Luton: previously they had been included in the South-East England Region. However, they are now part of the East of England Region. Consequently emerging planning guidance for the East of England will apply as soon as it is approved.

In terms of the sub-regional apportionment of the regional guidelines for aggregate provision, Bedfordshire now contributes towards the East of England Regional apportionment (Luton is not an active minerals producing area). A new sub-regional apportionment has been approved in the East of England based on the revised MPG6 guidelines under which Bedfordshire is expected to make provision for 1.93Mt of sand and gravel each year up to 2016.

At the beginning of 2003 Bedfordshire had a landbank of permitted sand and gravel reserves of approximately 26.2Mt. This equates to a landbank of just over 13.5 years which would be sufficient to last throughout the plan period which runs until 2015. In view of this, and the fact that other counties in the East of England Region did not operate separate landbanks for different types of sand and gravel aggregate (as Bedfordshire had been accustomed to doing for building sand and concreting sand and gravel), Bedfordshire decided that there was no need to put forward any additional proposed areas for extraction in the new plan.

However, advice in MPG6 states that separate landbanks may be appropriate providing that the reserves of different types of material may be identified separately and unambiguously. In the light of this advice, Bedfordshire will consult with the minerals industry to assess the appropriate split between building sand and concreting sand and gravel. This may then lead to a revised assessment of need over the plan period. A topic-based site specific plan would then be prepared to identify appropriate sites or preferred areas to meet any identified shortfall.

As adopted, the current plan does not support proposals for new mineral extraction sites (Policy M1) except where they confer an overall planning benefit or, in the case of concreting sand and gravel and silica sand there is a need to meet the landbank requirements set out in Policies M2 and M3 respectively. Policy M2 states that the MPA will endeavour to maintain a landbank of at least 7 years throughout the plan period for both concreting sand and gravel and building sand for aggregate purposes.

With regard to maintaining a 7 year landbank at the end of the plan period, as required by MPG6, Bedfordshire is aware from its consideration of sites put forward in the context of the plan review that a total of 27Mt of proven future reserve and a further 17Mt of probable future reserve exist within the county. Bedfordshire is therefore satisfied that a landbank can be maintained. It is not necessary to identify specific reserves for this purpose.

The current plan has adopted policies with the same thrust as was contained in the previous plan regarding alternative aggregates, Areas of Great Landscape Value and rail aggregate depots.

Bedfordshire – Key findings

Overall Bedfordshire has made provision for sufficient aggregate to meet the requirements of the sub-regional apportionment. However, given past patterns of supply and demand, it is possible that the buoyant landbank could mask a potential shortage of concreting sand and gravel. The need for further allocations of concreting sand and gravel is to be investigated by the County. Nevertheless, it appears that Bedfordshire would be able to identify additional potential reserves to make up any identified shortfall in supply.

17.6 CAMBRIDGESHIRE

Cambridgeshire is not within the Growth Zone but is close to it and is of importance because historically, significant quantities of sand and gravel have been exported from Cambridgeshire to Bedfordshire, Buckinghamshire and Northamptonshire. It is likely that exports to these areas will continue and additional demand may be generated as a result of the Growth Zone expansion. This could place particular pressure on Cambridgeshire reserves since they will also be called upon to supply the Cambridge Growth Zone.

Cambridgeshire Aggregates (Minerals) Local Plan, 1991

Sand and gravel are the most important of the County’s aggregate minerals, accounting for 90% of production in 1985. Limestone made up the remaining 10%. Although deposits are dispersed throughout the county, the principle workings at this time were in the river terrace deposits in the valleys of the Rivers Great Ouse, Nene and Welland. These deposits were worked extensively during the post war period. Production peaked in the late 1970s at over 3.7Mt per annum but fell during the 1980s to under 3Mt per annum. The high production during the 1970s coincided with general expansion in the Ouse Valley towns and major construction projects such as the new town expansion of Peterborough and major road schemes (M11, A45, A604).

The plan shows the county spilt into three production zones: Northern, Central and Southern & Eastern. At the time of plan preparation by far the largest producer was the Central Zone. Its proportional share was 80% in 1985. This zone comprises the Ouse Valley terrace gravels around Huntingdon, running east towards fen gravels. Also of importance was the Northern Zone, comprising the Nene Valley gravels. This zone would naturally serve the Peterborough area.

The plan strategy was based on the assumption that future production would continue to be predominantly from the river valley areas which coincide with areas of relatively lower agricultural value. Cambridgeshire has a high proportion of higher grade (1, 2 & 3) agricultural land, much of it falling within grades 1 & 2. The safeguarding of this, in line with national policy at that time, was a significant factor in the choice of future sites.

The County Council aimed to make provision for the extraction of 48.8Mt of sand and gravel during the period 1986-2000. This comprised an existing permitted reserve of 20.9Mt at January 1986 plus 27.9Mt of new permissions. It was expected that 6.2Mt would be made available from the Northern Zone and 21.6Mt from the Central Zone thus maintaining the relative proportions of contribution from the two zones.

The plan identified in Policy CALP 3 ten site specific extensions and three Areas of Search in which potential new sites might be identified. In addition to river valley deposits these included some fen edge deposits to the north east of Huntingdon, for example at Block Fen (Mepal). Policy CALP 4 restricted new workings outside the preferred areas. The majority of the identified sites in the Central Zone were well placed to export material to Bedfordshire, Northamptonshire and in some cases Milton Keynes.

The plan mentioned alternative aggregates but concluded on the basis of regional figures for East Anglia (200,000 tonnes sold in 1981) that sales of alternative aggregate were not significant in Cambridgeshire. The recycling of airfield pavements was acknowledged but not quantified.

Overall, the Plan sought generally to maintain the status quo with regard to sand and gravel production in Cambridgeshire. However, there appears to have been some shift in the emphasis from the exploitation of resources in the river valleys to those in the fen areas, although this is not explicit in the text. The existing permitted reserve of limestone in the county was such that no new areas were allocated in the plan.

Cambridgeshire and Peterborough Minerals and Waste Development Plan (Issues and Options Paper) June 2005
Cambridgeshire and Peterborough published an Issues and Options Paper in June 2005 which sought the views of stakeholders on a wide range of topics. The Paper did not attempt to set out the Councils' strategy for the provision of mineral in the future but rather provided background information on the requirement to make provision for future aggregate supplies and then offered alternatives as to how this provision could be made. A number of suggested future sites were shown but the Paper made clear that these were not being promoted by the Councils. They were put forward by the minerals industry and were shown in order to allow stakeholder consideration and comment. Following consideration of the representations made preferred options were prepared for consultation.

Cambridgeshire and Peterborough Minerals and Waste Development Plan (Preferred Options) November 2006
The draft plan published for consultation comprised of three documents: a Core Strategy; Site Specific Policies; and the Earith/Mepal Area Action Plan. Over all the plans made provision for slightly over the sub-regional apportionment of 2.82Mt per annum (3.0Mt) in order to provide flexibility and to acknowledge the level of development expected in the Cambridge and Peterborough areas. Eight preferred sand and gravel allocations were included which together were expected to yield approx 34Mt of aggregate with the largest site at Block Fen/Langworth Fen, Mepal yielding about 14.2Mt. Of the allocated sites Little Paxton, near St Neots, is the closest to the Growth Zone and some material might reasonably be expected to be sold within it. Several other sites, including those near Peterborough and the large allocation at Mepal, which covers an extensive area, generally between St. Ives and Chatteris, situated to the north-east of Huntingdon would be capable of serving the northern and eastern parts of the MKSM Growth Zone, although they are clearly better located to serve both Peterborough and Cambridge. In view of the expected level of growth in the Cambridge and Peterborough areas they could not therefore be considered well placed to become natural suppliers to the majority of the Growth Zone. Nevertheless, there is no reason to suppose that the level of exports from Cambridgeshire and Peterborough to neighbouring areas within the Growth Zone is likely to fall away, given that Cambridgeshire and Peterborough are unlikely to have any difficulty in making provision for the level of demand anticipated by the sub-regional apportionments. The consultation period on the preferred options closed at the end of 2006. It is expected that following a review of consultation responses a plan will be submitted to the Secretary of State for examination in Autumn 2007. The examination is expected to take place in May 2008 with adoption in early 2009.

Cambridgeshire – Key findings

Until such time as the Minerals and Waste Development Framework is adopted it is difficult to assess how future aggregate provision in Cambridgeshire is likely to affect the MKSM Growth Zone. However, what is clear is that in terms of making appropriate provision towards regional demand there is little doubt that Cambridgeshire is well placed to be able to fulfil its commitments and historic movements of material from Cambridgeshire into the growth zone might reasonably be expected to continue.

18 Appendix 5: Borehole Logs & geological interpretation

The geological interpretation for each borehole is shown below. The information is grouped by type of deposit being investigated. The national grid reference for each borehole is shown in square brackets after the borehole number.

18.1 GLACIOFLUVIAL SANDS AND GRAVELS IN THE NORTH OF THE PROJECT AREA

- **BH1 (and redrill 1a) [472716 300209 and 472671 300188]**

The borehole was investigating the sand and gravel mapped here and identified in existing borehole logs, with the aim of collecting particle size data.

BH1 encountered no sand and gravel and proved stiff clay with gravel and chalk down to 13.5m, where it met bedrock.

BH1a encountered a clayey very gravely SAND at 4.3-5.9m. PSA shows 15% silt/clay content. The overburden to mineral ratio for the deposit was 2.7:1.

- **BH2 [473166 299104]**

The borehole was investigating the sand and gravel mapped beneath the glacial till, with the aim of understanding the sand and gravel distribution and relationship and collecting particle size data.

The borehole discovered no sand and gravel, and proved variable clay down to 18.75m, where drilling ceased.

- **BH3 [474849 297156]**

Borehole 3 was drilled in an area mapped as glacial till, to investigate the sand and gravel mapped stratigraphically beneath it, to assess its distribution and gain particle size data.

Beneath the glacial till, a very clayey, very sandy GRAVEL was identified at 5.7-6.9m, and bedrock was reached at 8.6m. The silt/clay content is 27% and the overburden to mineral ratio in this borehole is 4.8:1.

- **BH4 [477047 298357]**

The geological map of the site of BH4 shows glacial sand and gravel at the surface, with overlying glacial till at a distance of 50m from the site.

The borehole revealed glacial till to bedrock, and recovered no sand and gravel, indicating the sand and gravel is not as widespread as mapped.

- **BH5 [476370 296733]**

The borehole was drilled within 50m of sand and gravel, on glacial till, with the aim of building an understanding of the stratigraphic relationship between the two.

Clayey very sandy gravel was identified at 7.9-8.6m. It had a silt/clay content of 11% and within this borehole an overburden to mineral ratio of 11:1.

- **BH6 [470954 297821]**

BH6 was drilled approximately 160m from an outcrop of sand and gravel, and was drilled to assess how continuous the deposit is beneath the glacial till.

The results of the drilling show a chalky glacial till to bedrock. This indicates one of two scenarios. Either the sand and gravel is of variable thickness beneath the overlying till, or it was deposited on top of the till and is within depressions in the till surface.

- **BH7 [468628 298200]**

BH6 was drilled approximately 150m from an outcrop of sand and gravel, and was drilled to assess how continuous the deposit is beneath the glacial till.

The borehole discovered no sand and gravel, consisting of variable glacial till. This suggests that the sand and gravel has a variable thickness beneath the till, or the deposit has been eroded and so is only present in patches.

- **BH8 [468900 295446]**

Borehole 8 was drilled within a sand and gravel deposit approximately 0.5km long and 150m wide, surrounded by glacial till. There was no existing PSA data for this deposit.

The borehole revealed slightly gravelly, very clayey SAND at 1.4-2.5m. It had a silt/clay content of 26% and an overburden to mineral ratio within this borehole of 1.3:1. Made Ground was recorded at th top of the borehole overlying the sand, and a firm till was recorded beneath to the terminal depth of the borehole (18.75m). This would suggest that the pocket of sand and gravel overlies the glacial till, and is therefore unlikely to be widespread.

- **BH9 [471681 294153]**

BH9 was drilled within a region of glacial till, with an aim of investigating the presence or absence of an underlying glacial sand and gravel.

The results of the borehole suggest there is no underlying sand and gravel, with glacial till recorded for the total borehole depth of 13m.

- **BH10 [494064 293968]**

BH10 was drilled in an area of glacial till, with sand and gravel mapped beneath it and outcropping within approximately 100m. The location was chosen to confirm the relationship between the two deposits, and gain PSA data for the sand and gravel.

The borehole revealed a clayey very gravely SAND at 2.4m, which had a depth of 1.1m. It had a low silt/clay content of 16% and was 51% sand. The overburden to mineral ratio at this location was 2.2:1.

- **BH11a [459662 289360]**

BH10 was drilled in an area of glacial till, with sand and gravel mapped beneath it and outcropping approximately 1.5km away. The location was chosen to confirm the relationship between the two deposits, to build an understanding of the distribution of the sand and gravel, and gain PSA data for the sand and gravel.

The borehole identified no sand and gravel. The total depth of the borehole was 19m, indicating that the sand and gravel is not continuous beneath the till.

- **BH11b [457864 287578]**

BH10 was drilled in an area of glacial till, with sand and gravel mapped beneath it and outcropping within approximately 100m. The location was chosen to confirm the relationship between the two deposits, and gain PSA data for the sand and gravel.

BH11b identified a thin deposit of clayey very sandy GRAVEL, at 7-7.8m. The deposit had a small silt/clay content of 6%, and contained 41% sand. The overburden to mineral ratio for this deposit is almost 9:1 at this location. The borehole demonstrated that glacial till is deposited above and below this gravel.

- **BH12 (and redrill 12b) [452989 283358 and 452994 283355]**

This borehole was drilled at the top of a valley side. The geological map showed the valley cutting through a succession of upper glacial till overlying a sand and gravel, and a lower glacial till at the base of the sequence.

The borehole identified upper sand (0.3-1.8m) and an underlying upper till (1.8-2.6m). These are underlain by thicker lower sand and gravel (2.6-7.9m) and till (7.9-19.6m). Drilling ceased due to a large cobble at 19.6m. 4 PSA tests were carried out on the sand and gravels: the upper deposit was clayey sand with 23% silt/clay, and the lower potential resource varied between sandy gravel and a gravelly sand. Throughout, the silt/clay content varies from 12% to 23% and the cobble content never rises above 1%. The overburden to mineral ratio for the lower sand and gravel is 0.5:1.

To gain more information on this sequence, drilling was resumed 5m from the original location (12b). This borehole did not encounter the upper till in BH12, but proved the thicker sand and gravel to 8.7m, with the underlying till to bedrock, which was reached at 16.5m. The potential resource was sampled at 2m intervals and revealed gravelly sand, becoming more gravelly with depth. The silt/clay content varied between 14 and 24% and the cobbles were only identified in the lower sample at 6m (1%).

- **BH13 [457670 285948]**

BH13 was drilled in an area mapped as glacial till with underlying sand and gravel. The borehole was drilled to assess the spread and distribution of the sand and gravel and to collect samples for PSA, as existing boreholes in the area suggest this sand and gravel maybe a significant potential resource.

The borehole identified the mapped glacial till from beneath the topsoil to a depth of 9m, and the underlying sand and gravel to the total depth of the borehole (25m). The PSA demonstrates that the deposit varies from a very clayey, very sandy GRAVEL (at 9m), to a clayey sandy GRAVEL with cobbles (10m), to a clayey very sandy GRAVEL (12m), becoming a clayey, very gravelly SAND (14m). Silty sand bands are present within the sand from a depth of 18m. PSA revealed that for the whole of the deposit the silt/clay content never rises above 23%. A large percentage (45%) of cobbles are identified in the 10m sample, probably caused by the presence of one or two large cobbles, otherwise cobble content remains below 1%. The overburden to mineral ratio for this potential resource is 0.36:1.

- **BH28 [462659 285760]**

BH28 was drilled in an area mapped as glacial till with underlying sand and gravel. The borehole was drilled to assess the spread and distribution of the sand and gravel and to collect samples for PSA as existing borehole records suggested the presence of a significant potential resource is present.

The borehole recovered glacial till to a depth of 7.9m. Below this the drillers recorded an Ironstone Gravel, to 8.5m. Below this, gravelly clay is recorded to 11.3m, and beneath this to a depth of 13.8m, is slightly clayey sandy GRAVEL. Bedrock (Lias Clay) is recorded from 13.8 to the total depth of the borehole (15.5m). PSA of the gravel reveals a silt/clay content of 3% and a large gravel content of 83%, and the overburden to mineral ratio for the deposit is 4.5:1.

18.2 GLACIOFLUVIAL SANDS AND GRAVELS IN THE SOUTH OF THE PROJECT AREA

- **BH21 [472811 231526]**

This borehole was drilled in an area mapped as glacial till with underlying sand and gravel. The borehole was drilled to assess the spread and distribution of the sand and gravel and to collect samples for PSA as there are very few existing boreholes in the area.

The borehole revealed a succession of glacial till at the surface to 4.8m, with a band of clayey sand within it, with a dense sand and gravel beneath it to a depth of 12.9m. Between 8.8-9.6m there was a bed of stiff clay within the sand and gravel. Considered as one unit, the overburden to mineral ratio of this deposit is 0.6:1. The PSA demonstrates that although the deposit varies from clayey sand to sandy gravel there is no distinct difference between the deposit above and below the stiff clay band. Silt/clay content varies from 3% to 25%, except for the 12.6m sample which shows a high silt/clay content of 46%.

- **BH24 [482221 228824]**

The geological maps show that BH24 was drilled on an outcrop of glacial sand and gravel, surrounded by overlying glacial till. There was no reliable existing PSA data for the deposit; however some records suggest it has relatively high silt/clay content.

The borehole revealed a thin deposit of sand and gravel at surface, an underlying till, beneath which was a thick (6.10-13.9m) deposit of sand and gravel. Till was recorded to the total depth of 18.5m. PSA data shows that the upper sand and gravel is very gravelly sand with 20% silt/clay. The lower thicker deposit is clayey sandy gravel, with an average silt/clay content of 15%, with a minimum of 13% and a maximum of 16%, increasing with depth. The overburden to mineral ratio for this lower sand is 0.8:1.

- **BH29 (and redrill 29a) [486437 226987 and 486207 226850]**

Borehole 29 was drilled on glacial till with glacial sand and gravel mapped beneath it. BH29a was drilled approximately 300m southwest of BH29, a location mapped as glacial sand and gravel with no overlying till. This location has chosen as there was very little existing borehole data for the sand and gravel unit.

Borehole 29 encountered an upper till above the sand and gravel deposit. This was not found in BH29a, supporting the geological mapping. Beneath the sand and gravel unit in BH29a was a lower till. Chalk clasts were identified within the BH29 sand and gravel unit. The PSA data demonstrated that in both boreholes the deposit was consistently clayey very sandy GRAVEL to a depth of 13.3m. Below 13.3m in BH29a the deposit changed to consistent clayey SAND. The units highest silt/clay content is 21%, at the 1m depth in BH29a, however, elsewhere it varies between 11-1%. The overburden mineral ratio for the sand in BH29a is 0.2:1.

- **BH30 (and redrill 30a) [489256 224939]**

BH30a was a redrill of 30a due to problems concerning inadequate casing diameter during BH30. Because of this the boreholes were drilled only a few metres apart. The location within the regional stratigraphy is identical to BH29, drilled through the overlying till to investigate the potential resource beneath.

The till contains two beds of sand and gravel. The upper one is 180cm thick at a depth of ~4m, and identified in both boreholes, the lower one only found in BH30a, with a thickness of 70cm. PSA analysis demonstrates that the upper bed is very clayey (26%) very gravelly SAND. The main body of sand and gravel, identified in both boreholes, is from a depth of around 14m, directly beneath the till. PSA has shown that this varies between very clayey very gravelly SAND to gravelly clayey SAND. Throughout the deposit, the silt/clay content never rises above 22%. The overburden to mineral ratio for this lower deposit is around 1.3:1.

18.3 GLACIOFLUVIAL SANDS AND GRAVELS IN THE WEST OF THE PROJECT AREA

- **BH31 [462338 244008]**

Borehole 31 was drilled to investigate the potential of a sand and gravel deposit beneath the glacial till mapped at the surface. A channel of sand and gravel is suggested by the geological map, but there were very few existing boreholes and no PSA data.

The borehole identified only a thin deposit of clayey very sandy GRAVEL at 4-4.5m, withi glacial till. The gravel deposit had a high silt/clay content of 28% and has an overburden to mineral ratio of 8:1. The channel is either narrow and was missed by this borehole or it may have drilled through the its narrow edge.

- **BH32 (and redrill 32a) [464479 238097 and 464493 238099]**

Borehole 32 (and redrill 32a) were drilled to investigate the potential of a sand and gravel deposit beneath the glacial till mapped at the surface. A channel of sand and gravel is suggested by the geological map, but there were very few existing boreholes and no PSA data.

Drilling of BH32 ceased at 2.5m due to a large cobble. Borehole 32a identified clayey gravelly SAND between 11-14.6m, sandwiched between an upper and lower till. The silt/clay content was consistently below 19%. The overburden to mineral ratio for this deposit is 3:1.

- **BH33 [467392 238683]**

The lack of PSA data for the sand and gravel exposed at the surface in the area, led to the drilling of borehole 33.

The borehole revealed sandy gravelly clay overlies the 2.5m thick potential resource of clayey very gravelly SAND. PSA of two samples revealed the silt/clay content for the sand varies between 12% and 15%. The overburden to mineral ratio at this location is 3.2:1.

- **BH35a [466899 241082]**

BH35a was drilled to investigate the potentially widespread sand and gravel beneath the till that blankets much of the region. Existing boreholes in the region indicate potential resource with an overburden to mineral ratio of 1:1.

The borehole proved glacial till for the depth of the borehole (19m). This suggests the sand and gravel mapped in the region may not be a consistent widespread deposit and that it varies in thickness.

- **BH35b [466773 242966]**

BH35b was drilled to investigate the potentially widespread sand and gravel beneath the till that blankets much of the region. Existing boreholes in the region indicate a potential resource with an overburden to mineral ratio of 1:1.

The borehole revealed glacial till for the depth of the borehole (19m). This suggests the sand and gravel mapped in the region may not be a consistent widespread deposit and that it varies in thickness.

- **BH36 [466240 246311]**

BH35b was drilled to investigate the potentially widespread sand and gravel beneath the till that blankets much of the region. Existing boreholes in the region suggest potential resource with an overburden to mineral ratio of 1:1.

Unlike BH35a and BH35b, this borehole identified an 8m thick deposit of sand and gravel, from a depth of 2m (overburden to mineral ratio of 0.25:1). The PSA reveals that the deposit is a generally a clayey very sandy GRAVEL, with silt/clay content between 10% and 29%.

18.4 SANDUR DEPOSITS

- **BH34 [467498 236081]**

The geological map indicates sand and gravel at the surface at the location of BH34. This location was chosen to gain PSA data for the sandur deposit.

The borehole identified an upper gravelly SAND to 6.5m, beneath which is a thin till to 7.6m, beneath which is a lower clayey sandy GRAVEL to 13.3m. The upper gravelly sand has a silt/clay content consistently close to 21%. The lower gravel has lower silt/clay content, an average of 9%. The overburden to mineral ratio for this lower gravel is 1:1.

- **BH48 [460509 231156]**

The geological map indicates sand and gravel at the surface at the location of BH48. This location was chosen to gain PSA data for the sandur deposit.

The borehole revealed little sand and gravel, encountering only till except for a thin 20m bed of sand and gravel at 5m.

- **BH49 [467945 231661]**

The geological map indicates sand and gravel at the surface at the location of BH49. This location was chosen to gain PSA data for the sandur deposit.

BH49 revealed a thick overburden of till, to a depth of 8.7m, beneath which was clayey gravelly SAND. The sand has a thickness of 2.6m and a silt/clay content of 7%. The overburden to mineral ratio for the deposit is 3.3:1.

- **BH50 [464538 231344]**

The geological map for the site of BH50 indicates till at the surface, overlying the widespread sandur deposit. Again, the location was chosen to gain PSA data for the sandur deposit and build an understanding of the till/sandur relationship.

The borehole revealed till to a depth of 9.5m with an underlying clayey very gravelly SAND to 13.5m, beneath which was a second till. The deposit has a consistently low silt/clay content of around 6%, and the overburden to mineral ratio for the gravely sand in this borehole was 2.4:1.

18.5 RIVER TERRACE DEPOSITS OF THE MIDDLE REACHES OF THE OUSE (AND TRIBUTARIES)

- **BH15 [508655 264647]**

BH15 was drilled in an area mapped as the 1st river terrace deposit. The borehole identified no terrace sand and gravel, but till to 1.6m, where bedrock was struck. This suggests the 1st river terrace deposit is not as extensive as mapped.

- **BH16 [500540 256444]**

BH16 was drilled in an area mapped as river terrace deposit (undifferentiated). The borehole discovered a 2.2m deposit of river terrace beneath 1m of weathered topsoil. The terrace deposit rests directly on bedrock. PSA data demonstrates that the terrace consists of sandy slightly clayey GRAVEL with cobbles. The silt/clay content is 1%.

- **BH17 [494600 255833]**

BH17 was drilled in an area mapped as river terrace deposit (undifferentiated) downstream of BH16, 19 and 20. As with BH16, it proved a river terrace deposit beneath weathered topsoil. The clayey very gravely SAND is 2m in depth, resting on bedrock. The silt/clay content is 20%.

- **BH19 [514506 252390]**

BH19 was drilled in an area mapped as 1st/2nd river terrace deposit upstream of BH16, 17 and 19. As with BH16 and BH17, it proves a river terrace deposit beneath weathered topsoil. The 3.25m thick sandy slightly clayey GRAVEL rests on bedrock. The silt/clay content is approximately 2%.

- **BH20 [515393 255674]**

BH20 was drilled into the 3rd (higher) river terrace deposit of the River Ouse, upstream of the other project boreholes. The borehole demonstrated that there are no underlying sand and gravels at this point, and proved till to bedrock at 2.1m. This suggests that the terrace feature could have been cut into an existing glacial till and no terrace deposits were laid down, or the terrace deposits have since been eroded, perhaps leaving pockets within undulations in the till surface. Further research is required to build a better understanding of this river terrace.

18.6 RIVER TERRACE DEPOSITS OF THE UPPER REACHES OF THE OUSE (AND TRIBUTARIES)

- **BH22 [470805 230351]**

BH22 was drilled on the 1st river terrace deposit of the Ouse. It encountered no river terrace deposits, and proved glacial till to bedrock at 3m. As with BH20 this could be due to a number of reasons; the terrace feature could have been cut into an existing glacial till and no terrace deposits were laid down, or the terrace deposits have since been eroded, perhaps leaving pockets within undulations in the till surface. Further research is required to build a better understanding of this river terrace.

- **BH27 [474764 248675]**

BH27 was drilled in an area mapped as river terrace deposit (undifferentiated) within the Tove valley. It recovered no river terrace deposits, and penetrated glacial till to bedrock at 2.3m. As with BH20 and BH27 this could be due to a number of scenarios; the terrace feature could have been cut into an existing glacial till and no terrace deposits were laid down, or the terrace deposits have since been eroded, perhaps leaving pockets within undulations in the till surface. Further research is required to build a better understanding of this river terrace.

18.7 RIVER TERRACE DEPOSITS OF THE UPPER REACHES OF THE RIVER ISE

- **BH38 [474077 282537]**

BH38 was drilled on the 1st river terrace deposit, within 5 metres of the higher 2nd river terrace. However, no potential resource was proved, only 2.5m of glacial till overlying bedrock. This could be due to a number of scenarios; the terrace feature could have been cut into an existing glacial till and no terrace deposits were laid down, or the terrace deposits have since been eroded, perhaps leaving pockets within undulations in the till surface.

- **BH39 [472265 282673]**

BH38 was drilled on the 1st river terrace deposit. No potential resource was encountered, with 2.3m of glacial till overlying bedrock, very similar to close by BH38. This could be due to a number of scenarios; the terrace feature could have been cut into an existing glacial till and no terrace deposits were laid down, or the terrace deposits have since been eroded, perhaps leaving pockets within undulations in the till surface.

18.8 RIVER TERRACE DEPOSITS OF THE WELLAND VALLEY

- **BH40 [468570 284508]**

BH40 was drilled on the 1st river terrace deposit of the Welland Valley. No potential resource was proved, only glacial till overlying bedrock. Bedrock was struck at 1.6m. The lack of river terrace deposits could be due to a number of reasons; the terrace feature could have been cut into an existing glacial till and no terrace deposits were laid down, or the terrace deposits have since been eroded, perhaps leaving pockets within undulations in the till surface.

- **BH41 [472093 286494]**

BH41 was drilled on alluvium overlying the 1st river terrace deposit of the Welland Valley. No potential resource encountered, with glacial till overlying bedrock at 2.1m depth. The lack of river terrace deposits could be due to a number of reasons; the terrace feature could have been cut into an existing glacial till and no terrace deposits were laid down, or the terrace deposits have since been eroded, perhaps leaving pockets within undulations in the till surface.

- **BH47 [477135 293513]**

BH47 was drilled on alluvium overlying the 1st river terrace deposit of the Welland Valley, upstream of BH40 and BH41. No potential resource was recovered, with glacial till overlying bedrock. Bedrock was identified at 1.8m. The lack of river terrace deposits could be due to a number of reasons; the terrace feature could have been cut into an existing glacial till and no terrace deposits were laid down, or the terrace deposits have since been eroded, perhaps leaving pockets within undulations in the till surface.

18.9 RIVER TERRACE DEPOSITS IN THE AVON AND LEAM VALLEYS

- **BH43 [459712 279238]**

BH43 was drilled on the 2nd river terrace deposits of the upper reaches of the River Avon. No potential resource was penetrated, with glacial till overlying bedrock. Bedrock was struck at 1.4m. The lack of river terrace deposits could be due to one of two reasons; the terrace feature could have been cut into an existing glacial till and no terrace deposits were laid down, or the terrace deposits have since been eroded, perhaps leaving pockets within undulations in the till surface.

- **BH44 [451514 265708]**

BH44 was drilled on 2nd river terrace deposits in the upper reaches of the River Leam. No potential resource was recovered, with glacial till overlying bedrock. Bedrock was identified at 1.2m. The lack of river terrace deposits could be due to a number of reasons; the terrace feature could have been cut into an existing glacial till and no terrace deposits were laid down, or the terrace deposits have since been eroded, perhaps leaving pockets within undulations in the till surface.

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 26/07/06 End date: 28/07/06	Terminal depth (m): 15.00m	Borehole No: MKSM BH1
Location: Rolleston Hall 1		Easting: 472716	Northing: 300209
Elevation (m OD): 183.6	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL with flint and chalk	183.6		0 (0.7)			Waste	
TILL: (D) Firm Brown boulder clay (TILL)	182.9		0.7 (2.2)	D D		Waste	
TILL: (D) Firm grey boulder clay (TILL)	180.7		2.9 (0.9)	D		Waste	
C: (D) Firm/stiff grey CLAY with small traces of gravel and chalk	179.8		3.8 (8.2)	D D D D D D D D		Waste	
C: (D) Stiff grey CLAY with traces of flint gravel and chalk	171.6		12 (1.5)	D		Waste	
MUDSTONE: (D) Stiff grey LIAS CLAY	170.1		13.5	D D			
END OF BOREHOLE	168.6		15	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
- Overburden
- Resource
- Waste

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SK70SW90	Sheet No: 1 of 1

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 10/08/06 End date: 11/08/06	Terminal depth (m): 13.00m	Borehole No: MKSM BH1A
Location: Rolleston Hall 2		Easting: 472671	Northing: 300188
Elevation (m OD): 184.3	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL with flint gravel	184.3		0 (0.5)			Overburden	
CS: (D) Brown sandy CLAY with flint gravel	183.8		0.5 (2.4)	D D D		Overburden	
CSZ: (D) Soft silty sandy CLAY	181.4		2.9 (1.4)	D D		Overburden	
SAGR: (D) Fine brown SAND and GRAVEL	180		4.3 (1.6)	B (4.30 to 5.90)	B1 Brownish grey clayey very gravelly SAND.	Resource	
TILL: (D) Brown/grey boulder clay (TILL)	178.4		5.9 (0.4)			Waste	
TILL: (D) Stiff grey boulder clay (TILL)	178		6.3 (2.2)	D D D		Waste	
TILL: (D) Stiff grey boulder clay (TILL)	175.8		8.5 (3.3)	D D D		Waste	
MUDSTONE: (D) Stiff grey MUDSTONE	172.5		11.8 (1.2)	D			
END OF BOREHOLE	171.3		13	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
Overburden
Resource
Waste

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SK70SW91	Sheet No: 1 of 1

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 01/08/06 End date: 01/08/06	Terminal depth (m): 18.75	Borehole No: MKSM BH2
Location: Noseley Hall		Easting: 473166	Northing: 299104
Elevation (m OD): 177.9	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) Brown TOPSOIL	177.9 177.7	0 0.2				
CV: (D) Brown CLAY with small gravel	177.5	0.4	D D			
TILL: (D) Firm Brown boulder clay (TILL)		(3.9)	D D D			
TILL: (D) Firm /stiff grey boulder clay (TILL)	173.6	4.3	D D U100 (6.00-6.46) D D D/SD (8.00-8.45) D SD (10.00-10.40) D D SD (12.00-12.40) D SD (14.00-14.40) D SD (16.00-16.40) D SD (18.00-18.40) D			32 21 (S) 34 (S) 31 (S) 38 (S) 36 (S) 44 (S)
		(14.45)				
END OF BOREHOLE	159.15	18.75				

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
Overburden
Resource
Waste

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP79NW2	Sheet No: 1 of 1

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Start date: 10/08/06	**Terminal depth (m):** 10.00	**Borehole No:** MKSM BH3	
End date: 10/08/06			
Location: Glooston Lodge, Goadby		**Easting:** 474849	**Northing:** 297156
Elevation (m OD): 142.9	**Drilling Company:** Williams Bros. Drilling		
Borehole diameter: 150mm	**Case diameter:** 150mm	**Drilling Method:** Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) Sandy TOPSOIL	142.9		0 (0.4)				
TILL: (D) Brown boulder clay (TILL)	142.5		0.4 (0.6)	D			
CSV: (D) Brown sandy CLAY with flint gravel	141.9		1 (1.9)	D D			
CS: (D) Brown very sandy CLAY	140		2.9 (1.9)	D D			
TILL: (D) Firm grey boulder clay (TILL)	138.1		4.8 (0.9)	D			
SAGR: (D) Fine brown SAND and GRAVEL with large cobbles	137.2		5.7 (1.2)	B (5.70-6.90)	B1 Yellowish brown very clayey very sandy GRAVEL		
TILL: (D) stiff grey boulder clay (TILL)	136		6.9 (1.7)	D D			
LIMESTONE: (D) Grey LIMESTONE (MARLSTONE ROCK FORMATION)	134.3		8.6 (1.4)	D			
END OF BOREHOLE	132.9		10	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
Overburden
Resource
Waste

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Project: MKSM	
Client: MIRO	
SOBI No: SP79NW3	**Sheet No:** 1 of 1

British Geological Survey	Start date: 02/08/06	Terminal depth (m): 15.00m	Borehole No: MKSM BH4
	End date: 02/08/06		

Location: Keythorpe Lodge		Easting: 477047	Northing: 298357
Elevation (m OD): 162.5	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	162.5	0 (0.6)			Waste	
C: (E) Soft brown clay. Weathers to brown mottled dark greyish brown slightly gravelly clay with occasional sub-angular oolitic limestone cobbles.	161.9	0.6 (0.7)	D		Waste	
CV: (E) Stiff very dark greyish brown (10YR 3/2) slightly gravelly CLAY. Gravel is subangular to subrounded fine to coarse yellow oolitic limestone, very dark grey mudstone (chalmouth/ lower lias), occasional medium weathered red sandstone, chalk, and dark grey (10YR 4/1) mudstone. amorphous hard coal, flint, rare medium grained chalcopyrite or pyrite.	161.2	1.3 (12.3)	D; D; D/U 100 (3.00-3.45); D; D; D; D; D; U100 (8.00-8.45); D; D; D; U100 (11.00-11.45); D; D; SD (12.00-12.45); D		Waste	40; 42; 44; 23 (S)
MUDSTONE: (D) Grey weathered MUDSTONE (WHITBY MUDSTONE FORMATION)	148.9	13.6 (1.4)	D; SD (14.00-14.45)			20 (S)
END OF BOREHOLE	147.5	15	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
Overburden
Resource
Waste

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP79NE/8	Sheet No: 1 of 1

British Geological Survey	Start date: 03/08/06	Terminal depth (m): 15.50	Borehole No: MKSM BH5
NATURAL ENVIRONMENT RESEARCH COUNCIL	End date: 04/08/06		

Location: Cock Abingdon Farm	Easting: 476370	Northing: 296733
Elevation (m OD): 153.5	Drilling Company: Williams Bros. Drilling	
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
CSV: (D) Brown sandy CLAY with small gravel	177.9		0 (0.3)			Overburden	
TILL: (D) Light brown boulder clay (TILL)	177.6		0.3 (1.4)	D D		Overburden	
TILL: (D) Dark brown boulder clay (TILL)	176.2		1.7 (2.6)	D D D		Overburden	
TILL: (D) Firm grey boulder clay with small cobbles (TILL)	173.6		4.3 (2.4)	D D D D		Overburden	
TILL: (D) Stiff grey boulder clay with light brown traces (TILL)	171.2		6.7 (0.6)	D		Overburden	
CSV: (D) Brown very sandy CLAY with small gravel	170.6		7.3 (0.6)	D		Overburden	
SAGR: (D) Fine brown SAND and GRAVEL	170		7.9 (0.7)	B (7.90-8.50)	b1 Grey clayey, very sandy GRAVEL	Resource	
TILL: (D) Stiff grey boulder clay (TILL)	169.3		8.6 (3.4)	D D D		Waste	
TILL: (D) Stiff grey boulder clay (TILL)	165.9		12 (2.2)	D D D		Waste	
SILTSTONE: (D) Grey SILTSTONE	163.7		14.2 (1.1)	D			
SANDSTONE: (D) Grey SANDSTONE	162.6		15.3	D			
END OF BOREHOLE	162.4		15.5				

Remarks:

Mineral Key: Overburden, Resource, Waste

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP79NE/9	Sheet No: 1 of 1

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 21/07/06 End date: 24/07/06	Terminal depth (m): 19.00m	Borehole No: MKSM BH6
Location: Thistle House Farm		Easting: 470954	Northing: 297821
Elevation (m OD): 162.4	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) Brown TOPSOIL	162.4		0 (0.7)				
C: (D) Stiff brown CLAY with coal traces	161.7		0.7 (2.2)	D D			
TILL: (D) Stiff grey boulder clay with chalk traces (TILL)	159.5		2.9 (16.1)	D D SD (4.00-4.45) D D D D D D D D D D D D D D			26 (S)
END OF BOREHOLE	143.4		19	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
Overburden
Resource
Waste

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP79NW4	Sheet No: 1 of 1

British Geological Survey	Start date: 24/07/06	Terminal depth (m): 16.00m	Borehole No: MKSM BH7
	End date: 26/07/06		

Location: Chestnuts Farm, Burton Overy	Easting: 468628	Northing: 298200

Elevation (m OD): 150.1	Drilling Company: Williams Bros. Drilling

Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	150.1		0 (0.8)				
TILL: (D) Brown boulder clay with grey traces (TILL)	149.3		0.8 (3.5)	D	(E) Firm to stiff dark yellowish brown (10YR 4/4) slightly gravelly CLAY. Gravel is fine to medium subrounded to sub angular flint, chalk (fine grained), mudstone, limestone. This is probably weathered Oadby Till.		
				D	(E) Firm to stiff brown (10YR 4/3) slightly gravelly CLAY. Gravel is fine to medium subrounded to sub angular flint, chalk (fine grained), mudstone, limestone. This is probably weathered Oadby Till.		
				D	(E) Very stiff very dark greyish brown (10YR 3/2) slightly gravelly CLAY. Gravel is angular to sub angular fine to coarse flint, rounded to subrounded fine to coarse soft chalk and subangular to subrounded medium dark gray crystalline limestone, and medium dark grey mudstone.		
TILL: (D) Stiff grey boulder clay with large sandstone cobbles (TILL) (continued on page 2)	145.8		4.3 (6)	D	(E) Very stiff very dark greyish brown (10YR 3/2) slightly gravelly CLAY. Gravel is angular to sub angular fine to coarse flint, rounded to subrounded fine to coarse soft chalk and subangular to subrounded medium dark grey crystalline limestone, and medium dark grey mudstone, occasional coarse gravel sized brown silt and medium oolitic limestone		
				D	(E) Mottled very dark greyish brown (10YR 3/2) to dark greyish brown (10YR 3/1) slightly gravelly CLAY. Gravel is angular to sub angular fine to coarse flint, rounded to subrounded fine to coarse soft chalk and subangular to subrounded medium dark grey crystalline limestone, and medium dark grey mudstone, occasional coarse gravel sized brown silt and medium oolitic limestone		
				D	(E) Mottled very dark greyish brown (10YR 3/2) to dark		
				D			
				D			

Remarks:

Mineral Key: Overburden, Resource, Waste

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP69NE/100	Sheet No: 1 of 2

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Start date: 24/07/06	**Terminal depth (m):** 16.00m		**Borehole No:** MKSM BH7
End date: 26/07/06			
Location: Chestnuts Farm, Burton Overy		**Easting:** 468628	**Northing:** 298200
Elevation (m OD): 150.1	**Drilling Company:** Williams Bros. Drilling		
Borehole diameter: 150mm	**Case diameter:** 150mm	**Drilling Method:** Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
				D	greyish brown (10YR 3/1) slightly gravelly CLAY. Gravel is angular to sub angular fine to coarse flint, rounded to subrounded fine to coarse soft chalk and subangular cobbles of moderatly strong crystalline limestone with spary bivalve fossils and vugs and medium dark grey mudstone, occasional coarse gravel sized brown silt and medium oolitic limestone		
				D			
TILL: (D) Grey brown boulder clay with red sand bands (TILL)	139.8		10.3 (0.20)	U100 (10.30-10.70)			
TILL: (D) Stiff grey boulder clay with sandstone cobbles (TILL)	139.6		10.5 (1)	SD (10.75-11.20)	(E) Mottled very dark greyish brown (10YR 3/2) to dark greyish brown (10YR 3/1) slightly gravelly CLAY. Gravel is angular to sub angular fine to coarse flint, rounded to subrounded fine to coarse soft chalk and subangular cobbles of moderatly strong crystalline limestone with spary bivalve fossils and vugs and medium dark grey mudstone, occasional coarse gravel sized brown silt and medium oolitic limestone. Very closely spaced thinly laminated dark yellowish brown fine sand, and the gravel includes fine gravel sized angular (blocky) coal and rounded medium quartz (carboniferous material).		49
							41
TILL: (D) Stiff grey clay with large sandstone cobbles (TILL)	138.6		11.5 (4.5)	D			
				D			
				D			
				D			
				SD (15.00-15.40)			
END OF BOREHOLE	134.1		16				

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
Overburden
Resource
Waste

Logged by: A Nuttall
Project: MKSM
Client: MIRO
SOBI No: SP69NE/100
Sheet No: 2 of 2

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 28/07/06 End date: 31/07/06	Terminal depth (m): 18.75	Borehole No: MKSM BH8
Location: opp Bungalow Farm, Kibworth Hall		Easting: 468900	Northing: 295446
Elevation (m OD): 145.7	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	145.7 145.6		0 0.1			Overburden	
MADE GROUND: (D) Brick ash FILL	145.2		0.5 (0.9)			Overburden	
MADE GROUND: (D) Sandy clay FILL	144.3		1.4	B	B1 Orange brown slightly gravelly, very clayey SAND.	Resource	
S: (D) Fine brown SAND			(1.1)			Resource	
CS: (D) Brown sandy CLAY	143.2		2.5 (1.8)	D D D		Waste	
TILL: (D) Firm brown boulder clay (TILL)	141.4		4.3 (0.5)	D		Waste	
TILL: (D) firm/stiff grey boulder clay (TILL)	140.9		4.8 (5.2)	D D D D D		Waste	
TILL: (D) Stiff grey boulder clay with sandstone (probably crystalline limestone D BOON) cobbles (TILL)	135.7		10 (8.75)	D U100 (11.00-11.40) D D D D D D D D		Waste	37
END OF BOREHOLE	126.95		18.75	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
- Overburden
- Resource
- Waste

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP69NE/101	Sheet No: 1 of 1

British Geological Survey	Start date: 09/08/06	Terminal depth (m): 13.00m	Borehole No: MKSM BH9
	End date: 09/08/06		

Location: nr telecom mast, Tur Langton	Easting: 471681	Northing: 294153
Elevation (m OD): 131	Drilling Company: Williams Bros. Drilling	
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL with flint gravel	131		0 (0.5)			Waste	
CSV: (D) Sandy CLAY with flint gravel	130.5		0.5 (0.5)			Waste	
TILL: (D) brown stiff boulder clay (TILL)	130		1 (0.5)	D		Waste	
CSV: (D) Brown sandy CLAY with flint gravel	129.5		1.5 (0.3)	D		Waste	
TILL: (D) Firm brown boulder clay (TILL)	129.2		1.8 (0.9)	D		Waste	
TILL: (D) Stiff grey boulder clay (TILL)	128.3		2.7 (8.1)	D, D, D, D, D, D, D, D, D		Waste	
C: (D) Stiff grey CLAY	120.2		10.8 (2.2)	B, D		Waste	
END OF BOREHOLE	118		13	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key: Overburden, Resource, Waste

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP79SW/10	Sheet No: 1 of 1

British Geological Survey (Natural Environment Research Council)	Start date: 02/08/06	Terminal depth (m): 4.50m	Borehole No: MKSM BH10
	End date: 02/08/06		
Location: Ferrels Wood, Red Lodge Farm		Easting: 494064	Northing: 293968
Elevation (m OD): 78.2	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
Z: (E) Compact dark yellowish brown slightly gravelly SILT, with medium gravel sized black carbonised roots. (TOPSOIL)	78.2		0 (1.4)	D D		Overburden	
CZ: (E) Firm dark yellowish brown (10YR 4/4) silty slightly gravelly CLAY. Gravel is very rounded medium to coarse dark grey spary limestone	76.8		1.4 (1)	D U100 (2.00-2.45)		Overburden	
SAGR: (E) Yellowish brown slightly clayey SAND and GRAVEL. Medium sand (mostly ooids), gravel is subangular tabular ironstone (Northampton sands Fm).	75.8		2.4 (1.1)	D D (2.50-2.95) B (3.00-3.50)	B1 Brown clayey very gravelly SAND	Resource	40 10 (C)
SAGR: (E) Yellowish brown slightly clayey SAND and GRAVEL. Medium sand (mostly ooids), gravel is subangular tabular ironstone (Northampton sands Fm) with clayey laminations.	74.7		3.5 (0.5)			Waste	
LIMESTONE: (E) Moderately weak to strong very pale brown (10YR 7/3) coarse ooidal LIMESTONE (LOWER LINCOLNSHIRE LIMESTONE MEMBER) with medium to very closely spaced very low persistance planar calcite mineral veins.	74.2		4 (0.5)	D D (4.00-4.50)			
END OF BOREHOLE	73.7		4.5				

Remarks:

Mineral Key: Overburden; Resource; Waste

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Logged by: P Williams	
Project: MKSM	
Client: MIRO	
SOBI No: SP99SW1082	Sheet No: 1 of 1

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	**Start date:** 27/07/06 **End date:** 28/07/06	**Terminal depth (m):** 19.00m	**Borehole No:** MKSM BH11A
Location: Bruntingthorpe Aerodrome 1		**Easting:** 459662	**Northing:** 289360
Elevation (m OD): 136.4	**Drilling Company:** Williams Bros. Drilling		
Borehole diameter: 150mm	**Case diameter:** 150mm	**Drilling Method:** Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
MADE GROUND: (D) Stone fill (MADE GROUND)	136.4 136.2		0 0.2				
MADE GROUND: (E) Soft to firm dark yellow brown sandy CLAY. (Made Ground)			(3.2)	D D D D D			
CV: (E) Firm to stiff very dark greyish brown (10YR 3/2) gravelly CLAY. Fine to coarse gravel and cobbles subangular to subrounded flint,chalk, quartz, weathered schist? and coal.	133		3.4 (1.1)	D			
CV: (E) Very stiff very dark greyish brown gravelly CLAY. Gravel consists of medium grained orange sandstone, fine deep red sandstone, grey siltstone and white chalk.	131.9		4.5 (1)	D			
TILL: (D) Stiff brown grey boulder clay (TILL)	130.9 130.6		5.5 (0.3) 5.8	D D U100			
C: (E) Very stiff dark brown (7.5YR 3/2) slightly gravelly CLAY. Fine to medium gravel sized sandstone and chalk.			(2.2)	D/SD (6.50-6.95)			35 23 (S)
C: (D) Stiff grey brown laminated CLAY	128.4		8 (1)	SD (8.50-8.95)			
TILL: (D) Stiff grey boulder clay with chalk gravel (TILL)	127.4		9 (1)				36 (S)
TILL: (D) Stiff grey boulder clay (TILL)	126.4		10 (9)	SD (10.50-10.95) SD (12.50-12.95) SD (14.50-14.95) SD (16.50-16.95) D			22 (S) 28 (S) 22 (S) 35 (C) 42 (C)
END OF BOREHOLE	117.4		19				

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
- Overburden
- Resource
- Waste

Logged by: P Williams	
Project: MKSM	
Client: MIRO	
SOBI No: SP58NE/20	**Sheet No:** 1 of 2

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 01/08/06 End date: 02/08/06	Terminal depth (m): 19.00m	Borehole No: MKSM BH11B
Location: Bruntingthorpe Aerodrome 2		Easting: 457864	Northing: 287578
Elevation (m OD): 136.1	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	136.1	0 (0.5)	D		Overburden	
C: (D) CLAY	135.6	0.5 (2.5)	D D D		Overburden	
CS: (D) Firm grey sandy CLAY	133.1	3 (1)	D U100 (3.10-3.55) D		Overburden	30
TILL: (D) Stiff grey boulder clay (TILL)	132.1	4 (3)	D D D		Overburden	
S: (D) Fine brown SAND and GRAVEL with large cobbles	129.1	7 (0.8)	B	B1 Dark brown clayey, very sandy GRAVEL.	Resource	
TILL: (D) Stiff grey boulder clay with chalk (TILL)	128.3	7.8 (6.2)	D D D D D D		Waste	
TILL: (D) Very stiff grey boulder clay with chalk (TILL)	122.1	14 (5)	D D D D D		Waste	
END OF BOREHOLE	117.1	19	D			

Remarks:

Mineral Key: Overburden, Resource, Waste

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Logged by: P Williams	
Project: MKSM	
Client: MIRO	
SOBI No: SP58NE/21	Sheet No: 1 of 2

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 21/07/08 End date: 21/07/08	Terminal depth (m): 19.00m	Borehole No: MKSM BH12
Location: Moorbarns Farm 1		Easting: 452989	Northing: 283358
Elevation (m OD): 118.7	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	118.7	0 (0.3)			Overburden	
SAGR: (D) Fine brown SAND and GRAVEL	118.4	(1.5)	B (0.30-1.00)	B1 Brown gravelly very clayey SAND	Resource	
CS: (D) Firm brown sandy CLAY	116.9	1.8 (0.8)	D		Waste	
SAGR: (D) Fine brown SAND and GRAVEL with small clay bands.	116.1	2.6 (5.3)	B B (3.00-5.00) B (5.00-7.00)	B2 Orange brown clayey very sandy GRAVEL B3 Brown clayey very gravelly SAND. B4 Brown clayey very sandy GRAVEL	Resource	
TILL: (D) Firm brown boulder clay (TILL)	110.8	7.9 (0.9)	D		Waste	
TILL: (D) Stiff grey boulder clay (TILL)	109.9	8.8 (9.8)	D D D D D D D D D D		Waste	
COBBLE: (D) Large COBBLE	100.1	18.6 (0.4)				
END OF BOREHOLE	99.7	19				

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key: Overburden, Resource, Waste

Logged by: P Williams	
Project: MKSM	
Client: MIRO	
SOBI No: SP58SW161	Sheet No: 1 of 2

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 25/07/06 End date: 25/07/06	Terminal depth (m): 16.70m	Borehole No: MKSM BH12B
Location: Moorbarns Farm 2		Easting: 452994	Northing: 283355
Elevation (m OD): 118.8	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: SP58SW/162	Drilling Method: Cable Percussion	

Description	Level (m OD)	Depth (thick) (m)	Samples	Sample Description	SPT N
(D) TOPSOIL	118.8 118.6	0 0.2			
SAGR: (D) Fine brown SAND and GRAVEL with small clay bands		(8.5)	B (0.20-2.00)	B1 Reddish brown clayey gravelly SAND	
			B (2.00-4.00)	B2 Brown very clayey very gravelly SAND	
			B (4.00-6.00)	B3 Orange brown clayey very gravelly SAND	
			B (6.00-8.00)	B4 Brown very clayey very sandy GRAVEL	
TILL: (D) Stiff grey boulder clay (TILL)	110.1	8.7 (7.8)	D DS/U100 (9.00-9.45) D U100 (11.50-11.95) DS (12.00-12.45) D DS (14.00-14.45) D D		40 34 (S) 60 69 (C) 41 (C)
LIMESTONE: (D) Limestone (LIMESTONE OF BLUE LIAS)	102.3 102.1	16.5 16.7	D		50+
END OF BOREHOLE					

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
Overburden
Resource
Waste

Logged by: P Williams	
Project: MKSM	
Client: MIRO	
SOBI No: Default Listing	Sheet No: 1 of 1

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 19/07/06 End date: 20/07/06	Terminal depth (m): 25.00m	Borehole No: MKSM BH13
Location: Usher Farm		Easting: 457670	Northing: 285948
Elevation (m OD): 133.5	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	133.5		0 (0.6)			Overburden	
TILL: (D) Firm brown boulder clay (TILL)	132.9		0.6 (5)	D	(E) Stiff to very stiff dark yellowish brown (10YR 4/4) very sandy CLAY with occasional (2%) medium to coarse gravel sized subrounded white chalk, buff yellow (Mid Jurassic) oolitic limestone, sandstone.	Overburden	
				D	(E) Stiff to very stiff dark yellowish brown (10YR 4/4) very sandy CLAY with occasional (2%) medium to coarse gravel sized subrounded white chalk, buff yellow (Mid Jurassic) oolitic limestone, sandstone and subangular flint cobbles.	Overburden	
				D	(E) Very stiff very dark greyish brown (10YR 3/2) SILT/CLAY. Occasional medium to coarse gravel sized sub-angular flint, chalk.	Overburden	
				D	(E) Very stiff very dark greyish brown (10YR 3/2) SILT/CLAY. Occasional medium to coarse gravel sized sub-angular flint, chalk and medium gravel sized angular very weak very dark grey (7.5YR 3/1) mudstone	Overburden	
				D	(E) Very stiff very dark greyish brown (10YR 3/2) SILT/CLAY. Occasional medium to coarse gravel sized sub-angular flint, chalk and medium gravel sized angular very weak very dark grey (7.5YR 3/1) mudstone containing 10mm diameter bivalves	Overburden	
TILL: (D) Very stiff brown boulder clay with large cobbles (TILL)	127.9		5.6 (1.8)	D	(E) Very stiff very dark greyish brown (10YR 3/2) SILT/CLAY. Occasional medium to coarse gravel sized sub-angular flint, chalk and medium gravel sized angular very weak very dark grey (7.5YR 3/1) mudstone containing 10mm diameter bivalves, and medium rounded quartz gravel.	Overburden	
				D		Overburden	
TILL: (D) Light brown boulder clay with large snadstone cobbles (TILL)	126.1		7.4 (0.5)	D		Overburden	
TILL: (D) Stiff grey boulder clay (TILL) (continued on page 2)	125.6		7.9 (1.1)	D	(E) Very stiff very dark greyish brown (10YR 3/2) SILT/CLAY. Occasional medium to coarse gravel sized sub-angular flint, chalk and medium gravel sized angular very weak very dark	Overburden	

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key: Overburden, Resource, Waste

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP58NE/22	Sheet No: 1 of 3

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 19/07/06	Terminal depth (m): 25.00m	Borehole No: MKSM BH13
	End date: 20/07/06		

Location: Usher Farm	Easting: 457670	Northing: 285948

Elevation (m OD): 133.5	Drilling Company: Williams Bros. Drilling

Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
					grey (7.5YR 3/1) mudstone containing 10mm diameter bivalves, and coarse sub-rounded quartz gravel (bunter) and occasional medium gravel sized uncompact light brown (7.5YR 6/3) silt and coarse gravel of 'strong' micritic limestone (possibly carboniferous).		
SAGR: (D) Very dense brown SAND with small gravel and sandstone cobbles	124.5		9	B (9.00-10.00)			
				B (10.00-11.00)	B1 Soft brown very clayey very sandy GRAVEL		
					B2 Brown clayey sandy GRAVEL with cobbles.		
				B (12.00-14.00)	B3 Brown clayey very sandy GRAVEL		
			(6.9)				
				B (14.00-16.00)	B4 Dark brown clayey very gravelly SAND		
S: (D) Fine brown SAND (continued on page 3)	117.6		15.9	B (16.00-18.00)			

Remarks:

Mineral Key:
- Overburden
- Resource
- Waste

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP58NE/22	Sheet No: 2 of 3

British Geological Survey (Natural Environment Research Council)	Start date: 19/07/06	Terminal depth (m): 25.00m	Borehole No: MKSM BH13
	End date: 20/07/06		
Location: Usher Farm		Easting: 457670	Northing: 285948
Elevation (m OD): 133.5	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
			(2.9)				
S: (D) Fine grey SAND with silty sand bands	114.7		18.8	D			
			(6.2)				
END OF BOREHOLE	108.5		25				

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
- Overburden
- Resource
- Waste

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP58NE/22	Sheet No: 3 of 3

British Geological Survey	Start date: 07/08/06	Terminal depth (m): 2.50m	Borehole No: MKSM BH15
	End date: 07/08/06		
Location: Manor Farm Pertenhall		Easting: 508655	Northing: 264647
Elevation (m OD): 33.6	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	33.6		0 (0.7)			Waste	
TILL: (D) Firm browm boulder clay (TILL)	32.9		0.7 (0.3)	D		Waste	
C: (D) Firm brown CLAY	32.6		1 (0.6)	D		Waste	
MUDSTONE: (D) Weathered grey MUDSTONE (OXFORD CLAY FORMATION)	32		1.6 (0.9)	D			
END OF BOREHOLE	31.1		2.5	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key: Overburden, Resource, Waste

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: TL06SE/22	Sheet No: 1 of 1

British Geological Survey	Start date: 26/07/06	Terminal depth (m): 5.50m	Borehole No: MKSM BH16
	End date: 26/07/06		

Location: Milton Ernest	Easting: 500540	Northing: 256444
Elevation (m OD): 37.6	Drilling Company: Williams Bros. Drilling	
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	37.6		0 (0.3)			Overburden	
TILL: (D) Firm brown sandy boulder clay with gravels (TILL)	37.3		0.3 (0.7)	D D		Overburden	
SAGR: (D) Fine brown SAND with river bed gravels	36.6		1 (2.2)	D B (1.00-3.00)	B1 Brown sandy slightly clayey GRAVEL with cobbles.	Resource	
CZ: (D) Dark gey silty CLAY	34.4		3.2 (2.3)	D D D		Waste	
END OF BOREHOLE	32.1		5.5	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
- Overburden
- Resource
- Waste

Logged by: P Williams	
Project: MKSM	
Client: MIRO	
SOBI No: TL05NW19	Sheet No: 1 of 1

British Geological Survey	Start date: 07/08/06	Terminal depth (m): 5.00m	Borehole No: MKSM BH17
	End date: 07/08/06		

Location: Victoria Farm	Easting: 494600	Northing: 255833
Elevation (m OD): 43.5	Drilling Company: Williams Bros. Drilling	
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	43.5		0 (0.1)			Overburden	
CV: (D) Firm brown gravelly CLAY	43.4		0.1 (0.7)	D		Overburden	
SAGR: (D) Fine brown SAND and GRAVEL	42.7		0.8 (2)	D B (1.00-2.80)	B1 Brown clayey very gravelly SAND	Resource	
MUDSTONE: (D) Stiff grey LIAS CLAY	40.7		2.8 (2.2)	D D			
END OF BOREHOLE	38.5		5	D			

Remarks:

Mineral Key:
Overburden
Resource
Waste

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Logged by: P Williams	
Project: MKSM	
Client: MIRO	
SOBI No: SP95NW11	Sheet No: 1 of 1

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 08/08/06 End date: 08/08/06	Terminal depth (m): 6.00m	Borehole No: MKSM BH19
Location: The Villas Nursery		Easting: 514506	Northing: 252390
Elevation (m OD): 20.7	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	20.7		0 (0.3)	D		Overburden	
CSV: (D) Firm brown sandy CLAY with gravels	20.4		0.3 (0.45)	D		Overburden	
SAGR: (D) Fine brown SAND and GRAVEL	19.95		0.75 (3.25)	B (0.80-2.80) B (2.80-4.00)	B1 Dark brown sandy slightly clayey GRAVEL B2 Brown sandy slightly clayey GRAVEL	Resource	
MUDSTONE: (D) Stiff grey LIAS CLAY	16.7		4 (2)	D D			
END OF BOREHOLE	14.7		6				

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
Overburden
Resource
Waste

Logged by: P Williams	
Project: MKSM	
Client: MIRO	
SOBI No: TL15SW97	Sheet No: 1 of 1

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 07/08/06 End date: 07/08/06	Terminal depth (m): 3.00m	Borehole No: MKSM BH20
Location: off Spinney Road		Easting: 515393	Northing: 255674
Elevation (m OD): 24.2	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	24.2		0 (0.6)				
C: (D) Brown CLAY	23.6		0.6 (0.3)	D			
TILL: (D) Firm brown boulder clay (TILL)	23.3		0.9 (0.3)	D			
CSV: (D) Brown sandy CLAY with flint gravel	23		1.2 (0.5)	D			
C: (D) Brown/grey CLAY	22.5		1.7 (0.4)	D			
MUDSTONE: (D) Grey weathered MUDSTONE	22.1		2.1 (0.9)	D			
END OF BOREHOLE	21.2		3	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
Overburden
Resource
Waste

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: TL15NE/129	Sheet No: 1 of 1

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Start date: 13/07/06	Terminal depth (m): 14.00m	Borehole No: MKSM BH21	
End date: 14/07/06			
Location: Grange Farm	Easting: 472811	Northing: 231526	
Elevation (m OD): 103.2	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	103.2		0 (0.6)				
C: (D) Brown CLAY with chalk traces	102.6		0.6 (1.2)	D			
C: (D) Firm brown CLAY	101.4		1.8 (1.6)	D D			
S: (D) Fine brown SAND	99.8		3.4 (0.3)	B (3.40-3.70)	B1 Brown slightly gravelly very clayey SAND (non-mineral, >40% fines)		
C: (D) Firm brown CLAY	99.5		3.7 (1.1)	D			
SAGR: (D) Dense brown SAND with small flint gravel	98.4		4.8 (0.8)	B (5.00-5.50)	B2 Brown very clayey SAND and GRAVEL		
SAGR: (D) Dense brown SAND and small/medium GRAVEL	97.6		5.6 (2.4)	B (6.00-6.50) B (7.00-7.50)	B3 Dark brown clayey very sandy GRAVEL B4 Greyish brown sandy very clayey GRAVEL		
SAGR: (D) Dense fine brown SAND with small/medium gravel	95.2		8 (0.8)	B (8.00-8.50)	B5 Brown gravelly slightly clayey SAND		
C: (D) Stiff grey CLAY	94.4		8.8 (0.8)	D			
SAGR: (D) Dense fine brown SAND and small/medium GRAVEL	93.6		9.6 (3)	B (9.70-10.30) B (11.00-11.50) B (12.00-12.50)	B6 Brown clayey very sandy GRAVEL B7 Brown clayey gravelly SAND B8 Brown slightly clayey very sandy GRAVEL		
SAGR: (D) Grey SAND and small/medium GRAVEL	90.6		12.6 (0.3)	B (12.60-12.90)	B9 Brown slightly gravelly CLAY and SAND (non-mineral, >40% fines)		
MUDSTONE: (D) Grey MUDSTONE	90.3		12.9 (1.1)	D			
END OF BOREHOLE	89.2		14	D			

Remarks:

Mineral Key:
Overburden
Resource
Waste

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

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Project: MKSM	
Client: MIRO	
SOBI No: SP73SW115	Sheet No: 1 of 1

British Geological Survey, Natural Environment Research Council	Start date: 08/08/06	Terminal depth (m): 6.50m	Borehole No: MKSM BH22
	End date: 09/08/06		

Location: Lenborough Farm	Easting: 470805	Northing: 230351
Elevation (m OD): 76.8	Drilling Company: Williams Bros. Drilling	
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
	76.8		0				
(D) TOPSOIL	76.7		0.1 (0.1)				
CSV: (D) Firm brown sandy CLAY with gravels			(1.9)	D D		Waste	
CS: (D) Firm grey sandy clay	74.8		2 (1)	D		Waste	
MUDSTONE: (D) Stiff grey LIAS CLAY (KELLAWAYS FORMATION)	73.8		3 (3.5)	D U100 (3.00-3.45) D D D D			40
END OF BOREHOLE	70.3		6.5				

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
- Overburden
- Resource
- Waste

Logged by: P Williams	
Project: MKSM	
Client: MIRO	
SOBI No: SP73SW116	Sheet No: 1 of 1

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 14/07/06 End date: 17/07/06	Terminal depth (m): 18.50m	Borehole No: MKSM BH24
Location: Mursley		**Easting:** 482221	**Northing:** 228824
Elevation (m OD): 157.3	**Drilling Company:** Williams Bros. Drilling		
Borehole diameter: 150mm	**Case diameter:** 150mm	**Drilling Method:** Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	157.3		0 (0.3)				
SAGR: (D) Fine brown SAND and GRAVEL	157		0.3 (0.9)	B	B1 Brown clayey very gravelly SAND		
CV: (D) Firm brown very gravelly CLAY	156.1		1.2	D	(E) Firm dark yellowish brown (10YR 3/6) slightly gravelly sandy CLAY. Medium to coarse subrounded to subangilar flint and sandstone (bunter) gravel		
				B	B2 Orange brown very clayey very sandy GRAVEL (potential resource? <40 % fines)		
				D	(E) stiff multicoloured brown (10YR 5/3) and dark yellowish brown (10YR 4/6) and white slightly sandy gravelly CLAY. Medium to coarse subangular to subrounded gravel and cobbles of flint and chalk and coarse gravel sized weathered orange silt.		
			(4.9)	D	(E) mottled dark yellowish brown (10YR 4/6) and white clayey SAND and GRAVEL. Sand is medium to coarse subrounded, gravel is fine to coarse subangular chalk, flint		
				D	(E) mottled dark yellowish brown (10YR 4/6) and white, clayey SAND and GRAVEL. Sand is medium to coarse subrounded, gravel is fine to coarse subangular chalk, flint		
SAGR: (D) Fine brown SAND and GRAVEL	151.2		6.1	B (6.20-7.00)	(E) mottled dark yellowish brown (10YR 4/6) and white, slightly clayey SAND and GRAVEL. Sand is fine to medium subrounded to subangular, gravel is fine to coarse flint, chalk, flint and occasional molluscs (gryphea)		
				B	B3 Dark brown clayey very sandy GRAVEL. E): Mottled dark yellowish brown (10YR 4/6) and white, clayey SAND and GRAVEL. Sand is medium to coarse subrounded, gravel is fine to coarse subangular chalk, flint and limestone		
				B	B4 Brown clayey very sandy GRAVEL. (E): Mottled dark yellowish brown (10YR 4/6)		

Remarks:

Mineral Key: Overburden, Resource, Waste

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Logged by: P Williams	
Project: MKSM	
Client: MIRO	
SOBI No: SP82NW42	**Sheet No:** 1 of 2

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 14/07/06 End date: 17/07/06	Terminal depth (m): 18.50m	Borehole No: MKSM BH24
Location: Mursley		Easting: 482221	Northing: 228824
Elevation (m OD): 157.3	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
					and white, very clayey SAND and GRAVEL. Sand is medium to coarse subrounded, gravel is fine to coarse subangular chalk, flint and limestone		
			(7.8)	D			
					B5 Brown clayey very sandy GRAVEL. (E): Mottled dark yellowish brown (10YR 4/6) and white, very clayey SAND and GRAVEL. Sand is medium to coarse subrounded, gravel is fine to coarse subangular chalk, flint and limestone		
				D			
				D	(E) mottled dark yellowish brown (10YR 4/6) and white, very clayey SAND and GRAVEL. Sand is medium to coarse subrounded, gravel is fine to coarse subangular chalk, flint and limestone		
				D	(E) stiff mottled dark yellowish brown (10YR 3/6) and white gravelly sandy CLAY (TILL)		
				B	B6 Dark brown clayey very sandy GRAVEL		
TILL: (D) Stiff brown boulder clay (TILL)	143.4		13.9 (0.4)	D			
TILL: (D) Very stiff grey boulder clay (TILL)	143		14.3				
				D			
				D			
			(4.2)				
				D			
				D			
END OF BOREHOLE	138.8		18.5				

Remarks:

Mineral Key:
- Overburden
- Resource
- Waste

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

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Project: MKSM	
Client: MIRO	
SOBI No: SP82NW42	Sheet No: 2 of 2

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 29/08/06 End date: 29/08/06	Terminal depth (m): 3.50m	Borehole No: MKSM BH27
Location: Home Farm, Stoke Bruerne		Easting: 474764	Northing: 248675
Elevation (m OD): 76.5	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
MADE GROUND: (D) Brick and black ash (FILL)	76.5		0 (1)				
TILL: (D) Firm brown boulder clay (TILL)	75.5		1 (0.9)	D B (1.00-1.50)	B1 Dark yellowish brown sandy gravelly CLAY		
C: (D) Grey/brown CLAY	74.6		1.9 (0.4)	D			
MUDSTONE: (D) Grey MUDSTONE	74.2		2.3 (1.2)	D D			
END OF BOREHOLE	73		3.5	D			

Remarks:

Mineral Key:
- Overburden
- Resource
- Waste

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP74NW12	Sheet No: 1 of 1

British Geological Survey — Natural Environment Research Council	Start date: 19/07/06	Terminal depth (m): 15.50m	Borehole No: MKSM BH28
	End date: 19/07/06		
Location: Sparrow Lodge		Easting: 462659	Northing: 285760
Elevation (m OD): 153.6	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	WS	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	153.6 153.4		0 0.2					
TILL: (D) Stiff brown boulder clay (TILL)			(0.8)		D			
TILL: (D) Firm brown sandy boulder clay (TILL)	152.6		1 (6.9)		D D D D D D D			
V: (D) Iron stone GRAVEL	145.7		7.9 (0.6)		D			
CV: (D) Soft brown very gravelly CLAY	145.1		8.5 (2.8)		D D D			
SAGR: (D) Fine brown SAND and GRAVEL	142.3		11.3 (2.5)		B (11.30-13.30)	B1 Dark brown slightly clayey sandy GRAVEL		
MUDSTONE: (D) Very stiff grey lias clay (BLUE LIAS FORMATION AND CHARMOUTH MUDSTONE FORMATION (UNDIFFERENTIATED))	139.8		13.8 (1.7)	▼	D D			
END OF BOREHOLE	138.1		15.5					

Remarks: Water strike at 14.00m

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
Overburden
Resource
Waste

Logged by: P Williams
Project: MKSM
Client: MIRO
SOBI No: SP68NW/46
Sheet No: 1 of 1

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 17/07/06 End date: 18/07/06	Terminal depth (m): 15.3	Borehole No: MKSM BH29
Location: Larkshill Farm 1		Easting: 486437	Northing: 226987
Elevation (m OD): 138.3	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Depth (thick) (m)
(D) TOPSOIL with small gravel	138.3	0 (0.6)
CS: (D) Brown sandy CLAY with cobbles and chalk traces	137.7	0.6 (1.2)
TILL: (D) Firm brown boulder clay with chalk pieces (TILL)	136.5	1.8 (1.9)
TILL: (D) Firm/stiff grey boulder clay with chalk pieces (TILL)	134.6	3.7 (1.2)
SAGR: (D) Fine grey SAND and small/medium GRAVEL with pieces of chalk	133.4	4.9 (2.6)
SAGR: (D) Grey SAND and small/medium GRAVEL with flint and chalk.	130.8	7.5
COBBLE: (D) Large COBBLE	130.6	7.7 (0.5)
SAGR: (D) Grey SAND and small/medium GRAVEL with flint and chalk with small clay band at 8.20m to 8.50.	130.1	8.2 (5.5)
S: (D) Fine grey SAND with small traces of gravel and chalk	124.6	13.7 (1.1)
SAGR: (D) Fine grey SAND and small/medium GRAVEL with flint and chalk.	123.5	14.8 (0.4)
COBBLE: (D) Large COBBLE	123.1	15.2
END OF BOREHOLE	123	15.3

Samples	Sample Description
D	(E) Firm dark yellowish brown(10YR 4/6) slightly silty CLAY. Occasional medium subrounded to subangular flint gravel (TOPSOIL)
D	(E) Stiff to firm dark yellowish brown (10YR 4/6) slightly gravelly CLAY. Fine to medium subrounded chalk, yellow and blue flint gravel.
D	
D	(E) Stiff brown (10YR 4/3) slightly gravelly CLAY. Fine to medium subrounded chalk, flint, grey mudstone gravel.
B (5.00-7.00)	(E) Stiff very dark greyish brown (10YR 3/2) slightly gravelly CLAY. Fine to coarse subrounded chalk, flint gravel. (Unweathered Oadby Till)
B (7.00-9.00)	B1 Dark brown slightly clayey very sandy GRAVEL
D	B2 Dark grey slightly clayey very sandy GRAVEL
B (9.00-1.00)	B3 Dark grey slightly clayey very sandy GRAVEL with chalk
B (11.00-13.00)	B4 Dark grey slightly clayey SAND and GRAVEL with chalk
B (13.00-15.00)	B5 Grey slightly clayey very sandy GRAVEL

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key: Overburden, Resource, Waste

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP82NE/5	Sheet No: 1 of 1

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 21/08/06	Terminal depth (m): 25.00m	Borehole No: MKSM BH29A
	End date: 24/08/06		
Location: Larkshill Farm 2		Easting: 486207	Northing: 226850
Elevation (m OD): 146.1	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 200/150mm	Case diameter: 200/150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL with flint gravel	146.1		0 (0.9)				
CSV: (D) Brown sandy CLAY with small gravel and flint	145.2		0.9 (2.4)	D B (1.00-1.50) D	B1 Brown very clayey very sandy GRAVEL		
SAGR: (D) Fine brown SAND and flint GRAVEL with large cobbles	142.8		3.3 (3.2)	D B (3.30-5.30)	B2 Dark brown clayey very sandy GRAVEL		
				B (5.30-7.30)	B3 Dark brown slightly clayey very sandy GRAVEL		
SAGR: (D) Fine SAND and GRAVEL with large cobbles	139.6		6.5 (5.6)	B (7.30-9.30)	B4 Brown slightly clayey very sandy GRAVEL		
				B (9.30-11.30)	B5 Brown clayey very sandy GRAVEL		
				B (11.30-13.30)	B6 Orange brown clayey very gravelly SAND		
S: (D) Fine brown SAND with traces of gravel	134		12.1 (1.3)				
S: (D) Fine brown SAND	132.7		13.4 (3.3)	B (13.30-15.30)	B7 Brown clayey SAND with some fine shell fragments		
				B (15.30-17.30)	B8 Dark brown clayey slightly gravelly SAND.		
S: (D) Light brown SAND	129.4		16.7 (3)	B (17.30-19.30)	B9 Dark brown clayey SAND		
TILL: (D) Stiff brown boulder clay (TILL)	126.4		19.7 (5.3)	D B (20.00-20.50) D D D D	B10 Brown gravelly sandy CLAY		
END OF BOREHOLE	121.1		25	D			

Remarks:

Mineral Key:
- Overburden
- Resource
- Waste

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP82NE/6	Sheet No: 1 of 1

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 10/08/06 End date: 14/08/06	Terminal depth (m): 20.00m	Borehole No: MKSM BH30
Location: Rock Lane Farm 1		Easting: 489256	Northing: 224939
Elevation (m OD): 131.3	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	131.3	0			Overburden	
(D) CLAY	131.2	0.1 (2.9)	D U100 (1.00-1.45) D SD (1.50-1.95) D SD (2.50-2.95)		Overburden	35 13 (S)
TILL: (D) Stiff grey boulder clay (TILL)	128.3	3 (0.6)	D U100 (3.00-3.45)		Overburden	14 (S) 45 (U)
SAGR: (D) Fine brown SAND and GRAVEL	127.7	3.6 (1.8)	D/SD (3.50-3.95) B (3.50-5.50) D (4.50-4.95)	B1 Orange brown very clayey very gravelly SAND	Resource	10 (S) 8 (S)
TILL: (D) Stiff brown boulder clay (TILL)	125.9	5.4 (0.6)	U100 (5.50-5.95)		Waste	
TILL: (D) Stiff grey boulder clay (TILL) (continued on page 2)	125.3	6 (6.5)	D/U100 (6.00-6.45) D/SD (6.50-6.95) D SD (7.50-7.95) D SD (8.50-8.95) D SD (9.50-9.95) D		Waste	35 (U) 45 (U) 19 (S) 18 (S) 20 (S) 49 (S)

Remarks:

Mineral Key: Overburden, Resource, Waste

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

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Project: MKSM	
Client: MIRO	
SOBI No: SP82SE/55	Sheet No: 1 of 2

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 10/08/06 End date: 14/08/06	Terminal depth (m): 20.00m	Borehole No: MKSM BH30
Location: Rock Lane Farm 1		Easting: 489256	Northing: 224939
Elevation (m OD): 131.3	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
				SD (10.50-10.95)			65 (S)
				SD (11.50-11.95)			54 (C)
CS: (D) Firm brown sandy CLAY	118.8		12.5	SD (12.50-12.95)			
			(1)	D			12 (S)
SAGR: (D) Fine brown SAND and GRAVEL	117.8		13.5	SD (13.50-13.95)	B2 Dark brown clayey very gravelly SAND		
				B (13.50-15.50)			15 (S)
				SD (14.50-14.95)			26 (S)
				SD (15.50-15.95)	B3 Brown very clayey very gravelly SAND		
				B (15.50-17.50)			28 (S)
			(6.5)	SD (16.50-16.95)			29 (C)
				SD (17.50-17.95)	B4 Brown clayey very gravelly SAND		
				B (17.50-19.50)			28 (C)
				SD (18.50-18.95)			33 (C)
				SD (19.50-19.95)			
END OF BOREHOLE	111.3		20				32 (C)

Remarks:

Mineral Key: Overburden, Resource, Waste

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

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Project: MKSM	
Client: MIRO	
SOBI No: SP82SE/55	Sheet No: 2 of 2

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 24/08/06 End date: 25/08/06	Terminal depth (m): 25.00m	Borehole No: MKSM BH30A
Location: George Farm, Hillesden		Easting: 489256	Northing: 224939
Elevation (m OD): 132.3	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 200/150mm	Case diameter: 200/150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL with small cobbles	132.3	0 (0.6)			Overburden	
TILL: (D) Firm brown boulder clay (TILL)	131.7	0.6 (1.9)			Overburden	
SAGR: (D) Fine brown SAND and GRAVEL	129.8	2.5 (1.9)			Resource	
CSZ: (D) Brown silty sandy CLAY	127.9	4.4 (0.4)			Waste	
TILL: (D) Firm brown boulder clay (TILL)	127.5	4.8 (1.3)			Waste	
TILL: (D) Firm grey boulder clay (TILL)	126.2	6.1 (1.1)			Waste	
S: (D) Fine grey SAND	125.1	7.2 (0.7)			Resource	
TILL: (D) Stiff grey boulder clay (TILL)	124.4	7.9 (6.9)			Waste	
SAGR: (D) Fine brown SAND and GRAVEL	117.5	14.8 (2.8)			Resource	
S: (D) Fine brown SAND	114.7	17.6 (7.4)	B (20.00-22.00)	B1 Dark brown gravelly clayey SAND	Resource	
			B (22.00-24.00)	B2 Brown clayey slightly gravelly SAND	Resource	
END OF BOREHOLE	107.3	25				

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
Overburden
Resource
Waste

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Client: MIRO	
SOBI No: SP82SE/56	Sheet No: 1 of 1

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Start date: 12/07/06	**Terminal depth (m):** 15.50m		**Borehole No:** MKSM BH31
End date: 12/07/06			
Location: Astwell New Park Farm		**Easting:** 462338	**Northing:** 244008
Elevation (m OD): 151.2	**Drilling Company:** Williams Bros. Drilling		
Borehole diameter: 150mm	**Case diameter:** 150mm	**Drilling Method:** Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	151.2		0 (0.5)				
TILL: (D) Firm brown boulder clay (TILL)	150.7		0.5 (3.1)	B	B1 Brown gravelly very sandy CLAY		
TILL: (D) Stiff grey boulder clay (TILL)	147.6		3.6 (0.4)	B (3.60-4.00)	B2 Brown very gravelly very sandy CLAY		
SAGR: (D) Fine brown SAND and GRAVEL	147.2		4 (0.5)				
TILL: (D) Stiff grey boulder clay (TILL)	146.7		4.5 (3.5)	B B	B3 Brown very clayey very sandy GRAVEL B4 Dark grey gravelly very sandy CLAY		
TILL: (D) Very stiff grey boulder clay (TILL)	143.2		8 (7.5)	B B			
END OF BOREHOLE	135.7		15.5				

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
Overburden
Resource
Waste

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Project: MKSM	
Client: MIRO	
SOBI No: SP64SW74	**Sheet No:** 1 of 1

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 12/07/06 End date: 12/07/06	Terminal depth (m): 2.50m	Borehole No: MKSM BH32
Location: Wood Green 1		Easting: 464479	Northing: 238097
Elevation (m OD): 133.7	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	133.7		0 (0.5)				
CV: (E) Stiff brown gravelly CLAY. Medium to coarse flint, quartz, limestone, strong crystalline limestone gravel and cobbles (mainly strong crystalline limestone). Refusal at 2.50m due to cobble.	133.2		0.5 (2)	B (0.50-1.00) U100 (1.00-1.45) D SD (1.50-1.95)			37 11 (S)
END OF BOREHOLE	131.2		2.5				

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
- Overburden
- Resource
- Waste

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP63NW34	Sheet No: 1 of 1

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Start date: 12/07/06	**Terminal depth (m):** 15.00m	**Borehole No:** MKSM BH32A	
End date: 13/07/06			
Location: Wood Green 2	**Easting:** 464493	**Northing:** 238099	
Elevation (m OD): 133.8	**Drilling Company:** Williams Bros. Drilling		
Borehole diameter: 150mm	**Case diameter:** 150mm	**Drilling Method:** Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	133.8		0 (0.5)			Overburden	
TILL: (E) Stiff to very stiff mottled reddy brown and bluey grey slightly gravelly CLAY with occasional cobbles. Gravel includes mollusc shells, white limestone, crystalline (magnesian) limestone and flint (TILL)	133.3		0.5 (4.2)	SD (3.00-3.45)		Overburden	22 (S)
TILL: (E) Very stiff dark blue grey slightly gravelly CLAY with cobbles. Gravel is generally fine to course. Rounded fine chalk gravel and course flint gravel (TILL)	129.1		4.7 (3.3)	B (4.70-5.10) B/U100 (5.10-5.55)		Overburden	41
TILL: (D) Stiff grey boulder clay (TILL)	125.8		8 (3)			Overburden	
SAGR: (D) Dense brown SAND and small flint GRAVEL	122.8		11 (3.4)	B (11.00-11.50)	B4 Grey clayey very gravelly SAND	Resource	
				B (12.00-12.50)	B5 Brown slightly clayey very gravelly SAND	Resource	
				B (13.00-13.50)	B6 Brown clayey very gravelly SAND	Resource	
				B (14.00-14.50)	B7 Dark greyish brown clayey gravelly SAND	Resource	
SAGR: (D) Wet band of SAND and small flint GRAVEL	119.4		14.4			Resource	
TILL: (D) Very stiff grey boulder clay (TILL)	119.2		14.6 (0.4)	B (14.60-15.00)		Waste	
END OF BOREHOLE	118.8		15				

Remarks:

Mineral Key: Overburden, Resource, Waste

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

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Project: MKSM	
Client: MIRO	
SOBI No: SP63NW35	**Sheet No:** 1 of 1

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 09/08/06	Terminal depth (m): 13.50m	Borehole No: MKSM BH33
	End date: 09/08/06		
Location: Stowe Park nr obelisk		Easting: 467392	Northing: 238683
Elevation (m OD): 147.6	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	147.6 147.5		0 0.1				
CSV: (D) Firm brown very sandy and gravelly CLAY			(7.9)	D D D D D D D D D			
SAGR: (D) Fine brown SAND and GRAVEL	139.6		8 (2.5)	B (8.00-10.00) B (10.00-10.50)	B1 Dark brown clayey very gravelly SAND B2 Brown clayey very gravelly SAND		
TILL: (D) Firm to stiff brown brown boulder clay (TILL)	137.1		10.5 (0.7)	D			
MUDSTONE: Stiff grey LIAS CLAY	136.4		11.2 (2.3)	D D			
END OF BOREHOLE	134.1		13.5	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
Overburden
Resource
Waste

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Project: MKSM	
Client: MIRO	
SOBI No: SP63NE/21	Sheet No: 1 of 1

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Start date: 18/07/06		Terminal depth (m): 17.50m	Borehole No: MKSM BH34
End date: 19/07/06			
Location: North of Park Farm		Easting: 467498	Northing: 236081
Elevation (m OD): 115.1	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Depth (thick) (m)	WS
(D) TOPSOIL	115.1 / 115	0 / 0.1	
SAGR: (D) Fine brown SAND and GRAVEL with small clay bands		(6.4)	
C: (D) Firm brown CLAY with large cobbles	108.6	6.5 (0.6)	
CZ: (D) Firm brown grey silty CLAY	108	7.1 (0.5)	
SAGR: (D) Fine brown SAND and GRAVEL	107.5	7.6 (5.7)	▼
V: (D) River bed GRAVEL	101.8	13.3 (1.3)	
MUDSTONE: (D) Stiff grey LIAS CLAY	100.5	14.6 (2.9)	
END OF BOREHOLE	97.6	17.5	

Samples	Sample Description
B	B1 Brown clayey very gravelly SAND
B	B2 Brown very clayey SAND and GRAVEL
B	B3 Brown clayey very gravelly SAND
B	B4 Brown gravelly very clayey SAND
D	
B	B5 Brown clayey sandy GRAVEL with cobbles
D	
B	B6 Greyish brown clayey very sandy GRAVEL
B	B7 Brown clayey very sandy GRAVEL
B	B8 Brown slightly clayey very sandy GRAVEL
B	B9 Dark brown clayey very sandy GRAVEL
B	B10 Brown slightly clayey sandy GRAVEL
D	
D	
D	
D	

Mineral: Overburden 0–0.1 m; Resource 0.1–6.5 m; Waste 6.5–7.6 m; Resource 7.6–14.6 m. SPT N: —

Remarks: Water strike at 11.00m

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key: Overburden, Resource, Waste

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Project: MKSM	
Client: MIRO	
SOBI No: SP63NE/22	Sheet No: 1 of 1

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Start date: 16/08/06	**Terminal depth (m):** 19.00m		**Borehole No:** MKSM BH35A
End date: 17/08/06			
Location: Silverston Race Circuit South	**Easting:** 466899	**Northing:** 241082	
Elevation (m OD): 153.7	**Drilling Company:** Williams Bros. Drilling		
Borehole diameter: 150mm	**Case diameter:** 150mm	**Drilling Method:** Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	153.7		0 (0.5)				
TILL: (D) Firm brown boulder clay (TILL)	153.2		0.5 (2.1)	D, D, D			
TILL: (D) Firm/stiff grey boulder clay (TILL)	151.1		2.6 (16.4)	D, D, D, D, D, D, D, D, D, D, D, D, U100 (12.50-12.95) D, B (13.50-14.00) D, D, D, D, D			50
END OF BOREHOLE	134.7		19	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
Overburden
Resource
Waste

Logged by: A Nuttall
Project: MKSM
Client: MIRO
SOBI No: SP64SE/105
Sheet No: 1 of 1

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 18/08/06 End date: 18/08/06	Terminal depth (m): 19.00m	Borehole No: MKSM BH35B
Location: Silverstone Race Circuit North		Easting: 466773	Northing: 242966
Elevation (m OD): 143.2	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	143.2	0 (0.5)				
TILL: (D) Soft brown boulder clay (TILL)	142.7	0.5 (0.5)	D			
TILL: (D) Brown/grey boulder clay (TILL)	142.2	1 (2.9)	D D D			
TILL: (D) Firm/stiff grey boulder clay (TILL)	139.3	3.9 (12.6)	D D D D D D D D D D D D D D			
TILL: (D) Stiff grey boulder clay with sand bands (TILL)	126.7	16.5 (2.5)	D D			
END OF BOREHOLE	124.2	19	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
Overburden
Resource
Waste

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP64SE/106	Sheet No: 1 of 1

British Geological Survey, Natural Environment Research Council	Start date: 11/07/06 End date: 12/07/06	Terminal depth (m): 14.50m	Borehole No: MKSM BH36
Location: Handley Barn		Easting: 466240	Northing: 246311
Elevation (m OD): 144.1	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Depth (thick) (m)	Mineral
(D) TOPSOIL	144.1	0 (0.6)	Overburden
CV: (D) Brown CLAY with small gravel and chalk traces	143.5	0.6 (0.7)	Overburden
CSV: (D) Brown sandy CLAY with flint gravel and chalk traces	142.8	1.3 (0.7)	Overburden
SZ: (D) Silty brown SAND with traces of chalk	142.1	2 (0.8)	Overburden
SAGR: (D) Fine brown SAND and small GRAVEL of flint	141.3	2.8 (2.5)	Resource
CS: (D) Brown sandy CLAY with flint gravel traces	138.8	5.3 (0.9)	Resource
SAGR: (D) Fine brown SAND with very small flint gravel	137.9	6.2 (3.4)	Resource
TILL: (D) Brown SAND and small GRAVEL	134.5	9.6 (0.5)	Resource
TILL: (D) Firm/stiff brown boulder clay (TILL)	134	10.1 (0.5)	Waste
MUDSTONE: (D) Stiff grey LIAS CLAY	133.5	10.6 (0.4)	
MUDSTONE: (D) Stiff LIAS CLAY with grey sand bands	133.1	11 (1)	
MUDSTONE: (D) Very stiff grey LIAS CLAY	132.1	12 (1.6)	
LIMESTONE: (D) Yellow LIMESTONE	130.5	13.6 (0.9)	
END OF BOREHOLE	129.6	14.5	

Samples: B (0.50 - 1.00); SD (1.00 - 1.45); B (2.00 - 2.50); B (3.00 - 3.50); B (4.00 - 4.50); B (5.00 - 5.50); B (5.50 - 6.00); SD (6.00 - 6.45); B (7.00 - 7.50); B (8.00 - 8.50); B (9.00 - 9.50); B (9.60 - 10.00); B (10.00 - 10.50); B (10.60 - 11.00); B/U100 (11.00 - 11.45); SD (12.00 - 12.45); SD (13.00 - 13.45); B (13.60 - 14.00); SD (14.00 - 14.45)

Sample Description:
- B1 Brown very clayey very sandy GRAVEL
- B2 Brown very clayey SAND and GRAVEL
- B3 Orange brown clayey very sandy GRAVEL
- B4 Brown very clayey very gravelly SAND
- B5 Brown gravelly very clayey SAND
- B6 Brown clayey very sandy GRAVEL
- B7 Brown clayey very sandy GRAVEL
- B8 Brown clayey very sandy GRAVEL
- B9 Brown clayey very sandy GRAVEL
- B10 Orange brown clayey very sandy GRAVEL
- B11 Orange brown clayey very sandy GRAVEL
- B12 Orange brown clayey sandy GRAVEL
- B18 Brown sandy very clayey GRAVEL

SPT N: 14 (S); 11 (S); 38 (S); 52 (S); 50+ (S)

Remarks:

Mineral Key: Overburden, Resource, Waste

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

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Project: MKSM	
Client: MIRO	
SOBI No: SP64NE/203	Sheet No: 1 of 1

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Start date: 20/07/06		Terminal depth (m): 4.00m	Borehole No: MKSM BH38
End date: 20/07/06			
Location: Arthingworth		Easting: 474077	Northing: 282537
Elevation (m OD): 113.9	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	113.9		0 (0.4)			Waste	
C: (D) Firm brown CLAY	113.5		0.4 (0.9)	D		Waste	
MUDSTONE: (D) Weathered MUDSTONE	112.6		1.3 (1.2)	D			
MUDSTONE: (D) Grey MUDSTONE	111.4		2.5 (1.5)	D, D			
END OF BOREHOLE	109.9		4	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key: Overburden, Resource, Waste

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Project: MKSM	
Client: MIRO	
SOBI No: SP78SW12	Sheet No: 1 of 1

British Geological Survey	Start date: 21/07/06	Terminal depth (m): 4.00m	Borehole No: MKSM BH39
	End date: 21/07/06		
Location: Spinney Farm		Easting: 472265	Northing: 282673
Elevation (m OD): 125.8	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	125.8		0				
			(0.3)				
C: (D) Firm brown CLAY with grey/yellow traces	125.5		0.3				
				D			
			(2)				
				D			
MUDSTONE: (D) Grey MUDSTONE	123.5		2.3	D			
				D			
			(1.7)				
END OF BOREHOLE	121.8		4	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
Overburden
Resource
Waste

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP78SW13	Sheet No: 1 of 1

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 20/07/06 End date: 20/07/06	Terminal depth (m): 3.00m	Borehole No: MKSM BH40
Location: Essex Farm		Easting: 468570	Northing: 284508
Elevation (m OD): 108.9	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	108.9		0 (0.6)	D		Waste	
MUDSTONE: (D) Firm brown grey mottled clay (Prob Weathered Chalmouth Mudstone DBOON)	108.3		0.6 (1)	D U100 (1.30-1.75)	(D) Firm brown grey mottled CLAY (Prob Weathered Chalmouth Mudstone DBOON) (D) Firm brown grey mottled CLAY and weathered brown grey MUDSTONE(Prob Weathered Chalmouth Mudstone DBOON)	Waste	
MUDSTONE: (D) Weathered brown grey MUDSTONE	107.3		1.6 (1.4)	SD (1.80-2.25) D	(D) Very stiff to hard dark greenish grey (GLAY 1 10Y 4/1) MUDSTONE. Reddy brown staining on fissures and bedding planes		30 31 (S)
END OF BOREHOLE	105.9		3	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key: Overburden, Resource, Waste

Logged by: P Williams	
Project: MKSM	
Client: MIRO	
SOBI No: SP68SE/17	Sheet No: 1 of 1

British Geological Survey, Natural Environment Research Council	Start date: 03/08/06 End date: 03/08/06	Terminal depth (m): 5.00m	Borehole No: MKSM BH41
Location: Farndon Fields Farm		Easting: 472093	Northing: 286494
Elevation (m OD): 81.7	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	81.7		0 (0.3)				
CS: (D) Firm brown sandy CLAY	81.4		0.3 (1.8)	D D D			
C: (D) Stiff grey brown mottled CLAY	79.6		2.1 (1.1)	D D			
MUDSTONE: (D) Stiff grey LIAS CLAY with limestone bands	78.5		3.2 (0.2)	D			
MUDSTONE: (D) Stiff grey LIAS CLAY	78.3		3.4 (1.6)	D			
END OF BOREHOLE	76.7		5	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key: Overburden, Resource, Waste

Logged by: P Williams	
Project: MKSM	
Client: MIRO	
SOBI No: SP78NW116	Sheet No: 1 of 1

British Geological Survey (Natural Environment Research Council)	Start date: 20/07/06	Terminal depth (m): 4.00m	Borehole No: MKSM BH43
	End date: 20/07/06		
Location: Stanford Hall		Easting: 459712	Northing: 279238
Elevation (m OD): 107.7	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	107.7		0				
			(0.6)				
				D			
C: (D) Firm brown grey mottled CLAY	107.1		0.6				
			(0.8)	D			
				U100 (1.20-1.65)			
MUDSTONE: (D) Weathered grey LIAS CLAY	106.3		1.4				
							23
				D			
				SD (1.70-2.15)			
							19 (S)
			(2.6)				
				D			
END OF BOREHOLE	103.7		4	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key:
- Overburden
- Resource
- Waste

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP57NE/161	Sheet No: 1 of 1

British Geological Survey, Natural Environment Research Council	Start date: 04/08/06 End date: 04/08/06	Terminal depth (m): 4.00m	Borehole No: MKSM BH44
Location: Wixam Tree Farm		Easting: 451514	Northing: 265708
Elevation (m OD): 86.4	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	86.4		0 (0.3)	D		Waste	
C: (D) Firm brown grey mottled CLAY	86.1		0.3 (0.9)	D		Waste	
MUDSTONE: (D) Firm grey LIAS CLAY	85.2		1.2 (2.8)	D D D D			
END OF BOREHOLE	82.4		4	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key: Overburden, Resource, Waste

Logged by: P Williams	
Project: MKSM	
Client: MIRO	
SOBI No: SP56NW43	Sheet No: 1 of 1

British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL	Start date: 03/08/06 End date: 03/08/06	Terminal depth (m): 5.00m	Borehole No: MKSM BH47
Location: Manor Farm		Easting: 477135	Northing: 293513
Elevation (m OD): 65.3	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	65.3		0 (0.3)	D		Waste	
C: (D) Firm brown grey mottled CLAY	65		0.3 (0.5)	D		Waste	
CZ: (D) Firm brown silty CLAY	64.5		0.8 (1)	D U100 (1.00-1.45) D		Waste	25
MUDSTONE: (D) Firm greyish brown weathered MUDSTONE	63.5		1.8 (1.7)	D D			
MUDSTONE: (D) Dark grey MUDSTONE	61.8		3.5 (1.5)	D D			
END OF BOREHOLE	60.3		5	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key: Overburden, Resource, Waste

Logged by: P Williams	
Project: MKSM	
Client: MIRO	
SOBI No: SP79SE/4	Sheet No: 1 of 1

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Start date: 27/07/06	Terminal depth (m): 7.00m	Borehole No: MKSM BH48	
End date: 27/07/06			
Location: Home Farm, S. Bruerne		Easting: 460509	Northing: 231156
Elevation (m OD): 117.1	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	117.1	0 (0.3)		(E) Dark yellowish brown slightly clayey SAND and GRAVEL		
(D) Fine brown sandy soil with gravels	116.8	0.3 (0.8)	B (0.30-1.10)			
CSV: (D) Firm brown very sandy CLAY with gravels	116	1.1 (3.8)	D D D D			
SAGR: (D) Fine brown SAND and GRAVEL	112.2	4.9 (0.2)	D (5.00-5.10)			
TILL: (D) Stiff grey boulder clay (TILL)	112	5.1 (0.4)	D	(E) Stiff to very stiff dark yellowish brown sandy CLAY		
TILL: (D) Stiff brown boulder clay (TILL)	111.6	5.5 (0.3)	D U100 (5.50-5.95)	(D) Stiff grey boulder clay (TILL) and weathered (plastic) grey MUDSTONE		
MUDSTONE: (D) Weathered grey MUDSTONE	111.3	5.8 (1.2)	D			50
END OF BOREHOLE	110.1	7	D			

Remarks:

Mineral Key: Overburden, Resource, Waste

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Logged by: P Williams	
Project: MKSM	
Client: MIRO	
SOBI No: SP63SW18	Sheet No: 1 of 1

British Geological Survey, Natural Environment Research Council	Start date: 08/08/06	Terminal depth (m): 13.00m	Borehole No: MKSM BH49
	End date: 08/08/06		
Location: George Farm, Hillesden		Easting: 467945	Northing: 231661
Elevation (m OD): 110.832	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	Samples	Sample Description	Mineral	SPT N
(D)TOPSOIL with flint gravel	110.8		0 (0.50)			Overburden	
CSV: (D) Brown sandy CLAY with flint gravel	110.3		0.50 (3.10)	D, D, D		Overburden	
TILL: (D) Firm brown boulder clay (TILL)	107.2		3.60 (0.50)	D		Overburden	
TILL: (D) Firm grey boulder clay (TILL)	106.7		4.10 (1.90)	D, D		Overburden	
CSZ: (D) Yellow silty sandy CLAY	104.8		6.00 (2.70)	D, D, D		Overburden	
SAGR: (D) Yellow SAND and flint GRAVEL	102.1		8.70 (2.60)	B (8.70 - 10.50)	B1 Orange brown clayey very gravelly SAND	Resource	
				B (10.50 - 11.30)	B2 Brown clayey gravelly SAND	Resource	
C: (D) Stiff grey CLAY	99.5		11.30 (1.70)	D, D			
END OF BOREHOLE	97.8		13.00	D			

Remarks:

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Mineral Key: Overburden, Resource, Waste

Logged by: A Nuttall	
Project: MKSM	
Client: MIRO	
SOBI No: SP63SE/182	Sheet No: 1 of 1

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Start date: 13/07/06	Terminal depth (m): 14.50m		Borehole No: MKSM BH50
End date: 13/07/06			
Location: Barton Hartshorn		Easting: 464538	Northing: 231344
Elevation (m OD): 115.9	Drilling Company: Williams Bros. Drilling		
Borehole diameter: 150mm	Case diameter: 150mm	Drilling Method: Cable Percussion	

Description	Level (m OD)	Legend	Depth (thick) (m)	WS	Samples	Sample Description	Mineral	SPT N
(D) TOPSOIL	115.9		0 (0.3)					
TILL: (D) Firm brown boulder clay (TILL)	115.6		0.3 (2.7)		D, D			
TILL: (D) Stiff grey boulder clay (TILL)	112.9		3 (6.5)	▼	D, D, D, D, D, D, D			
SAGR: (D) Fine brown SAND and GRAVEL	106.4		9.5 (4)		B (9.50-10.00)	B1 Brown clayey very gravelly SAND		
					B	B2 Brown slightly clayey very gravelly SAND		
					B	B3 Brown clayey very gravelly SAND		
					B	B4 Dark brown slightly clayey very gravelly SAND		
C: (D) Stiff grey CLAY	102.4		13.5 (1)		B, D	B5 Brown clayey SAND and GRAVEL		
END OF BOREHOLE	101.4		14.5		D			

Remarks: Water strike at 14.00m

Mineral Key:
- Overburden
- Resource
- Waste

Key to SPT: C=Cone, S=Standard
Key to Description: D=Driller's, E=Engineer's
Key to Samples (type): B=Bulk, D=Disturbed, U100=Undisturbed, SD=Disturbed Shoe

Logged by: P Williams	
Project: MKSM	
Client: MIRO	
SOBI No: SP63SW19	Sheet No: 1 of 1

19 Appendix 6: A3 versions of detailed figures

Detailed map figures are reproduced here at A3 for clarity

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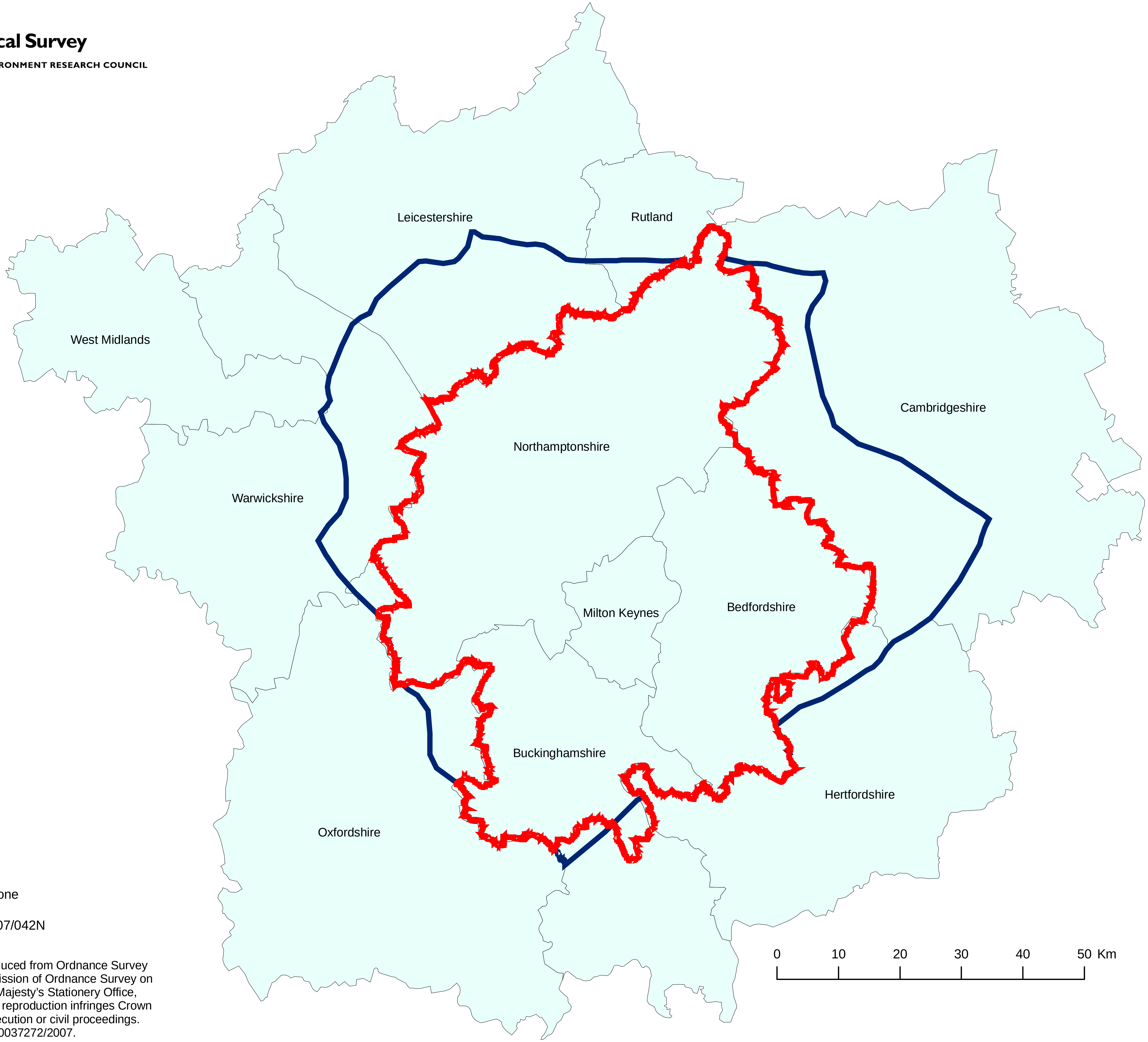
Figure 2 The Project Area



Project Area
MKSM Growth Zone

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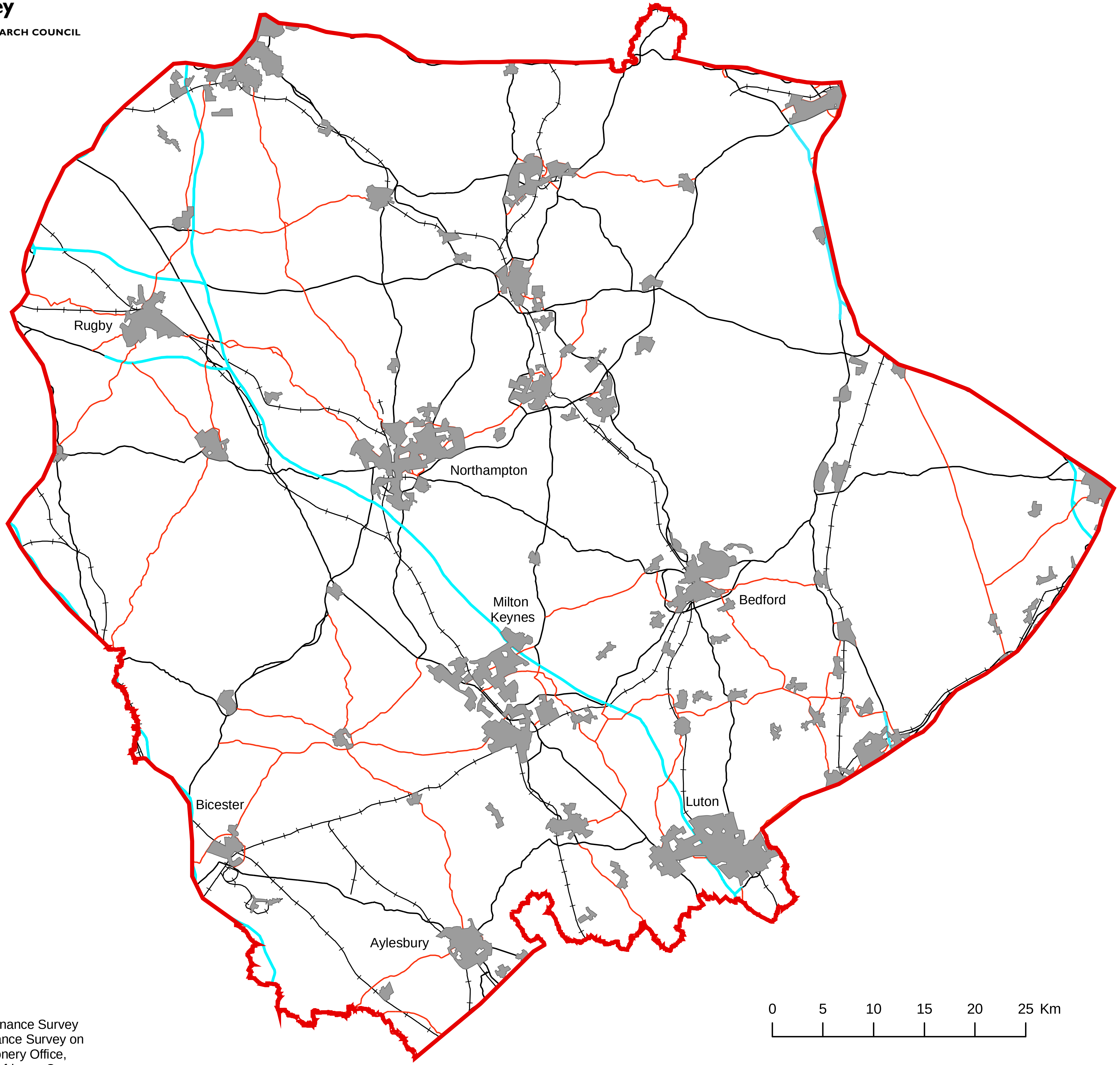

Figure 3 Major Urban Areas, Roads & Railways within the Milton Keynes South Midlands Growth Zone Study Area

Major Urban Areas
Railway
Motorway
Primary Road
A Road

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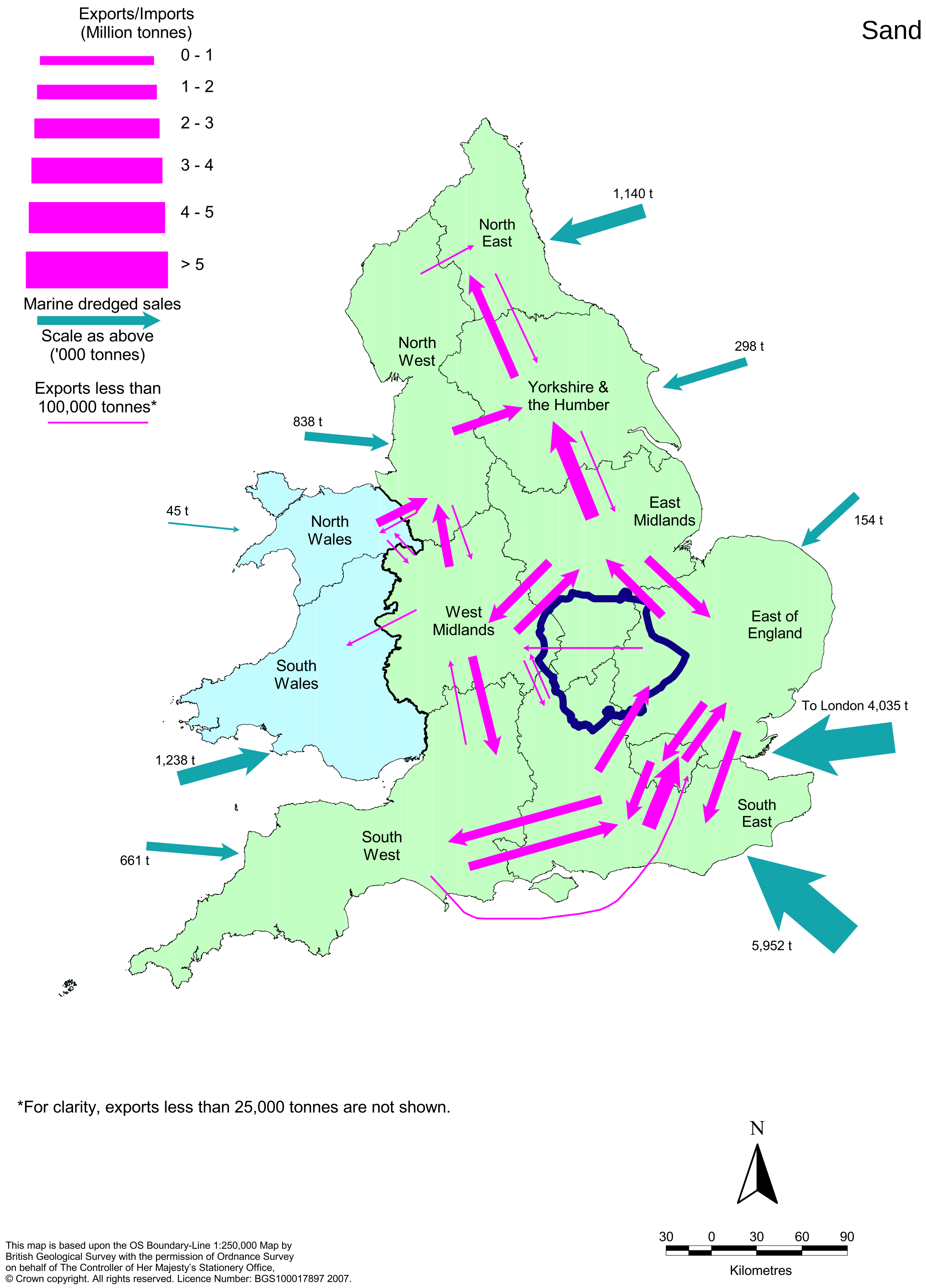

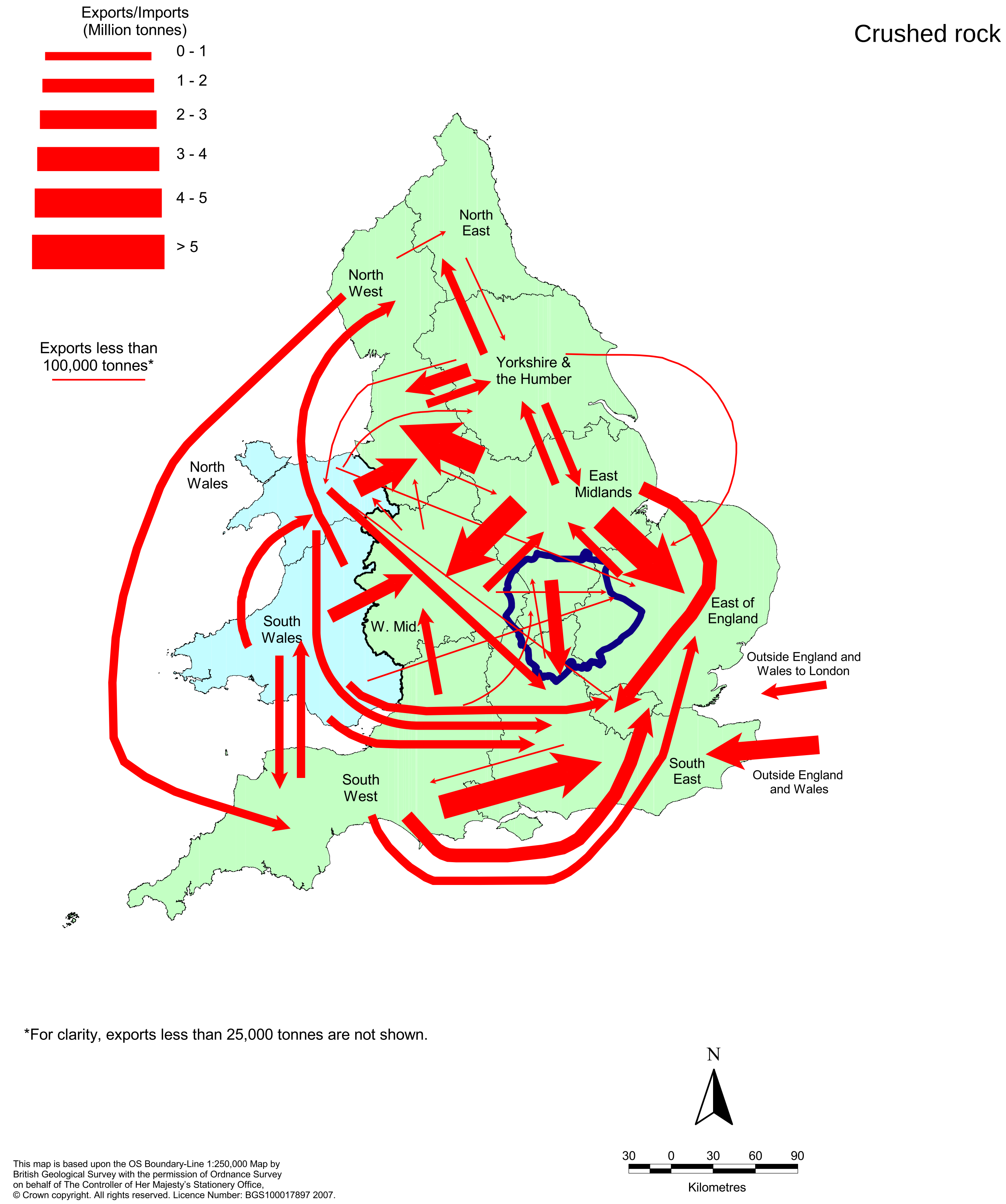

Figure 4 AM 2005 regional flows for sand and gravel and crushed rock exports for England and Wales

Provisional maps supplied by BGS on behalf of Communities and Local Government (2007).

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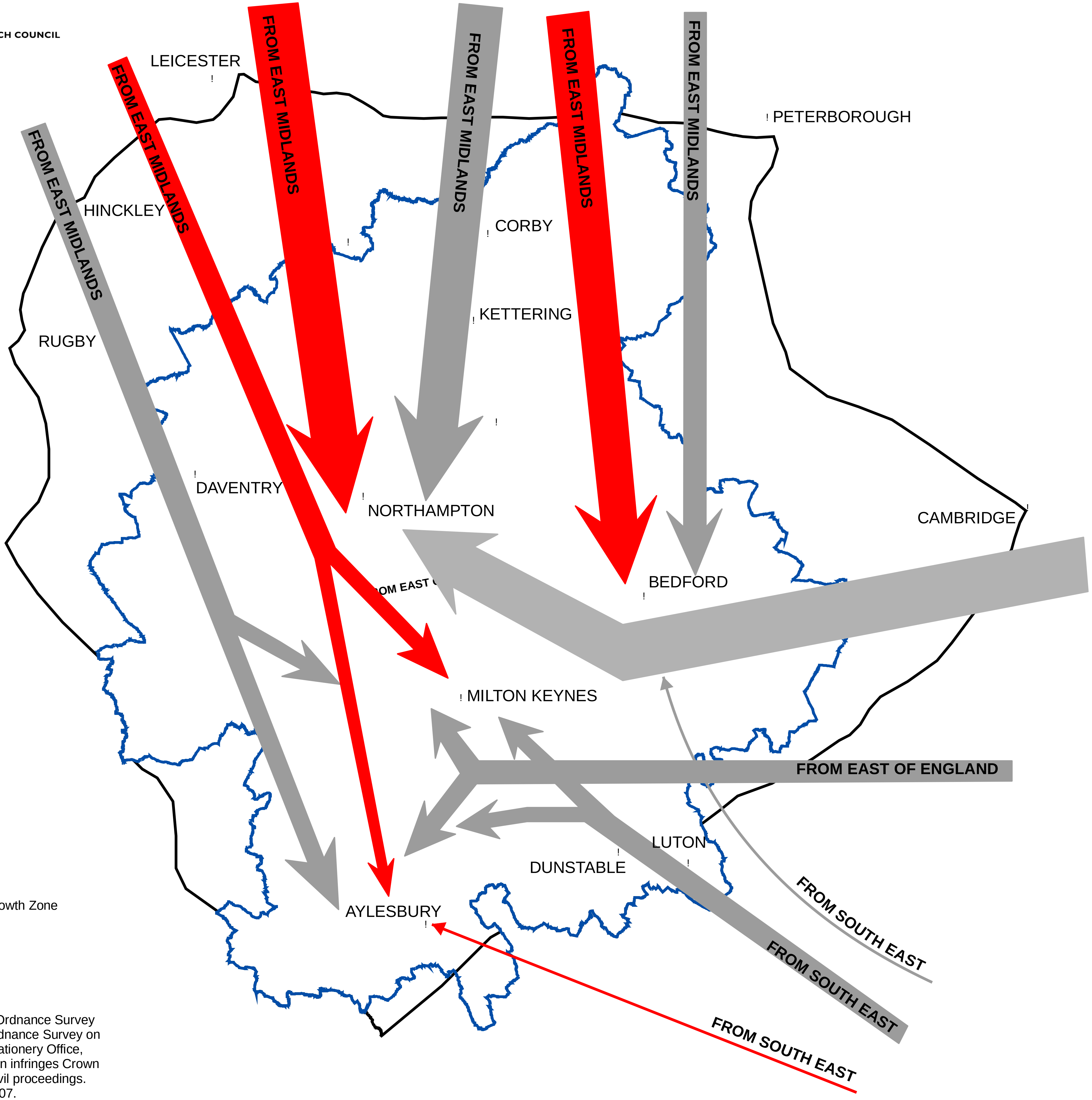

Figure 7 Flows into Growth Zone - 1997 Pattern

Project Area
Milton Keynes & South Midlands Growth Zone
Sand & Gravel
Crushed Rock

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Figure 10 Pre-existing Boreholes in Milton Keynes South Midlands Growth Zone Study Area

IMAU Boreholes
! Boreholes

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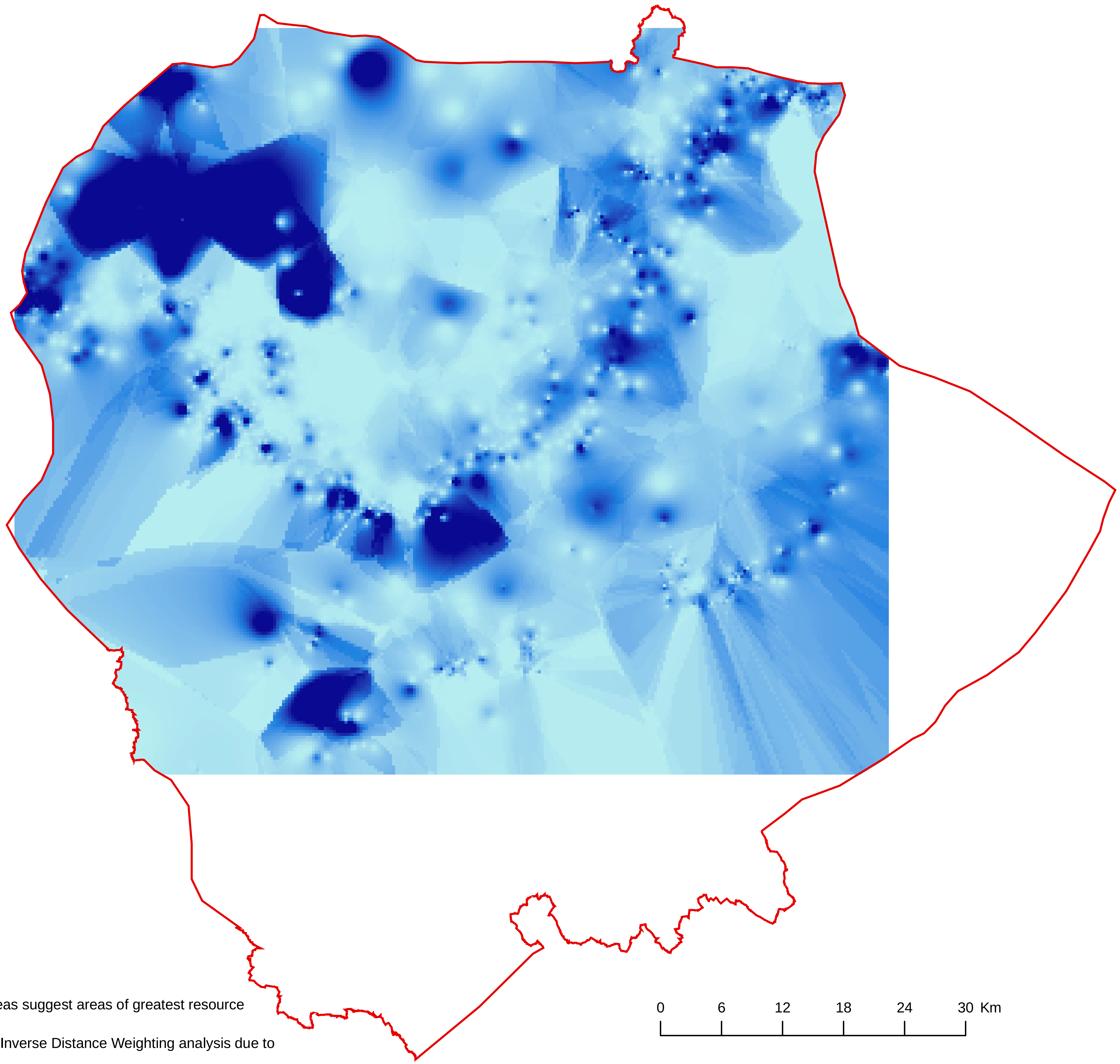

Figure 11 Inverse Distance Weighting interpolation indicating predicted areas of thickest resource.

Inverse Distance Weighting

Value

Greater thickness of resource predicted

Lesser thickness of resource predicted

Inverse Distance weighting technique uses known data points and interpolates between them. The darker areas suggest areas of greatest resource thickness.

The southern part of the project area is excluded from the Inverse Distance Weighting analysis due to lack of borehole data points.

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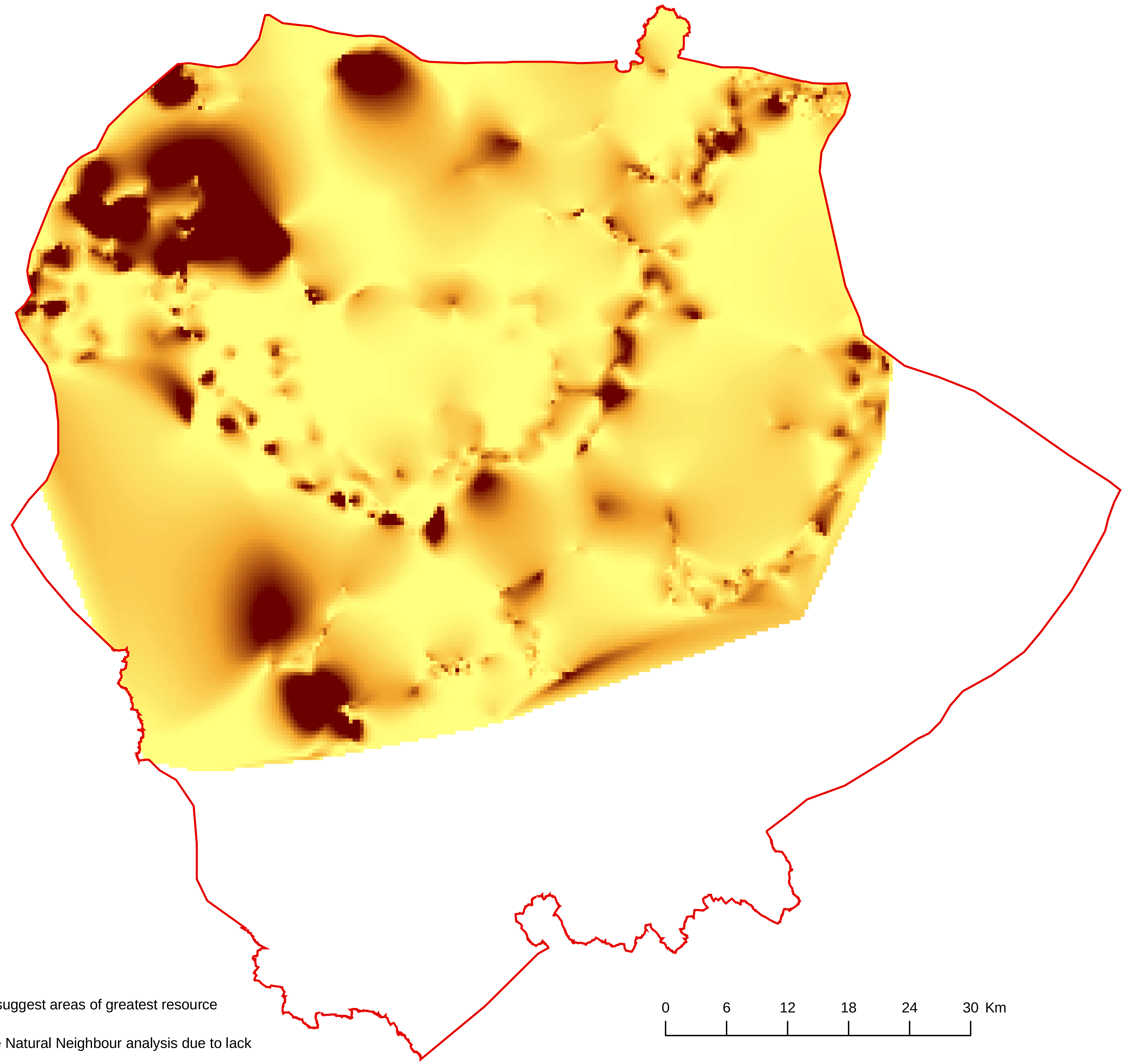

Figure 12 Natural Neighbour interpolation indicating predicted areas of thickest resource.

Natural Neighbour

Value

Greater thickness of resource predicted

Lesser thickness of resource predicted

Natural Neighbour technique uses known data points and interpolates between them. The darker areas suggest areas of greatest resource thickness.
The southern part of the project area is excluded from the Natural Neighbour analysis due to lack of borehole data points.

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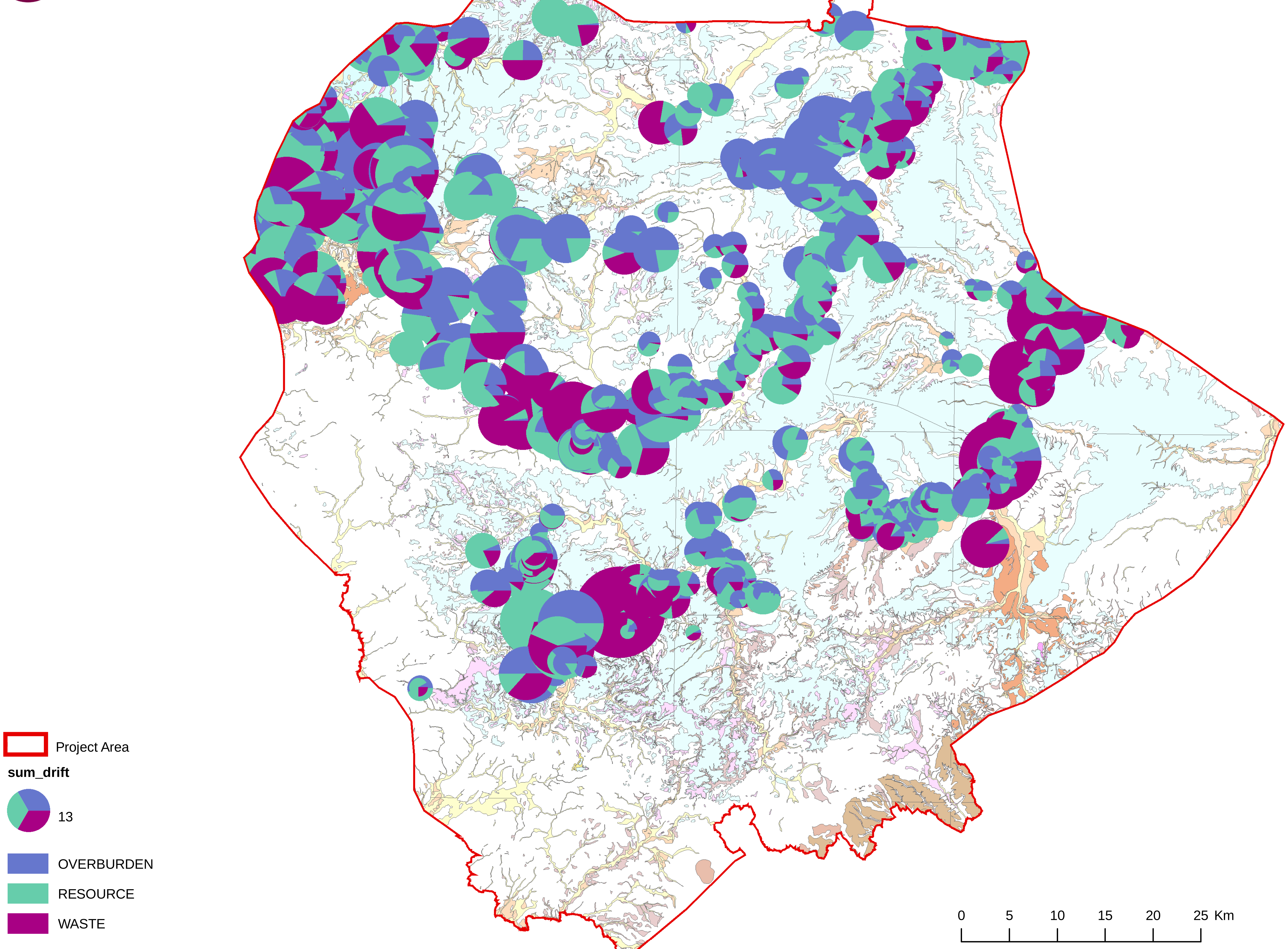

Figure 14 Pie charts indicating content of boreholes within the Milton Keynes South Midlands Growth Zone Project Area

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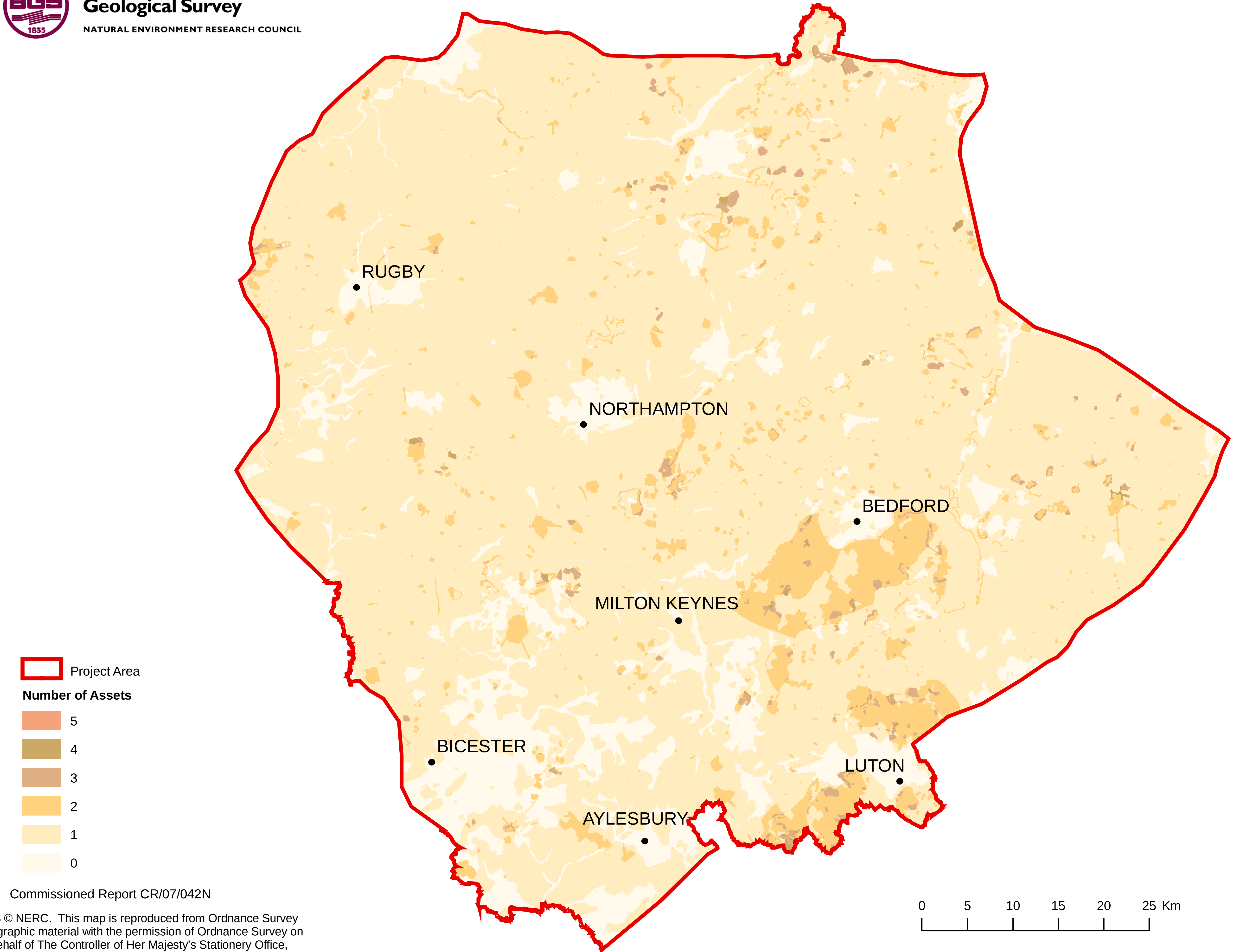

Figure 17 Environmental Sensitivity data within the Milton Keynes South Midlands Growth Zone Project Area

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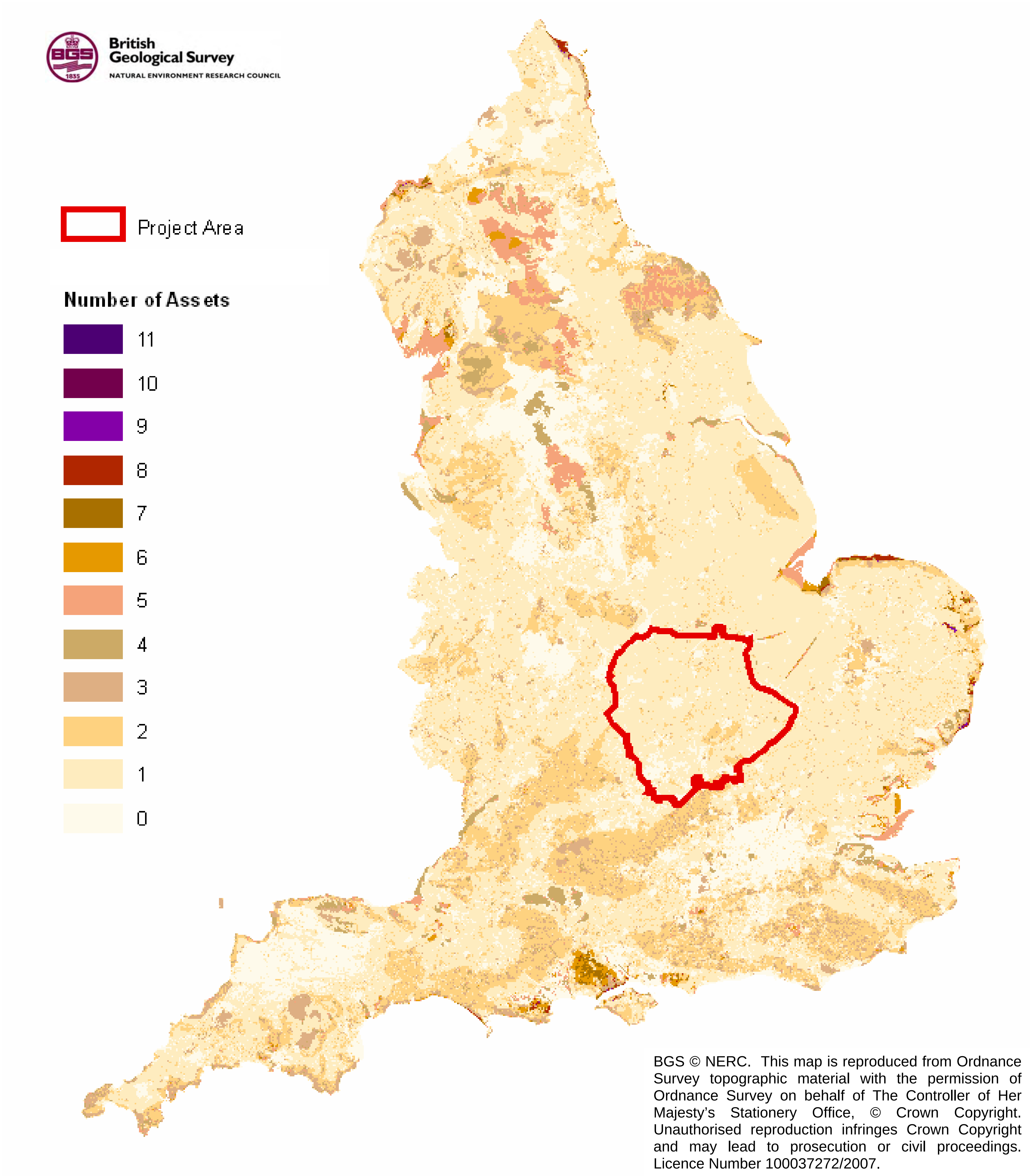

Figure 18 Environmental sensitivity for England showing the Project Area

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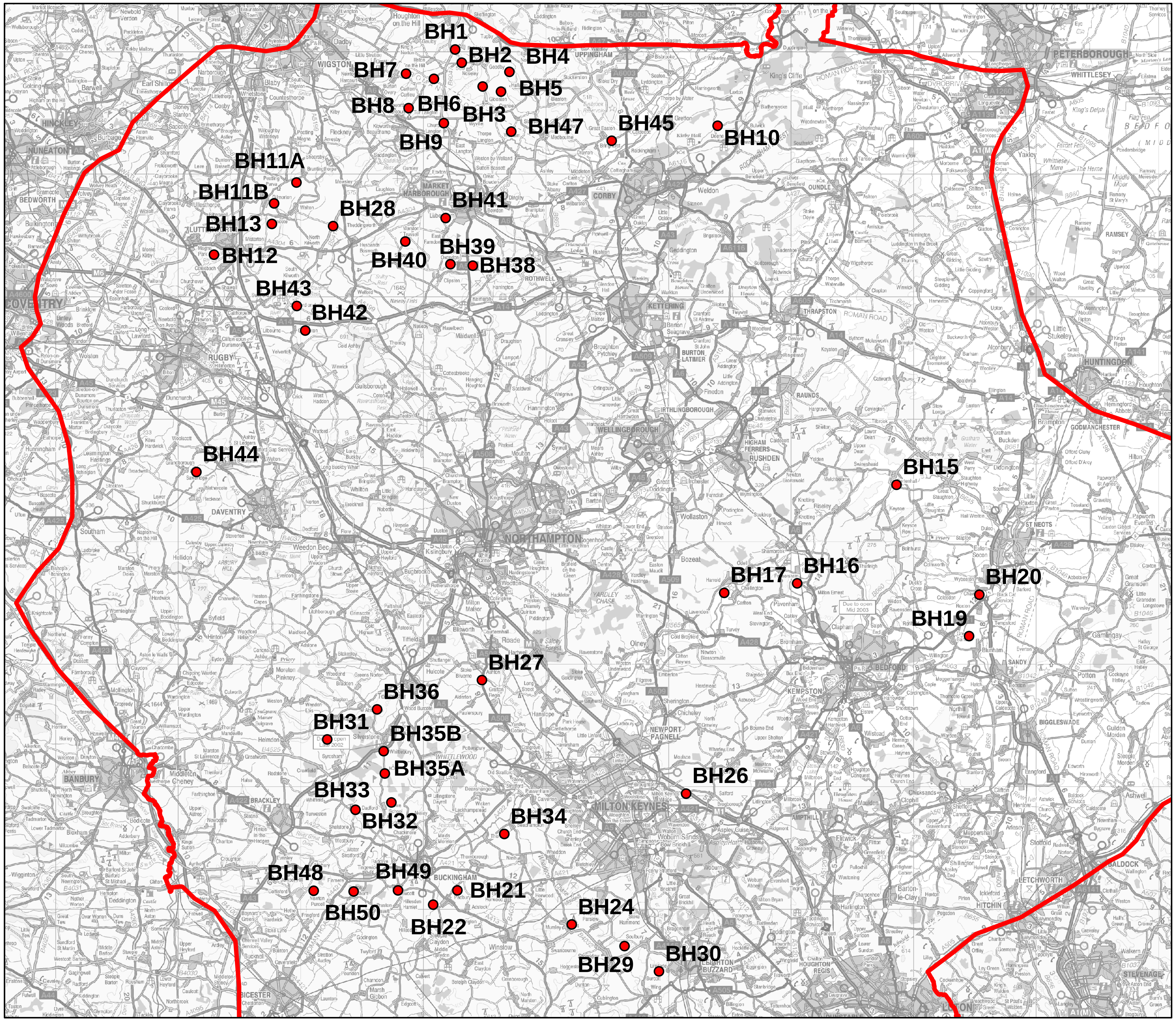

0 6,250 12,500 25,000 37,500 50,000 Meters

Figure 20 Locations of the boreholes drilled for the project

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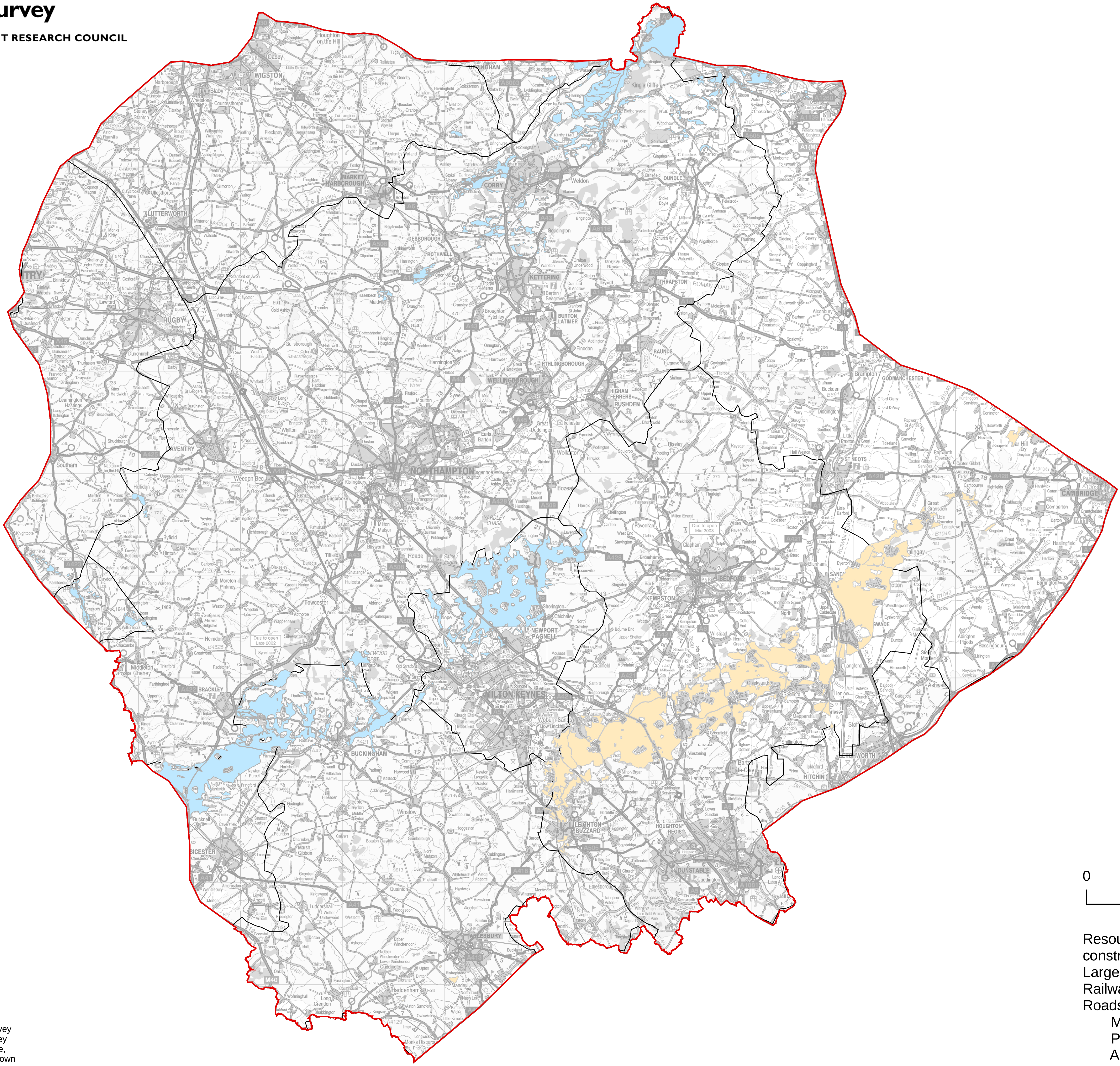
Figure 22 Limestone and Bedrock Sand and Gravel Resources in the project area minus areas constrained by infrastructure or environmental assets



1:400,000

Project Area

Sand & Gravel Resource

Limestone Resource

0 5 10 15 20 25 Km

Resource areas covered by the following constraints have been erased:
Large urban areas (plus 100m buffer)
Railways (plus 100m buffer)
Roads
- Motorway (plus 100m buffer)
- Primary Road (plus 20m buffer)
- A Road (15m buffer)

Mineral Planning Permissions
Drift thickness of greater than 10m
More than 1 Environmental asset

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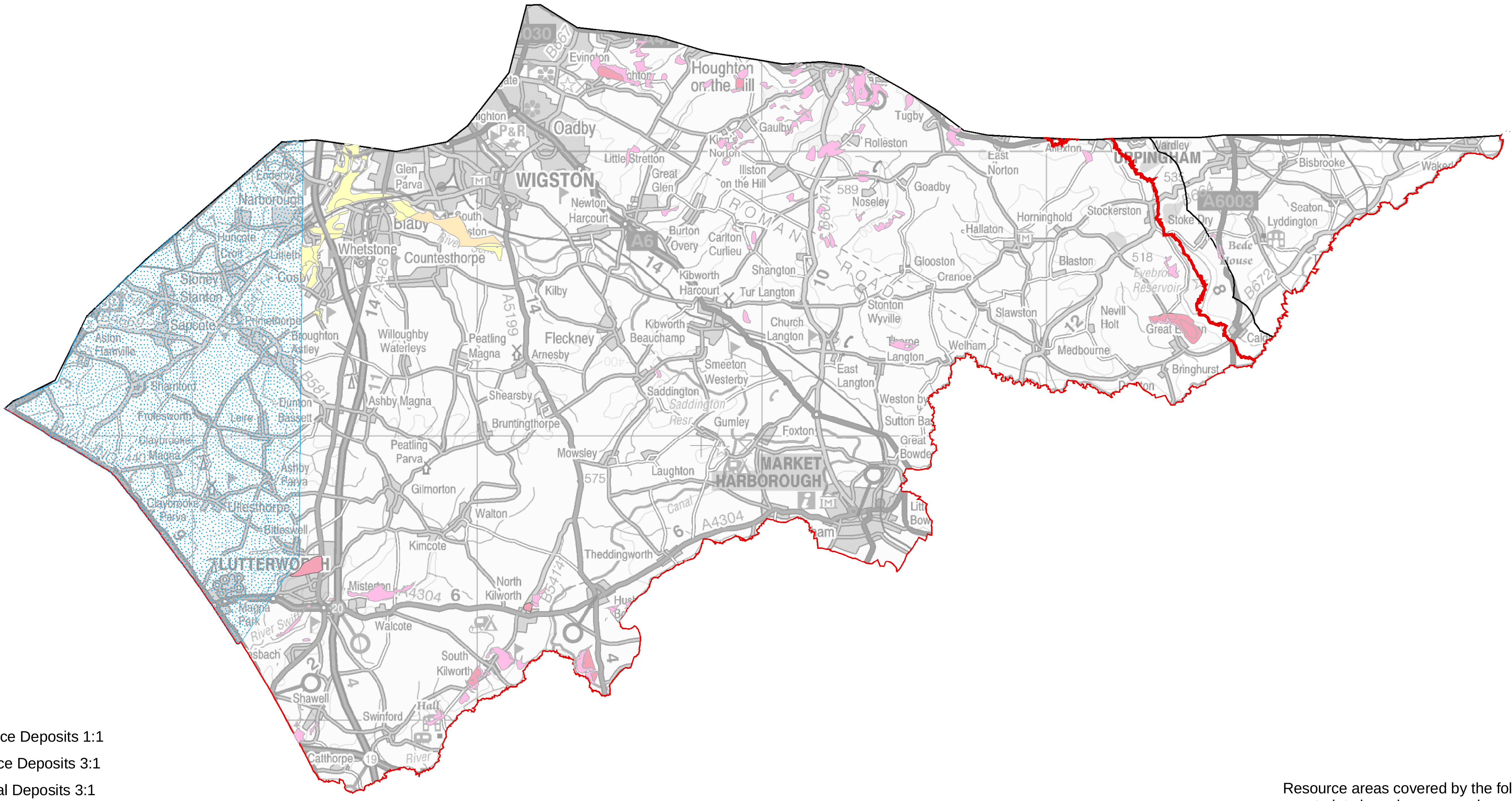
Figure 23 Leicestershire & Rutland River Terrace and Glaciofluvial Deposits minus areas constrained by infrastructure or environmental assets.



1:150,000

River Terrace Deposits 1:1
River terrace Deposits 3:1
Glaciofluvial Deposits 3:1
Glaciofluvial Deposits 1:1
Area_Not_Assessed

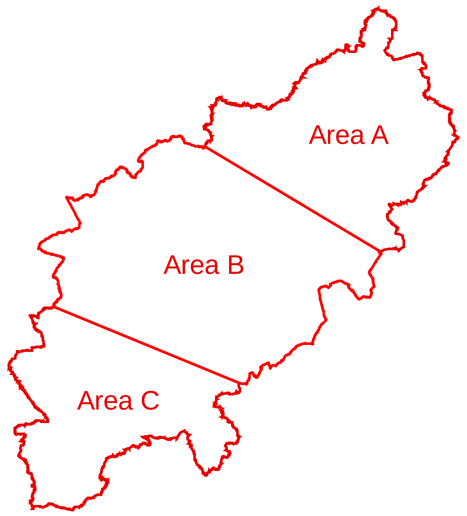
Commissioned Report CR/07/042N

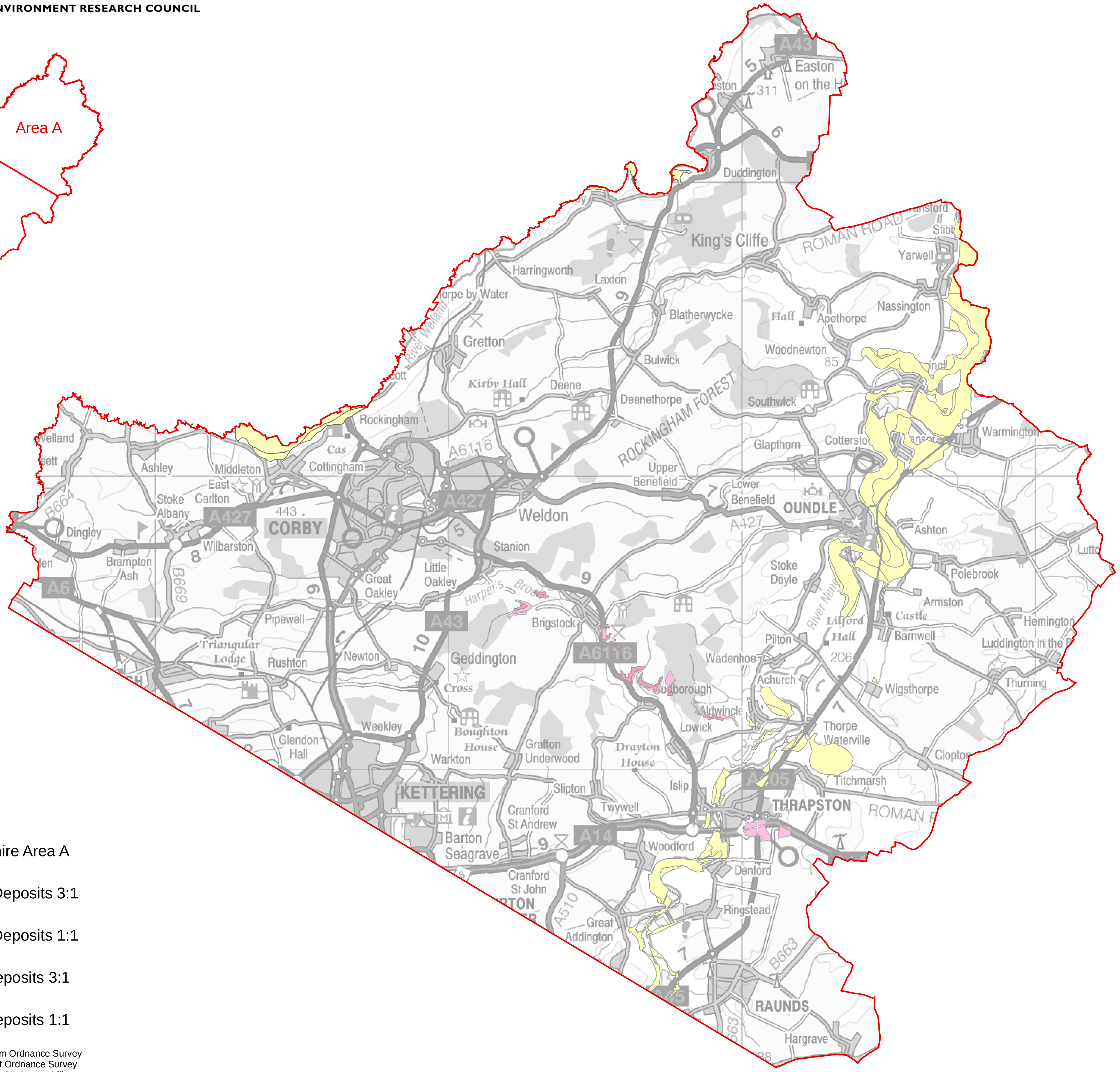
Resource areas covered by the following constraints have been erased:
Large urban areas (plus 100m buffer)
Railways (plus 100m buffer)
Roads
- Motorway (plus 100m buffer)
- Primary Road (plus 20m buffer)
- A Road (15m buffer)

Mineral Planning Permissions
More than 1 Environmental asset

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Figure 24 Northamptonshire Area A River Terrace and Glaciofluvial Deposits minus areas constrained by infrastructure or environmental assets.





1:150,000

(red outline)	Northamptonshire Area A
(colour)	River Terrace Deposits 3:1
(colour)	River Terrace Deposits 1:1
(colour)	Glaciofluvial Deposits 3:1
(colour)	Glaciofluvial Deposits 1:1

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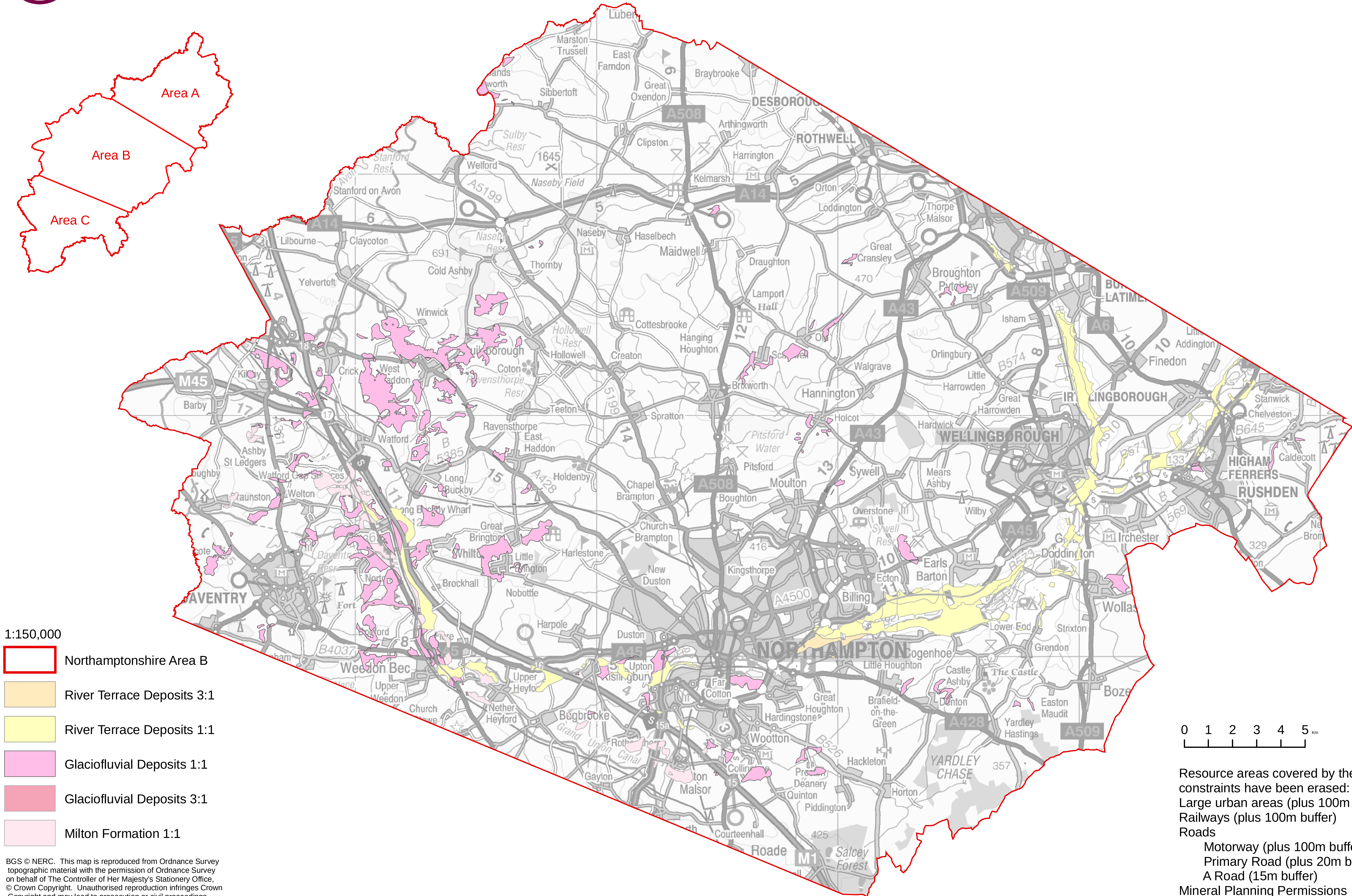
0 1 2 3 4 5 Km

Resource areas covered by the following constraints have been erased:
Large urban areas (plus 100m buffer)
Railways (plus 100m buffer)
Roads
- Motorway (plus 100m buffer)
- Primary Road (plus 20m buffer)
- A Road (15m buffer)

Mineral Planning Permissions
More than 1 Environmental asset

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Figure 25 Northamptonshire Area B River Terrace and Glaciofluvial Deposits minus areas constrained by infrastructure or environmental assets.



1:150,000

(red outline)	Northamptonshire Area B
(swatch)	River Terrace Deposits 3:1
(swatch)	River Terrace Deposits 1:1
(swatch)	Glaciofluvial Deposits 1:1
(swatch)	Glaciofluvial Deposits 3:1
(swatch)	Milton Formation 1:1

0 1 2 3 4 5 Km

Resource areas covered by the following constraints have been erased:
Large urban areas (plus 100m buffer)
Railways (plus 100m buffer)
Roads
- Motorway (plus 100m buffer)
- Primary Road (plus 20m buffer)
- A Road (15m buffer)

Mineral Planning Permissions
More than 1 Environmental asset

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NATURAL ENVIRONMENT RESEARCH COUNCIL

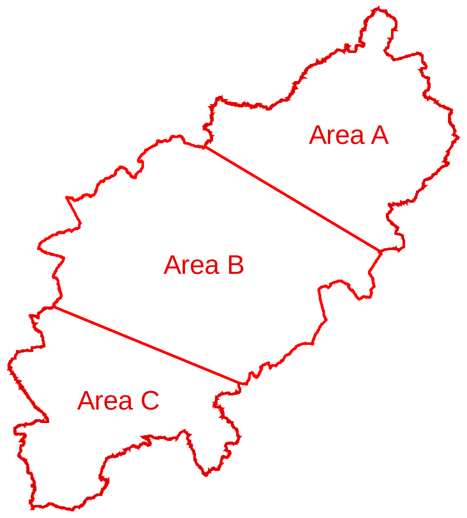

Figure 26 Northamptonshire Area C River Terrace Deposits minus areas constrained by infrastructure or environmental assets.

1:150,000

Northamptonshire Area C

River Terrace Deposit 3:1

River Terrace Deposit 1:1

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0 1 2 3 4 5 Km

Resource areas covered by the following constraints have been erased:
Large urban areas (plus 100m buffer)
Railways (plus 100m buffer)
Roads
- Motorway (plus 100m buffer)
- Primary Road (plus 20m buffer)
- A Road (15m buffer)

Mineral Planning Permissions
More than 1 Environmental asset

Due to lack of borehole data in this area of Northamptonshire no glacial resources have been evaluated.

British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

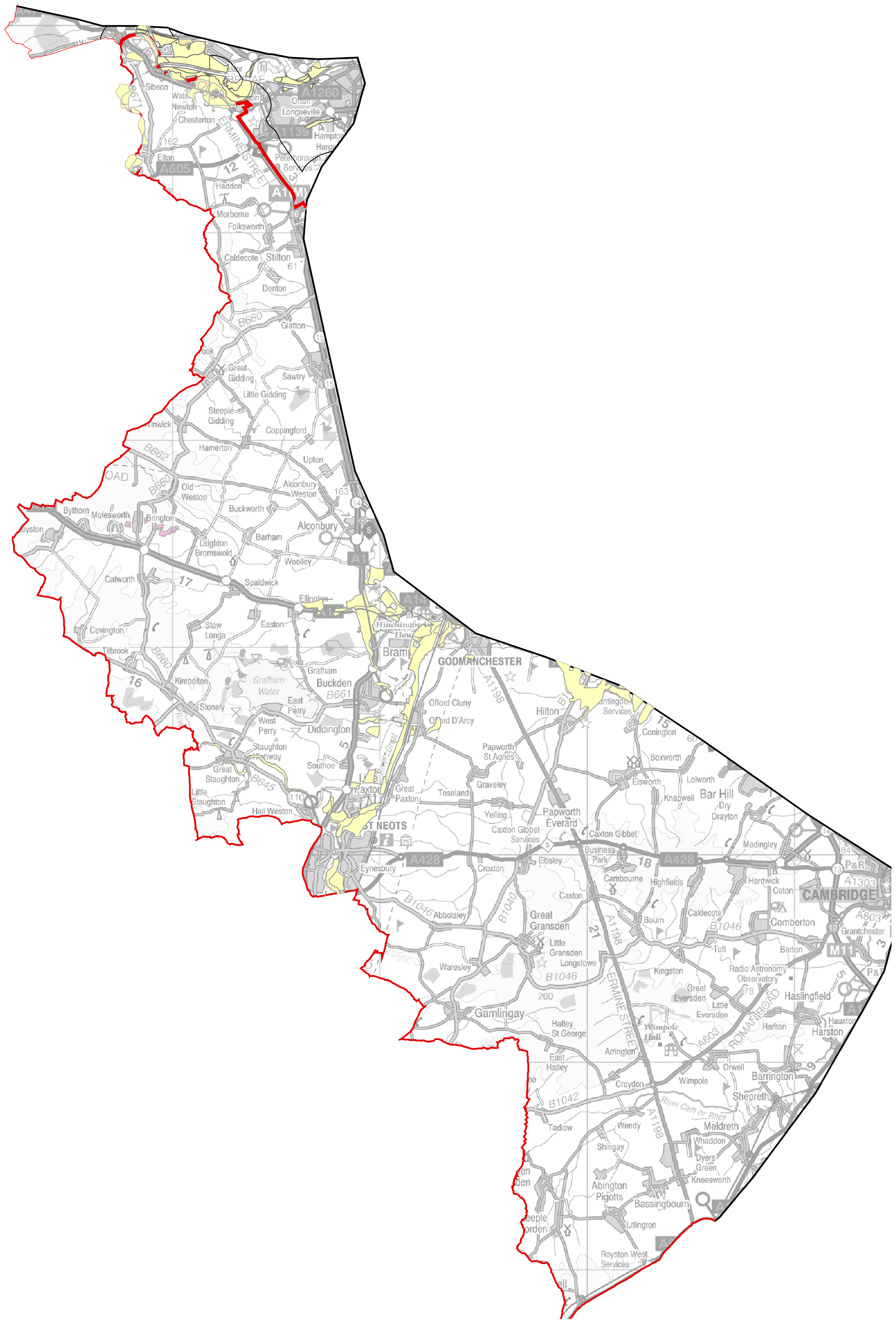

Figure 27 Cambridgeshire & Peterborough River Terrace and Glaciofluvial Deposits minus areas constrained by infrastructure or environmental assets.

1:240,000

- Glaciofluvial Deposits 1:1
- River Terrace Deposits 1:1
- River Terrace Deposits 3:1

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Resource areas covered by the following constraints have been erased:

Large urban areas (plus 100m buffer)

Railways (plus 100m buffer)

Roads

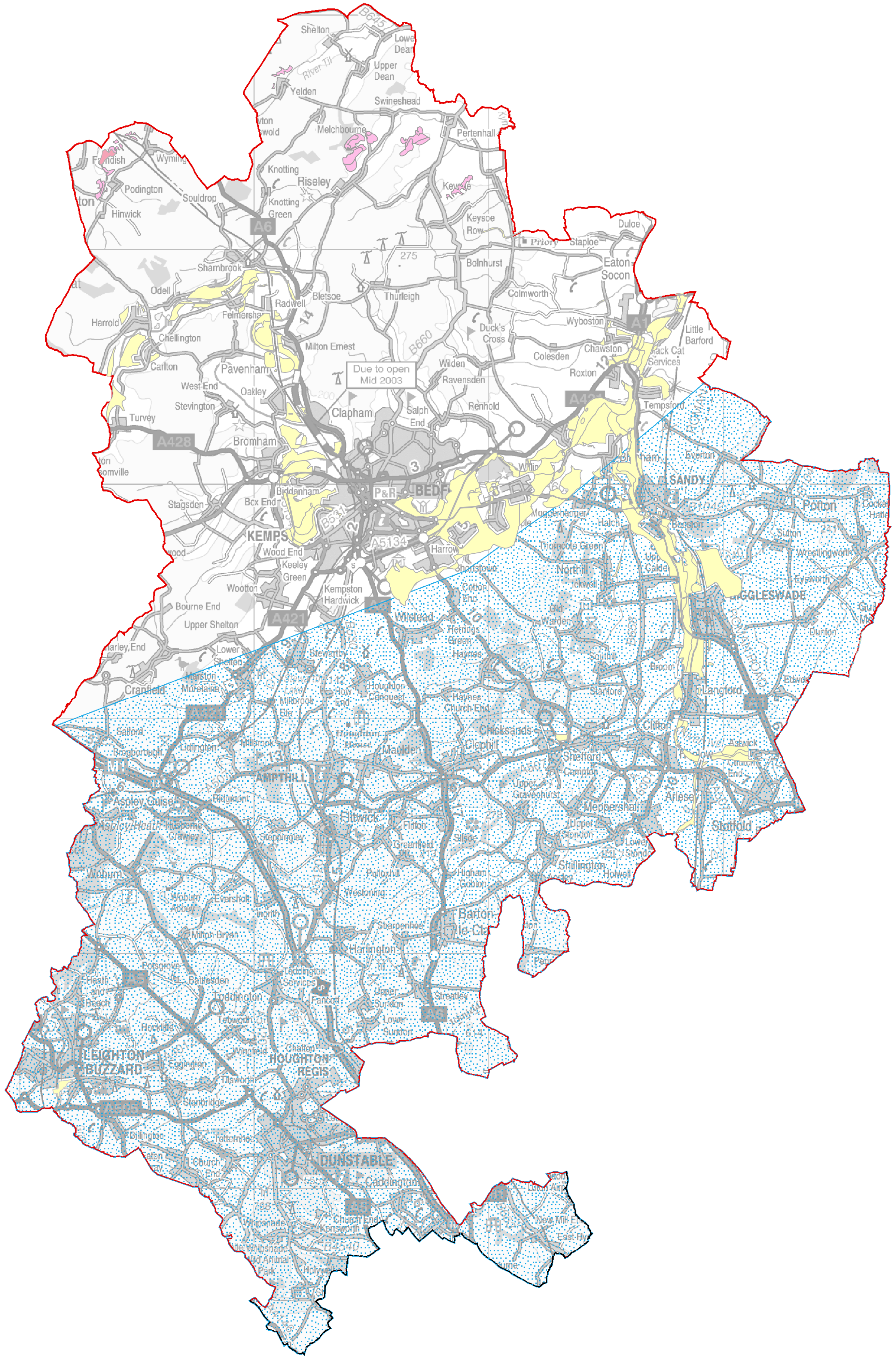
- Motorway (plus 100m buffer)
- Primary Road (plus 20m buffer)
- A Road (15m buffer)

Mineral Planning Permissions

More than 1 Environmental asset

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Figure 28 Bedfordshire River Terrace and Glaciofluvial Deposits minus areas constrained by infrastructure or environmental assets.



1:210,000

River terrace Deposits 1:1

Glaciofluvial Deposits Not Assessed

Glaciofluvial Deposits 1:1

Glaciofluvial Deposits 3:1

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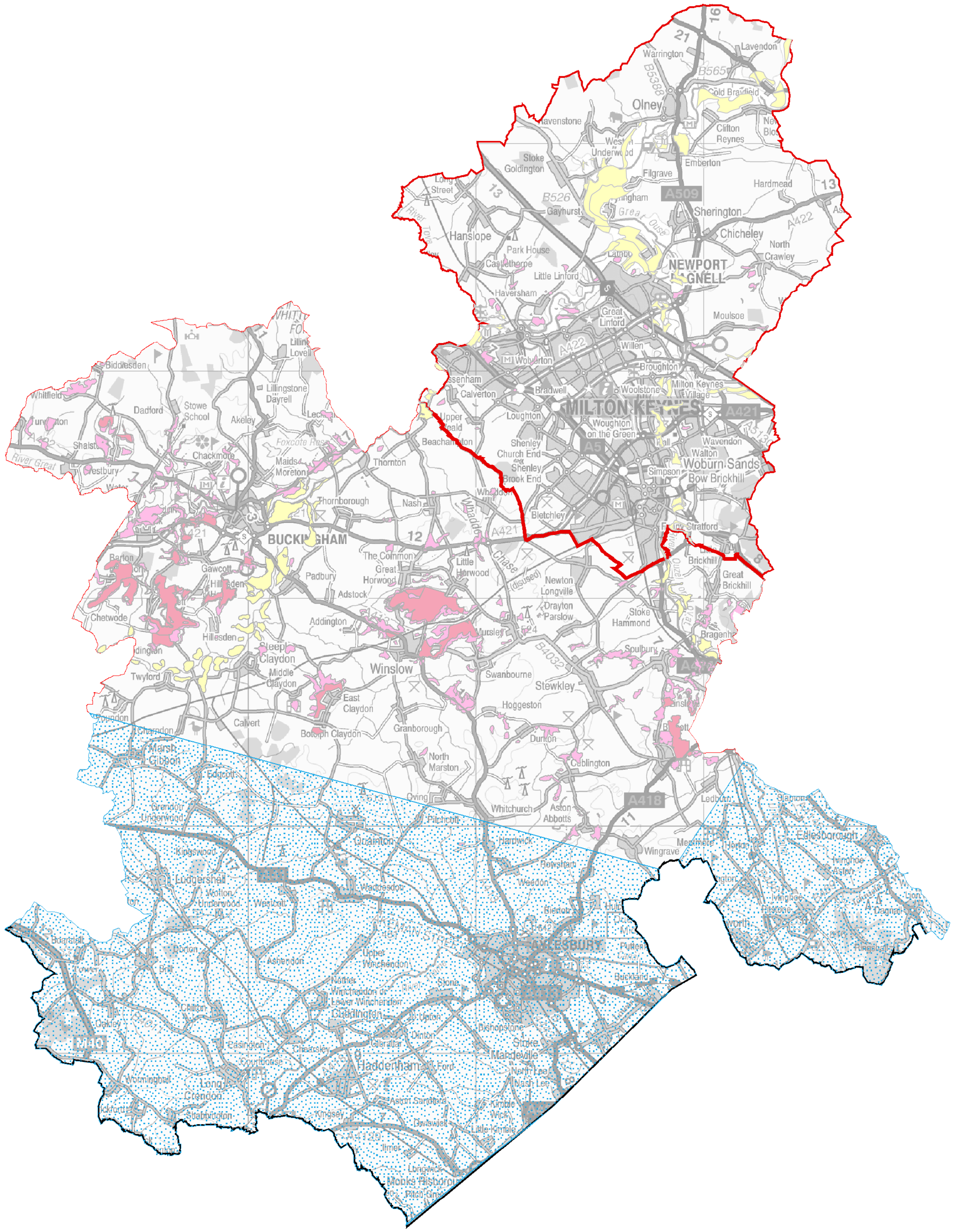
Resource areas covered by the following constraints have been erased:
Large urban areas (plus 100m buffer)
Railways (plus 100m buffer)
Roads
- Motorway (plus 100m buffer)
- Primary Road (plus 20m buffer)
- A Road (15m buffer)

Mineral Planning Permissions
More than 1 Environmental asset

British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Figure 29 Buckinghamshire & Milton Keynes River Terrace and Glaciofluvial Deposits minus areas constrained by infrastructure or environmental assets.



1:240,000

River Deposits Not Assessed

River terrace Deposit 1:1

Glaciofluvial Deposit 3:1

Glaciofluvial Deposits 1:1

Commissioned Report CR/07/042N

Resource areas covered by the following constraints have been erased:
Large urban areas (plus 100m buffer)
Railways (plus 100m buffer)
Roads
- Motorway (plus 100m buffer)
- Primary Road (plus 20m buffer)
- A Road (15m buffer)

Mineral Planning Permissions
More than 1 Environmental asset

20 Appendix 7: Consultation and dissemination

The following consultation and dissemination has been undertaken as part of the project:

- A meeting was held in Northampton in March 2005 with Mineral Planning Authorities from the Project Area. The purpose of this meeting was to inform them of the project's aims and objectives. This meeting was also important to reinforce the Project Team's contacts in the Project Area. This was important for information gathering phase of the project.
- Informal meetings with various mineral planners and industry have occurred during the project.
- A summary document was sent to mineral companies in December 2006 outlining the project and informing them of a consultation event in January 2007.
- A consultation meeting was held on January 30th 2007 which was attended by planners and industry in the Project Area. The purpose of the meeting was to disseminate the draft results of the project so far, in particular the spatial outputs, and to invite discussion on how best to present the results of the project.

The Executive Summary will be available to download, as a pdf, from www.MineralsUK.com in summer 2007.