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An Enhanced Classification for Artificial Ground

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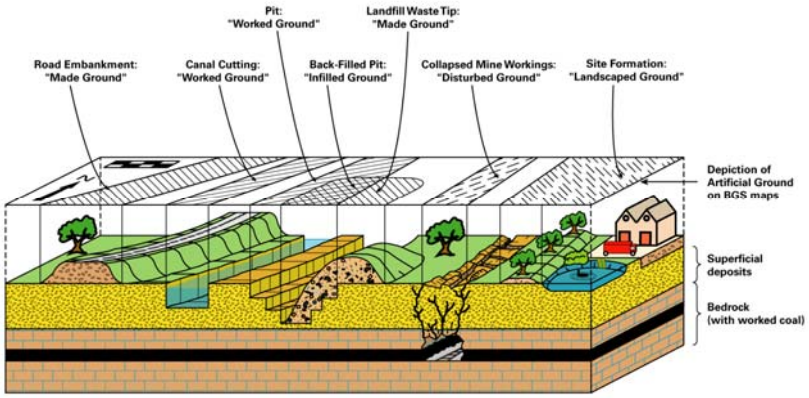

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OPEN REPORT OR/10/036

An Enhanced Classification for Artificial Ground

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Key words

Artificial Ground; Classification; Lexicon; Mapping; Modelling.

Bibliographical reference

FORD, J., KESSLER, H., COOPER, A.H., PRICE, S.J, HUMPAGE, A.J. 2010. An Enhanced Classification For Artificial Ground *British Geological Survey Open Report*, OR/10/036. 32pp.

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Acknowledgements

This report attempts to bring together comments and ideas from a large number of individuals. The authors would like to thank those people that have contributed throughout the development of this work. We would particularly like to thank Paul Lappage for his assistance in preparing various figures. Martin Culshaw, Poul Strange, Andrew McMillan, John Powell and Dave Lowe are especially thanked for their support and encouragement in undertaking the work.

Contents

1 Introduction

The geological map shows a wide range of geoscientific information, primarily Bedrock Geology, Superficial Geology, Mass Movement Geology and Artificial Ground. The emphasis has traditionally been on “bedrock geology” and “superficial geology”, but an improved understanding of the nature and distribution of Artificial Ground is becoming increasingly relevant to development and regeneration in the urban environment (Rosenbaum et al., 2003). Information about previously developed ground is especially important, as it is often associated with potentially contaminated material, unpredictable engineering conditions and unstable ground. The mapping and classification of Artificial Ground using borehole information, historical maps and field visits provides valuable information to a variety of BGS and external users.

Artificial Ground is currently classified in the BGS Lexicon of Named Rock Units (http://www.bgs.ac.uk/lexicon/lexicon_intro.html) into Made Ground (including engineered and non-engineered material), Worked Ground, Infilled Ground, Disturbed Ground and Landscaped Ground (BGS, 2000; McMillan and Powell, 1999) (Fig.1). These five classes are shown on current 1:10,000, 1:25,000 and 1:50,000 scale BGS maps. However, this basic approach to mapping Artificial Ground allows only limited information to be recorded. Until now for example, it has not been possible to distinguish between a landfill waste tip and a road embankment (see Figure 2).

MADE GROUND	Areas where material is known to have been placed by man on the pre-existing natural land surface (including engineered fill)
WORKED GROUND	Areas where the pre-existing land surface is known to have been excavated by man
INFILLED GROUND	Areas where the pre-existing land surface has been excavated (Worked Ground) and subsequently partially or wholly backfilled (Made Ground)
DISTURBED GROUND	Areas of surface or near-surface mineral workings where ill-defined excavations (Worked Ground), areas of subsidence caused by the workings and spoil (Made Ground) are complexly associated with each other.
LANDSCAPED GROUND	Areas where the pre-existing land surface has been extensively remodelled but where it is impracticable to delineate separate areas of Made Ground, Worked Ground or Disturbed Ground.

Figure 1. The Current Artificial Ground Classification

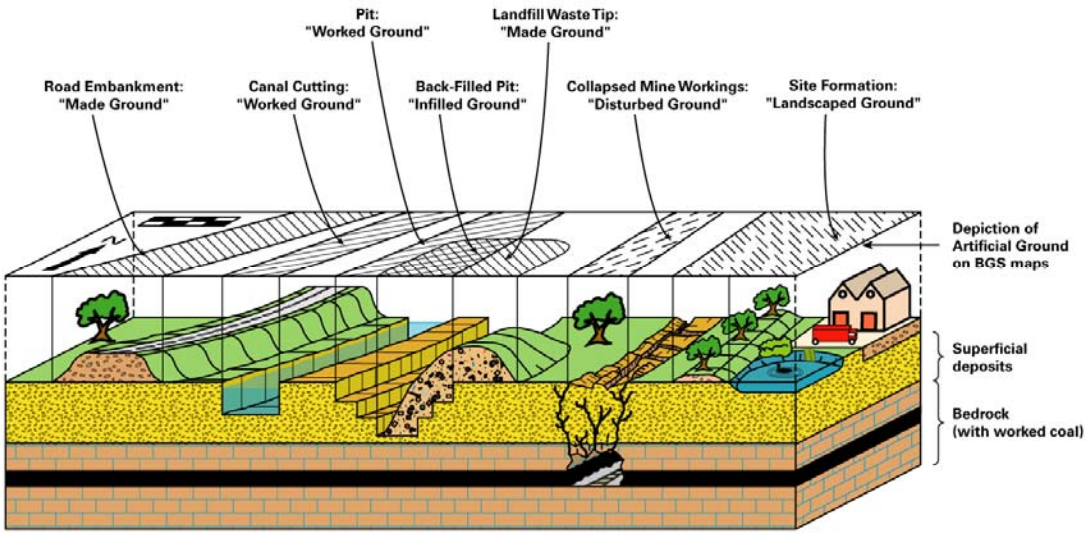

Figure 2. Examples of the main types of Artificial Ground and how they are shown on the geological map (modified after McMillan, and Powell, 1999)

In response to the increased emphasis on mapping Artificial Ground and the limitations of the five classes, a new scheme has been developed for mapping and 3-D modelling purposes that extends the existing classification. This report presents a framework that categorises Artificial Ground in a useful and useable way that is compatible with the needs of BGS and the potential users of the information.

The new scheme subdivides the existing classification of Artificial Ground within the frameworks of:

- the current BGS stratigraphical Lexicon of Named Rock Units
- the BGS Rock Classification Scheme
- the structure of DigMapGB (**Dig**ital Geological **Map** of **G**reat **B**ritain)
- the practices of BGS Cartographic Services
- the requirements of the SIGMA (**S**ystem for **I**ntegrated **G**eospatial **Ma**pping) and DGSM (**D**igital **G**eoscience **S**patial **M**odel) projects for digital map compilation and 3D modelling
- the need to extract information that is useful for land use and contaminated land studies
- to need to supply information for GeoHazarD (Potential **Geo**logical **Hazar**ds **D**ata Provision)
- the requirements of external users including planners and engineers
- a logical hierarchical scheme
- the need of a classification compatible with the BOREHOLE_GEOLOGY tables
- an extensible scheme to accommodate new entries as and when required by the user

This report describes the new scheme and shows how it may be applied to geological mapping. A series of tables detail each of the proposed categories of Artificial Ground that comprise the new scheme. This report does not examine the composition (lithology) of Artificial Ground, which is the subject of a separate BGS report currently under preparation.

2 Background to the Classification of Artificial Ground

The BGS Technical Report by McMillan and Powell (1999), http://www.bgs.ac.uk/bgsrcs/docs/Superficial.pdf) includes a relationship diagram for Artificial ("man-made") Ground (see Figure 3). This diagram defines the current BGS classification, including the five basic mapping categories of Made Ground, Worked Ground, Infilled Ground, Disturbed Ground and Landscaped Ground (Figure 3, "Level 2"). These five categories exist in the BGS Lexicon of Named Rock Units, and appear on published 1:10,000, 1:25,000 and 1:50,000 scale maps. However, this general subdivision does not provide sufficient detail to support the increased emphasis on mapping Artificial Ground.

An increased level of detail is defined in the subdivisions shown at "Level 3". However, these categories do not exist in the BGS Lexicon of Named Rock Units. The new scheme addresses this limitation by extending and formalising this aspect of the classification.

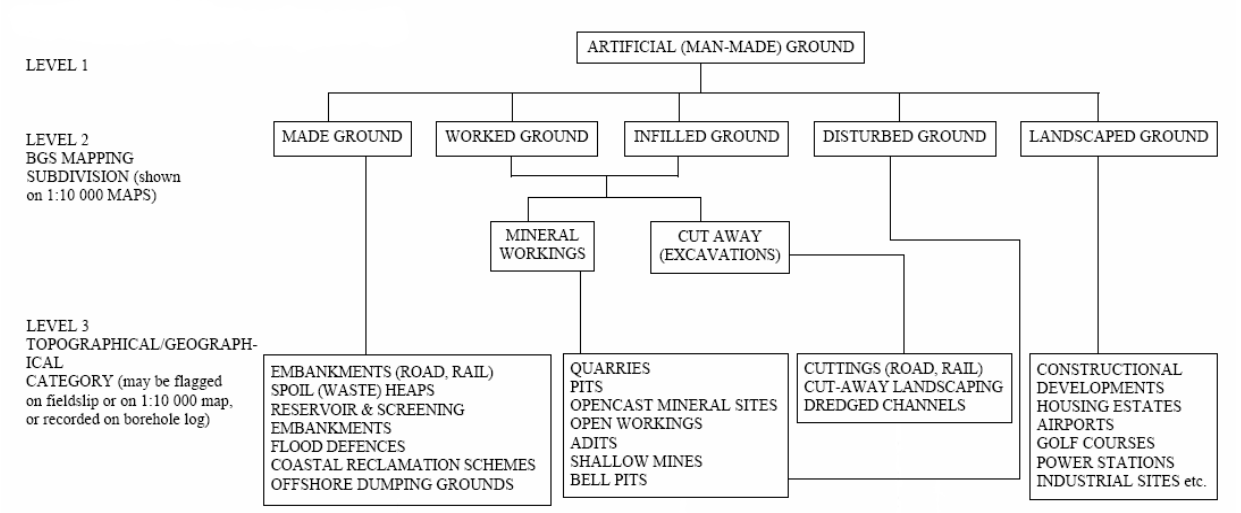

Figure 3. Artificial Ground (modified after McMillan and Powell, 1999)

Another classification scheme used locally in BGS was that derived for the ALGI (**A**ddress **L**inked **G**eological **I**nventory) London and Bristol schemes (Humpage 1997). The ALGI scheme hangs below three of the Artificial Ground classes and does not use Disturbed or Landscaped Ground (except in the Bristol area). The ALGI scheme mixes Artificial Ground type with lithology, land use and stratigraphy. It works well as a stand-alone scheme, but does not integrate with the current BGS map, 3-D modelling or borehole systems. It is however a useful list of information, that has helped define the Types and Units described below.

A further BGS scheme that included Artificial Ground was the landform dictionary generated for the first generation of the GSD (**G**eological **S**patial **D**atabase) map compilation system. This dictionary resides on the BGS ORACLE database servers under BGS.DIC_ARTIF_FORM. All the entities included in that dictionary have been incorporated in the scheme proposed below, but the unique computer codes for each type of Artificial Ground could not be used because many of them were incompatible with existing entries in the stratigraphical lexicon.

An additional BGS project that also gathers data about Artificial Ground is MINGOL (**M**inerals **I**nformation **GIS** **O**n-**L**ine). The proposal to introduce a better classification of Artificial Ground

will eventually allow the MINGOL entries to be associated with the appropriate digital map polygon. Consequently, the suggested scheme has been kept simple to avoid duplication of the current and historical database of information about mineral extraction contained within MINGOL.

Detailed mapping of Artificial Ground features in several BGS planning and development studies (Jackson and Lawrence, 1990; Lake et al., 1992; Wilson et al., 1992). Due to the inherent regional variability in characteristic forms of Artificial Ground, each study established a locally derived classification. Typically, the resulting categories combine the type of Artificial Ground with lithological information. Incompatibility issues prevent the interoperability of these local classifications.

Dearman et al. (1977) gave another example of detailed artificial ground mapping, for a site in Newcastle upon Tyne. They did not present a classification scheme, but identified made ground related to refuse, road works and railway works attributed with dates based on levels and features on historical topographical maps. They also commented on artificial ground related to opencast sites, clay pits, limestone quarries, infilled valleys, infilled creeks, and ballast spoil heaps. They pointed out the need for good artificial ground information for engineering purposes. They also noted the need for geological map information that became more detailed at larger scales culminating in site-specific details.

External industrial classification schemes for anthropogenic deposits are typically defined in terms of lithology (composition) or on licensing characteristics, rather than the origin and landform of the deposit or excavation. British Standard, BS5930:1999 differentiates Made Ground on the basis of its composition and provides a methodology for its description. Within BS5930, Made Ground is divided into soil comprising reworked natural material and soil comprising anthropogenic material. In addition, a distinction is made between *"Made Ground"* and *"Fill"*, where *Fill* is defined as material placed in a controlled manner and *Made Ground* is material placed in an uncontrolled manner. BS5930 therefore provides a means of description of the material based on particle size and other criteria such as the presence of voids or hollow objects but does not establish a strict lithological classification based on the type of anthropogenic material.

Other schemes, such as the proposed European Waste Catalogue (DEFRA, 2002) created by European Commission Decision 94/3/EC provide twenty categories of anthropogenic material that can be considered as waste. The categories, identified by a six digit codes are based on the material composition and the industry or process from which it was sourced. This scheme provides a definitive list of anthropogenic material, but is impractical to use for mapping or borehole logging purposes as Artificial Ground is commonly made up of a composite of many different types of anthropogenic material. Consequently, a classification based on grouped anthropogenic materials is required.

A similar lithology/licencing characterisation scheme is the SiteFile Digest (formerly by Aspinwall and Company Limited and now by Landmark Information Group) which provides a description of 43 classes of wastes, ranging from specific components (e.g. "asbestos") to more generic terms (e.g. "inert") for describing permissible material allowable under waste disposal site licences. However, the sites are themselves only defined using a four-fold classification:
inert only; non-hazardous; household ; difficult.

Lithological schemes describe Artificial Deposits, and can provide a classification based on the composition, size distribution, and engineering characteristics at a particular locality. However, a scaleable classification of Artificial Ground based on morpho-stratigraphical criteria is more applicable to mapping and modelling. The enhanced classification for Artificial Ground aims to

provide an industry standard framework that will allow external users to complement their conventional lithological description of anthropogenic deposits with a mappable classification defined by landform and origin.

Due to the development requirements of various BGS projects, there is an urgent need for an enhanced classification of Artificial Ground. The report by Walton and Lee (2001) has stated that the Quaternary Methodologies and Training Programme will: "Work with other BGS programmes to set up a national database of information on the thickness, character and relevant properties of natural and artificial Quaternary deposits". It is therefore imperative that a system is developed to enable improved data supply for local authorities; identification and prioritisation of contaminated land; and GeoHazarD (Potential **Geo**logical **Hazar**ds **D**ata Provision).

The new classification for Artificial Ground proposed here provides a flexible framework that accounts for the regional variability of Artificial Ground, and allows a standardised approach to data gathering and representation.

3 The Enhanced Classification for Artificial Ground

Compared to previous attempts, the new scheme allows potentially more detailed information to be captured by offering a systematic three-tier classification of Artificial Ground based on the origin and landform of the deposit or excavation. The new scheme uses a hierarchy of Class, Type and Unit, with Class being the most basic level of information (equivalent to the five existing classes defined by McMillan and Powell, 1999) and Unit being the most detailed, similar to the way the stratigraphical lexicon is ordered by Group, Formation and Member (Figure 4). As stated previously, a complementary scheme for the material type is currently being investigated, and this will sit alongside the enhanced classification to provide a full LEX-ROCK coding scheme usable with the BGS DigMapGB system.

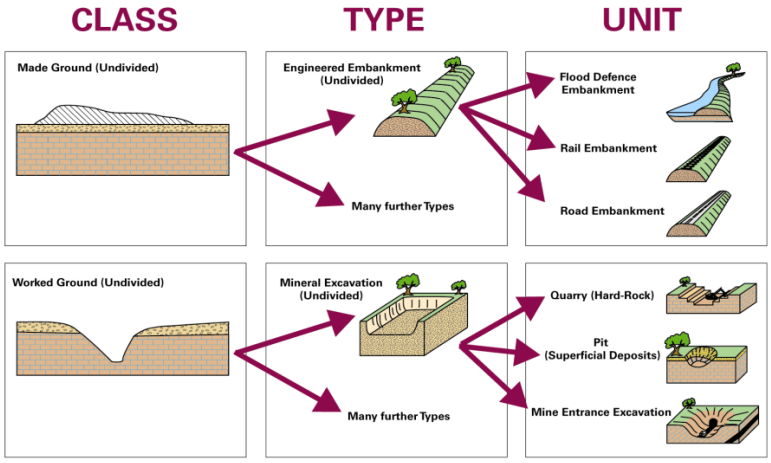

Figure 4. Selected examples of branches of the Artificial Ground hierarchy

The typical usage is intended to be intuitive, and is described below:

Unit-level codes provide the highest level of detail, allowing specific types of Artificial Ground to be recorded. It is suggested that this level of detail is suitable for 1:10,000 scale or greater surveying and logging.

Type-level codes are suggested for use where a Unit-level classification is impossible due to insufficient data, site complexity or limited project resources. The Type-level subdivisions retain a moderate level of detail and allow the selection of Unit-level datasets with related characteristics. This level of detail is suitable for 1:10,000 surveying where deposits cannot be differentiated, or where the time available will not allow subdivision.

Class-level corresponds to the existing level of detail currently available through the BGS lexicon and used on the current published 1:50,000 scale (and previously published 1:10,000 and 1:25,000 scale) geological maps. A general classification and selection of Artificial Ground is possible, but specific observations and significant information may be lost through generalisation.

As shown, each level in the hierarchy can be subdivided to give progressively more detail. Consequently, either basic or detailed information can be captured, depending on the scale of survey, project resources or available information or knowledge.

This arrangement allows “children” to be assigned to their “parents” and numerous types can be included within a class or units within a type. The new codes can be combined with the

hierachical lithology codes currently under development to provide the full BGS DigMapGB hyphenated code (For example, MRIT-FILLU for Land Raising Inert Fill (MRIT) composed of Undifferentiated Fill (FILLU)). This current proposal subdivides Artificial Ground along these lines with a logical coding system.

Tables 1 to 4 (Appendix 1) show the framework for the new scheme, and provides a proposed set of codes. Table 5 (Appendix 1) describes each new entry in detail. In each case, the three-tier hierarchy (Class, Type, Unit) provides a flexible and logical subdivision of the existing categories into an increasingly descriptive set of codes that are assigned to essentially morpho-stratigraphical divisions. Some subdivisions are made based on genesis, but the attribution is not lithological, as that is part of the rock classification scheme forming the second part of the attributing seed.

An example of the new scheme, in the case of Worked Ground, may be a quarry where limestone has been extracted. This may be mapped as Worked Ground at Class level, Mineral Excavation at Type level or Quarry (Hard Rock) at Unit level. Similarly for Made Ground, a road embankment can be mapped as Made Ground at Class level, Engineered Embankment (Undivided) at Type level and Road Embankment) at Unit level.

Infilled Ground is extremely important and can arise from a number of complex processes of removal and deposition of material. Infilled Ground can be thought of as the combination of one or more phases of excavation where material has been extracted (Worked Ground) and one or more phases of deposition of material (Made Ground) within the excavation. The definition of Made Ground in this scheme is therefore extended to include material placed on an artificial ground surface, in addition to the natural ground surface.

Therefore Infilled Ground is defined during surveying and map compilation by coincident areas of Worked Ground and Made Ground. The hierarchical nature of the new scheme allows the surveyor to combine any Class, Type or Unit of Worked Ground and Made Ground to derive a corresponding classification for Infilled Ground. For example, where detailed information is available concerning both the “cut” and the “fill”, appropriate Unit level descriptions may be used. Where only partial information is available for the “cut”, and more detailed information known about the “fill”, a Class level description for the “cut” may be combined with a Unit level description for the “fill” (see Figure 5).

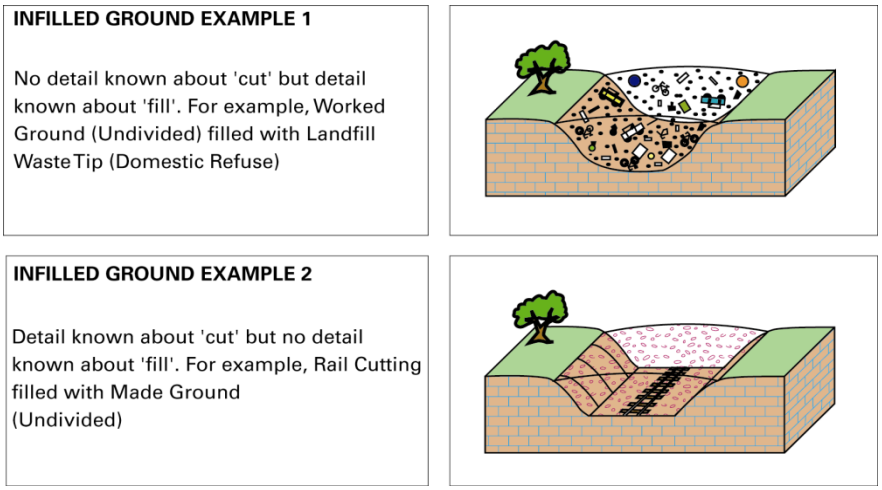

Figure 5. Selected examples of the many types of Made Ground and Worked Ground that can be combined to derive Infilled Ground

Following consultations with BGS Cartographic Services and the Digital Map Manager, it has been agreed that for 1:10,000 scale digital map capture it will be permissible to have individual layers for each Artificial Ground type. Consequently, all Worked Ground will be identified on one layer and all Made Ground on another. Any polygons of Infilled Ground will thus be derived from these two layers for use as a single layer on the 1:50,000 scale maps and DigMap50. This approach makes the modelling of Artificial Ground much easier. Furthermore, it is envisaged that, in the future, information on different generations of Worked Ground and Made Ground may be gathered and this approach allows multiple layers attributed with date information.

Two other classes of Artificial Ground are included in the new scheme. Disturbed Ground includes those areas where the ground surface is affected by near-surface workings or subsidence, for example, caused by shallow coal mine workings. Landscaped Ground is mapped where the ground has been extensively remodelled, for example, closely associated Made Ground and Worked Ground for site formation.

In the case of Landscaped Ground, the classification is not subdivided beyond the Type-level. For subdivision down to Unit-level it is suggested that the codes are assigned by reference to the National Land Use Database (NLUD) (Harrison, 2006). This is intended to avoid duplication of information that is available from other sources and to make the Artificial Ground at this level directly equivalent. In a similar way, it is suggested that the subdivision of archaeological Made, Worked and Landscaped Ground is related directly to the English Heritage classification (English Heritage 2002) to avoid duplication and ensure compatibility.

4 Application of the Enhanced Classification for Artificial Ground

The following example illustrates how the new scheme may be applied to the capture of Artificial Ground data during map compilation.

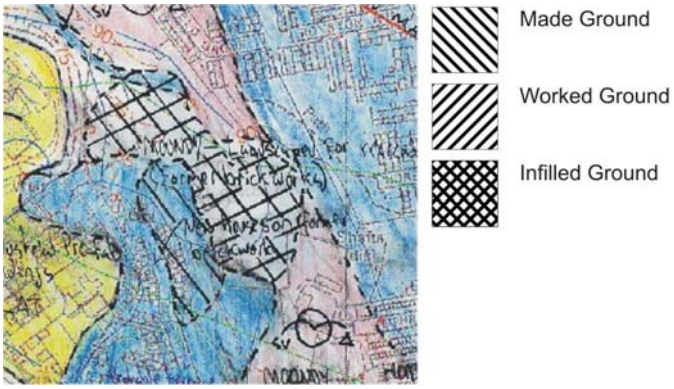

Figure 6 Example showing the traditional representation of Artificial Ground on a 1:10,000 scale fieldslip (not to scale). Digital compilation using the current classification can result in the loss of relevant information.

Figure 6 shows an extract of a 1:10,000 scale fieldslip. The area illustrated is typical of many urban situations in the UK where the distribution and character of Artificial Ground is often complex. The fieldslip and field notes provide detailed descriptions of the extent and nature of any fill or excavation. Using the current five-class scheme (McMillan and Powell, 1999), digital compilation of this data can result in the loss of valuable information. In the example, the geologist has identified a disused brick-pit, infilled by a colliery waste tip. Using the current scheme, the map would be seeded simply with “Made Ground” and “Infilled Ground”.

In contrast, the new scheme allows the geologist to attribute each component part of the Artificial Ground with a fully descriptive code. In this case, detailed information is available to support the interpretation. Consequently, the unit-level codes for “Opencast (Non-Metalliferous Mineral)” and “Mine Waste Tip (Colliery)” may be applied.

The hierarchical structure of the new scheme provides a flexible approach to classification. If sufficient information were unavailable to confidently describe a feature at unit-level, a more generalised classification at type-level (“Mineral Extraction Undivided” / “Waste Tip Undivided”) or class-level (“Worked Ground Undivided” / “Made Ground Undivided”) may be applied.

In this example, the mine waste tip is more extensive than the disused brick pit. By maintaining separate GIS layers for Worked and Made Ground, the full extent of each component part may be recorded and retrieved (see Figure 7).

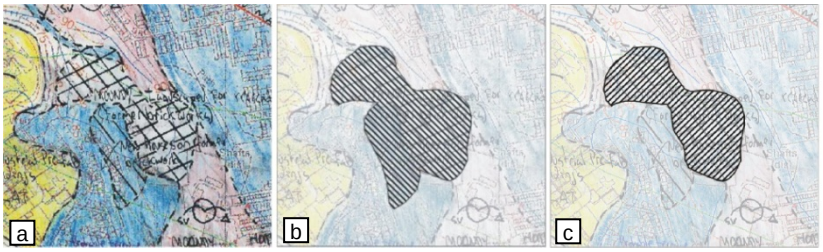

Figure 7. Example showing how the full extent of Made Ground data is maintained on a separate GIS layer to Worked Ground data (not to scale). This approach allows a complete attribution to be recorded for each Artificial Ground occurrence
a) Current extent recorded on fieldslip
b) Fully attributed digital extent of made ground
c) Fully attributed digital extent of worked ground

This approach facilitates the capture of data from diverse sources (e.g. historical maps, site-investigation reports, field observations), and allows an appropriate level of attribution to be applied.

Where multiple sources or generations of Artificial Ground data exist, the temporal and aerial extent from each source may be recorded and given the appropriate attribution. If the GIS is suitably enabled, overlapping extents are permissible, and in conjunction with date information, can represent the evolution of the Artificial Ground through time (see Figure 8).

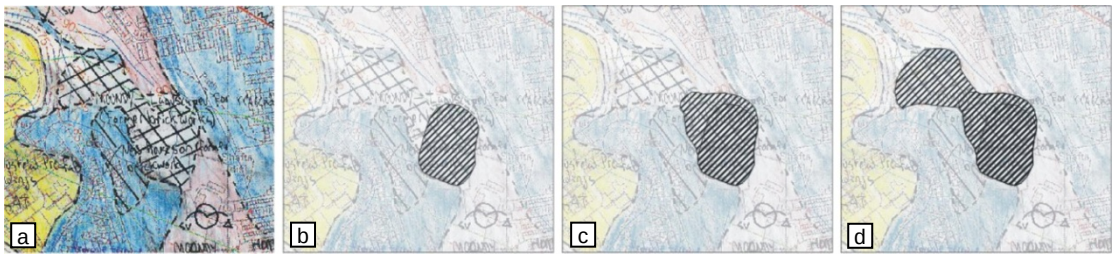

Figure 8. Example showing how Worked Ground data from diverse sources may be collated (not to scale). This illustrates how the new scheme provides a framework for modelling the evolution of Artificial Ground:
a) Current extent recorded on fieldslip
b) Extent derived from first generation of historical topographic map
c) extent derived from second generation of historical topographic map
d) Combined extent from field observation and historical topographic maps

It should be noted that the digital code for each classification has been constructed to allow the simple derivation of parent classes. For example, the unit-level code for Mine Waste Tip (Colliery) is MWCY. Replacing the characters “CY” (representing “Colliery”) with the character “U” (representing “Undivided”) results in the corresponding type-level code for Waste Tip Undivided. Further substitution of the character “WU” for “GR” returns to the class-level code of “MGR” (Made ground Undivided).

This logical sequencing of characters means that Artificial Ground data can be recorded and classified at various levels within the hierarchy. Subsequent normalisation of the data to a common level of detail is a readily automated task.

As per the current scheme, appropriate visualisation of Made Ground and Worked Ground identifies areas of Infilled Ground (Made and Worked Ground). However, by maintaining the Made Ground and Worked Ground as separate extents, a full attribution for the components is preserved. Consequently, any combination of “cut” or “fill” can be modelled, without loss of primary information.

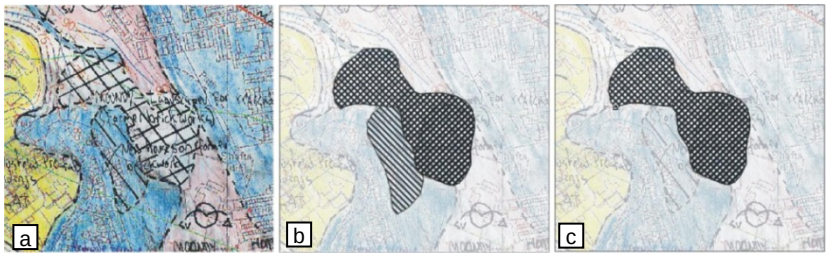

Figure 9. Example showing how appropriate visualisation and processing identifies areas of infilled ground without loss of primary attribution (not to scale):
a) Fieldslip showing traditional representation of Artificial Ground
b) Conventional visualisation of Artificial Ground data attributed from new scheme
c) Derived extent of Infilled Ground for incorporation into legacy datasets.

In Figure 9, the derived extent of “Infilled Ground” is attributed as a “Non-Metalliferous Mineral Opencast infilled by a Colliery Waste Tip”. If less detailed information is available for either of the component parts, then the resulting combination will reflect this. The most basic case will result when the primary attribution of the overlapping component parts is simply “Made Ground Undivided” and “Worked Ground Undivided” (i.e. “Infilled Ground” in the current scheme).

5 Conclusion

This enhanced classification for Artificial Ground has been developed in response to the increasing role of BGS in the urban environment, and the corporate need for an improved method of classifying man-made landforms in the context of ground conditions, geohazards (including potential contamination) and landscape evolution.

The new scheme is intended to replace the current classification that underpins a wide range of BGS products and services, ranging from strategic mapping to commissioned 3-D modelling.

This innovative scheme integrates seamlessly with existing corporate databases and applications, and it can be applied directly to modern mapping and modelling methodologies (including the GSD2 and LithoFrame10). The scheme allows integration with related externally developed classifications, including the National Land Use Database (NLUD).

The scheme is structured as a three-tier hierarchy, using *Class*, *Type* and *Unit*. An overview of the hierarchical structure is presented in Appendix 1 (Tables 1-5), and a detailed description of each of the codes used is shown in Appendix 1 (Table 6). This three-tier structure offers direct compatibility with existing corporate applications and legacy data at the *Class*-level, and an increasingly detailed description through levels 2 and 3. The structure of each of the codes ensures that "parent-child" relationships are clearly recognised, allowing *Unit*- or *Type*-level codes to be easily generalised to their respective *Class*-level parents.

A particular strength of this scheme is its ability to describe infilled ground in a comprehensive and flexible way. By bringing together any appropriate combination of Worked Ground and Made Ground descriptions from across the hierarchy a highly informative classification of Infilled Ground can be made.

The three-tier approach allows artificial ground to be classified at a level of detail that is commensurate with the remit of the work, project resources and data availability. This report suggests that *Class*-level may be appropriate for mapping at 1:50 000 scale, and that *Unit*-level may be applied at 1:10 000 scale where sufficient supporting material is available (and justification for a high level of detailed classification of Artificial Ground exists).

The open structure of this classification scheme provides an extensible framework that can be adapted and applied to a diversity of both modern and ancient industrial and urban environments.

This report is intended to form the basis of subsequent external publications aimed to promote the use of this enhanced scheme by external users. The scheme will be publicly available through the internet Lexicon of Named Rock units. This wider acceptance of this scheme by external users will encourage consistency between BGS and private sector geological investigations, facilitating a greater interoperability of data, including digital borehole information.

The present scheme does not attempt to provide a classification for the material comprising artificial ground (i.e. the descriptive component that would be represented by the BGS Rock Classification Scheme). A corresponding classification, based on the descriptive attributes of anthropogenic materials would add considerable value BGS's capability in the urban environment.

6 References

Most of the references listed below are held in the Library of the British Geological Survey at Keyworth, Nottingham. Copies of the references may be purchased from the Library subject to the current copyright legislation.

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Appendix 1 Tables detailing the Artificial Ground Classification

The following tables detail each of the proposed classes of Artificial Ground that comprise the new scheme.

Table 1
Made Ground

Class	Type	Unit
MGR Made Ground (Undivided)	MBU Engineered Embankment (Undivided)	MBRO Road Embankment
		MBRA Rail Embankment
		MBFL Flood Defence Embankment
		MBRV Reservoir Embankment
		MBSR Screening Embankment
		MBSE Sewer Outfall or Raised Pipe Embankment
		MBCA Canal Embankment
		MBDA Dam or Barrage
	MWU Waste Tip (Undivided)	MWCY Mine Waste Tip (Colliery)
		MWME Mine Waste Tip (Metalliferous Mineral)
		MWNO Mine Waste Tip (Non-Metalliferous Mineral)
		MWHR Quarry Waste Tip (Hard Rock)
		MWPI Pit Waste Tip (Superficial Deposit)
		MWID Industrial Waste Tip
		MWIT Inert Waste Tip
		MWLA Landfill Waste Tip (Domestic Refuse)
	MRU Raised Fill (Undivided)	MRIT Land Raising Inert Fill
		MRCY Land Raising Mine Fill (Colliery)
		MRME Land Raising Mine Fill (Metalliferous Mineral)
		MRNO Land Raising Mine Fill (Non-Metalliferous Mineral)
		MRHR Land Raising Quarry Fill (Hard-Rock)
		MRPI Land Raising Pit Fill (Superficial Deposit)
		MRID Land Raising Industrial Fill
		MRLA Land Raising Domestic Refuse Fill
		MROF Offshore Dumping Grounds
		MRWA Warp Land
	MLU Artificial Lagoon (Undivided)	No Units defined
	MQU Archaeological Raised Ground (Undivided)	Refer to English Heritage classification

Table 2
Worked Ground

Class	Type	Unit
WGR Worked Ground (Undivided)	WEU Engineered Excavation (Undivided)	WERO Road Cutting
		WERA Rail Cutting
		WECA Canal Cutting
		WEDR Dredged or Drainage Channel
		WECU Cut Away Landscape
		WEML Artificial Pond or Artificial Lake
		WEAG Agricultural Cutting
	WMU Mineral Excavation (Undivided)	WMCY Opencast (Colliery)
		WMME Opencast (Metalliferous Mineral)
		WMNO Opencast (Non-Metalliferous Mineral)
		WMHR Quarry (Hard Rock)
		WMPI Pit (Superficial Deposit)
		WMEN Mine Entrance Excavation
		WMBP Bell Pit
	WQU Archaeological Excavation (Undivided)	Refer to English Heritage classification

Table 3
Disturbed Ground

Class	Type	Unit
DDGR Disturbed Ground (Undivided)	DMU Mineral Extraction (Undivided)	DMAD Mine Adit
		DMSH Shallow Mine Working
		DMDI Dissolution Mining
	DSR Subsurface Structure (Undivided, Unrelated To Mining)	No Units defined
	DWA War Damage (Undivided)	DWBC Bomb Crater
		DWCB Collapsed Building

Table 4
Landscaped Ground

Class	Type	Unit
LSGR Landscaped Ground (Undivided)	LFU Landscaping For Site Formation (Generally Engineered)	Refer to NLUD classification
	LRU Landscaping For Recreational Purposes (Generally Not Engineered)	Refer to NLUD classification
	LQU Landscaping Associated With Archaeological Sites	Refer to English Heritage classification
	LVU Landscaping Associated With Raised, Covered Structures	Refer to NLUD classification

Table 5

Code Descriptions

Code	Description
DDGR	Disturbed Ground (Undivided) (Parentage: top level of Artificial Ground, no parent – existing Lexicon entry) Existing Lexicon entry: “Variable composition; Man-made drift deposit. Areas of ill-defined surface workings and excavations; complex association between areas of subsidence and Made Ground. [Generic description].” An area of ill-defined surface disruption associated with surface or near surface development or collapse. The disturbance is typically complex, dominated by zones of subsidence, and including areas of Worked Ground and Made Ground. The origin of the disturbed ground is unspecified. Composition: Variable
DMAD	Mine Adit (Parentage: Disturbed Ground (Undivided), Mineral Extraction (Undivided)) An area of Disturbed Ground associated directly with the collapse of an access (i.e. adit) to a subsurface mining operation. The disturbance is typically complex, dominated by zones of subsidence, and including areas of Worked Ground and Made Ground. Composition: variable
DMDI	Dissolution Mining (Parentage: Disturbed Ground (Undivided), Mineral Extraction (Undivided)) An area of Disturbed Ground associated with collapse due to the mining of soluble strata by the extraction of natural or artificially introduced mineral-rich groundwater. The disturbance is typically complex, dominated by zones of subsidence, and including areas of Worked Ground and Made Ground. Composition: variable
DMSH	Shallow Mine Working (Parentage: Disturbed Ground (Undivided), Mineral Extraction (Undivided)) An area of Disturbed Ground associated with collapsed shallow sub-surface mineral extraction, including horizontal tunnelling and workings. The disturbance is typically complex, dominated by zones of subsidence, and including areas of Worked Ground and Made Ground. Composition: variable
DMU	Mineral Extraction (Undivided) (Parentage: Disturbed Ground (Undivided)) An area of Disturbed Ground associated with surface or near surface mining operations. The disturbance is typically complex, dominated by zones of subsidence, and including areas of Worked Ground and Made Ground. Composition: variable
DSR	Subsurface Structure (Undivided, Unrelated To Mining) (Parentage: Disturbed Ground (Undivided)) An area of Disturbed Ground associated with collapsed structures or workings that do not relate directly to Mineral Extraction, or War Damage. The disturbance is typically complex, dominated by zones of subsidence, and including areas of Worked Ground and Made Ground. Composition: variable

Code	Description
DWA	War Damage (Undivided) (Parentage: Disturbed Ground (Undivided)) An area of Disturbed Ground associated with wartime damage to surface or subsurface structures as a result of explosive or incendiary munitions. The disturbance is typically complex, dominated by zones of crater damage and backfill with subsidence, and including areas of Worked Ground and Made Ground. Composition: variable
DWBC	Bomb Crater (Parentage: Disturbed Ground (Undivided) War Damage (Undivided)) An area of War Damage associated with the pit and debris resulting from the explosion of a mine of bomb. The disturbance is typically complex, dominated by zones of Worked Ground, and including areas of and Made Ground. Composition: variable
DWCB	Collapsed Building (Parentage: Disturbed Ground (Undivided) War Damage (Undivided)) An area of War Damage associated with the in-situ remains of a surface or subsurface structure or building destroyed by explosive or incendiary munitions. The disturbance is typically complex, including areas of Worked Ground, Made Ground and subsidence. Composition: variable
LFU	Landscaping For Site Formation (Generally Engineered) (Parentage: Landscaped Ground (Undivided)) An area of Landscaped Ground where the land surface (natural or artificial) has been extensively remodelled in the creation of a site where a structure or group of structures is located. The NLUD classification is recommended for further subdivision of this type of Landscaped Ground. Composition: variable
LQU	Landscaping Associated With Archaeological Sites (Parentage: Landscaped Ground (Undivided)) An area of Landscaped Ground where the land surface (natural or artificial) has been extensively remodelled in the creation of a recognised ancient or pre-historic structure. The exact nature of the structure is unspecified The English Heritage classification (National Monuments Record Monument Type Thesaurus) is recommended for further subdivision of this type of Archaeological feature. Composition: variable
LRU	Landscaping For Recreational Purposes (Generally Not Engineered) (Parentage: Landscaped Ground (Undivided)) An area of Landscaped Ground where the land surface (natural or artificial) has been extensively remodelled in the creation of a site that is used for sports or other recreational purposes. The NLUD classification is recommended for further subdivision of this type of Landscaped Ground. Composition: variable

Code	Description
LSGR	Landscaped Ground (Undivided) (Parentage: top level of Artificial Ground, no parent – existing Lexicon entry) Existing Lexicon entry: “Variable composition. Man-made drift deposit. Areas where the original surface has been extensively remodelled, but where it is impractible or impossible to delineate separate areas of 'Worked Ground' or 'Made Ground'. [Generic description: Bristol ALGI].” An area where the land surface (natural or artificial) has been extensively remodeled, but where it is impracticable or impossible to delineate separate zones of Made Ground, Worked Ground, or Disturbed Ground. Composition: variable
LVU	Landscaping Associated With Raised, Covered Structures (Parentage: Landscaped Ground (Undivided)) An area of Landscaped Ground where the land surface (natural or artificial) has been extensively remodelled in the creation of a site that includes covered sub-surface structures. The NLUD classification is recommended for further subdivision of this type of Landscaped Ground. Composition: variable
MBCA	Canal Embankment (Parentage: Made Ground (Undivided), Engineered Embankment (Undivided)) An Engineered Embankment used to support an artificial waterway or artificially canalised river. Composition: variable
MBDA	Dam or Barrage (Parentage: Made Ground (Undivided), Engineered Embankment (Undivided)) An Engineered Embankment used as a barrier against the passage of a liquid or loose material, or to provide control over the level or flow. Composition: variable
MBFL	Flood Defence Embankment (Parentage: Made Ground (Undivided), Engineered Embankment (Undivided)) An Engineered Embankment used to hold back extreme water flows and provide a barrier against inundation. Composition: variable
MBRA	Rail Embankment (Parentage: Made Ground (Undivided), Engineered Embankment (Undivided)) An Engineered Embankment used to support a railway track and / or associated development (e.g. drainage, signalling etc). Composition: variable
MBRO	Road Embankment (Parentage: Made Ground (Undivided), Engineered Embankment (Undivided)) An Engineered Embankment supporting a roadway and / or associated development (e.g. drainage, signage etc). Composition: variable

Code	Description
MBRV	Reservoir Embankment (Parentage: Made Ground (Undivided), Engineered Embankment (Undivided)) An Engineered Embankment used to contain regular bodies of still water Composition: variable
MBSE	Sewer Outfall or Raised Pipe Embankment (Parentage: Made Ground (Undivided), Engineered Embankment (Undivided)) An Engineered Embankment used to provide support and / or protection for a channel or conduit designed for the passage of water or other liquid. Composition: variable
MBSR	Screening Embankment (Parentage: Made Ground (Undivided), Engineered Embankment (Undivided)) An Engineered Embankment used to obscure visual / noise / dust or other forms of pollution. Composition: variable
MBU	Engineered Embankment (Undivided) (Parentage: Made Ground (Undivided)) An area of Made Ground forming a mound or bank. The exact purpose of the mound or bank is unspecified, but may be to provide protection (e.g. Screening Embankment) or support for a linear construction (e.g. Rail Embankment). Composition: variable
MGR	Made ground (Parentage: top level of Artificial Ground, no parent – existing Lexicon entry) Existing Lexicon entry: “Variable composition. Man-made drift deposit (generic). Areas where the ground is known to have been deposited by Man, eg. embankments, flood defences, spoil heaps. Many types: BGS recognises many different categories. [Generic description: Bristol ALGI].” An area where the pre-existing (natural or artificial) land surface is raised by artificial deposits. The purpose of the made ground is unspecified. Composition: As above
MLU	Artificial Lagoon (Undivided) (Parentage: Made Ground (Undivided)) An area of Made Ground where the pre-existing (natural or artificial) land surface is raised by deposition from a shallow man-made body of liquid waste material. The exact nature of the lagoon is unspecified. Examples include mine tailing lagoons and settling ponds. Composition: variable
MQU	Archaeological Raised Ground (Undivided) (Parentage: Made Ground (Undivided)) An area of Made Ground where the pre-existing (natural or artificial) land surface is raised by artificially deposited material as part of a building or structure of an early epoch (including prehistorical remains). The exact nature of the structure is unspecified The English Heritage classification (National Monuments Record Monument Type Thesaurus) is recommended for further subdivision of this type of Archaeological feature. Composition: variable

Code	Description
MRCY	Land Raising Mine Fill (Colliery) (Parentage: Made Ground (Undivided), Raised Fill (Undivided)) An area of Raised Fill where the pre-existing (natural or artificial) land surface is raised by artificially deposited material from a subsurface or opencast coal mine for the purpose of subsequent construction or reclamation. Composition: variable
MRHR	Land Raising Quarry Fill (Hard-Rock) (Parentage: Made Ground (Undivided), Raised Fill (Undivided)) An area of Raised Fill where the pre-existing (natural or artificial) land surface is raised by artificially deposited material from a subsurface or opencast hard rock mine or quarry (e.g. limestone quarry material) for the purpose of subsequent construction or reclamation. Composition: variable
MRID	Land Raising Industrial Fill (Parentage: Made Ground (Undivided), Raised Fill (Undivided)) An area of Raised Fill where the pre-existing (natural or artificial) land surface is raised by artificially deposited material from an industrial operation (other than mining or quarrying operations) for the purpose of subsequent construction or reclamation. Composition: variable
MRIT	Land Raising Inert Fill (Parentage: Made Ground (Undivided), Raised Fill (Undivided)) An area of Raised Fill where the pre-existing (natural or artificial) land surface is raised by artificially deposited non-industrial stable material for the purpose of subsequent construction or reclamation. Composition: variable
MRLA	Land Raising Domestic Refuse Fill (Parentage: Made Ground (Undivided), Raised Fill (Undivided)) An area of Raised Fill where the pre-existing (natural or artificial) land surface is raised by artificially deposited solid household refuse for the purpose of subsequent construction or reclamation. Composition: variable
MRME	Land Raising Mine Fill (Metalliferous Mineral) (Parentage: Made Ground (Undivided), Raised Fill (Undivided)) Area of Raised Fill where the pre-existing (natural or artificial) land surface is raised by artificially deposited material from a subsurface or opencast metalliferous mine (e.g. copper mine material) for the purpose of subsequent construction or reclamation. Composition: variable
MRNO	Land Raising Mine Fill (Non-Metalliferous Mineral) (Parentage: Made Ground (Undivided), Raised Fill (Undivided)) An area of Raised Fill where the pre-existing (natural or artificial) land surface is raised by artificially deposited material from a subsurface or opencast non-metalliferous mine (e.g. salt mine material) for the purpose of subsequent construction or reclamation. Composition: variable

Code	Description
MROF	Offshore Dumping Grounds (Parentage: Made Ground (Undivided), Raised Fill (Undivided)) An area of Raised Fill where the previously naturally submerged land surface is raised by artificially deposited rubbish or refuse for the purpose of subsequent construction or reclamation. Composition: variable
MRPI	Land Raising Pit Fill (Superficial Deposit) (Parentage: Made Ground (Undivided), Raised Fill (Undivided)) An area of Raised Fill where the pre-existing (natural or artificial) land surface is raised by artificially deposited material from an excavation of superficial deposits or unconsolidated material (e.g. sand and gravel pit material) for the purpose of subsequent construction or reclamation. Composition: variable
MRU	Raised Fill (Undivided) (Parentage: Made Ground (Undivided)) An area of Made Ground where the pre-existing (natural or artificial) land surface is artificially increased or restored for the purpose of subsequent construction or reclamation. Composition: variable
MRWA	Warp Land (Parentage: Made Ground (Undivided), Raised Fill (Undivided)) Area of Raised Fill where the pre-existing land surface is raised by artificially induced sedimentation from a natural body of water (typically to the shoreward side of flood defence embankments) for the purpose of reclamation and agriculture. Composition: variable
MWCY	Mine Waste Tip (Colliery) (Parentage: Made Ground (Undivided)), Waste Tip (Undivided)) A Waste Tip created by dumped spoil from a subsurface or opencast coal mine. Composition: variable
MWHR	Quarry Waste Tip (Hard Rock) (Parentage: Made Ground (Undivided)), Waste Tip (Undivided)) A Waste Tip created by dumped spoil from a subsurface or opencast hard rock mine or quarry (e.g. limestone quarry). Composition: variable
MWID	Industrial Waste Tip (Parentage: Made Ground (Undivided)), Waste Tip (Undivided)) A Waste Tip created by dumped industrial waste (other than material from mining or quarrying operations). Composition: variable
MWIT	Inert Waste Tip (Parentage: Made Ground (Undivided)), Waste Tip (Undivided)) A Waste Tip created by dumped non-industrial stable material generated by the demolition of buildings, dredging of channel ways or through the excavation of tunnels and cuttings other than adits or other mine workings (e.g. road or rail tunnel). Composition: variable

Code	Description
MWLA	Landfill Waste Tip (Domestic Refuse) (Parentage: Made Ground (Undivided)), Waste Tip (Undivided)) A Waste Tip created by dumped solid household refuse. Composition: variable
MWME	Mine Waste Tip (Metalliferous Mineral) (Parentage: Made Ground (Undivided)), Waste Tip (Undivided)) A Waste Tip created by dumped spoil from a subsurface or opencast metalliferous mine (e.g. copper mine). Composition: variable
MWNO	Mine Waste Tip (Non-Metalliferous Mineral) (Parentage: Made Ground (Undivided)), Waste Tip (Undivided)) A Waste Tip created by dumped spoil from a subsurface or opencast non-metalliferous mine (e.g. gypsum mine). Composition: variable
MWPI	Pit Waste Tip (Superficial Deposit) (Parentage: Made Ground (Undivided)), Waste Tip (Undivided)) A Waste Tip created by dumped spoil from an excavation of superficial deposits or unconsolidated material (e.g. sand and gravel pit). Composition: variable
MWU	Waste Tip (Undivided) (Parentage: Made Ground (Undivided)) An area of Made Ground forming a temporary or permanent accumulation of refuse. The exact nature of the accumulation is unspecified, but may include mine-related spoil, industrial, or domestic waste. Composition: variable
WEAG	Agricultural Cutting (Parentage: Worked Ground (Undivided), Engineered Excavation (Undivided)) An area of Engineered Excavation where the land surface (natural or artificial) has been lowered due to removal of material by excavations associated directly with the construction of agricultural works (other than drainage). Composition: N/A (void)
WECA	Canal Cutting (Parentage: Worked Ground (Undivided), Engineered Excavation (Undivided)) An area of Engineered Excavation where the land surface (natural or artificial) has been lowered due to removal of material by excavations associated directly with the construction of a canal or artificially improved navigable waterway. Composition: N/A (void)
WECU	Cut Away Landscape (Parentage: Worked Ground (Undivided), Engineered Excavation (Undivided)) An area of Engineered Excavation where the land surface (natural or artificial) has been lowered due to removal of material by excavations associated directly with landscaping, or to accommodate engineered constructions other than roadways, railways etc. Composition: N/A (void)

Code	Description
WEDR	Dredged or Drainage Channel (Parentage: Worked Ground (Undivided), Engineered Excavation (Undivided)) An area of Engineered Excavation where the land surface (natural or artificial) has been lowered due to removal of material by excavations associated directly with the construction of a drainage channel. Composition: N/A (void)
WEML	Artificial Pond or Artificial Lake (Parentage: Worked Ground (Undivided), Engineered Excavation (Undivided)) An area of Engineered Excavation where the land surface (natural or artificial) has been lowered due to removal of material by excavations associated directly with the construction of a pond or lake. Composition: N/A (void)
WERA	Rail Cutting (Parentage: Worked Ground (Undivided), Engineered Excavation (Undivided)) An area of Engineered Excavation where the land surface (natural or artificial) has been lowered due to removal of material by excavations associated directly with the construction of a railway and / or associated development (e.g. drainage, signaling etc). Composition: N/A (void)
WERO	Road Cutting (Parentage: Worked Ground (Undivided), Engineered Excavation (Undivided)) An area of Engineered Excavation where the land surface (natural or artificial) has been lowered due to removal of material by excavations associated directly with the construction of a roadway and / or associated development (e.g. drainage, signage etc). Composition: N/A (void)
WEU	Engineered Excavation (Undivided) (Parentage: Worked Ground (Undivided)) An area of Worked Ground where the land surface (natural or artificial) has been lowered due to removal of material by engineering works (other than mining or quarrying operations). Composition: N/A (void)
WGR	Worked Ground (Undivided) (Parentage: top level of Artificial Ground, no parent – existing Lexicon entry) Existing Lexicon entry: “Areas where the ground is known to have been cut away by Man, eg. quarries, pits, cut-away landscaping, dredged channels. BGS recognises many different categories. [Generic description: Bristol ALGI].” An area where the land surface (natural or artificial) has been lowered as a result of man-made excavations. The purpose of the excavation is unspecified. Composition: N/A (Excavation forms a void)

Code	Description
WMBP	Bell Pit (Parentage: Worked Ground (Undivided), Mineral Excavation (Undivided)) An area of Worked Ground where the land surface (natural or artificial) has been lowered due to an obsolete method of shallow mining whereby a vertical shaft is sunk to the target horizon and the workings extended in all directions until the opening is no longer safe to work. To be applied in cases where individual Bell Pits are mappable, else use Disturbed Ground due to Shallow Mine Workings. Composition: N/A (void)
WMCY	Opencast (Colliery) (Parentage: Worked Ground (Undivided), Mineral Excavation (Undivided)) An area of Worked Ground where the land surface (natural or artificial) has been lowered due to removal of material by an opencast or strip mining operation for the extraction of coal deposits. Composition: N/A (void)
WMEN	Mine Entrance Excavation (Parentage: Worked Ground (Undivided), Mineral Excavation (Undivided)) An area of Worked Ground where the land surface (natural or artificial) has been lowered due to removal of material by excavation associated directly with the construction of an access (i.e. adit) to a subsurface mining operation. Composition: N/A (void)
WMHR	Quarry, hard rock (Parentage: Worked Ground (Undivided), Mineral Excavation (Undivided)) An area of Worked Ground where the land surface (natural or artificial) has been lowered due to removal of material by a quarry operation for the extraction of hard rock deposits (e.g. limestone quarry). Composition: N/A (void)
WMME	Opencast (Metalliferous Mineral) (Parentage: Worked Ground (Undivided), Mineral Excavation (Undivided)) An area of Worked Ground where the land surface (natural or artificial) has been lowered due to removal of material by an opencast or strip mining operation for the extraction of metalliferous deposits (e.g. copper mine). Composition: N/A (void)
WMNO	Opencast (Non-Metalliferous Mineral) (Parentage: Worked Ground (Undivided), Mineral Excavation (Undivided)) An area of Worked Ground where the land surface (natural or artificial) has been lowered due to removal of material by an opencast or strip mining operation for the extraction of non-metalliferous deposits (e.g. gypsum mine). Composition: N/A (void)
WMPI	Pit (Superficial Deposit) (Parentage: Worked Ground (Undivided), Mineral Excavation (Undivided)) An area of Worked Ground where the land surface (natural or artificial) has been lowered due to removal of material by an opencast or strip mining operation for the extraction of unconsolidated (superficial) deposits. Composition: N/A (void)

Code	Description
WMU	Mineral Excavation (Undivided) (Parentage: Worked Ground (Undivided)) An area of Worked Ground where the land surface (natural or artificial) has been lowered due to removal of material by an opencast mining or quarrying operation. The exact nature of the mining or quarrying operation is unspecified. Composition: N/A (void)
WQU	Archaeological Excavation (Undivided) (Parentage: Worked Ground (Undivided)) An area of Worked Ground where the land surface (natural or artificial) has been lowered due to removal of material by earthworks or an early epoch (including prehistoric). The exact nature of the earthworks is unspecified. The English Heritage classification (National Monuments Record Monument Type Thesaurus) is recommended for further subdivision of this type of Archaeological feature. Composition: N/A (void)