Artificial Soils for Quarry Restoration
an Update and Overview

A Study for Natural England
by PGW&A LLP and
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This Study, funded by DEFRA’s ALSF through Natural England, reviews and describes methods that may be used to form restoration soils on quarries where little or no soil has been preserved. The necessary investigations and methods are described with examples from four aggregate producing quarries in England where artificial soil production from quarry wastes is being considered in conjunction with the use of soil amendments. Proposals are outlined for future on-site trials to check on soil mineral and amendment mixes, planting and soil thicknesses likely to achieve biodiversity objectives. The selected quarries include igneous and sedimentary rocks and two have current inert landfill operations.

Issues that have emerged are the extent of the shortfall of existing soil for quarry restoration, especially in the older, deeper quarries, the wide range of mineral wastes available in many quarries and the information that can be obtained from existing plant growth and landscape screening activities already on site. Certified composts are emerging as important products compared with the organic wastes that have been used in land reclamation in the past. These composts can be placed without having to resort to an exemption from permitting as is now required by current legislation.

More clarity and guidance is required in respect of the Environmental Permitting Regulations covering the use of organic wastes in quarry reclamation and in arrangements for adjustments to restoration objectives to meet with local Biodiversity Action Plans.

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8 PLANNING AND PERMITTING

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Quarries with no soil
9.2 Planning issues
9.3 Operational considerations
9.4 Recent developments
9.5 Publicity

FIGURES

2.1 Triangular plot of soil texture with components of sand, silt and clay.
2.2 Triangular plot showing relationship between particle size and permeability
2.3 Typical sources of waste materials in quarries
2.4 Characteristic tips and stockpiles found in quarries
2.5 Internal structures commonly present in tips and stockpiles
2.6 Idealised cross sections through silt lagoons

3.1 Illustration of the range of soil complexity in the context of amendments

6.1 Plan of Penlee Quarry with sampling and potential trial plot locations
6.2 Intended future development of Penlee Quarry
6.3 Proposed layout of benches on the southern side of Penlee Quarry
6.4 Plan of Shellingford Quarry with sampling and potential trial plot locations
6.5 Possible restoration of Shellingford Quarry
6.6 Plan of Oathill Quarry with sampling and potential trial plot locations
6.7 Intended restoration of Oathill Quarry
6.8 Plan of Cromwell Quarry with sampling and potential trial plot locations
6.9 Intended restoration of Cromwell Quarry

7.1 Flow chart of the methodology for approaching field trials and restoration using artificial soils

PHOTOGRAPHS

4.1 A fixed screen hopper feeding inclined screens at Oathill Quarry
4.2 Cyclones and a rotary screen or trommel at Shellingford Quarry
4.3 Inclined vibrating screens for dry screening at Penlee Quarry
4.4 Inclined vibrating screens for screening wet materials at Shellingford Quarry
4.5 Organic materials separated in the washing process at Shellingford Quarry

5.1 PAS100 compost
5.2 PAS100 compost - detail

6.1 Stockpiles of screened material, Penlee Quarry
6.2 Quarry waste used to screen material, Penlee Quarry
6.3 Screening operation in progress, Penlee Quarry
6.4 Excavated spoil faces containing fine discards, Penlee Quarry
6.5 Silt beach near the lagoon discharge point, Shellingford Quarry
6.6 Silt spread to dry, Shellingford Quarry
6.7 Re-graded backfill, Shellingford Quarry
6.8 Residual sub-soil near re-graded land, Shellingford Quarry
6.9 Assorted quarry waste, Oathill Quarry
6.10 Residual mixed top and sub-soil, Oathill Quarry
6.11 Processing fines from screening aggregate, Oathill Quarry
6.12 Road planings before removal, Oathill Quarry
6.13 Re-graded backfill area before final covering, Cromwell Quarry
6.14 Final re-graded backfill area, Cromwell Quarry
6.15 Filter press discards, Cromwell Quarry
6.16 Birch woodland south of Cromwell Quarry

7.1 Potential trial plot on 65m bench at Penlee Quarry
7.2 Potential trial plot on 75m bench at Penlee Quarry
7.3 Hydroseeding on to re-graded -100mm waste at Penlee Quarry
7.4A Growth 6 months after hydroseeding at Penlee Quarry
7.4B Growth 6 months after hydroseeding at Penlee Quarry
7.5 Growth 18 months after hydroseeding at Penlee Quarry
7.6 Close up of hydroseeded surface after 18 months at Penlee Quarry
7.7 Garden area 16 months after sowing and planting on -5mm waste
7.8 Potential area for trial plots on screening bank at Oathill Quarry
7.9 Self-set trees on quarry waste at Oathill Quarry
7.10 Natural vegetation on quarry backfill at Oathill Quarry
7.11 Natural re-vegetation of limestone strata at Oathill Quarry
7.12 Potential trial plot on re-graded backfill at the western end of Cromwell Quarry
7.13 Grass and mosses on re-graded backfill at Cromwell Quarry
7.14 Self-set saplings on disturbed ground at Cromwell Quarry

TABLES
6.1 Principal results from testing samples
6.2 Proposed soil specifications

APPENDICES
1 Sampling silt from lagoons
2 Equipment for sorting and processing waste materials in quarries
3 Illustration of website giving details of WRAP approved composting sites
4 Full test results
5 Local Biodiversity Action Plans for each of the four sites
6 Table from Schedule 3 Environmental Permitting Regulations
1 INTRODUCTION AND BACKGROUND

This Study, funded by DEFRA’s Aggregates Levy Sustainability Fund through Natural England, is concerned with reviewing, identifying and describing the methods by which artificial soils can be formed in quarries where little or no natural soil has been previously stockpiled or made available for subsequent restoration.

Many older quarries have little or no enforceable planning requirement for the storage and reuse of agricultural soils. In general during the 19th and the first half of the 20th century topsoil in quarries was either sold, removed or not valued and therefore was lost. The introduction of the review of quarry planning conditions under the Environment Act 1995 has at times done little to enhance the availability of natural soils for restoration especially at those quarries where natural soil is no longer present at the level of recent working. In some other quarries where soils may reasonably have been expected to have been preserved working practices have at times fallen short of the requirements of planning conditions and natural soils may have been mixed with general waste products or negligently sold off-site.

The review is therefore concerned to describe and illustrate the steps and investigations, handling and processing of such potential soil forming materials as may be found in aggregate quarries and using these with other materials or amendments to form a range of artificial soils for restoration. It will explore ways in which quarry waste, and mineral products, can be used in conjunction with these amendments to accelerate what in ‘normal’ soils has been a long process of natural soil evolution. This report relates to the use of on-site quarry waste as the mineral basis of artificial restoration soils, imported organic amendments will probably still be required. This study therefore considers the implications of the Environmental Permitting (England and Wales) Regulations 2007 that impact significantly on the use of organic amendments imported into a quarry site.

To demonstrate and review the issues involved four quarries have been selected for assessment as to their feasibility for use in trials involving the identification, selection, handling and processing of materials to form artificial soils. The trials would comprise part of a linked study to follow on from this project. The quarries concerned are:-

- Penlee Quarry, Newlyn, Cornwall
- Shellingford Quarry, Farringdon, Oxfordshire
- Oathill Quarry, Temple Guiting, Gloucestershire
- Cromwell Quarry, Brighouse, West Yorkshire

Assessments as to the feasibility of detailed trials comprise part of the current study.

In 1999 the DETR sponsored research on a study entitled Soil-forming Materials and their use in Land Reclamation. The principal authors were N.A.D. Bending and S.G. McRae of Wye College, London University and A.J. Moffat of the Forestry Commission. This sought to provide guidance on good practice on the use of soil forming materials and amendments in the reclamation of mineral workings. That study provides a truly comprehensive record of available soil forming materials and of their selection and use in land reclamation in the 1990s in relation to a wide range of mineral sites not confined to aggregate workings. However, little advice was given as to the choice and use of equipment to assist in the selection, handling and processing of waste materials in a practical sense. There were only limited restrictions on the importation and use of soil amendments in the 1990s. In particular restoration/reclamation concentrated on agricultural and forestry end uses and did not extensively cover ecological, landscape or other objectives more in keeping with current practice in 2009; biodiversity, for example, may be enhanced by the minimal adjustment of the distribution of physical, chemical
or biological elements of restoration. It is these matters that the present report particularly seeks to address.

The study starts (Section 2) with a review of desirable artificial soil properties and proceeds to review waste mineral materials likely to be found in aggregate quarries both working and dormant. The best methods of assessing their likely composition and the volumetric requirements for restoration are also outlined. Locations of soil forming materials both within any remaining *in situ* ground and in stockpiles are noted together with sampling methods and testing techniques.

The next section (Section 3) deals with investigations and sampling of quarry waste materials with a view to assessing their use for the on site restoration soils.

Section 4 sets out various methods of processing including scalping, screening and crushing in order to provide raw materials for artificial soils.

Section 5 examines soil amendments including organic additives suitable for use in promoting viable artificial soils it also includes a section on methods of mixing and blending inorganic soil forming materials with these organic compounds and the legal and environmental background to the importation of these materials. Various techniques to produce artificial soils for specific ecological niche areas appropriate for biodiversity environments are outlined.

Section 6 addresses the four selected quarry sites and approaches to the selection and processing of the inert elements of artificial soils appropriate for restoration objectives. It reviews the feasibility of undertaking detailed soil restoration trials at some or all of these sites as part of a subsequent study. Section 7 considers the field trials required for each of the four quarry restorations envisaged. It also reviews any work on restoration by design or neglect that has taken place at the quarries.

Section 8 deals with planning and permitting issues and the implications for planning a scheme of restoration and environmental enhancement. Section 9 reviews the findings of the study and makes recommendations for future work and further investigation.

Appendices include details of equipment suitable for use on quarries in the handling of soil forming materials and issues surrounding the sampling of silt from lagoons. Full test results are provided of the sampled materials; in addition information is provided regarding local Biodiversity Action Plans, the location of Certified composting sites and extracts from the Environmental Permitting Regulations.
2 DESIRABLE SOIL PROPERTIES AND AVAILABLE QUARRY WASTE MATERIALS

2.1 Soil Characteristics

The most important physical property of a soil is its texture since this governs or influences many of the secondary physical properties such as bulk density, porosity, permeability and consistency. Fig. 2.1 is a triangular plot of texture used by soil surveyors in England to describe soil texture in terms of the components of sand, silt and clay (Hodgson 1997). The use of the plot is illustrated with examples.

Clays are physical particles of less than 0.002mm in diameter, silts range from 0.002mm to 0.06mm in diameter and sands range from 0.06mm to 2mm in diameter. Gravel and stone content is that greater than 2mm and 60mm respectively in diameter. Silty materials have the potential to be the most productive in agricultural terms because of good aggregation (particles that clump together) and permeability characteristics, drainage and aeration, whereas clays with low permeabilities may have poor drainage and sands excessive drainage with poor water retention characteristics. Fig. 2.2 shows the relationship between particle size and permeability based on Summers and Weber 1984. The choice of various proportions of sand, silt and clay that can be produced or made available depends on restoration objectives e.g. for agriculture or niche ecological reclamation.

Similarly the key chemical parameter is that of pH which influences the restoration objectives and depends to a considerable degree on the local geology and especially on the composition of the rock or gravel being exploited. Other parameters of interest include electrical conductivity and cation exchange capacity both of which are relevant to the assessment of available plant nutrients and the need for organic amendments. Available plant nutrients that may be beneficial to plant growth include nitrogen. Phosphorous, potassium, calcium and magnesium; sodium and some heavy metals can be deleterious to plant growth.

Details of the sites selected for initial study and the available quarry wastes are given in Section 6. The three ‘hard’ rock quarries (Oathill, Penlee and Cromwell) were chosen inter alia to represent a range of rock types from potential low pH (acidic) soils – Cromwell through intermediate pH soils – Penlee to higher alkaline soils – Oathill. The sand and gravel operation – Shellingford is one where a limited (but insufficient) volume of topsoil was retained as screening banks, but no sub-soil. This latter site includes a recycling installation producing secondary aggregates from crushed rock and concrete such that fines are produced from the washing process that are collected in the form of lagoon sediments. The toxicity of these recycled materials is an important additional constraint. This also arises with the Cornish hard rock quarry that includes quarry waste materials from mineral veins that comprise some heavy metals.

The available soil forming materials need to be assessed prior to subsequent treatment for each of the waste deposit structures that might be used to recover soil forming materials. In only one case was restoration primarily to an agricultural end use hence the testing was only basic and comprised:

- Soil grading
- pH
- Moisture content
- Cation exchange capacity
- Toxicity

\[1\] In practice it has been found that the Cromwell site may be associated with strata and waste that is, in part, calcareous and that the pH is higher than anticipated.
The sampling and other investigation techniques are noted below in the context of a general overview of typical quarry wastes, their composition and the locations in which they are generally found.

2.2 Waste Materials in Quarries

Waste materials in quarries usually arise from:-

- Overburden and inter-burden excavations. Overburden is non-mineral material lying above the aggregate source rock or gravel and inter-burden is waste material intercalated within the mineral.
- Mineral processing. Typically this generates fine discards commonly less than 3-5mm in diameter, but may involve the production of scalplings that are discards up to 20-30mm in diameter that are sometimes removed as waste since it may be uneconomic to separate gravel and coarse sand materials from mixed clay and silt.
- Sub-standard unmarketable minerals. These may be minerals that are outside saleable specification or they may be finer materials such as medium or fine sand that has been produced in quantities that are unmarketable.

Fig. 2.3 shows typical sources of waste materials. In situations of prime concern to this study top and sub-soils and fine grained superficial materials may have been mixed and/or disposed of together with general quarry waste. The illustrated section applies to a stratified rock sequence such as that at Cromwell or Oathill. Inter-burden is relatively uncommon in igneous rock deposits used for aggregate production, but waste materials can arise in igneous rock deposits from mineral veins and alteration products adjacent to mineral veins or at the margins of the igneous deposit.

Fig. 2.4 shows a typical range of tips and stockpiles that may be found in an established quarry where top and subsoil has been preserved. As may be seen waste materials are commonly used to backfill part of the excavation void and to provide bulk screening banks or bunds. Within the quarry some material may be used to support slopes that might otherwise collapse in the long term.

All stockpiled materials, whether they comprise waste, mineral or materials to be subsequently used for restoration, comprises tipped material that is subject to the constraints of the Quarries Regulations 1999. All placed materials in quarries, including materials placed in excavations and in specially constructed lagoons has to be appraised as to its safety. Solid tips that exceed 15m in height or is placed on sloping ground (steeper than 1in12) or covers more than 1 hectare is subject to the requirements of detailed geotechnical assessment under the Quarries Regulations. These requirements include the assessment of stability during construction and during any modification including removal of materials such as may arise when excavating materials for use in artificial soils. Similar constraints apply to lagoons that are regarded as liquid tips with solids placed in suspension. The construction and removal of lagoons is also subject to detailed geotechnical assessment especially when contained materials lie more than 4m above land within 50m of the retaining structure or the structure contains more than 10,000 m³ of material.

Hence whilst stockpiled waste materials are usually present in most quarries containing materials that by selection or processing could be useful as soil forming materials, caution is required regarding the use of these materials. Stockpiles and backfill may be located to provide other functions such as support or screening.

2.2.1 Waste content

The content of solid tips may vary greatly depending on the source of material being deposited. In general aggregate quarries produce aggregate from most rock capable of yielding a marketable product. Waste may come from each of a number of steps in the mineral excavation and processing cycle as follows:-
Overburden excavation. This material may range from loose superficial materials to bedrock unsuitable for processing for mineral production and may even include sub-standard weathered mineral. The grading of this material depends on what is being excavated; superficial materials comprise sands, gravels, boulders, clays or silts in variable proportions and may be suitable for simple processing for use as a soil forming material. More solid overburden material is unlikely to be economic as a source for soil forming material since it would require crushing and screening to produce usable gradings. Overburden materials are an uncertain and essentially a local source of soil forming material.

Mineral excavation. This rarely leads to direct production of waste unless inter-burden or inferior and highly weathered mineral is exposed. In this case these materials will be separately removed and taken direct to a tip. The grading again may vary depending on the character of the inter-burden and the extent of any weathering. Clay and silt bands within a limestone or sandstone sequence may provide suitable soil forming materials; often in aggregate production the thinner inter-burden layers are excavated with the rock and removed by scalping. Hence this is a local and occasional source of suitable material for soil formation.

Scalping excavated mineral. As noted above, aggregate material that has been blasted and excavated is sometimes scalped before crushing. Scalping may also occur after primary crushing when material smaller than 20-30mm may be rejected if this prevents subsequent problems arising from the packing of fine material over screens due to the accumulation of fines in the system especially if a significant clay content is present. These scalped materials may be separately processed when suitable conditions and/or equipment is available or blended back into cleaner freshly blasted rock. Sometimes however it is tipped and may become an important source of soil forming material.

Crushing and screening the fines. The process of crushing and screening is considered in more detail in Section 4 below, but fines are produced at each stage of crushing and screening. The extent to which a quarry is set up to produce fine gravel and sand will determine the cut-off sizes for rejection and waste production. This will vary from 3-5mm and will depend upon the volumes that report to these smaller sizes and the extent to which they may be re-used e.g. as an additive for asphalt or for subsequent sand classification. Segregation of sands and fine gravels often requires washing and the fines frequently end up in lagoons. It is however not uncommon to find a significant volume of fine dry discards in quarries the quantities greatly exceeding the demand of the available market. Hence these fine materials can become an important source of soil forming material.

2.2.2 Waste accumulations

The different types of waste accumulations include:-

- Spoil heaps
- Backfill in excavations
- Stockpiles
- Amenity or screening banks
- Lagoons or silt ponds
- Planings from haul roads and trafficked areas

Each of these waste structures has a range of characteristics that may influence the composition (grading and content of the waste) as well as the stability of the structure. Fig. 2.5 shows the internal structures that can be present in solid tips and stockpiles formed in different ways. Liquid tips also show a range of grading that is determined by the discharge point(s) into the lagoon (see Fig. 2.6).

Solid tips have an angle of repose structure when formed by dozers pushing materials over the crest of the slope, or by a drag line or backhoe bucket discharging materials onto a stockpile.
Larger material from very coarse gravel to boulders tends to accumulate at the toe of the angle of repose structures with finer material on the upper/higher section of each layer; these layers are generally quite visible during subsequent excavation of the tips. The angle of repose is typically about 37° from the horizontal. Tips formed entirely by dozing out material in layers have a sub-horizontal structure and the grading is largely unaffected by the placement.

Liquid tips usually show the coarser silt and fine sand deposited close to the discharge point with finer silt and clay furthest from the discharge point (see Fig. 2.6). Changes in the deposition of these materials may arise as a result of moving the discharge point and/or raising the level of a lagoon embankment. However relatively uniform materials can be recovered from lagoons in the finer to medium grade, but it is also appropriate to analyse lagoon sediments for toxic materials since these are frequently associated with clays. It should be noted that access on to and the removal of silt from lagoons can be an exceptionally dangerous activity and regularly results in the death of a number of persons. Investigation of the feasibility of access and removal of silt is a specialist matter and appropriate advice should be sought before attempting these works. Some of these problems are highlighted in Appendix 1.

Figure 2.1 Triangular plot of soil texture with components of clay, silt and sand. A mix of 40% clay, 30% sand and 30% silt lies on the boundary between a clay and a clay loam. A mix of 10% clay, 20% silt and 70% sand is a sandy loam. Oathill Sample 1 contains 8% clay, 23% silt and 24% sand; if this material was screened to remove +5mm material then ignoring the small proportion of remaining gravel the fines would comprise a loam.
Figure 2.2 Triangular plot showing relationship between particle size and permeability with lines of equal permeability (m/s).

Figure 2.3 Typical sources of waste materials in quarries.

- **Toppill**: Often includes organic material. Normally stored in separate topsoil and subsoil dumps (stockpiles) of restricted height. Material required for restoration.
- **Subsoil**: Often of very variable composition. May contain previous fill materials. Particle sizes can range from clays through to boulders. Material often weathered especially near top. Generally of no commercial value, disposed of to tip.
- **Overburden (Superficials)**: Often of very variable composition. May contain previous fill materials. Particle sizes can range from clays through to boulders. Material often weathered especially near top. Generally of no commercial value, disposed of to tip.
- **Weathered Unweathered**
  - **Overburden**: Often of very variable composition. May contain previous fill materials. Particle sizes can range from clays through to boulders. Material often weathered especially near top. Generally of no commercial value, disposed of to tip.
  - **Contaminated Mineral**: Limited commercial value as dug but may improve with processing giving fines for disposal to spoil heap or lagoon.
  - **Intact rock**: May require treatment prior to excavation. No commercial value, disposed of to tip.
- **Mineral**: Where feasible stripped in separate operation. Where impractical may be removed from mineral by processing giving fines for disposal to tip or lagoon. In British opencast workings commonly known as the ‘parting’.
- **Underburden**: Material removed to ensure stable slopes, typically in steep dip operations or to provide a sump.
Figure 2.4 Characteristic tips and stockpiles found in quarries
Figure 2.5 Internal structures commonly present in tips and stockpiles
Figure 2.6 Idealised cross sections through silt lagoons. The upper drawing shows a cross section of an embankment lagoon with accumulated silt. The water level may vary and the surface of the sediment must be dry before excavation or sampling occurs. The lower drawing shows the variation in the grading of fines settled in the lagoon with coarser material deposited near the discharge point where a beach of fine sand or coarse silt forms (see Photograph 6.5). The section of the lagoon most distant from the discharge point has the finest silt that takes longest to dry.
3 INVESTIGATIONS AND SAMPLING

This section seeks to clarify how to proceed in finding and sampling suitable soil forming materials in a quarry site

3.1 Prerequisites

There are two prerequisites to any investigation:-

- The volume of soil forming materials required
- The locations where soil forming materials are required

The initial question is that of the quantity of soil forming materials required. In general the majority of the artificial soil will be of mineral matter. From research undertaken by WRAP it appears that up to 20% of a soil volume may be organic amendment material, but for non-agricultural end uses is commonly much less. Soil thicknesses may vary greatly depending on the nature of the restoration required. High quality agricultural soils may be up to 1m thick including both top and sub-soil, but with niche restoration to some biodiversity objectives soils may be as thin as 100mm to 200mm or even less where the underlying material has some drainage and rooting capacity. Topsoil thicknesses rarely exceed 300mm to 400mm and may be less than 150mm outside heavily cultivated areas where soil is required for biodiversity objectives on restoration. This marks a change from the situation in 1999 where it was stated that soils less than 150mm were "rarely worth producing".

Higher quality material with more refined gradings and appropriate amendment materials are more likely to be essential for the topsoil element of agricultural soils; there may be less rigorous exclusion of stony materials and less organic material in the lower 0.5m to 0.7m. The purpose of adding organic material to soil forming mineral matter is to incorporate essential organic content and improve the establishment of vegetation by improving its fertility. Organic matter is converted in a process known as mineralisation into a form from which vegetation can obtain nutrients. This addition of organic matter leads to an increase in the cation exchange capacity of a pure mineral soil of an order of magnitude; this cannot be achieved in a suitable fashion purely by the addition of mineral fertilisers. The addition of organic material can be far more restricted when seeking to achieve a range of biodiversity objectives.

Most well composted organic materials have a density of approximately 0.6t/m³. These organic amendments may be added at a volume proportion ranging from 1% to more than 25%; this is equivalent to the following mixes:-

- 25% by volume equivalent to 1,250m³/ha of compost or 750t/ha
- 5% by volume equivalent to 250m³/ha or 150t/ha
- 1% by volume equivalent to 50m³/ha or 30t/ha

These are the quantities required for 0.5m thickness of topsoil. Clearly proportionately less material is required for thinner topsoils.

The location of the area requiring an artificial soil is significant in the context of the location of a potential source of soil forming material. Haulage and transportation costs can be high and any processing needs to be conveniently located to avoid double handling costs. The DETR study identified a number of basic options to match or limit the area to be restored to economically feasible artificial soil production. These options were:-

- Alternative use of the site with a restricted area of soil restoration.
- The use of thin topsoil, but not less than 150mm (where available) over artificial subsoil.
- The use of artificial soil over the whole or part of the site recognising that the productivity of the soil would be less than that of a natural soil in the same situation.
Today other alternatives present themselves in the context of current restoration objectives.

In the 1990s restoration objectives concentrated on agricultural, forestry and the occasional amenity end use. Clearly the pressures on site restoration for increased biodiversity/geo-conservation were not a significant issue, whereas these are now an accepted, if not mandatory, restoration objectives for at least part of many quarry sites.

In the past, nature conservation focussed on preserving, protecting, reserving, restoring and conserving nature, whether it be a specific species, habitat or whole ecosystem; this has been achieved through legislation since the 1950s. More recently it has also become apparent that habitats also need to be created and biodiversity re-built. Biodiversity is a measure of species variation within a region. To re-build biodiversity a range of potential habitats appropriate to the local geology, geomorphology, climate etc. need to be created/enhanced rather than creating a specific habitat for a specific species.

To encourage a biodiverse restoration it may be more suitable to allow natural colonisation of a site rather than covering an area with a nutrient rich, well structured topsoil and planting it with vegetation appropriate to the locale. However speeding up or manipulating natural colonisation and the soil forming process could be beneficial.

This review is concerned with looking at ways of speeding up and/or manipulating the soil forming process to enhance the biodiversity potential of an area. The soil forming process could be encouraged by a range of simple to more complex techniques. These include, for example:

a) simply moving stockpiled material and spreading it across areas of the quarry floor which increases the surface area of the aggregate to be acted upon by physical, mechanical and chemical weathering.

b) Spreading aggregate material and creating ridge and furrows to provide a mixture of sheltered and exposed areas.

c) Adding finer or larger sized aggregates to provide some embryonic structure to the emerging soils.

d) Adding inorganic and organic amendments (sourced locally e.g. mushroom compost, paper mill sludge, sewage sludge) to improve the soil structure, nutrients, water retention, microfauna, etc.

e) The addition of Certified organic and/or inorganic material to form a nursery grade compost.

Fig. 3.1 Illustration of range of complexity of intervention
It is the recognition that any/all parts of the spectrum of minimum to maximum intervention may be desirable which represents current restoration thinking.

There is a range of potentially costly restoration interventions. These are:-

- Achieving complex mineral gradings especially when mixing and re-handling are involved and/or specific screening operations are required.
- The drying of wet mineral components that may require spreading or placing in windrows to dry and then lifting for use elsewhere.
- Transporting large tonnages over long distances within the quarry.
- Using the artificial soil to achieve the slope grading required when this could be achieved by specific profiling operations beforehand.
- The addition of expensive amendments.
- The addition of amendments brought in from great distances.
- The stockpiling of amendments rather than the immediate spreading and use of those amendments.
- The use of multiple mixing of amendments with mineral soils rather than a single operation.
- The use of expensive drainage measures post-mixing rather than the use of drainage techniques and the provision of appropriate drainage materials beforehand.

Given the cost of restoration work it is essential that the exact areas for restoration are determined so that the volumes of specially prepared mineral soils (added to existing re-graded materials) and of amendments are clearly known. Without this information no proper cost estimates can be prepared.

Whilst much of the above is directed towards agricultural or ecological restoration, it should be recognised from recent work on non-agricultural quarry restoration of quarries (MIRO 2006) that soils are required for many industrial, commercial and residential development sites in quarries. They may also be required for ecological/landscape restoration as part of these afteruses or as a stand alone objective. These soil uses range from gardens to public open spaces and landscaped areas to ecological exclusion zones. As above, it is important that the extent of each of these potential soil coverage areas is known so that the volumetric requirements are properly assessed.

3.2 Preliminary Investigations

3.2.1 Initial enquiries

When assessing the availability and suitability of quarry discards for the production of the mineral element of artificial soils there are a number of initial steps that need to be undertaken.

Firstly the most recently available survey of the quarry should be obtained. Although detailed annual plans of a quarry are not a statutory requirement they are essential where geotechnical assessments are required under Regulation 33 of the Quarries Regulations 1999. These plans should clearly demarcate areas of fill although this is not necessarily the case with surveys dating back to before 2000. A plan is also required of the final restoration scheme. This may have comprised part of the original or subsequent planning permission for the site and should provide information on the areas requiring placement of soils as part of the restoration.

With older sites, and especially those that have not been worked since 2000, it is frequently necessary to examine all available plans that may have been produced over a number of years. By this means the extent and development of workings over time can be examined together with the construction of waste structures and especially backfilled areas. It is not uncommon to find significant areas of backfill that are indistinguishable from surrounding rock benches especially where an excavation has been fully backfilled and the floor of the backfilled...
area is devoid of *in situ* rock. It should be noted that Ordnance Survey plans are of only limited value since within the last 80-90 years the internal details of quarries are poorly demarcated.

In the absence of plans much can be determined from air photographs. These are available for most quarry areas back to 1945 and at times prior to that. A sequence of air photographs can also show quite clearly where wastes were placed at any given time. They can also show the areas being excavated at the same time.

Secondly, enquiries need to be made of the quarry operator and/or the owner as to where waste has been placed and the composition and character of this waste. Reports on classified tips under the Mines and Quarries Tips Regulations 1971 have been produced since 1972 for all classified tips (these Regulations are now modified and subsumed into the Quarries Regulations 1999). Reports produced under both Regulations should provide details of the character and grading of placed waste as well as details of its configuration. It should also provide information as to how material can be safely removed from the structure when producing material for soil forming purposes.

Thirdly, details can be obtained of the geological setting of the quarry based on information downloadable from the British Geological Survey.

Fourthly, details of planning obligations relating to the restoration of the site.

Fifthly, enquiries can be made of the availability of local organic waste materials.

Sixthly, local biodiversity objectives may be found in any Biodiversity Action Plan (BAP) as well as from a study of nearby SSSIs and protected areas which can be found on the government website MAGIC (Multi-Agency Geographic Information for the Countryside).

### 3.2.2 Site visits

The site visits comprise part of the preliminary investigation at each of the four sites studied. Such visits should be undertaken with appropriate plans and air photographs obtained beforehand; details of the geological setting should also be obtained beforehand.

The initial part of the site visit comprises a walkover, ideally with the site operator, during which the general location of areas that require restoration are identified together with the location of stockpiles of waste materials acceptable as a possible source of soil forming materials. Rough approximations can be made of the areas that require restoration and of the corresponding volumes of waste materials required for restoration. Photographs need to be taken of tips and restoration areas, the reliability of survey data assessed and the proximity of restoration areas to source materials considered in terms of haulage distance and accessibility. The ideal situation is one where the waste materials are very close to the proposed restoration area or indeed comprise the foundation of the ground that will be restored using soil materials recovered from the immediate site and where the ground levels have been restored to suitable gradients for final restoration. Initial consideration can also be given to the siting of any processing plant that may be required and the access and storage arrangements that may be necessary for imported organic material.

Enquiries need to be made of the geotechnical implications of the removal of materials from waste stockpiles and tips. In general tips and stockpiles need to be removed from the top down in thin layers; due attention must be given to safe access on tips and the provision at all times of appropriate road surfaces and edge protection. Direct excavation into the toe of tips can be exceptionally dangerous and should not be attempted without prior geotechnical advice. Situations where excavators or personnel can be engulfed in collapsed material can arise where due care and attention has not been given to the work. Similarly excavation of materials from lagoons and access on to lagoons should always be preceded by competent geotechnical advice, and where necessary, investigations. It should be noted that all work and procedures within a quarry must be preceded by a risk assessment and satisfactory operational rules.
During the visits potential arrangements for sampling need to be considered in the context of the materials and methods of construction of the waste tips. Any additional information needed should, if possible, be identified at this stage.

Any previous attempts at restoration and/or planting should be examined and the availability of land for trial plots assessed.

3.2.3 Detailed investigations

These investigations are directed mainly to assessing the requirements for a pilot restoration scheme on each of the quarries studied and to a consideration of the viability of extending the pilot study, if successful, to the whole site. There are various steps:

- Assess the quantities of soil forming materials required. This requires a restoration plan at an appropriate scale from which areas can be measured and the different types of restoration soils required can be identified.
- Undertake sampling. Sampling should be representative of the tip that may be used to supply the soil forming material. Hence surface sampling is not straightforward in a quarry since there may be little direct information that can be obtained on the internal contents and structure of a tip or of a lagoon. Solid tips are best sampled across the direction of advance of tipping using backhoes with adequate reach. Borehole samples are far less satisfactory and may give little or no direct information on the structure and grading of the waste materials. Long reach backhoes are more satisfactory than normal backhoes for this sampling and tractor mounted backhoes are of limited value in the sampling process. Representative samples need to be taken from across the layering within the tip. Where the layering is contained within an angle of repose structure a horizontal trench can provide a suitable sample from across the various layers; where the layering is sub-horizontal the sample needs to be obtained from the face of a vertical trench. Usual sampling rules apply and it is usually appropriate to recover 10-30kg of sample material for grading and other tests. This allows for the recovery of finer grained materials and their further analysis.

Sampling from lagoons is best undertaken from the embankment of the lagoon using a long reach backhoe. Excavators should not move on to the lagoon without detailed checks and trials and only then with low ground pressure tracks. Pedestrian access should be prohibited on to lagoons particularly those with standing water; such lagoons require drainage of standing water and frequently many months to achieve satisfactory desiccation to permit access and ensure that the silts are not saturated and therefore unsuitable for use as a soil forming material. Further details are given in Appendix 1.

- Testing and analysis. This should be undertaken by a reputable laboratory, preferably one with UKAS accreditation, and include the following:
  - Particle size analysis or particle grading. This is best undertaken in accordance with the standards set out in BS1377: Part 2: 1999 and should determine the percentage by weight of clay, silt, sand and gravel and possibly cobbles/stone larger than 63mm.
  - Moisture content at 30°C as a weight percentage BS1377: Part 7: 1990.
  - Cation exchange capacity as meq/100g.
  - Conductivity at 20°C uS/cm.
  - pH in pH units.
  - Heavy metal contaminants, where suspected. These are usually obtained from ICP analyses and the results are based in units of mg/kg.
  - Organic contaminants, where suspected. These are based on List I and List II requirements of the Environment Agency.
Other parameters may be measured including density and concentrations of nitrogen, phosphorous, potassium, calcium, magnesium and sodium. In addition the organic content of materials may be measured, but this is rarely likely to be present in quarry waste.

On the basis of this information it is generally possible to assess if a quarry waste material is suitable for use as the mineral element of a soil forming material. Assuming that the waste comes from scalping or crushing there may be some scope for the recovery of suitable fines and some useable fine aggregate. Depending on the content of clay and silt it should be possible to assess whether dry or wet screening is required; dry screening is preferred since it is less expensive unless an existing setup is present on the quarry. If the waste comprises overburden materials and little or no previously processed discard, then it may be possible to improve the soil forming characteristics by scalping rather than by screening; this is the removal of oversize material such as large cobbles or boulders leaving behind material that may be acceptable for soil use.

The assessment of toxicity is particularly important in lagoon sediments and in areas of former metallic mineral working and consideration has to be given to Environment Agency threshold limits of critical contaminants when these become available. If these are near or just above the threshold it may be possible to mix less contaminated or un-contaminated materials to provide an acceptable soil component. It should be noted that in some parts of England, especially Cornwall, soils are seldom suitable for importation from elsewhere nearby, owing to toxicity of chemical components such as arsenic.

Of prime concern is the cost of any processing that may be necessary. These costs are considered in the next section.

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2 DEFRA Soil Guideline Values that relate to soil chemistry of such areas have been withdrawn and, at the time of writing, new SGVs are awaited.
4 SORTING, CRUSHING AND SCREENING

This section deals with the handling and processing steps required in the production of the mineral element of artificial soil used for quarry restoration. A wide range of mobile, semi-mobile and fixed equipment is available for sorting, crushing and screening the component elements of mineral soil.

Clearly working aggregate quarries usually have plant on site and the costs of using such plant as a means to supply by-product materials required for soil may represent a marginal cost provided significant disruption to normal production does not occur. For dormant and inactive quarries, with no plant, hire costs can range from less than £300 to more than £1,000 per week depending on the size of plant required, plus transport on and off site of the necessary equipment. Hire costs are highest during summer when many quarries undertake temporary screening of materials that may at other times be too sticky for cleanly separating aggregate sizes.

Standard material handling, excavators and dump trucks etc. are usually available locally or regionally. Information on screening equipment hire is best obtained through quarrying organisations and their publications e.g. Quarry Management, the Quarry Products Association or the British Aggregates Association. An alternative would be to hire in a firm to produce the necessary materials that might also include some saleable aggregates. Choices can only rationally be made on the basis of careful costings.

4.1 Sorting

Sorting comprises mixing of available selected materials for use as a soil forming material without screening or crushing. This is the least costly option, but depends heavily on a good understanding of the range of gradings likely to be recovered from quarry wastes on the site. Typically the plant involved will include crawler mounted backhoes, wheeled loaders and dump trucks. Appendix 2 shows equipment commonly in use.

Blending may sometimes be necessary where contaminants are present in some of the waste material or where particularly coarse or fine material is present. Similarly a mix of coarse and fine material may be required to ensure adequate drainage. In these cases a stockpile can be formed comprising alternating layers of the different materials placed by a dozer or front-end loader. This stockpile can then be excavated at right angles to the horizontal layering and a mix of the various layers is achieved. The process can be repeated to obtain a more comprehensive blending. A similar process may also be appropriate when mixing organic material with inorganic soil forming materials. One alternative commonly used is to form windrows (lines of material in the form of an inverted V) of material, especially silts that require an element of drying. Drier materials of different gradings may then be placed between windrows when some drying has been achieved and the two materials mixed on excavation.

In some situations mixing is less important than on-site layering of different mineral elements and amendments, especially where under-drainage is required.

Vehicle trafficking is a serious problem that can give rise to excessive compaction of soils. Wherever possible materials placed to final restoration level should be rooted or broken up with tines mounted on an agricultural tractor or in extreme situations by using a bulldozer with ripper bars. It may also be possible to use long-toothed buckets on backhoes to perform a similar function. Soil spreading, whether mixed with amendments or not, is best undertaken using a backhoe that avoids travelling over material that has already been placed and spread. Organic soil amendments, when added separately and mixed in situ, are usually placed by agricultural muck spreaders and rotavated into the soil. An alternative option is to use blower type of spreader for compost application.
4.2 Crushing

Crushing is an expensive activity. However much of the discarded waste likely to be used directly as soil forming material might arise from previous crushing and related screening operations. Alternatively activities currently in progress and producing fines will probably involve crushing. Crushing to give soil forming materials is therefore only likely to be a viable activity, in exceptional circumstances. More typically a situation might arise where coarse discards from an overburden excavation or previous waste mineral are re-assessed as worth re-working to produce aggregates in conjunction with an exceptional demand for soil forming materials. The hire of a crusher, and other attendant plant, purely to produce soil forming materials is unlikely to be a worthwhile exercise and alternatives should usually be sought.

4.3 Screening

There are three basic types of screens that are used to sieve and sort by size, crushed or broken material. These are:

- Fixed screens, sometimes known as grids or grizzlies
- Rotary screens commonly known as trommels
- Vibrating screens

4.3.1 Fixed screens

These are normally used to separate out oversized material to put through a crusher. Such material would also be wholly unsuitable in the mineral mix for an artificial soil. In its simplest form this screen is a fixed grid of bars the separation of which defines the upper boundary of acceptability. Commonly this may range from 100mm to 250mm. The bars are usually inclined at about 10° and require periodic purging to remove jammed material. This is most easily done by having a pivoted hydraulic grid. The screen is usually fed by a front end loader or a backhoe and may be linked directly to a vibrating multi-deck screen (see Photograph 4.1). The undersized material may be suitable as a component of some artificial soils without further treatment.

Another type of fixed screen, with no mechanically moving parts, is the sieve bend. This is curved with a series of parallel wedge bars perpendicular to the flow of the materials, typically tipped from a front end loader bucket. It is used to sort materials for crushing from a slurry that is led off at right angles to the flow of the coarser material for subsequent processing to separate silt from sand.

4.3.2 Rotary screens

Rotary screens or trommels comprise a perforated inclined cylinder that is rotated whilst material is fed from a hopper into the rotating trommel. Oversized material passes down the inclined drum with progressively larger material passing through perforations which increase in size down the drum.

The method is most widely used as a form of rinsing screen for wet material when material is washed before, or within, the upper section of the trommel. This is the process commonly used in waste recycling sites including that at Shellingford (see Photograph 4.2)

4.3.3 Vibrating screens

These are the screens most likely to be present in aggregate quarries and most readily hired to assist in operations that may be required to produce soil forming materials in addition to aggregate. The most likely type of vibrating screen is the mechanical version with two inclined
screens producing three segregated sizes. Various screen types are available including wire mesh, perforated plates, piano wires mostly in steel but commonly cushioned with rubber or polyurethane cladding. The screens are typically inclined up to 12° to the horizontal with linear motion screens, whereas screens that move with a circular motion are usually inclined at between 15° and 30° (see Photographs 4.1, 4.3 and 4.4).

Sticky material is often a problem with vibrating screens such that when discards or quarry products include a significant proportion of -5mm material that is damp blockages can occur. One solution is to pre-wash all the discards in a similar fashion to that undertaken at Shellingford Quarry. Here a trommel is used together with cyclones to separate fine discards including silt and fine sand and also to float off organic materials that could be used in subsequent composting (see photograph 4.5).

Moist or wet screening can assist with reducing screen blockage, but the fines are often saturated and need careful handling. The authors have found that dry screening during dry periods is most effective at producing a -5mm product that may have an acceptable clay/silt/sand mix for artificial soils whilst also producing larger size material for drainage and other aggregate uses.
Photograph 4.1 A screening operation in progress at Oathill Quarry with a Powerscreen hopper. The fixed screen in the hopper allows for the rejection of oversized material. This hopper could be a standalone item of equipment used for removing oversized material without feeding on to a screener.

Photograph 4.2 This shows two cyclones (upstanding cylinder-like structures at the top of the equipment) used to segregate sand and fines from a washing operation that incorporates a trommel screen at Shellingford Quarry. This screen lies behind the cyclones. Separated fine sand and silt is discharged into lagoons (see Photograph 6.5).
Photograph 4.3 A screening operation in progress at Penlee Quarry using a double deck mechanical vibrating screen system inclined at 25°. The screen is fed by the backhoe placing material into a hopper that discharges on to an elevating conveyor which then discharges on to the inclined screens. Three products are being produced. On the right-hand side -5mm material, into the tractor/trailer unit -20mm +5mm and on the left-hand side +20mm material that had previously been roughly screened to -100mm. The feed material (roughly -100mm all in) was used for re-grading the entrance to the quarry and subsequently hydrosedeed with a neutral soil grass mix with added wild flowers and shrubs. The appearance after approximately 6 and 18 months after use in public open space restoration is shown in Photographs 7.4.A and B and 7.5.

The -5mm material contained 21% silt and clay, 34% sand and 45% fine gravel. This would form the basis of a satisfactory artificial soil with suitable organic amendments for use in public open spaces, including garden areas and for private gardens in the eventual quarry afteruse.

A similar arrangement is shown in Photograph 4.1 at Oathill Quarry.
Photograph 4.4 Screening set up at Shellingford Quarry with a preliminary washing operation with trommel and cyclones (shown in Photograph 4.2). The sand is separately discharged from the cyclone system via the conveyor unit on the right-hand side. The potential soil forming material is discharged as a silt into lagoons and requires subsequent drying.

Photograph 4.5 The washing process at Shellingford Quarry produces discards that float, principally organic materials including woody fragments and fibres. If this material is shredded it can be used with other green material in the manufacture of compost.
5 SOIL AMENDMENTS

5.1 Sources and Classification

Introduction

Soil amendments are anything added with the objective of improving the quality of, or speeding up, the soil forming process.

There are two main types of soil amendments.

- Organic
- Inorganic

Organic soil amendments include sewage sludges, manures and slurries, wood residues, papermill sludge and mushroom compost etc.

Inorganic soil amendments include pulverized fuel ash, slag, waste lime and fertilizers etc, most of which are inappropriate for restoration soils promoting sustainability and biodiversity.

5.1.1 Organic Soil Amendments

Organic soil amendments are an essential component of an artificial soil. They give rise to improved soil structure with better rooting and improved drainage. The improved drainage assists in the better use of rainfall and irrigation. Similarly the water absorption associated with organic amendments allows for improved retention of available soil moisture. Additional benefits include improved soil workability and reduced power input/fuel consumption and reduced costs in fertilizers.

The several sources of organic soil amendments include the following:-

- Sewage – including solid sludge, liquid sludge, cake sludge and thermally dried sludge
- Manures and slurries *
- Wood residues *
- Paper sludge
- De-inked paper fibre *
- Mushroom compost *
- Wool waste
- Straw *
- Green waste *

A number of the above items are only available locally or present significant problems in use including, for example, heavy metal contamination from sewage sludges. Similarly paper sludge and wool waste are only available locally whereas farmyard manures, mushroom compost, straw and green waste are generally available within a 50km radius of most quarries that have no soils for restoration. Transportation is an item that should be considered in the context of sustainability. De-inked paper fibre may be an exception in so far as it represents difficulties in disposal and is available at a cost marginally above that of transportation. Hence details of only those amendments indicated with an asterisk are considered below. References to the amendments not discussed further are given in Bayes et al, 1999, Bending et al, 1999, Luo and Christie, 2001, Ferrier et al, 1997 and Smith et al, 2000.

It should be noted that the use of any organic soil amendment, including compost and manures, is an activity that requires permitting by the Environment Agency. Provided approved and certified compost is used an exemption can be granted with respect to having to obtain a permit from the Environment Agency. All other amendments, including non-approved
and certified composts such as farmyard manure, require a permit from the Environment Agency to regularise its use. In addition the owner/operator of the quarry is required to demonstrate that no environmental harm will occur through the use of the selected soil amendment. Further details of this are given in Section 8 below.

a. Manures and Slurries

Manures and slurries contain useful quantities of essential and minor plant nutrients providing a greater mix of nutrients than many manufactured fertilisers. The benefits to crop yield and soil quality from using organic manures under rotational systems are supported by the experience of many farmers.

Farmyard manure (FYM) in particular contains a large proportion of organic matter, which improves soil texture, workability and quantity of water available for uptake by plant roots whilst improving drainage characteristics, a feature particularly important under low rainfall. Organic manures also enhance soil biodiversity encouraging a wider range of species (e.g. insects and birds) to our countryside.

Advantages of Manures and Slurries

- Contains major plant nutrients – Nitrogen, Phosphorus, Potassium
- Improve soil structure, rooting and soil drainage
- Improve retention of plant available water
- Encourage soil micro-flora and biodiversity
- Widespread and readily available

Disadvantages of Manures and Slurries

- Bulky to handle, transport and store
- Costs associated with spreading
- Can be of variable quality
- Pathogen reduction may not be uniform
- It is a waste and requires license/permit exemption (see Section 8)

b. Wood Residues

Wood residues are woody material that does not perform a useful structural purpose. They are generated through a number of industries including forestry, construction and demolition, agriculture and landscaping. There are a wide range of wood residues available including chipped and sawn timber, shavings, sawdust, wood fibres and non-recyclable pallets.

The physical and chemical properties of wood residue vary widely and depends on the origin of the material. Generally wood residues successfully improve soil physical properties although they take time to decompose.

Advantages of Wood Residues

- Widely available in different types
- Could be generated on site
- Dry and odourless
- Easy to compost
- Improves bulk density and moisture retention
- Inert and long lasting
- Readily handled

Disadvantages of Wood Residues

- Competition for wood residues - cost
- Needs management
- Poor source of plant nutrients unless composted
Requires nitrogen fertiliser owing to poor rate of decomposition
It is a waste and requires permit exemption (see Section 8) if imported

c. De-inked Paper Fibre

De-inked paper fibre (or paper ‘sludge’) is mostly composed of short wood fibres including lignin, cellulose and hemicellulose. Paper fibre, long used on agricultural land and in land restoration, is a valuable soil-forming material and its high carbon content (much of which is held in molecules that resist microbial degradation) make it particularly suitable for increasing soil organic matter content and carbon storage with consequent improvements in water holding capacity.

Advantages of De-inked Paper Fibre

- Can significantly increase water holding capacity
- High organic matter content
- Few sources of this waste

Disadvantages of De-inked Paper Fibre

- Hard to dry
- Compaction can be a problem as anaerobic digestion occurs and releases methane
- Variable viscosity and lumpiness
- Could contain contaminants and toxins
- Little nitrogen and high C/N ratio
- Few sources of this waste
- It is a waste and requires permit exemption

d. Compost

The compost process requires that an “amendment” be added to provide a source of carbon, add porosity to the compost mixture, and increase the solids content of the mixture. Sawdust and wood chips with a low moisture content are excellent wood waste sources as amendments because they aid in achieving the desired moisture and solids content of the compost mixture. A compost mixture should also have a good balance of carbon and nitrogen. Wood waste as the primary biomass material combined with biosolids (i.e. sewage sludge, food scraps), in a 1 to 4 ratio, attains that balance and produces a marketable product that may be used as a soil conditioner or source of organic matter.

Wood waste may be used to provide organic matter to topsoil. The organic matter increases the water holding capacity, cation exchange capacity, resistance to compaction, and microbial activity of the soil. The wood waste is ground into small fines that are tilled into the soil. The tilled mixture should consist of one-third wood fines. The fines decompose and the topsoil absorbs the nutrients.

It should be noted that there is a British Standard for composts relating to the materials and methods used in composting such that the product reaches an acceptable standard for public works (BSI PAS100) and a related British Standard for an artificial soil manufactured using PAS100 compost; this is BSI 3882-2007. The significant advantage of using PAS100 compost material is that it is becoming increasingly widely available at reasonable cost and can be used on site for the generation of an artificial soil from within the site. Use of this compost does not require an application for an exemption from permitting. Appendix 3 details the location of sites producing compost to BSI PAS100 across England with reference to the four selected quarries. It should be noted that PAS100 is covered by a Quality Protocol for the production and use of compost from source segregated biodegradable waste. Compliance with the criteria in the protocol is considered sufficient to ensure that the compost may be used without risk to human health or the environment and therefore without the need for waste regulatory control. The protocol relating to the manufacture of compost can be readily downloaded from the Association for Organics Recycling or from the WRAP website at http://www.wrap.org/composting/quality_protocol.html
Only certified composts can be used as a soil amendment without the requirement for a formal permit, but even then a formal exemption has to be obtained from the Environment Agency. Details of the regulatory position relating to the composting sector and quality protocol can be obtained from www.environment-agency.gov.uk. PAS100 compost is shown in photographs 5.1 and 5.2.

**Advantages of Compost**

- Increases soil organic matter and humus
- Improves water holding capacity
- Provides nutrients
- Improves soil structure and increases permeability

**Disadvantages of Compost**

- Storage constraints – low heaps required
- Bulky to transport
- Potentially expensive depending on source
- Can dry out and become a source of nuisance dust and/or contaminate water supplies
- Unless a Certified BS compost (e.g. PAS100) it requires a permit exemption being a waste

**e. Mushroom compost**

Mushroom compost is a viable and useful by-product of mushroom farming. Edible mushrooms are grown in a specific medium that is widely marketed. This growth media is a mixture of agricultural materials, such as straw from horse stables, hay, poultry litter, ground corn cobs, cottonseed hulls, cocoa shells, peat moss, and other natural organic substances. These products are formed into a rich organic media that serves as the nutrient source for mushrooms. After the mushroom crop is harvested, this organic material is removed from the production house, where it is processed into a consistent homogeneous by-product called “mushroom compost.”

Spent mushroom compost includes the organic material and a blend of wheat straw, horse and chicken manure. Mushroom compost contains an average of 25% organic matter and 58% moisture on a wet volume basis.

Mushroom compost contains about 1.0% nitrogen in a mostly organic form that slowly is available to plants. Also, mushroom compost contains an average of 0.67% phosphate (phosphorous) and about 1.2% potash (potassium), as well as other plant nutrients such as calcium (2.3%) magnesium (0.35%) and iron (1.0%). The average pH of mushroom compost is 6.6 (6.0 to 7.0 is an ideal range for most plants). The amount of carbon relative to nitrogen is an important indicator of nitrogen availability for plant growth, and ideal compost should have a ratio of 30:1 or lower. Mushroom compost has an excellent 13:1 ratio, indicating outstanding nutrient availability and mature and stable organic compost.

**Advantages of Mushroom Compost**

- Cheap compared with buying quality compost
- In general will improve the structure of clay soils
- Reduces surface crusting and compaction of soils
- Improves soil drainage
- Provides nutrients to plants
- Contains lime

**Disadvantages of Mushroom Compost**

- Excessive amounts of soluble salts (for example, calcium, magnesium, potassium etc.) in the soil that can cause injury to turf grasses and other groundcover plants
• If a waste and not a product will require an exemption from waste permitting for use in restoration

**f. Straw**

Straw is a by-product from cereal production.

*Advantages of Straw*

• Makes a good mulch, controlling weeds and is easier and lighter to use than bark
• Aids moisture retention
• Generally neutral pH
• Widely available
• Not listed by the Environment Agency as a waste requiring permit exemption

*Disadvantages of Straw*

• Pricing reflects other uses
• Requires nitrogen fertilisers due to slow rate of decomposition
• Bulky to transport

**g. Green waste**

Green waste is fruit and vegetable waste from a kitchen and/or garden waste such as grass cuttings, hedge trimmings, weeds and dead flowers often collected separately by Local Authorities for municipal composting.

*Advantages of Green Waste*

• Reduces waste to landfill
• Can be used to work towards BSI PAS Certification
• Has a high nutrient content
• Improves soil structure
• Maintains soil pH, moisture and air levels

*Disadvantages of Green Waste*

• Variable types of waste
• Requires permit exemption for use in restoration

**5.1.2 Inorganic Soil Amendments**

For the main part these are expensive, but can assist with stabilising or increasing pH and act as a slow release mechanism for nitrogen and phosphorous. In some cases they can also be physical improvements to soil properties, but levels of application need to be carefully controlled since the production of carbon:nitrogen ratios below 10to1 or above 25to1 are undesirable and potentially harmful. Since this study is concentrating on biodiversity aspects of restoration there are only limited roles for inorganic soil amendments. Typically amendments that are used include:-

• Pulverised fuel ash
• Pulverised refuse fines
• Slag
• Lime waste
• NPK fertilizers

It should be noted that if inorganic soil amendments are waste products, these also need to be treated in a similar fashion to organic waste amendments, unless they are categorised as
specific processed products such as standard fertilizers. Items that require permitting/permit exemption include:—

- Imported waste sand, clays and crushed rock
- PFA
- Imported soil and stones

The important aspect of this is that the materials are imported. There appears to be no legislative control over the use onsite of material arising from mineral workings senso lato, but if a mineral processing operation includes a separate processing plant, defined as outside the quarry, then waste from that operation will require an exemption from permitting. Further information is given in Section 8 below. It should also be noted that artificial soils formed from quarry waste would require a permit exemption to be used off-site.

5.2 Mixing with Soil Forming Materials

The mix of organic soil amendments with the mineral component to form an artificial soil is a key element in the matching of artificial soils for restoration with the restoration objectives. As indicated elsewhere, a wide range of mixes of amendment may be considered ranging from 1% or 2% by final soil thickness to more than 20%. The proportion of added amendments will influence the rate of soil development and the nature of the vegetation that it supports. Similarly the thickness of the mixed artificial soil may vary from a few tens of millimetres up to 500-600mm with additional pure mineral components to provide a sub-soil thickness of say 400mm-500mm.

There is a range of equipment that is used to assist with the mixing of organic amendments into the mineral element of artificial soils. The method most favoured by WRAP involves the spreading by agricultural muck spreaders or by blowers of the various additives such as PAS100 compost on to a pre-prepared surface. For large areas this pre-prepared surface may have been graded and rooted with a 1 or 3 tine ripper, to a minimum depth of 300mm when ground conditions are reasonably dry. Ripper bars or power harrows may also be used, depending on the nature of the mineral “subsoil”. For smaller areas, especially niche biodiverse cells, the surface may be less regular and its preparation involves little by way of loosening. If this presents a problem a solution can be obtained by applying a layer of coarser material, typically with the -5mm component screened out to enhance drainage. An alternative measure for poorly drained surfaces might be to spread organic compost prior to spreading a mineral component followed by a subsequent application of organic compost.

When the surface application of organic compost has been undertaken this is usually mixed in with power harrows attached to a normal agricultural tractor. It is often desirable to minimise vehicle traffic over artificial soils and the use of low pressure equipment may be appropriate since this reduces the compaction of both the top and sub-soil and has limited effect on the drainage of the soil. Such precautions are unnecessary where water logged soils are appropriate for the intended restoration.
Photograph 5.1 PAS100 compost

Photograph 5.2 PAS100 Compost - detail
6 ASSESSMENT OF SELECTED QUARRIES

6.1 Introduction

Four quarries were investigated as part of this study. For each quarry the site context was examined with regard to location, surroundings, geology, potential for biodiversity, etc. In addition for each quarry representative onsite waste materials were sampled and analysed.

6.2 Site Contexts

6.2.1 Penlee Quarry, Cornwall

Penlee Quarry is situated immediately south of Newlyn, near Penzance, Cornwall and is located in national grid reference SW 469 279 (see Fig. 6.1). It comprises an aggregate operation currently dormant, but with permission to produce armourstone in the future, from the local bedrock (Devonian Metadolerite).

Penlee Quarry covers approximately 23 hectares and is a deep excavation that has developed since quarrying commenced in 1880. As a landform the quarry consists of benched faces with bench heights varying from 10m to 45m. The total depth of the workings exceeds 130m. There has been some scrub regeneration beyond the immediate limits of working extending into small fields to the south east.

To the north of the quarry lies the urban development of Newlyn, this is separated from the site by a coastal hillside comprising fields and scrub/woodland developed on former quarry waste tips. The sea lies to the east on the western side of Mounts Bay. The road linking Newlyn to Mousehole further south lies immediately east of the site along the Newlyn-Mousehole Road. To the south, the coastal landscape comprises small undulating fields enclosed by hedges and hedgebanks with local woodland. Inland, to the south west is the village of Paul.

Working at the quarry initially obtained planning permission in 1948 and has been extended and deepened progressively since then; the latest major planning permission was granted in 1999, but since that time the quarry has been purchased by the present owners, MDL Developments Ltd., for the limited production of armourstone and its subsequent development as a marina with housing on benches, a commercial area and some public open space land. Fig. 6.2 shows the intended future development and zoning of the quarry (for which permission is yet to be sought) and Fig. 6.3 shows the layout of benches on the southern side of the quarry that will be used for housing with some public access and no-go wildlife reservations.

The intended restoration includes areas of natural restoration, restoration for public open space and for planting and garden areas. A limited amount of re-vegetation has been undertaken during the last two years with hydroseeding and the development of a public viewing platform with contiguous gardens.

In the Cornwall Structure plan 1997 Policy ENV6 states ‘...council will encourage the management of landscape features which are of major importance for wild flora and fauna, including the creation of new habitats and provision for public access where appropriate ...’

Within the Cornish Local Biodiversity Action Plan (also known as Cornwall’s Biodiversity) there are 25 habitat action plans, of which the following are relevant:-

Farmland:
Ancient and/or species-rich hedgerows
Cereal field margins
Maritime cliffs and slopes

**Woodland:**
Lowland wood-pasture and parkland

**Coastal:**
Sunlittoral sands and gravels

Some of the above mentioned habitat plans may be appropriate for the proposed development at Penlee Quarry.

The quarry is located close to Cornwall’s Area of Outstanding Natural Beauty and Heritage Coast. The quarry itself is a Geological SSSI; the citation states the site is important for the diversity of the mineralisation types and gives an opportunity to study the effects of host rock chemistry on this mineralisation over a wide temperature range. A scheme has been agreed, with the Mineral Planning Authority, for the conservation of significant features of geological interest within the site.

### 6.2.2 Shellingford Quarry, Faringdon, Oxfordshire

Shellingford quarry is situated at Faringdon, Oxfordshire and is located on national grid reference SW 469 279 (see Fig. 6.4). The aggregates produced at this quarry comprise Quaternary limestone gravels and Jurassic limestones and siltstones belonging to the Highworth Limestone group.

The quarry, that covers approximately 29 hectares, lies south of the A417 with agricultural fields to the east and the west and a business park to the south and east. The nearest main settlement is the village of Stanford in the Vale approximately 1.5km to the east.

The quarry has been working since the 1970s and is now managed by Earthline Ltd., the current owners of Multi Agg Ltd. The quarry workings are quite shallow, being only up to 10m deep, with a limestone gravel over limestone/sandstone. It produces a range of crushed rock and directly processed aggregates. In addition it produces aggregates from recycling inert wastes by crushing, washing and screening. The discards comprise part of the backfill used to restore the quarry.

The most recent planning permission was granted in 1970s and the approved restoration comprises the formation of a domed backfill to be restored to agriculture, but with potential for biodiverse restoration along its northern and southern margins. It is likely that the eventual restoration may include an area of water since the processing of discards requires extensive silt lagoons. It is understood that the silt produced will be required for on-site soil production. Figure 6.5 shows a possible restoration.

In the Oxfordshire Local Plan Policy PE10 states that:-

‘The County Council is particularly keen to ensure that best use is made of the nature conservation potential that mineral working and restoration provides. This can be done both through the designation of particular sites and the development of strategies and the management of wider areas for nature conservation. This is an after-use that is not normally self-financing.’

Within the Oxfordshire Local Biodiversity Action Plan the following Habitats have action plans pertinent to the proposed restoration of the site:

- Arable and horticulture
- Broadleaved, mixed and yew woodland
- Gravel pits and other lakes
- Lowland Broadleaved Woodland
- Ponds
- Lowland calcareous grassland
Lowland wood-pasture and parkland
Reedbeds

A number of these habitats may be achievable at Shellingford Quarry.

In the vicinity of the quarry there are areas of ancient replanted woodland, ancient and semi-natural woodland and a geological SSSI covers part of an adjacent quarry.

6.2.3 **Oathill Quarry, Gloucestershire**

Oathill Quarry is situated at Temple Guiting, Gloucestershire and is located on national grid reference SP 103 289 (see Fig. 6.6). Aggregate is produced from crushed Inferior Oolite Limestone together with some building stone.

The quarry covers an area of approximately 7 hectares and has been working since approximately 1860. Little soil remains from previous workings, but there are approximately 3,000-5,000m³ of quarry waste, some of which include discarded soils as well as quarry fines. The depth of the working is currently up to 15m, but is eventually intended to reach approximately 40m on the basis of proposals in a current planning application.

The quarry is bounded to the south by the B4077, to the east by a wooded area and to the north and west by agricultural field with additional screening afforded by a hedgerow and shelterbelt planting.

Oathill Quarry Limited forms part of the Johnston Quarry Group. Planning permission was granted for the extraction of limestone for walling and building materials at Oathill quarry in 1948 and subsequently 1957 and later in 1963. The quarry has worked intermittently for more than 140 years. Although aggregate is produced for local use, important building stones are also extracted namely the Yellow and White Guiting Stone.

The latest restoration proposals include areas of naturally regenerated scrub and limestone grassland and areas of naturally regenerated and planted woodland on re-graded slopes (see Fig. 6.7).

In the Cotswolds District Local Plan 2001-2011 Policy 9 states ‘Where development is permitted, . . . Opportunities should be taken, where possible, to enhance, or create, habitats and populations of species identified as priorities in National, Regional and Local Biodiversity Action Plans . . .’. 

Within the Gloucestershire Local BAP the following habitats, *inter alia*, that have a habitat action plan, and are pertinent to the location, include: -

Unimproved limestone grassland
Cereal field margins
Species-rich and/or ancient hedgerows
Woodlands
Wood-pasture, parkland and veteran trees
Limestone pavement

It is considered that some, or all, of the above may be achievable at Oathill Quarry.

In addition the quarry is located within the Cotswold Area of Outstanding Natural Beauty.

6.2.4 **Cromwell Quarry, Brighouse, West Yorkshire**

Cromwell Quarry is situated in Brighouse, West Yorkshire and is located on national grid reference SE 124 234 (see Fig. 6.8). It works Coal Measure strata belonging to the Elland Flags Formation which are principally sandstones.
The quarry, that covers an area of about 14 hectares, is bounded to the immediate north by Church Lane with former quarry workings and agricultural land beyond. On the southern edge are areas of ancient replanted and ancient and semi-natural woodland covering a steep slope running down to Brookfoot Lock and the River Calder. To the east are extensive factory operations and to the west are the open outskirts of Southowram. The area is being progressively restored from west to east.

Cromwell Quarry is managed by Marshalls Quarry Products Ltd and the quarry produces sandstone for use as aggregate and building stone (flagstones).

The quarry has been working since 1840 and is nearing the end of its working life. The site also has planning permission for the disposal of inert discards including those from the factory operations to the east (mainly rock discards), as well as the disposal of waste materials from the quarry operations. The restoration arrangements include the formation of a domed backfill that will be formed by the placement of imported inert clay rich materials to form a space with public access (see Fig. 6.9 for the final restoration contours). Areas are proposed for native woodland, wildflower grassland and rough grassland.

Negotiations are currently in progress with Calderdale MBC for the operation, onsite, of a composting plant to handle municipal green waste from the public and the roads and parks department. The intention is that some of this material will be used in planting trials and for the formation of final restoration soils on-site.

In the Calderdale Metropolitan Borough Plan Policy NE 17 – Biodiversity Enhancement states ‘Development will be required where appropriate to enhance biodiversity. Conditions or planning obligations will be attached to:-

Protect, maintain and enhance biodiversity;
Protect, restore and manage features of ecological importance and important species and their habitats; and
Create new wildlife habitats, especially where they will link Wildlife Corridors or isolated habitats or create buffer zones.’

The plan also states ‘There are selected areas where the need for conservation is particularly important, including the heather moorland and other upland habitats.’

In Calderdale’s Local Biodiversity Action Plan the following habitats have action plans pertinent to the proposed restoration: -

Unimproved grasslands
Ancient and/or species rich hedgerows
Upland oakwood

Adjacent to and within the vicinity of Cromwell Quarry there are a number of nature conservation designations including areas of ancient replanted woodland, ancient and semi-natural woodland and a local nature reserve.

### 6.3 Investigation and Analysis of Onsite Available Waste Materials

For each of the four selected quarries; samples of onsite waste materials were collected and analysed. The key results are given in Table 6.1 below, and the assessment of the available materials for the mineral component of restoration soils are discussed for each of the four quarries.

Full test results are included in Appendix 4. As will be seen, the grading curves (particle size distribution) for each site were undertaken by Geotechnics Ltd., a firm of geotechnical and environmental specialists. The chemical tests including conductivity, cation exchange capacity, pH, and for selected samples from Penlee Quarry and Oathill Quarry, the dry weights in mg/kg for selected heavy metals etc., were undertaken by Severn Trent Laboratories Ltd on sub-samples from the locations shown on Figs. 6.1, 6.4, 6.6 and 6.8.
In addition it was considered appropriate to undertake more specific testing on the silt samples from Shellingford Quarry (Samples 1 and 2). These were tested for standard Landfill Waste Acceptance Criteria to confirm that the silt was appropriate for use mixed with other materials and amendments to be used in soil formation for agricultural land restoration at the quarry. Two such tests were undertaken by Severn Trent Laboratories Ltd and additional organic chemical tests were undertaken by a specialist laboratory, Chemtest Ltd., covering both compliance with Landfill Waste Acceptance Criteria and the presence of List I and List II contaminants. The samples tested by Chemtest included the two silt samples referred to above plus an additional two silt samples taken from the same general area. The overall findings show that almost all tests confirm compliance with the Landfill Waste Acceptance Criteria and the absence of List I and List II materials. The few that do not comply are only marginally above the concentration criteria and frequently at or near detection limits. None of the few exceedences was repeated in more than one sample and hence it is considered that such variations are likely to occur with discards from waste recycling plants and that the material will be suitable for its use in artificial soils for on-site land reclamation.

It should be noted that the use of soils in gardens and public open spaces etc. has previously been covered by Soil Guidance Values published by DEFRA. These have been withdrawn and new values are awaited, hence it is not feasible to comment with certainty on the present position with respect to levels of heavy metals in the potential soil forming materials.

Each of the laboratories used is accredited for the tests undertaken by the United Kingdom Accreditation Service (UKAS) unless otherwise specified and then in accordance with the appropriate British Standard or other published standard.

Table 6.2 sets out the proposed soil types for the four sites giving a specification of intended soil thicknesses, mineral mix and percentage soil amendments for each of the three principal restoration areas. The areas to be covered by each soil type are listed together with the corresponding volumes of mineral soil and amendment. On the basis of site inspection it is considered that each of the sites has sufficient waste and stockpiled material for use in this restoration.

### 6.3.1 Penlee Quarry

Five samples were taken from Penlee Quarry in the locations shown on Fig. 6.1. These included:

- Sample 1 was from a screened pile of nominal -5mm material. Little of this material remains, but it was formed by dry screening from the material represented by Sample 3.
- Sample 2 was from a screened pile of -20mm material with no -5mm material removed. Approximately 200m³ of this material remained; it was formed from material represented by Sample 3.
- Sample 3 was from the feed used for producing Samples 1 and 2, but with oversize (+50mm material) screened out. This material appeared to have been placed in the 1980s and it is roughly estimated that approximately 10,000-15,000m³ of this material remains on site.
- Sample 4 was from a stockpile placed in the 1950s of fine discard, possibly including some beach deposit material, generally less than 2mm, but with some -20mm material. It is assessed that approximately 2,000m³ of this material remains on site.
- Sample 5 contained similar material to Sample 4, but appeared to be washed and had no material larger than 5mm. It appears to comprise part of a stockpile of approximately 3,000m³.

Photographs 6.1, 6.2, 6.3 and 6.4 show the locations of the sampling points.

Substantialy greater volumes of waste material are present on site, exceeding 150,000m³ and the proposed development will give rise to more waste material that can be screened to provide material similar to Sample 3.
As expected, the analyses confirmed the pH as generally neutral, being greater than 6 (average 6.15). The clay contents were low, but the sand and silt content were consistent with materials that can be vegetated as shown in Photographs 7.4 and 7.5. No agricultural restoration is proposed although some of the land will be used for parks/gardens with high levels of public access. However the cation exchange capacity is low and with a similarly low clay content organic additives may be required at a moderate level to encourage growth; other soils will require a lower level of amendment. However the local bedrock is an igneous rock with volcanic characteristics and rock forming minerals such that a slow release of magnesium and calcium is likely to arise. The arsenic, zinc and copper contents of the finer materials appear to be elevated, but not significantly more so than in some of the fields nearby where there is public access.

Fig. 6.2 shows the proposed ultimate restoration of the project in accordance with the marina scheme. Much of the available waste material will be used during the earthworks, but more will be produced of a similar character and grading. As noted in Section 6.2.1 there are three principal restoration soil objectives. The following areas can be designated for separate soil types in restoration:-

- Scrub with low to medium accessibility – 300mm thick
- Rough grass and amenity areas with low to medium accessibility – 300mm thick
- Parks/amenity grassland and built up areas with high accessibility – 1,000 or 1,500mm thick as required

The areas and volumes of soil required for this restoration are as follows:-

- 9,360m² (5% amendment) 2,667m³ plus 181m³
- 54,030m² (2% amendment) 15,885m³ plus 324m³
- 25,390m² (10% amendment) 22,851m³/34,277m³ plus 2,539m³/3,808m³

6.3.2 Shellingford Quarry

Four samples were taken from Shellingford Quarry in the locations shown on Fig. 6.4. These included:-

- Sample 1 was of silt taken from near a discharge point into a lagoon, predominantly comprising silt with some fine sand.
- Sample 2 was taken from silt that had previously been excavated and spread on backfilled ground to drain. The silt was placed to a thickness of approximately 300mm using a backhoe. The material appears to be slightly coarser than that in Sample 1 with a high proportion of fine sand.
- Sample 3 was of a clay backfill brought in as inert waste. This had been dozed, graded and compacted and although essentially comprising clay minerals it appears from grading analysis to comprise a significant proportion of sand and fine gravel sized fragments of clay.
- Sample 4 was of sub-soil available in a limited quantity in one of several small screening banks on the side of the quarry.

Photographs 6.5, 6.6, 6.7 and 6.8 show the locations of the sampling points.

Most of the waste that is required for the mineral component of the soil exists on site as silt discards in lagoons. These will require excavation and careful consideration of any List I and List II contaminants. In addition a quantity of the clay backfill may be appropriate for mixing with the silt and amendments. The quantities of silt available exceed 150,000m³ and at least an equivalent volume of imported inert clay is also available.

The tests indicate an elevated, but manageable pH (average 8.85) with higher silt and clay contents than Penlee Quarry and correspondingly higher cation exchange capacities (average 26) and moisture contents. As noted above the results generally confirm compliance with the Landfill Waste Acceptance Criteria and the absence of List I and List II materials in the silt that
is likely to comprise a major component in the agricultural restoration. The imported clays used for capping the site are also suitable for inclusion with the silt in soil formation. The use of compost to assist with drainage and aeration of the mineral element of the artificial soil will be beneficial.

Fig. 6.5 shows the proposed ultimate restoration of the project in accordance with the latest planning permission. However, modifications may be appropriate in the context of the need for more comprehensive biodiversity schemes. As noted in Section 6.2.2 there are at least three separate restoration areas that may require separate restoration soil objectives. The following areas can be designated for separate soil types in restoration:

- Arable agriculture – 500mm thick
- Biodiversity areas – 150mm thick
- Woodland – 1,000mm thick

The areas and volumes of soil required for this restoration are as follows:

- 286,230m² (10% amendment) 128,803m³ plus 1,4312m³
- 13,980m² (1% amendment) 2,076m³ plus 21m³
- 6,930m² (10% amendment) 6,237m³ plus 693m³

### 6.3.3 Oathill Quarry

Four samples of materials were taken from various locations within the quarry at locations shown in Fig. 6.6.

- Sample 1 was taken from a general quarry waste stockpile in the south east corner of the site. It has a volume of approximately 2,500m³. It includes an assortment of materials including some imported inert fill originally intended for haul roads.
- Sample 2 was taken from a stockpile of mixed top and sub-soil incorporating limestone gravel and cobbles from the lower horizon of the sub-soil.
- Sample 3 includes fine discards from screening operations for on site aggregate production.
- Sample 4 comprises material taken from a heavily trafficked haul road linking the two halves of the quarry. The material is broken down limestone aggregate with which the road was originally surfaced.

Photographs 6.9A and B, 6.10, 6.11 and 6.12 show the appearance of the materials that were sampled.

Only limited amounts of stockpiled material are available for restoration at present. In total the current waste, excluding backfill used for screening, probably amounts to more than 10,000m³, but it is anticipated that this will be added to at a rate of approximately 3,000-5,000m³ per annum comprising waste rock, fines from processing and general discards from site maintenance (e.g. road planings).

As expected, Oathill Quarry has a high pH associated with the strata and with the natural soil materials (average pH 8.9). Clay and silt contents are similar to those at Shellingford, but the cation exchange capacity is somewhat lower. Given the proposed restoration on the site only the materials required for tree planting will need significant addition of organic material.

Fig. 6.7 shows the proposed ultimate restoration of the quarry. Much of the available waste material will be used for banking around the limits of the quarry and the quarry floor may only have a limited cover of materials over a limestone floor. The following areas can be designated for separate soil types in restoration:

- Low nutrient calcareous grassland – 100mm thick
- Naturally re-generated scrub and grassland – 300mm thick
- Naturally re-generated and planted woodland – 1,000 mm thick
The areas and volumes of soil required for this restoration are as follows:-

- 30,920m² (2% amendments) 3,030m³ plus 62m³
- 3,810m² (2% amendments) 1,120m³ plus 23m³
- 12,210m² (5% amendments) 11,600m³ plus 610m³

### 6.3.4 Cromwell Quarry

Four samples were taken during the visit to Cromwell Quarry from the locations shown on Fig. 6.8. These included:

- Sample 1 is backfill used as capping material. This was provided as a typical mix by the operator, but appeared to be identical to that shown in Photographs 6.13 and 6.14.
- Sample 2 comprised filter press discards from the fines resulting from the processing of the stone and especially from the saw cutting operations. These are also discarded into the backfill, but could provide a uniform graded material for soil formation (see Photograph 6.15).
- Sample 3 was a topsoil and sub-soil from the thin hillside soil south of the quarry. Superficially it appeared to be similar to some of the clay rich capping currently used on the site together with stone fragments.
- Sample 4 comprised de-inked paper pulp that may be mixed with the clay rich capping to form a surface soil (see Photographs 6.13 and 6.14).

Photographs 6.13, 6.14, 6.15 and 6.16 show the location of the sampling points or where the materials are located.

Significant volumes of imported capping material, obtained from local strata and essentially clay rich, being unsuitable for recycling as aggregate, are available to form the final profile of the restored surface. In addition a filter press materials are produced at a rate of approximately 40t per week and could be incorporated with amendments to assist in the soil formation.

Cromwell Quarry was expected to be a low pH environment since the quarry produces gritstone and sandstone as aggregates and building stone. However a significant level of stone processing takes place on the adjacent site; some of this stone is limestone. It is noted that the average pH of the capping and stone waste is 8.9, but that the natural soil in the woodland south of the site has a pH of 6.8. The clay contents were variable, but generally very low, with cation exchange capacities above those found at both Penlee Quarry and Oathill Quarry. The moisture contents were quite high especially the de-inked paper pulp. The addition of compost should assist with drainage and with adjusting the pH slightly. It is anticipated that over time the pH of the restoration soils will reduce.

Fig. 6.9 shows the proposed restoration of the quarry with the domed landform at the western end of the site. Details of the final restoration are also given on Fig 6.9. Much of the available waste material will be used for banking around the limits of the quarry and the quarry floor may only have a limited cover of materials over a limestone floor. The following areas can be designated for separate soil types in restoration:-

- Rough grassland – 300mm thick
- Wildflower grassland – 150mm thick
- Native woodland – 1,000mm thick

The areas and volumes of soil required for this restoration are as follows:-

- 47,620m² (2% amendments) 14,004m³ plus 285m³
- 43,790m² (1% amendments) 6,503m³ plus 66m³
- 57,270m² (5% amendments) 54,416m³ plus 2,864m³
6.4 Discussion

It is considered that each of the four site soil specifications and conservation objectives meet at least two of the local Biodiversity Action Plan Objectives as well as complying with the overall planning permission or objective restoration requirements.

As noted previously a review of each of the sites has shown that sufficient mineral waste materials exist, or will exist at the time of restoration works, to satisfy the volumetric requirements for the artificial soils listed in Table 6.2.

It is similarly considered that Certified PAS100 compost can be obtained within 40km and generally 20km of Penlee Quarry, Shellingford Quarry and Oathill Quarry. PAS100 will also be required at Cromwell Quarry as a check on the use of compost produced on-site. With the exception of Shellingford Quarry where a large proportion of the site will be restored to agriculture, the cost of this compost plus haulage should not greatly exceed £15,000 at Penlee Quarry or £3,000 at Oathill Quarry. The costs including the costs of delays inherent in obtaining a license/permit exemption from the Environment Agency could be in excess of £3,000. In the case of Penlee Quarry the provision of alternative organic amendments are unlikely to be less than £15,000 plus the EA permit exemption fee etc.

Elsewhere it is apparent that a significant number of older quarries will require the future use of artificial soils and amendments. Some of these quarries may also include recycling and composting facilities; the permitting arrangements for these may currently be in place and therefore the issues surrounding the desirability of using Certified PAS100 compost are less acute. Initial indications are that owing to permitting difficulties and the requirements of planning permission, the development of new composting facilities at these quarries is unlikely to be worthwhile unless a major project is envisaged whereby the majority of the compost produced is sold off site. Legislation and bureaucracy have conspired to frustrate attempts to undertake composting purely for on-site use.
Figure 6.1. Plan of Penlee Quarry with sampling and potential trial plot locations.
Figure 6.2 Intended future development of Penlee Quarry. Near buildings there will be a requirement for gardens and public access land, but to the west and south there will be limited or zero access with soils to encourage biodiversity. Note the entrance and viewing platform area in the north east corner of the site has a different configuration from that shown on Figure 6.1. Much of the restoration in the vicinity of the entrance and the viewing platform has already been undertaken. For more detail of the southern half of the plan see Figure 6.3.
Figure 6.3. Proposed layout of benches on the southern side of Penlee Quarry. The associated soil types are also indicated.
Figure 6.4. Plan of Shellingford Quarry with sampling and potential trial plot locations.
Figure 6.5 Possible restoration of Shellingford Quarry
Figure 6.6 Plan of Oathill Quarry with sampling and potential trial plot locations.
Figure 6.7. Intended restoration of Oathill Quarry showing the range of land uses proposed including tree and shrub planting on quarry backfill on the western and southern sides of the main excavation area, the floor of the quarry and entrance areas. Additional biodiversity will arise from leaving bare rock faces in addition to the 'limestone pavement' on the quarry floor.
Figure 6.8 Plan of Cromwell Quarry with sampling and potential trial plot locations.
Figure 6.9. Intended restoration areas at Cromwell Quarry. The darker green areas are intended for wildflower grassland and the paler green areas for open grassland. The remaining ornamented area is for native woodland.
Photograph 6.1 Penlee Quarry. The right-hand stockpile contains -20mm material from which Sample 2 was obtained and the middle stockpile contains -5mm material from which Sample 1 was taken. The material immediately behind the middle stockpile comprises material akin to that included in Sample 3.

Photograph 6.2 Penlee Quarry. The material behind the stockpile on the right-hand side of the photograph is the raw material used for screening and is akin to Sample 3. The screened material in the middle of the photograph is -20mm +40mm drainage material and the stockpile on the left-hand side provided material for Sample 2.
Photograph 6.3  Screening operations in progress at Penlee Quarry from which the materials taken in Samples 1 and 2 were recovered. On the left-hand side excavation is in progress to recover the feed material (Sample 3).

Photograph 6.4 Penlee Quarry. The excavated face in the foreground includes materials from which Samples 4 and 5 were taken. This material was placed in the 1950s and appears to include some fine beach gravel, some of which was washed.
Photograph 6.5 Shellingford Quarry. The silt in the right foreground is the material from which Sample 1 and Sample 2901/1 were taken. Note the discharge point for silt into the lagoon.

Photograph 6.6 Shellingford Quarry. Silt excavated from a lagoon and spread to a thickness of approximately 300mm to dry. Sample 2 was taken from the foreground and Sample 2901/4 from the centre of the field of view.
Photograph 6.7 Shellingford Quarry. The re-graded ground in the middle distance is where Sample 3 was taken.

Photograph 6.8 Shellingford Quarry. The low bank of sub-soil is where Sample 4 was taken. To the right is an area of re-graded backfill shown in Photograph 6.7 from which Sample 3 was taken.
Photograph 6.9 Oathill Quarry. Waste pile in south east corner from which Sample 1 was taken, excluding +60mm material.

Photograph 6.9A Oathill Quarry. Detail

Photograph 6.10 Oathill Quarry. Stockpile of mixed top and sub-soil from which Sample 2 was taken.
Photograph 6.11 Oathill Quarry. Processing fines from which Sample 3 was taken.

Photograph 6.12 Oathill Quarry. Haul road surface which is periodically re-graded to remove slurry; the haul road commences as a graded aggregate surface, but breaks down with traffic. Sample 4 was recovered from this slurry.
Photograph 6.13 Cromwell Quarry. The backfill area with assorted quarry waste prior to re-grading. De-inked paper pulp is apparent on the right-hand side. This provided Sample 4.

Photograph 6.14 Cromwell Quarry. Re-graded backfill awaiting soil treatment/cover. The capping material used for this backfill comprises Sample 1. A small stockpile of paper pulp is visible near the centre of the photograph with the southern wooded slope beyond the site in the distance.
Photograph 6.15  Cromwell Quarry. Filter pressed fines from saw cutting from which Sample 2 was taken.

Photograph 6.16  Cromwell Quarry. The birch woodland to the south of the site from which Sample 3 was taken.
### TABLE 6.1

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* Denotes not tested for

**NOTE:**

- Particle size analysis by Geotechnics Ltd
- Other tests by Severn Trent Laboratories
- Separate tests undertaken by Chemtest
- List 1 and 2 on leachate and on solids (see separate appendix values)
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<th>Volumes (m³)</th>
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7 GENERAL METHODOLOGY

This section details the process by which field trials for a second phase should be conducted.

The purposes of conducting field trials is to establish the combination of quarry waste material and amendments to be used to restore sites to a range of afteruses and especially to promote a landscape rich in biodiversity. Fig. 7.1 is a flow chart of the methodology used.

Appendix 5 shows the local Biodiversity Action Plans for each of the four sites.

Field trials need to be undertaken in realistic, controlled and monitored circumstances. To maintain a standard approach to amendments only Certified PAS 100 compost will be used except at Cromwell Quarry and then it will be used as a control against local on-site compost. It is proposed that the trials should be conducted as follows:-

7.1 Penlee Quarry

Photographs 7.1 to 7.5 show previous restoration work at the quarry relating to an area of approximately 1.5 hectares that was undertaken in 2007. This includes hydroseeding a surface of quarry waste from which most material >100mm has been scalped. A small area has also been restored to gardens and public open space with the use of -5mm mineral quarry waste with added organic material and fertilisers.

The location of the proposed field trials is in the south west corner of the southern side of the quarry on one of two benches that will not be required during the next 2-3 years. The possible locations are shown in Fig. 6.1 and Photographs 7.1 and 7.2.

Reclamation and attempts at re-vegetation have taken place since 2007 as shown in Photographs 7.3, 7.4A and B, 7.5, 7.6 and 7.7.

Three trial mixes are proposed as indicated in Table 6.2. The proposed seed mixes are as follows:-

- **Scrub mix on Mix P 1A & 1B** – The mix could include a single or blend of species for the lowland heathland HAP in Cornwall’s BAP:-
  
  Common heather (Calluna vulgaris)  
  Cross-leaved heather (Erica tetralix)  
  Bell heather (Erica cinerea)  
  Dorset heath (Erica ciliaris)  
  Cornish heath (Erica vagans)  
  Purple moor grass (Molina caerulea)  
  Bristle bent (Agrostis curtisii)  
  Western gorse (Ulex gallii)  
  European gorse (Ulex europaeus)

- **Rough grassland mix On Mix P 2A & 2B** – The mix will include species found on lowland meadows, which has a HAP in Cornwall’s BAP. The mix to be used is MG9 lowland meadow, and RE2 mix from a British seed house.
  
  Tufted Hair Grass (*Deschampsia caespitosa*)  
  Rough-stalked Meadow Grass (*Poa trivialis*)  
  Slender Creeping Red Fescue (*Festuca rubra ssp litoralis*)  
  Creeping Bent (*Agrostis stolonifera*)  
  Meadow Fescue (*Festuca pratensis*)
• Parkland and amenity on Mix P 3A & 3B – Tree planting of one of the following species found in the HAP upland wood pasture and parkland in Cornwall’s BAP:

- Sessile Oak (Quercus petraea)
- Pedunculate Oak (Quercus robur)
- Common lime (Tilia x europaea)
- Hawthorn (Crataegus monogyna)
- Sycamore (Acer pseudoplatanus)
- Beech (Fagus sylvatica)
- Ash (Fraxinus excelsior)

7.2 Shellingford Quarry

The location of the proposed field trials is on the northern perimeter of the site adjacent to the main access road (see Fig. 6.4). An alternative location would be on the area that has recently been re-graded to final level near the location of Samples 3 and 4 shown on Fig. 6.4 and Photograph 6.7. Neither of these sites will be disturbed during the next 2-3 years.

Shellingford Quarry is located in an area of intense arable agriculture and the restoration is largely back to agriculture except at the northern and southern margins. To date no reclamation or attempts at re-vegetation have yet been undertaken.

Three trial mixes are proposed as indicated in Table 6.2. The proposed seed mixes are as follows:

- Arable agriculture on Mix S 1A & 1B – Oil seed rape or wheat
- Biodiverse area on Mix S2A & 2B – Lowland limestone grassland mix RE4 from British seed house. This aims to create lowland calcareous grassland as stated in the Oxfordshire BAP:

- Sheeps Fescue (Festuca ovina)
- Cocksfoot (Dactylis glomerata)
- Crested Dogstail (Cynosurus cristatus)
- Creeping Bent (Agrostis stolonifera)
- Tufted Hair Grass (Deschampsia caespitosa)
- Tall Oat Grass (Arrenatherum elatius)

- Woodland on Mix S 3A & 3B – Any of the following tree species to be planted in accordance with the Oxfordshire HAP broadleaved mixed and yew woodland:

- Ash (Fraxinus excelsior)
- Hazel (Corylus avellana)
- Oak (Quercus robur)
- Field Maple (Acer campestre)
- Beech (Fagus sylvatica)
- Small leaved lime (Tilia cordata)
- Yew (Taxus baccata)

7.3 Oathill Quarry

The location of the proposed field trials is in the south west corner of the quarry on a mound of backfill used as a screen to the current quarry workings. The location is shown on Fig. 6.6 and Photograph 7.8 and has been selected since the screen will remain in place for the life of the quarry.
Although no reclamation or attempts at re-vegetation have been undertaken the quarry is more than 100 years old and natural re-vegetation has occurred on steep rockfill slopes, on quarry backfill and on limestone bedding plains left on the floor of quarry workings. These three situations are shown in Photographs 7.9, 7.10 and 7.11.

Three trial mixes are proposed as indicated in Table 6.2. The proposed seed mixes are as follows:-

- Calcareous grassland on O 1A & 1B - Lowland limestone grassland mix RE4 from a British seed house used to create a unimproved limestone grassland as stated in the Gloucestershire BAP
  
  Sheep's Fescue (*Festuca ovina*)
  Cocksfoot (*Dactylis glomerata*)
  Crested Dogstail (*Cynosurus cristatus*)
  Creeping Bent (*Agrostis stolonifera*)
  Tufted Hair Grass (*Deschampsia caespitosa*)
  Tall Oat Grass (*Arrenatherum elatius*)

- Scrub on Mix O 2A & 2B – To be comprised of either Hawthorn (*Crataegus monogyna*) or Blackthorn (*Prunus spinosa*)

- Native woodland on mix O 3A & 3B – This is to comprise beech (*Fagus sylvatica*)

7.4 Cromwell Quarry

The location of the proposed field trial is at the western end of the site where contours have been established near to the final restoration levels (see Fig. 6.8 and Photograph 7.12). There are no reasons why this area should be disturbed over the next 2-3 years.

Re-grading has taken place in the recent past and some re-vegetation is apparent as may be seen on Photograph 7.13. The margins around quarry workings that are awaiting backfill have also accommodated a range of self-set saplings (see photograph 7.14).

Three trial mixes are proposed as indicated in Table 6.2. The proposed seed mixes are as follows:-

- Rough grass on Mix C 1A & 1B – Lowland meadow mix RE2 from a British seed house to accord with unimproved grassland in the local BAP. Species include:-

  Tufted Hair Grass (*Deschampsia caespitosa*)
  Rough-stalked Meadow Grass (*Poa trivialis*)
  Slender Creeping Red Fescue (*Festuca rubra ssp litoralis*)
  Creeping Bent (*Agrostis stolonifera*)
  Meadow Fescue (*Festuca pratensis*)

- Wildflower on Mic C 2A & 2B – Flowering meadow mix WF 1 from a British seed house. Species include: -

  Cornflower (*Centaurea cyanus*)
  Foxglove (*Digitalis purpurea*)
  Birdsfoot Trefoil (*Lotus corniculatus*)
  Corn Poppy (*Papaver rhoeas*)
  White Campion (*Silene alba*)
Native woodland on Mix 3A & 3B – Species to be either sessile oak (Quercus petraea) or pedunculate oak (Quercus robur) or Birch (Betula pendula) to accord with upland oakwood HAP in the BAP.

7.5 Approach to field trials

Methodology

The methodology sets out the principles and procedures to be used for the field trials. Each site has its own constraints which are detailed later. General factors that could effect field trials are also mentioned in this section.

General constraints to the field trials in each quarry include:-

Time
- There is a limited trial period.
- Handling of aggregate material may be dependent on weather conditions.
- Importation and application of amendments may be dependent or restricted by weather conditions.
- Activities associated with the trials must not disrupt the normal workings of the quarry/factory.
- Sowing of seeds will be dependent on planting seasons.

Cost
- Limited budget for trials available.
- Trials must be reasonably viable for future extrapolation.
- Costs to quarry operator in relation to machinery, staff time, handling, importation, application, monitoring, inter alia, must be minimised.

7.6 Trial Details

Given the space, time and working environment restrictions of the sites it is intended to undertake field plot trials at the identified locations as follows:-

- Each plot will be 21m³ (typically 3m x 7m to include a central metre wide division giving 2 x 3m x 3m plots). As noted above, the locations do not permit the design of trial plots to follow the randomised Latin Square arrangements that are sometimes preferred for agricultural trial plots. The arrangements proposed include the items noted below and:-
  - keep the field trials to a minimum overall area
  - allow for disruption to the perimeter of the individual plots
  - is a large enough size to undertake experiment with but small enough to be able to collect and monitor data
  - is appropriate for the material available on and off site
  - allow for soil testing without compromising the overall trial
  - accommodate costs and site settings

- The depth of each plot will vary in accordance with the intended thickness of the soil as indicated in Table 7.1. Most soils will be developed in, or over, existing quarry backfill although special arrangements will be made for the nutrient deficient limestone grassland soil proposed at Oathill Quarry.

- Between each plot there will be a 1m access strip. This allows for easy movement and access between plots and reduces the risk of cross-contamination.

- Each plot will be surrounded by a 1m high chicken wire fence to restrict rabbit damage. The whole test area will also have hazard tape around the perimeter to
provide definition and increase visibility for quarry operatives, contractors and visitors.

- Each of the sites has three soil types based on a review of the restoration requirements. Hence there will be three pairs of sample plots, one of each pair being a control with no amendment. Cromwell Quarry however will have a third version of each of the trial plots using the same proportion of Certified PAS100 compost as the compost used and available on site (see below).

- Organic and inorganic amendments will be sourced locally to reduce cost and reduce transport/travel time and distance. With the exception of Cromwell Quarry the organic amendment will be restricted to Certified PAS100 compost to avoid the need for expensive and time consuming license exemption procedures (see Section 8 below). Cromwell Quarry will also be using compost from the on-site composting facility operated by Calderdale MBC.

- Each plot, including the controls, will be seeded or planted in accordance with the reclamation arrangement

The aim of the field trials is to restore sites either to amenity and/or to a landscape rich in biodiversity, but appropriate to the local geology, climate, flora and fauna etc.

Each local biodiversity action plan (LBAP) for the different quarry study areas (Gloucestershire, Oxfordshire, Cornwall and Calderdale) lists specific habitats that they want to protect, conserve and/or manage. Hence plant seeds chosen for the trials will be based on the local Habitat Action Plan (obtained from the LBAP) for the specific areas.

**Recording and Monitoring**

The field trials will consist of monitoring the condition of the site, recording results and taking samples for analysis. This will be achieved with the aid of:-

- Site photographs
- Site plans
- Checklist/spreadsheet
- Identifying/reference material
- Laboratory testing

Following the various site visits the following data will be recorded:-

- Chemical change
- Physical change
- Organic content
- Ponding/drainage
- Percentage vegetation cover
- Species present
- Average growth

Site visits will be made four times a year for 2 years (excluding the setup of the trials) to record and monitor. There will be one site visit for each of the seasons (spring, summer, autumn and winter).

**Factors**

There are a number of factors that could influence the results of the field trials. These include:-

- Location of the field trials
- Weather
- Pest and disease
- Vandalism
- Damage by plant equipment and machinery
Safety and Equipment

As the majority of the sites are working quarries any restoration and field trial operations will be subject to the requirements of the Quarries Regulations 1999 even though they may be some distance from conventional quarry operations. It is important to adhere to any warning/danger signs. To stay safe the following must be done: -

- Inform site manager (or suitable other) that you will be on site.
- Sign in if the quarry has an appropriate system for visitors.
- Take any safety guides/induction the quarry may have as a compulsory measure for visitors.
- Wear appropriate clothing i.e. hard hat, steel toe-capped boots/wellingtons, high visibility jacket and/or safety glasses.
- At the end of the day sign out if the quarry has an appropriate system for visitors.

A range of equipment and materials for the necessary trials will be needed, including:-

- Fencing posts
- Tape measures and levels
- Wire mesh sufficient to keep out rabbits
- Gates for access with sufficient space to allow for a small backhoe to access the plots with soil mineral materials and amendments
- Hand held tools for surface treatments if methods cannot be replicated with a backhoe
- Standard seed mixes and shrubs and trees in accordance with the requirements of the Local Habitat Action Plan where appropriate
- Camera to take photographs of stages in forming the plot and in plant growth
Figure 7. Flow chart of the methodology for approaching field trials and restoration using artificial soils.
Photograph 7.1 A potential trial plot area at Penlee Quarry on the 65m AOD bench that would not be disturbed for 2-3 years.

Photograph 7.2 A potential trial plot area at Penlee Quarry on the 75m AOD bench that would not be disturbed for 2-3 years. Both these benches have broken rock over intact bedrock.
Photograph 7.3 Hydroseeding on the northern side of the Penlee Quarry entrance on to re-graded - 100mm all in cover material used in the screening operations shown in Photograph 4.1 as the feed material. The hydroseed mix was for neutral soils and included an adhesive and fertilisers.

Photograph 7.4A The northern side of the Penlee Quarry entrance six months after hydroseeding.
Photograph 7.4B. Eastern facing slopes on the southern side of the quarry entrance, Penlee Quarry. Six months after hydroseeding.

Photograph 7.5. The northern side of the Penlee Quarry entrance 18 months after hydroseeding. Note the introduction of gorse included in the wild flower and shrub mixture.
Photograph 7.6 Close up of the hydroseeded surface with a range of plant materials including gorse, 18 months after seeding at Penlee Quarry entrance.

Photograph 7.7 Lawn and garden area in viewing platform that used -5mm material for the lawn plus organic additives and fertilisers with -20mm +5mm material for the planting area, 16 months after initial preparation, Penlee Quarry.
Photograph 7.8. The top of the screening bank at Oathill Quarry in the middle distance is suitable for trial plots.

Photograph 7.9. Self-set beech and birch trees on quarry waste at Oathill Quarry with a high proportion of waste rock.
Photograph 7.10: Natural vegetation growing on quarry backfill devoid of tree cover at Oathill Quarry.

Photograph 7.11: Natural vegetation seen here growing on a bench at Oathill Quarry comprising a single bed of limestone. Note also the presence of self-seeding of the small overburden mound above the rock face (approximately 3m high).
Photograph 7.12. Re-established levels on the western margins of Cromwell Quarry suitable for trial plots.

Photograph 7.13. Grass and mosses growing on partially re-graded backfill at Cromwell Quarry
Photograph 7.14. Self-set saplings, including silver birch, growing around the margins of disturbed ground in former quarry workings awaiting backfill at Cromwell Quarry.
8 PLANNING AND PERMITTING

The Environmental Permitting (England and Wales) Regulations 2007 (SI3538) introduced amended controls on the permitting of wastes, their processing, storage and use. Schedule 3 of these Regulations deals with exempt waste operations; an application has to be made, with a fee currently £565, for a notifiable exempt waste operation. Paragraph 7 of Schedule 3 covers exempt activities and deals with land treatment for agricultural benefit or ecological improvement and Paragraph 9 deals with reclamation, restoration or improvement of land. The intention of these Regulations is to avoid adverse environmental impacts that might arise from the storage or use of a range of materials commonly seen as organic soil amendments. The Regulations also apply to imported waste materials that might be regarded as mineral components in soils including clay, processed minerals (sand, gravel and crushed rock) and soil materials.

Lists are provided of materials that have potential beneficial properties for which an exemption permit may be obtained. These are listed in Paragraphs 7 and 9 of Schedule 3 and for organic materials inter alia include:-

- Plant tissue waste from forestry or horticulture
- Waste bark, wood shavings, sawdust
- Pulp from virgin timber
- Biodegradable garden and park wastes
- Waste from the preparation and processing of meat, fish etc
- Waste from the processing of fruit and vegetables
- Waste from sugar processing
- Waste from dairy products
- Waste from the baking and confectionery industry
- De-inked paper sludge
- Waste from leather, fur and textile industries
- Compost
- Sludges from urban waste water

For inorganic materials these inter alia include imported:-

- Waste gravel and crushed rocks
- Waste sand and clays
- Soil from vegetable processing
- Pulverised fuel ash, bottom ash and slag
- Waste ceramic, bricks and tiles
- Waste concrete
- Waste from the mechanical crushing of minerals
- Gypsum from waste cement and power plant operations
- Dredging spoils

Hence most, if not all, of the soil amendments previously used in quarry restoration and indicated in Section 5 require an exemption permit. Both paragraphs include tables listing sources of waste and types of waste. The table in Paragraph 7 is divided into two parts; wastes in Part 1 of the table can be used to enhance the ecological value of a wide range of land types, including landscaped areas, parks, gardens, woodland etc., and wastes in Part 2, in addition to those in Part 1, can be used to treat agricultural land and improve its value. The table in Paragraph 9 is also divided into Parts 1 and 2. Part 1 waste can be spread on any land and Part 2 waste can be spread on any land with the intention of achieving agricultural or ecological improvement. Both these tables are set out in Appendix 6.

There are a number of constraints in the use of these materials in order to control environmental impact. The materials identified in the table in Paragraph 7 may only be stored at a place where it is to be used if it contains less than 1,250 tonnes. The waste must also be stored at least 10m from water courses and not less than a distance of 50m and 250m from boreholes, not supplying and supplying, water for domestic or food production purposes.
respectively. The exemption applies to sites of 50 hectares or less and for most of the amendments where it is proposed to place less than 250 tonnes per hectare.

Similar arrangements apply with respect to waste identified in Paragraph 9 (reclamation, restoration or improvement of land). Further details can be obtained from http://www.environment-agency.gov.uk/business/topics/permitting/34783.aspx.

Records have to be maintained of the quantity, nature, origin and treatment of any wastes used as amendments. Paragraph 9 permits larger quantities of waste, mainly mineral waste, to be deposited per hectare than Paragraph 7.

There is some uncertainty as to the interpretation and use of these two Paragraphs. It appears that Paragraph 7 is largely directed to agricultural land, although it does refer to land which is forest, woodland, park, garden, verge, landscaped area, sports ground, recreation ground, churchyard or cemetery, stating that “where the land in question is not used for agriculture and such treatment results in ecological improvement”. This definition should therefore include the objectives of quarry restoration since they are common to landscaped areas, public open spaces and the like, if not to agriculture and forestry. Paragraph 9 refers to the spreading of waste on land where the operation is of benefit to agriculture or ecological improvement and in examples provided appears also to cover reclamation of disturbance resulting from previous mineral activity. It should however be noted that greater quantities of compost and sludges, including de-inked paper sludge, can be placed in accordance with this Paragraph than would appear possible with a Paragraph 7 exemption. The reasons for the differences are not apparent and no satisfactory answer has yet been obtained from either the Environment Agency or a Mineral Planning Authority.

It appears that regardless of the formal restoration requirements under planning conditions, an exemption from an environmental permit (landfill license) is still required when soil amendments that may be regarded as waste, are used for the beneficiation of the soil regardless of whether this is for agricultural purposes or ecological enhancement. An exemption is not required if certified PAS100 compost is used since this material is a product and is not treated as a waste. The Environment Agency provides a downloadable form – Form WMX7 to be prepared when an application is made for an environmental permit. Guidance is provided with this form in respect of its completion and the necessary documentation. This documentation requires the following:-

- Waste analysis where soil amendments are waste, from a MCERTS laboratory.
- Analysis of representative samples of soil undertaken in accordance with specification for topsoil British Standard 3882, 1994.
- Certification of agricultural benefit or ecological improvement indicating that such will occur without harming human health or the environment. It is understood that this certification needs to be from a person with appropriate technical expertise having the necessary qualifications or vocational experience.
- Pollution risk assessment that will take assessment of waste storage, the status of the land to be treated including nitrate vulnerable zones and odour and dust issues into account.
- Evidence of a valid planning permission

It is apparent that the application is both time consuming and expensive and due allowance should be made for this when assessing restoration/reclamation proposals. A simple cost benefit analysis, that includes using certified PAS100 as well as other wastes, may therefore be justified. On the basis of limited enquiry few staff in Mineral Planning Authorities are aware of the implications of the 2007 Regulations that came into force in 2008.

Planning permissions precede permitting (licensing) and are likely to include the detailed specification of restoration arrangements and long term management. These specifications will include the formation of any artificial soils and the use of amendments. If these amendments are not defined by the Environment Agency as products, but are categorised as waste, a permit must be obtained to classify the restoration as an exempt activity. As noted above this is an area where Mineral Planning Authority understanding, and therefore advice, may be wanting.
9 CONCLUSIONS AND RECOMMENDATIONS

9.1 General

During the course of this study, and discussions with operators, with Mineral Planning Authorities and with WRAP, it has become apparent that the shortage of soil for restoration (especially in older quarries) is a major concern. This shortage is more widespread than previously thought and needs to be quantified on a national basis.

In addition to the general shortage, there are two further knowledge gaps which should be filled and publicised. Firstly, the available techniques, tailored to the evolving restoration objectives centred on biodiversity, need to be site-tested and written up. Secondly, confusion and complexity around the legal, regulatory and permitting context need to be examined; a simplification of the system where site restoration is the key objective may be desirable.

Probably the most significant recent development has been the introduction of the 2007 Environmental Permitting Regulations. The full impact of this has not been recognised by many in the quarrying industry or in Mineral Planning Authorities. Similarly the difference between what was previously regarded as organic wastes suitable for mixing as a component of artificial soils and additives that are Certified Products rather than waste are not widely understood.

9.2 The extent of the soil shortfall

It would appear reasonable to undertake a comprehensive study of the full extent of the problem by reviewing extant (operational and dormant) aggregate quarries in England. A survey of a number of representative MPA areas may be adequate and may help to establish not just the shortfall but also the soil ‘types’ required to meet restoration and, in particular, biodiversity objectives.

MPAs are committed to reviewing existing planning permissions on a regular basis and it would seem appropriate that information regarding the means of overcoming a shortage of restoration soils is provided to those operators and quarries that have a shortfall of available soils or difficulties with specific restoration objectives. Currently no such information is readily available that adequately addresses the matter.

9.3 Soil forming or enhancing techniques

This study has highlighted the soil shortfall, the restoration/biodiversity objectives, the available on-site quarry waste materials and the available off-site organic and inorganic amendments for four representative quarries in Cornwall, Gloucestershire, Oxfordshire and West Yorkshire. A series of on-site trials is suggested, monitored over 2 years, which will attempt to establish the simplest, cost-effective and sustainable methods and combinations which will deliver the relevant restoration/biodiversity objectives.

An examination of the four study quarries has established a wide range of on-site available waste materials; these include lagoon silts, processing discards up to 20mm, clays, poor subsoils, haul road planings, filter press discards etc. Similarly, a range of organic amendments is widely available including composites, farm manures, forestry by-products, straw and green waste. Other amendments such as de-inked paper fibre and mushroom compost are available from fewer sources.

From an examination of the restoration proposals for each site coupled with the local Biodiversity Action Plan objectives a range of desirable soil types and volumes was established. These were proposed following laboratory tests on the available on-site wastes,
volume calculations of these wastes and the establishment of the availability and type of off-site amendments.

Appropriate mixes of wastes and amendments were devised to deliver, in a cost-effective, sustainable way, the volumes and types of required soil.

Combinations which would comprise the on-site trials have been suggested for the four quarries. A methodology is included for undertaking these trials. The need for trials on sites representative of final restoration gradients and locations is not new, but the range of soil thicknesses and amendments is somewhat changed compared with the previous decade. This report seeks to employ a simple system that is more likely to be suitable for the limited spaces available in working operations than larger scale trial plots used in the past. Many of the older quarries are likely to have numerous benches most of which will be linear rather than laterally extensive.

9.4 Planning and regulatory issues

It is apparent that all planning authorities are addressing, in their policies, the need for biodiversity and restoration. This, of course, does not address existing restoration arrangements, many of which were prepared before biodiversity became a significant issue in the 1990s.

As noted above, the Review of Old Mineral Planning Permissions (ROMPs) is an appropriate place for a different approach to restoration, particularly those with limited stockpiles of natural soils. In addition to the widespread biodiversity objectives, restoration land-uses are evolving such that the typical palette of agriculture, forestry and amenity is being supplemented by a raft of built and broader development uses in isolation or in combination. There should be a careful review of the ways in which biodiversity objectives that may differ from previous planning conditions can be implemented without increasing the planning burden on mineral operators.

It is in the legal and regulatory framework relevant to the import and/or processing of organic material for incorporation as amendments with quarry waste to form restoration materials that there appears to be some confusion and complexity. From a planning perspective it appears that:-

- S33 of the Environmental Protection Act 1990 (“the Act”) requires that a person shall not deposit controlled waste or knowingly cause or permit controlled waste to be deposited in or on any land unless an environmental permit is in force. It is understood that the requirement for an environmental permit does not apply to quarry waste used on site at a quarry or from a farm used for agricultural purposes on that farm.
- Regulation 12 provides that no person may operate a regulated facility except under, and to the extent authorised by an environmental permit, where a “regulated facility” includes a waste operation not carried on at an installation or by means of mobile plant, and where “waste operation” means “recovery or disposal of waste”.
- The Regulations define “waste” as anything that is waste for the purposes of the Waste Framework Directive (2006/12/EC) and that is not excluded from the scope of that Directive by Article 2(1) thereof.
- S33 of the Act also provides that the requirement for an environmental permit does not apply to waste operations that are “exempt waste operations”. A waste operation is defined in the Regulations as an exempt waste operation if it meets the requirements of paragraph 3(1) of Schedule 2 of the Regulations and it falls within a description in Part 1 of Schedule 3, and the type and quantity of waste submitted and the method of disposal or recovery are consistent with the need to attain the objectives of Article 4(1) of the Waste Framework Directive.
- Paragraph 3(1) of Schedule 2 requires that an establishment or undertaking must be registered in relation to the waste operation. Registration for these purposes requires the name and address of the establishment or undertaking carrying on the
exempt waste operation, the waste operation which constitutes the exempt waste operation and the place where the exempt waste operation is carried on.

- Additional information must be given by way of notice to the exemption registration authority (usually the Environment Agency) where the waste operation falls within paragraphs 6, 7, 9, 10, 19, 40 and 46 of Schedule 3. The notice needs to include, *inter alia*, details of the quantity of waste to be disposed of or recovered. This notice engenders a fee and needs to be renewed annually.
- Paragraphs 7 and 9 of Schedule 3 deal respectively with waste for the benefit of land and land reclamation or improvement and both paragraphs contain limits on quantities of waste which can fall within the relevant exemption. Where these limits are exceeded, an operator will need to apply for an environmental permit.
- Note that S33 of the Act provides that the Secretary of State shall, when prescribing regulations under this section, have regard to the expediency of excluding from the need for an environmental permit ‘any deposits which are small enough or of such a temporary nature that they may be so excluded’. There appears to be no reference to minimum thresholds in the Regulations.

As currently understood and in the absence of *simple* guidance published with the Regulations (as was so published in the case with the Quarries Regulations 1999) specific advice needs to be sought on a case by case basis so as to be certain whether a permit or an exemption is required or not.

### 9.5 Recommendations

The recommendations are as follows:-

1. The geographical and volumetric extent of the shortfall of soils for aggregate quarry restoration in England should be determined. This could either be established completely or extrapolated from specific studies of typical MPA areas.

2. Every quarry should have an inventory of its quarry waste materials that should include the following details:-
   - Location and size (volume)
   - Characterisation
   - Current function
   - Potential for re-processing sale and/or use as an artificial soil
   - Appraisal and geotechnical assessments under Quarries Regulations

Approaches to assessing these items have been outlined in Sections 2 and 3 and the equipment most suitable for use in respect of preparing, sorting, handling and placing the mineral components of artificial soils have been detailed.

3. On-site trials as described in Sections 6 and 7 should be undertaken at the four designated quarries. Ideally these should be monitored over a 2 year period (or longer). The amendments should comprise/include BSI PAS100 compost wherever possible.

The methodology for creating soils from on-site quarry wastes and amendments should be refined in the light of the findings noted above. Exemplar combinations of wastes and amendments (with seeding/planting suggestions) should be covered for each of the four studied quarries. Typical costs for standard combinations and activities should be provided.

4. Further investigation and discussion with interested stakeholders should take place with regard to the legal, regulatory and planning framework. The overall objective of improving aggregate quarry restoration by sustainable use of on-site quarry wastes and appropriate locally sourced amendments should clearly be encouraged, in the context of clearer information noted in 5 below.
5. More clarity is required, possibly in the form of succinct, published guidance, approved by the Environment Agency and DEFRA in respect of the interpretation of the Environmental Permitting Regulations regarding the use of amendments for reclamation in quarries. Similar information is needed regarding up-to-date Soil Guideline Values in respect of soil chemistry.

6. The findings of this current study need to be circulated through a range of professional and industry publications including Quarry Management, the Quarry Products Association and the British Aggregates Association as well as Natural England and DEFRA websites. The outcomes from the further recommended work should similarly be widely circulated to the industry, MPAs and other relevant authorities.
Appendix 1. Sampling from silt lagoons

Silts comprise an important component in artificial soils and are a commonly found quarry waste. Although described as silts these materials range from clay to medium sand in size depending on the type of lagoon and the configuration of materials discharge into the lagoon. Silts are deposited in lagoons from the wet washing of aggregate following crushing and screening and from settlement ponds constructed to collect suspended solids from a run-off prior to discharge into off-site water courses. Many lagoons are periodically cleaned out, but the collected silt generally has to be contained within some form of earth embankment since it might otherwise flow away from the point of deposit. Another technique for handling excavated silts involves the spreading of silt in thin layers (as shown in Photograph 6.6 at Shellingford Quarry).

Sampling silts is a hazardous process whether it is from existing lagoons or silts that have been excavated from a lagoon. Under no circumstances should the sampler walk on to the surface of stockpiled silts or a silt lagoon without having previously discussed the matter with the quarry manager and investigated the nature of the surface with a backhoe, preferably a long reach backhoe, used to assess the compressibility and bearing capacity of the lagoon surface.

Wherever possible samples should be taken with a backhoe and collected in the backhoe bucket. The excavation of a trial pit for sampling is also potentially hazardous and under no circumstances should the sampler enter any such trial pit in a silt lagoon or on a silt stockpile. The use of drilling rigs, including lightweight soil sampling rigs, should only ever be considered after a detailed investigation involving remote excavation with a backhoe and a subsequent risk assessment.

The sampling of lagoon surfaces, which may require capping and covering with soil as part of a restoration programme is also hazardous and the capping process can be equally hazardous. It should be remembered that lagoons form a potential hazard long after a site has become disused and where capping is necessary and the lagoon contents cannot be removed, the lagoons should be:-

- Drained with the removal of surface water, if necessary with trenches excavated by a long reach backhoe and any water collecting in the trenches removed.
- Over-tipped with capping and soil forming materials only after a crust has formed and further tests have been undertaken with respect to the bearing capacity.
- Where vehicular access on to a lagoon is essential this should only be undertaken after the investigations noted above and using low ground pressure plant with over-tipping in uniform thin layers to minimise the risk of plant being lost following the collapse of the surface crust. A recommended means of covering a lagoon is shown below together with some of the hazards that might be encountered (see Appendix Figures 1.1 and 1.2).
Appendix Figure 1.1 Sequence of operations in capping dried out lagoons with crusts, and spreading soil, using low pressure equipment placing thin layers of uniform thickness.
Appendix Figure 1.2 Illustrations of problems that might arise from capping and soil spreading over insufficiently dry lagoon sediments. This also illustrates where incorrect equipment may have been used or used incorrectly. The upper two figures show problems arising from over-thick layers and/or failing to use low ground pressure equipment. Trucks should never be used to tip on to lagoon sediments and should not travel over lagoon sediments.
Appendix 2 Equipment for sorting and processing waste materials in quarries

The following plant is commonly used in quarries and appropriate for handling soil forming materials and associated operations. More detailed specification can be obtained from equipment suppliers’ handbooks e.g. the CAT Handbook or downloaded from the suppliers websites. If plant is brought on to a quarry it is important to confirm that access arrangements are in place including size and headroom. This plant should only be used by qualified and trained operatives with appropriate certification.

**Hydraulic Backhoe Excavator.** This is a versatile and extensively used machine with a significant capacity for digging at and below crawler level and for spreading materials including soils. Backhoes are also suitable for mixing soil components within or from different stockpiles. Bucket capacity can range from 2m³ to 30m³. Smaller backhoe loaders may be tractor mounted and are best used for ancillary work such as loading muck spreaders and are not suited to sorting and spreading soil forming materials.

**Wheeled Loader (Front End Loader).** Extensively used to load soil and well fragmented quarry waste and to move short distances loading trucks, although may be used for limited spreading of materials and for mixing soil forming components. Most commonly used around stockpiles, the bucket capacity may range from 2m³ to 10m³. This machine may also be suitable for mixing soil mineral components.
**Crawler Loader.** Fulfils a similar role to the Wheeled Loader, but better suited to poor ground conditions. Mobility reduced compared with the Wheeled Loader, but its functions are almost identical with similar bucket capacities.

**Dump Truck.** These are available as rigid body or articulated vehicles. Articulated vehicles are often preferred for work involving the handling of soil materials. These have capacities ranging from 15t to 45t (10-30m³) although larger capacity vehicles are available and used on many quarries. Articulated dump trucks generally require less prepared roads. The rear dump versions are most widely used although side dump vehicles are available.

**Scraper.** These vehicles are used to excavate, transport and spread soil materials and loose overburden although the ground sometimes requires ripping prior to scraping. It is possible to load scrapers from stockpiles and use them for transportation and spreading soils although there are problems with over compaction of the soil by the large rubber tyres. Scapers can be as shown or with an additional rear engine or with no engine and towed by a crawler tractor/bulldozer. The payload capacity is about 6m³ to 30m³ (4t-20t).
**Crawler Tractor/Bulldozer.** This is extensively used in the re-grading of quarry waste both in tipping operations and to spread materials to a final profile. Blade shapes vary in plan and profile to assist with re-grading. Units are frequently equipped with a rear-mounted ripping bar or bars that are often used to loosen compacted, re-graded material prior to spreading of topsoil or the mixing of re-graded material with amendments by power harrowing.

**Grader.** This is most commonly used for grading and maintaining the running surface on un-surfaced quarry roads that have been constructed from crushed rock. The material removed frequently has a grading that is suitable for artificial soils (see Photograph 6.12 of potential planings from the road surface at Oathill Quarry – also see results from Sample 4 at Oathill Quarry where the fines have a soil texture of a loam verging on a sandy loam with 19% fine to medium gravel). Graders may also be used to finish off the spreading of soil, but compaction is a problem notwithstanding the width of the grader blade. This blade can be angled to assist with grading.
Appendix 3. Illustration of website giving details of WRAP approved composting sites.

This documentation is provided through WRAP to allow for producers of PAS100 compost and Certified PAS100 that is not treated as waste, but as a product and therefore does not require an application for an exemption under the Environmental Permitting (England and Wales) Regulations 2007. The web address is:

http://compostsuppliers.wrap.org.uk

It is necessary to input the post code and to identify the required material as soil improver. Examples are given below of the output for Penlee Quarry and Shellingford Quarry.
APPENDIX 4 Full test results from Geotechnics, Severn Trent Laboratories and Chemtest.

<table>
<thead>
<tr>
<th>LIST OF CONTENTS</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of Contents</td>
<td>Page 1</td>
</tr>
<tr>
<td>1.0  Laboratory Results</td>
<td>Pages 2 to 6</td>
</tr>
<tr>
<td>Appendix 1  Chemical Analysis performed by Severn Trent Laboratories Midland</td>
<td>Pages 7 to 12</td>
</tr>
<tr>
<td>Appendix 2  Data Sheet and UKAS Accreditation Certificate and Schedule.</td>
<td>6 No. Pages</td>
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LABORATORY REPORT FOR
LABORATORY TESTING
PROJECT NO: PC093760

Shellingford Quarry

LIST OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Pages</th>
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<tr>
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<td>Laboratory Results</td>
<td>Pages 2 to 5</td>
</tr>
<tr>
<td>Appendix 1</td>
<td>Chemical Analysis performed by Severn Trent Laboratories Midland</td>
<td>Pages 6 to 14</td>
</tr>
<tr>
<td>Appendix 2</td>
<td>Data Sheet and UKAS Accreditation Certificate and Schedule.</td>
<td>6 No. Pages</td>
</tr>
</tbody>
</table>

Artificial Soils for Quarry Restoration
an update and overview

Page 91 of 108
## Additional Data Analysis

<table>
<thead>
<tr>
<th>Sample</th>
<th>Tissue</th>
<th>Amount Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>2.3</td>
<td>5.8</td>
</tr>
<tr>
<td>Sample 2</td>
<td>3.4</td>
<td>7.6</td>
</tr>
<tr>
<td>Sample 3</td>
<td>4.5</td>
<td>8.7</td>
</tr>
</tbody>
</table>

### Sample Comments

- Sample 1: Slight excess beyond the limit, no action required.
- Sample 2: Within acceptable limits.
- Sample 3: Slight deficiency, further investigation needed.

### Additional Notes

- Recommendations for future analyses.
- Compliance status update.

---

## Additional Data Analysis

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- Recommendations for future analyses.
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</tr>
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<td>4.5</td>
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</tr>
</tbody>
</table>

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- Sample 2: Within acceptable limits.
- Sample 3: Slight deficiency, further investigation needed.

### Additional Notes

- Recommendations for future analyses.
- Compliance status update.
LABORATORY REPORT FOR
LABORATORY TESTING
PROJECT NO: PC993766

Oathill Quarry

LIST OF CONTENTS

List of Contents

1.0 Laboratory Results

Appendix 1 Chemical Analysis performed by Severn Trent Laboratories Midland

Appendix 2 Data Sheet and UKAS Accreditation Certificate and Schedule.
Method Comments for Report  COV/578103/2009

Date of Issue: 04 February 2009

Method

Statement

17

15a

30

Metals are extracted from soil samples by boiling with hydrochloric/acetic acids (3:1 ratio). The measurement of metal concentrations is determined directly on an ICP-OES at defined wavelengths.

30A

Metals are extracted from solid samples by boiling with hydrochloric/acetic acids (3:1 ratio). For the measurement of metal concentrations is determined on an ICP-OES at defined wavelengths. Where a result is 25mg/kg or above results are obtained directly. Otherwise results are obtained via hydride generation.

32a

Moisture Content is the weight difference between an as-received sample and the air-dried sample at 35 degrees C.

33

The test is carried out by extraction using deionised water with agitation. The pH of this suspension is read directly from an electronic pH meter.

Stones

The percentage weight of the stones that are naturally occurring and are greater than 10mm in diameter to the total weight of sample.
Appendix 5 Local Biodiversity Action Plans

Penlee Quarry and Shellingford Quarry BAPs
Oathill Quarry and Cromwell Quarry BAPs
## Appendix 6 Table from Schedule 3 Environmental Permitting Regulations

This includes other pertinent information presented as Paragraph 7 and Paragraph 9 Exemptions. Paragraph 7 deals primarily with organic additives and Paragraph 9 includes compost, but also mineral soil components.

### Paragraph 7 Exemption

**Waste for the benefit of land**

**What the legislation says:**

7 (1) Subject to sub-paragraph (5), treatment of land used for agriculture with any kind of waste specified in column 2 of the Table in sub-paragraph (3) form the corresponding source specified in column 1 of that Table where such treatment results in benefit to agriculture or ecological improvement.

7 (2) Subject to sub-paragraph (5), treatment with a kind of waste specified in column 2 of Part 1 of the Table in sub-paragraph (3) from the corresponding source specified in column 1 of part 1 of that Table of –

(a) operational land of a railway, light railway, water undertaker, internal drainage board, British Waterways board or the Agency; or

(b) land which is forest, woodland, park garden, verge, landscaped area, sports ground, recreation ground, churchyard or cemetery,

Where the land in question is not used for agriculture and such treatment results in ecological improvement.

7 (3) The Table referred to in sub-paragraph (1) and (2) is set out below.

<table>
<thead>
<tr>
<th>Source of waste</th>
<th>Kind of waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wastes from forestry, aquaculture, horticulture and fishing</td>
<td>Plant tissue Waste</td>
</tr>
<tr>
<td>Wastes from sugar processing</td>
<td>Soil from cleaning and washing beet</td>
</tr>
<tr>
<td>Waste from wood processing and the production of panels and furniture</td>
<td>Waste bark and Cork Sawdust shavings, cuttings, wood and particle board</td>
</tr>
<tr>
<td>Wastes from pulp, paper and cardboard production and processing</td>
<td>Waste bark and wood, pulp from virgin timber.</td>
</tr>
<tr>
<td>Soil (excluding excavated soil from contaminated sites), stones and dredging spoil</td>
<td>Soil and stones</td>
</tr>
<tr>
<td>Wastes from aerobic treatment of solid wastes</td>
<td>Compost of biodegradable garden and park waste</td>
</tr>
<tr>
<td>Garden and park wastes (including cemetery waste)</td>
<td>Biodegradable waste Soil and stones</td>
</tr>
</tbody>
</table>

**PART 2**

<table>
<thead>
<tr>
<th>Source of waste</th>
<th>Kind of waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wastes from the preparation and processing of meat, fish and other foods of animal origin</td>
<td>Blood and gut contents from abattoirs, poultry preparation plants or fish preparation plants Wash waters and sludges (with or without treatment) from abattoirs, poultry preparation plants or fish preparation plants. Shells from shellfish processing.</td>
</tr>
<tr>
<td>Wastes from fruit, vegetables, cereals, edible oils, cocoa, coffee, tea and tobacco preparation and processing; conserve production; yeast extract production, molasses preparation and fermentation.</td>
<td>All wastes derived from the processing of such materials.</td>
</tr>
<tr>
<td>Wastes from sugar processing</td>
<td>All wastes derived from the processing of such materials</td>
</tr>
<tr>
<td>Wastes from the dairy products industry</td>
<td>Wastes derived from the processing of dairy products</td>
</tr>
<tr>
<td>Wastes from the baking and confectionery</td>
<td>All waste derived from the processing of the raw</td>
</tr>
<tr>
<td>Industry/Manufacturing Sectors</td>
<td>Materials Used</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Industry materials used in the baking and confectionery industry</td>
<td></td>
</tr>
<tr>
<td>Wastes from the production of alcoholic and non-alcoholic beverages (except coffee, tea and cocoa)</td>
<td>All wastes derived from the processing of the raw materials used in the production of such beverages</td>
</tr>
<tr>
<td>Wastes from pulp, paper and cardboard production and processing.</td>
<td>De inked paper sludge and de-inked paper pulp from paper recycling. Lime mud waste</td>
</tr>
<tr>
<td>Wastes from the leather and fur industry</td>
<td>Sludges from on-site effluent treatment free of chromium</td>
</tr>
<tr>
<td>Wastes from the textile industry</td>
<td>Organic matter from natural products Wastes from finishing other than those containing organic solvents Sludges from on-site effluent treatment Wastes from textile fibres</td>
</tr>
<tr>
<td>Wastes from the manufacture of cement, lime and plaster and articles and products made from them</td>
<td>Wastes from calcinations and hydration of lime Gypsum</td>
</tr>
<tr>
<td>Wastes from power stations and other combustion plants</td>
<td>Gypsum</td>
</tr>
<tr>
<td>Soil (including excavated soil from contaminated sites) stones and dredging spoil</td>
<td>Dredging spoil (other than those containing dangerous substances)</td>
</tr>
<tr>
<td>Waste from aerobic treatment of waste</td>
<td>Compost derived from source segregated biodegradable waste Liquor from aerobic treatment of source segregated biodegradable waste Digestate from aerobic treatment of source segregated biodegradable waste</td>
</tr>
<tr>
<td>Waste from anaerobic treatment of waste</td>
<td>Compost derived from source segregated biodegradable waste Liquor from anaerobic treatment of source segregated biodegradable waste Digestate from anaerobic treatment of source segregated biodegradable waste</td>
</tr>
<tr>
<td>Wastes from the preparation of water intended for human consumption or water for industrial use</td>
<td>Sludges from water clarification.</td>
</tr>
</tbody>
</table>

(4) Secure storage, at the place where it is to be used, of not more than 1,250 tonnes of waste intended to be used for a treatment falling within sub-paragraph (1) or (2), if –

(a) the waste is stored at distance of at least:
   (i) 10 metres from any watercourse
   (ii) 50 metres from any spring or well, or from any borehole not used to supply water for domestic or food production purposes, and
   (iii) 250 metres from any borehole used to supply water for domestic or food production purposes;
(b) no waste is stored within 0.3 metres of the top of any open storage container or within 0.75 metres of the top of an earthbank tank or lagoon; and
(c) the waste is stored for no more than 12 months.

(5) An operation only falls within sub-paragraph 91) or (2) if –

(a) it is carried on in relation to an area of land of 50 hectares or less;
(b) no more than the following quantities of waste are used on the land in any period of 12 months:
   (i) in the case of sugar beet soil, 1,500 tonnes per hectare
   (ii) in the case of dredging spoil from inland waters, 5,000 tonnes per hectare, or
   (iii) in the case of any other waste, no more than 250 tonnes per hectare; and
(c) the operation is carried on in accordance with any requirement imposed by:
   (i) in England, the Animal By-Products Regulations 2005;
   (ii) in Wales, the Animal By-Products (Wales) Regulations 2006
(6) In this paragraph –

(a) “agriculture” has the meaning given by section 109 of the Agriculture Act 1974
(b) “operation land” in relation to an internal drainage board means land which is held for the purpose of carrying out its functions as an internal drainage board.

Paragraph 9 Exemption
Land Reclamation or Improvement

What the legislation says:

9 (1) Subject to sub-paragraph (3) –

(a) spreading a kind of waste specified in column 2 of Part 1 of the Table in sub-paragraph (2) from the corresponding source specified in column 1 of Part 1 of that Table on any land; or

(b) spreading a kind of waste specified in column 2 of Part 2 of the Table in sub-paragraph (2) from the corresponding source specified in column 1 of Part 2 of that Table on any land where the operation results in benefit to agriculture or ecological improvement.

(2) The Table referred to in sub-paragraph (1) is set out below.

<table>
<thead>
<tr>
<th>Source of waste</th>
<th>Kind of waste</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PART 1</strong></td>
<td></td>
</tr>
<tr>
<td>Wastes from the physical and chemical processing of non-metalliferous minerals</td>
<td>Waste gravel and crushed rocks</td>
</tr>
<tr>
<td>Wastes from sugar processing</td>
<td>Waste sand and clays</td>
</tr>
<tr>
<td>Wastes from power stations and other combustion plants (except waste from waste management facilities, off-site waste water treatment plants and the preparation of water intended for human consumption and water for industrial use)</td>
<td>Soil from cleaning and washing beet</td>
</tr>
<tr>
<td>Wastes from manufacture of ceramic goods, bricks, tiles and construction products.</td>
<td>Pulverised fuel ash, bottom ash and slag.</td>
</tr>
<tr>
<td>Wastes from manufacture of cement, lime and plaster and articles and products made from them.</td>
<td>Waste concrete and concrete sludge</td>
</tr>
<tr>
<td>Concrete, bricks, tiles and ceramics</td>
<td>Bricks</td>
</tr>
<tr>
<td>Wastes from the mechanical treatment of waste (for example sorting, crushing, compacting, palletising) not other specified</td>
<td>Tiles and ceramics</td>
</tr>
<tr>
<td>Wastes from soil and groundwater remediation</td>
<td>Mixtures of concrete, bricks, tiles and ceramics.</td>
</tr>
<tr>
<td>Garden and park wastes (including cemetery waste)</td>
<td>Minerals (for example sand, stones)</td>
</tr>
<tr>
<td>Soil (including excavated soil from contaminated sites), stones and dredging spoil</td>
<td>Solid wastes from soil remediation (other than those containing dangerous substances)</td>
</tr>
<tr>
<td><strong>PART 2</strong></td>
<td></td>
</tr>
<tr>
<td>Wastes from pulp, paper and cardboard production and processing.</td>
<td>De-inked paper sludge and de-inked paper pulp</td>
</tr>
<tr>
<td>Soil (including excavated soil from contaminated sites), stones and dredging spoil</td>
<td>Lime mud waste</td>
</tr>
<tr>
<td>Wastes from aerobic treatment of solid wastes</td>
<td>Soil and stones other than those containing dangerous substances</td>
</tr>
<tr>
<td>Wastes from waste water treatment plants</td>
<td>Dredging spoil other than those containing dangerous substances</td>
</tr>
<tr>
<td>Wastes from the preparation of water intended for human consumption or water for industrial use</td>
<td>Sludges from treatment of urban waste water</td>
</tr>
<tr>
<td>Wastes from soil and groundwater remediation</td>
<td>Sludges from water clarification</td>
</tr>
<tr>
<td>Wastes from soil and groundwater remediation</td>
<td>Sludges from soil remediation (other than those containing dangerous substances)</td>
</tr>
</tbody>
</table>
(3) An operation does not fall within sub-paragraph (1) unless –

(a) the waste is spread for the purpose of reclamation, restoration or improvement of land which has been subject to industrial or other man-made development, and the use to which that land could be put would be improved by the spreading

(b) the waste is spread in accordance with any requirement of or under the Town and Country Planning Act 1990

(c) the waste is spread to a depth not exceeding the lesser of:
   (i) 2 metres, or
   (ii) the final cross-section shown on any plan submitted under paragraph 8 of Schedule 2; and

(d) no more than 20,000 cubic metres of waste are spread per hectare.

(4) Secure storage for a period not exceeding 6 months, at the place where it is to be spread, of waste intended to be spread in reliance on sub-paragraph (1)