



Trial pit reference STP03



Collapsing excavations within trial pit reference STP04



General trial pit excavations



General trial pit excavations



General trial pit excavations



General trial pit excavations

Sheffield City Council – Environmental Protection Service

Date: 16/02/09

Verification of Gas Protection Measures.

The detailed design of gas protection measures and verification methodology shall be based upon appropriate gas monitoring and risk assessment and shall form part of the Remediation Method Statement to be agreed in writing by the local authority prior to any construction works.

The following policy sets out the *minimum* verification requirements that will be considered acceptable by the local authority, before consideration can be given to recommending discharge of relevant planning conditions.

1. The applicant shall appoint a suitably qualified and experienced independent individual to oversee and verify the installation of *all* gas protection measures.
2. Said individual shall ensure that component specification and installation complies with both the manufacturer's guidelines/instructions and the agreed Remediation Method Statement.
3. All components of the agreed gas protection system shall be subject to verification. Documentary evidence, for example in form of a checklist, will be required and shall itemise the specification and inspection of all individual gas protection components and their correct installation for each plot.
4. Photographic evidence clearly illustrating all the points covered by the checklist and correct installation of all gas protection components will be required for each plot. Failure to provide satisfactory evidence will automatically require verification of measures via intrusive investigation.
5. All data to form part of a Verification Report which must include, inter alia, prints of all digital photographs titled with plot number and feature depicted. A CD with files of all digital photographs must be provided with the Verification Report, which must be submitted for the written approval of the local authority.

Sheffield City Council – Environmental Protection Service.

Date: 22/05/13

Acceptable Methods of Validating Capping Thickness.

Option 1

1. Record topographic site levels of the formation layer at a minimum of three locations in every residential garden area (both front and rear) and soft landscaped area prior to capping application. Large soft landscaped areas may require a greater number of levelling locations at the discretion of the Local Authority.
2. Digital photographs for every residential garden area (both front and rear) and soft landscaped area must adequately illustrate formation layer in relation to reference points such as brick/block courses and driveway edges.
3. Record topographic site levels at a minimum of three locations in every residential garden area (both front and rear) and soft landscaped area post capping application. Large soft landscaped areas may require a greater number of levelling locations at the discretion of the Local Authority.
4. Digital photographs for every residential garden area (both front and rear) and soft landscaped area must adequately illustrate capping application in relation to reference points such as brick/block courses and driveway edges.
5. All data to form part of a Validation Report which must include, inter alia, prints of all digital photographs titled with plot number, front or rear garden, or location of soft landscaped area. A CD with files of all digital photographs must be provided with the Validation Report.

Option 2

1. Environmental Engineer to inspect formation layer to verify that site levels permit application of agreed capping thickness. Environmental Engineer to digitally photograph formation layer. Digital photographs for every residential garden area (both front and rear) and soft landscaped area must adequately illustrate formation layer in relation to reference points such as brick/block courses and driveway edges.
2. Environmental Engineer to verify thickness of capping layer via minimum of three augered or hand dug exploratory holes (hand dug or machine excavated only where capillary break layer incorporated) within each residential rear garden area and soft landscaped area. In residential front gardens, for each discrete soft landscaped area (may be one house or two adjacent houses), the minimum number of verification locations to be determined on an area basis; up to 20 m² = 1 hole, 20 to 50m² = 2 holes, over 50m² = 3 holes. Large soft landscaped areas may require a greater number of exploratory verification holes at the discretion of the Local Authority.
3. Environmental Engineer to digitally photograph every residential garden area (both front and rear) and soft landscaped area post capping.
4. All data to form part of a Validation Report which must include, inter alia, prints of all digital photographs titled with plot number, front or rear garden, or location of soft landscaped area. A CD with files of all digital photographs must be provided with the Validation Report.



APPENDIX C

SIRIUS SPECIFICATION FOR ENGINEERED FILLS

OUGHTIBRIDGE MILL**SIRIUS SPECIFICATION FOR ENGINEERED FILLS****Prepared for****COMMERCIAL ESTATES GROUP****CONTENTS**

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APPENDICES**APPENDIX A MCHW TABLES 6/1, 6/2 & 6/4****APPENDIX B TABLE 1 TESTING TO BE CARRIED OUT BY THE
CONTRACTOR**

1.0 Site Description/ General Information

- 1.1 The site is located off Main Road and Langsett Road North, Oughtibridge, approximately 10km northwest of Sheffield City Centre.
- 1.2 The site is irregular in shape, with approximate dimensions of 900m in length and 200m in width, and comprises a number of existing and recently demolished structures, associated with the former Oughtibridge Paper Mill. The southern boundary of the site runs approximately north west-south east parallel to the road. The River Don runs centrally through the site, bisecting it into two portions. The river flows towards the south east. A Mill Race and reservoirs and ponds were historically present within the north west of the site. A bridge suitable for vehicle access is present across the river.
- 1.3 It is proposed to develop the site for residential end use, comprising the construction of low rise residential properties with gardens, residential apartment blocks, estate roads and associated infrastructure together with public open space/ soft landscaping areas.

Landfill Area:

- 1.4 Ground conditions within the landfill area comprised made ground, to depths typically between 2.70m and 5.60m bgl. The cohesive fill was recorded to comprise soft to firm, locally extremely soft, sandy clay with gravels of brick, concrete and locally coal, ash and clinker. Reworked alluvial soils within the landfill comprised sandy clay with gravel of brick, sandstone, mudstone, peat and/or organic debris and locally re-bar, wood and ash, plus localised decayed paper. Granular fill was recorded to generally comprise loose to medium dense, locally very loose, sandy gravel / gravelly sand, sand & gravel and gravel & cobbles of brick, concrete, and locally wood.

Within approximately half the exploratory holes excavated / drilled within the former landfill area the granular fill was also noted to comprise large proportions of ash and clinker. This material was recorded at depths between ground level and 5.60m.

- 1.5 Cohesive alluvial soils were recorded underlying made ground soils across the majority of the former landfill area, generally comprising soft to firm (locally very soft or stiff) sandy clay / silt with gravel sized fragments of sandstone. Locally organic debris and peat were noted. Granular alluvial soils were recorded to comprise sandy gravel of sandstone and locally mudstone.
- 1.6 Residual soils underlain by competent bedrock were recorded at variable depths of between 3.6m and 10.8m within the landfill area.

Mill Area:

- 1.7 Ground conditions within the mill area comprised made ground, to depths typically between 0.35m and 3.60m bgl. Locally, within the north western portion of the former mill area, made ground extended to >6.00m and the full depth was not proven.

Granular made ground appeared to predominate across the area, typically comprising very loose to medium dense sandy gravel, clayey gravelly sand and sand and gravel. The gravel fraction typically comprising concrete and brick. Within approximately a quarter of the exploratory holes excavated / drilled within the former mill area the granular fill was also noted to comprise large proportions of ash and clinker. This material was recorded at depths between 0.05m and >6.00m. Frequent concrete and sandstone obstructions were encountered within the made ground soils.

Cohesive fill was recorded to typically comprise soft to firm, sandy clay with gravel of brick, concrete, sandstone and locally ash, slate, wood, charcoal, clinker and mudstone.

Reworked alluvial soils were encountered at depths between 0.20m and 2.70m bgl, comprising very soft very gravelly sandy clay with occasional organic inclusions.

- 1.8 Cohesive alluvial soils generally comprised soft to firm (locally very soft or stiff) sandy clay / silt with gravel sized fragments of sandstone.

Locally the alluvial soils to the southeastern portion were noted to contain organic inclusions at depths between 0.55m and >4.00m bgl. Locally within STP17 a c. 100mm thick of fibrous peat was recorded at a depth of 1.10m bgl. Granular alluvial soils were recorded to comprise gravelly sand or silty gravel of sandstone.

- 1.9 Residual soils underlain by competent bedrock were recorded at variable depths of between 0.4m and 7.4m within the mill area.

North Western Area:

- 2.0 Ground conditions within the north western area comprised made ground soils comprised cohesive fill, consisting of soft to firm, locally stiff sandy clay/silty clay with gravel sized fragments of plastic, brick, concrete, wood, timber, ash, clinker and wires. Locally, in the former reservoirs, a c. 0.10m thick band of soft slightly organic sandy silt, with reeds was recorded at depths between 2.50m and 2.80m bgl.

A soft gravelly sandy silt/clay with organic and wood inclusions was encountered at depths of between 2.00m and 3.30m bgl within the area of the former reservoirs.

Granular fill was also encountered at depths between ground level and 5.30m bgl. This material typically comprised clayey sands and gravel, gravelly silty sand, gravelly sand and sandy gravel. The granular fill encountered within the slope was generally described as very loose to loose locally clayey sandy gravel of brick, concrete and sandstone to depths between 0.80m and 5.90m.

- 2.1 Cohesive alluvial soils generally comprised very soft to firm sandy clay with gravel sized fragments of sandstone and mudstone. Granular alluvial soils comprised medium dense to dense slightly clayey sandy / silty gravel of sub-angular to sub-rounded sandstone
- 2.2 Residual soils underlain by competent bedrock were recorded at variable depths of between 4.8m and 7.7m within the mill area.

South West Area:

- 2.3 Ground conditions within the lower level of the south western site area comprised granular fill generally described as silty sandy gravel. The gravel fraction comprised fragments of brick, concrete, sandstone and locally ash. The cohesive fill comprised soft to firm sandy clay with gravel and locally cobbles and boulders of sandstone, brick, concrete and locally coal and mudstone. Demolition fill comprised sandy gravel and cobbles of brick, concrete, metal and wood to a maximum proven depth of 4.10m within the upper level.

Locally reworked alluvial soils were recorded to a maximum proven depth of 2.80m bgl, comprising a soft very sandy locally gravelly clay.

- 2.4 Cohesive alluvial soils generally comprised very soft slightly sandy slightly gravelly clay / silt.

2.0 Preamble to Specification

- 2.1 This specification is intended to be used in connection with the construction of low-rise residential buildings and highways on engineered fill. The specification is believed to be suitable for most purposes but there may be special conditions existing at some sites which are not treated in this document and which should be taken into account in arriving at a properly engineered fill. It is emphasised that clay fills can be at least as susceptible to settlement or heave due to climatic, vegetation or other effects, as naturally occurring cohesive soils.
- 2.2 This specification is for contracts which are designed and supervised by Sirius.
- 2.3 With respect to materials sourced from within the site, a site investigation has been commissioned to provisionally classify cut materials prior to the works. The Resident Engineer shall request supplementary testing to enable satisfactory classification of materials in accordance with Table 6/1 and 6/2 appended to this specification. Notwithstanding the above, compaction of materials shall not take place until classification of materials has taken place.
- 2.4 In the event materials are to be imported to site, the Contractor is required to refer to Table 1, also appended to this specification. Compaction of materials imported to site shall not commence until classification of materials in accordance with Table 6/1 has taken place to the Resident Engineers satisfaction.
- 2.5 Note should be taken of the requirements of the current Construction (Design and Management) Regulations to the extent that they may be relevant to the works.
- 2.6 This specification has been prepared by Sirius and is based on the Highways Agency "Specification for Highway Works", Volume 1 of the Manual of Contract Documents for Highway Works (MCHW), November 2004 (as amended), as described in the following sections.

3.0 Engineered Fill

3.1 Engineered fill is defined as fill which is selected, placed and compacted to an appropriate specification so that it will exhibit the required engineering behaviour.

3.2 Grading limits for the most common types of fill are presented in Table 6/1 which is appended to this specification.

3.3 Fill shall be classified as follows:-

- Unsuitable fill.
- General fill.
- Restricted fill.
- Special fill.

Note: all material classifications are as defined within MCHW Volume 1, Table 6/1 and 6/2.

3.4 *Unsuitable Fill*

3.4.1 Unsuitable fill shall comprise any material so designated by the Engineer and shall include:-

- Cohesive soils having a liquid limit in excess of 90% or plasticity index in excess of 65%.
- Chalk having a fine fraction (<400µm) in excess of 10% at the borrow pit.
- Any material containing topsoil, wood, peat or lignite.
- Any material with a biodegradable content.
- Any materials containing scrap metal.
- Frozen or waterlogged substances.
- Material defined as unsuitable by the Resident Engineer because of its type or level of contamination.
- Material which, by virtue of its particle size or shape, cannot be properly and effectively compacted (e.g. oversize material, gravels which are tabular and some slate wastes).
- Expansive steel slag.

Unsuitable fill shall not be used at any structurally load bearing location and domestic gardens. However, it may be used under landscaped areas and public open space with the agreement of the Resident Engineer. The final location of the unsuitable fill shall be shown on the "as-built" survey drawings.

3.5 *General Bulk Fill*

3.5.1 General fill shall comprise all fill except unsuitable fill, restricted fill and special fill. The majority of fill on site will probably be classified as general fill.

3.6 *Restricted Fill*

3.6.1 Restricted fill shall comprise material which would otherwise be classified as general fill but which contains materials hostile to the built environment and shall include:-

- Pyritic shales
- Gypsiferous clays
- Burnt colliery discard
- Pulverised fuel ash
- Spent oil shale
- Incinerator waste
- Demolition and construction industry waste, at the discretion of the Engineer.

3.6.2 Such fill shall be precluded from use in designated zones, or maybe exported from site in lieu of backfilling with more suitable materials. Such zones will be agreed with the Geotechnical Engineer prior to remediation works, including locations where groundwater may rise to the level of the underside of the deepest foundation and where its use will be condemned by the appropriate authorities on pollution or engineering grounds. Such fill shall not be placed to a depth less than one metre from the underside of the deepest foundation.

3.7 *Special Fill (classes 6A, B, C, I and J and 6F 1, 2 and 3)*

3.7.1 Special fill is high quality material and shall comprise material which would otherwise be classed as general fill, but which contains durable well graded natural sand and natural gravel or crushed rock, other than argillaceous rock, or durable clean crushed demolition rubble of similar particle size and free from any contaminants. Its use should normally be restricted to specifically derived purposes such as capping layers beneath structure/foundations, beneath roads or as backfill to retaining walls.

4.0 Selection of Compaction Specification

- 4.1 Dependant on material class and the ability to perform laboratory classification tests, such as dry density moisture content relationship testing, the fill shall be compacted to either an end product specification or a method specification.

5.0 **End Product Compaction**

- 5.1 End product compaction should be used for all material classified as cohesive general fill and for specific Special Fills.

For end product compaction a graph should be produced which shows dry density plotted against moisture content for each compaction test, the corresponding optimum moisture content and maximum dry density and 0%, 5% and 10% air voids lines (air voids to be related to the determined particle density of the soil tested).

- 5.2 The required level of compaction will be indicated by selecting appropriate moisture content and dry density values. This level of compaction shall form the basis of the end product compaction specification. As a minimum, compaction shall achieve >95% relative compaction (when compared to the relevant compaction test) and <5% air voids. Both criteria shall be met to establish acceptable levels of compaction.

Note: Fills with a significant proportion of coarse particles present a problem for determination of acceptability criteria, as these soils often prove inappropriate for either laboratory testing or in-situ density determination. A compaction site trial may be required to be carried out for these materials, combined with an experience based approach to allow the Resident Engineer to determine the most appropriate method for testing and management of the fill. The expert advice of the Geotechnical Engineer should be sought as required.

6.0 Method Compaction

- 6.1 Method compaction should be for all materials classified as granular fill, for specific Special Fills and for cohesive general fill with a significant proportion of coarse particles. When method compaction is used then site trials shall be carried out to confirm the effectiveness of the proposed method.
- 6.3 A separate compaction trial shall be carried out for each type of fill to be used on the site.
- 6.4 Crushed product derived from the screening and crushing of relic foundations, concrete slabs and oversize materials could yield good quality granular Class 6F1, 2 and 3 materials (125mm to dust) which at the discretion of the Resident Engineer does not require a site trial to confirm the method specification for its compaction and the method given in Table 6/1 of MCHW Volume 1, which is appended to this specification can be adopted.

Note: If the soil grading allows, the results of the site trial shall also be compared to the results of a relevant laboratory compaction test.

7.0 Compaction Site Trials

- 7.1 Notwithstanding the requirements of Clause 612 and sub clause 6 of the MCHW Volume 1, the following shall form an addendum to aforementioned Clause.
- 7.2 Sufficient quantities of each type of material shall be excavated and screened of deleterious material to lay a 10m x 4m x approximately 0.25m thick trial pad on a previously rolled horizontal area of the site. Any soft spots in the subgrade below the trial pad should be removed and replaced with compacted granular material. A guide to the thickness of layer that may be suitable may be obtained from Table 6/1 appended to this specification.
- 7.3 The trial shall be conducted using the same compaction plant as is proposed for the main compaction works. A guide to the size and type of plant that may be suitable may be obtained from MCHW Table 6/4 appended to this specification.
- 7.4 The bulk density and moisture content of the fill in the trial pad shall be determined by sand replacement test (granular or stony cohesive) or clay corecutter (cohesive) and oven-drying in two locations immediately after placement and spreading by the dozer but before any rolling. Use of nuclear density gauges may be permitted if conditions allow.
- 7.5 Bulk density and moisture content determinations shall be carried out at different locations after subsequent passes by the roller to give density and moisture content determinations after 2, 4, 6, 8 and 10 passes of the roller.

Note: This will give a total of 10 no tests for each material.

- 7.6 Laboratory determinations of particle density, grading, dry density/mc relationship and Atterberg limits/ remoulded shear strength (if applicable), shall be carried out for each type of material.
- 7.7 The graph of dry density against number of passes shall be drawn and the number of passes required to achieve maximum dry density in the field trial shall be determined. If applicable, this shall also be compared to the maximum dry density achieved in the relevant laboratory compaction test, with the aim of achieving >95% compaction.

Note: In the field, when compacting fills with a significant proportion of coarse particles, it will be difficult to achieve an air void content of 5% or less. A strict aim of achieving less than 5% air voids is therefore impracticable and inappropriate, but should still be used as a general guide.

- 7.8 As a guide, the number of passes derived in 7.5 above should be equal to or greater than the number derived from Table 6/4 appended to this specification. The number of passes derived from the site trial shall form the method specification for site compaction of that class of material at the in situ moisture content.
- 7.9 If it is required to calibrate a Nuclear Density Meter (NDM) then measurements of bulk density and moisture content shall be made using the NDM at locations adjacent to those carried out by sand replacement tests or corecutter samples, depending on material type, in Section 7.4.
- 7.10 If the source for the fill materials alters, and a new material is therefore proposed for use, then a site trial shall be performed on this material to demonstrate that it can be compacted satisfactorily before this material is used in the works.

8.0 Preparation of Site

- 8.1 Drainage grips or trenches shall be excavated, as necessary, uphill of the area to be filled to prevent the area becoming flooded. Drainage shall be affected without causing siltation or erosion and water shall be disposed of in a manner to be agreed with the Engineer.
- 8.2 The area to be filled, whether an existing excavation or otherwise undisturbed ground, shall be graded to falls, and sump pumping or other suitable dewatering facilities shall be provided as necessary by the Contractor to keep the base of the excavation dry at all times.
- 8.3 Where the area to be filled comprises an existing excavation, the excavation shall be inspected and subsequently monitored by the Contractor, to ensure that there is no danger of collapse during the works with consequences for safety, for existing buildings or for other construction adjoining.
- 8.4 Any topsoil present shall be stripped and, where required for further use, stockpiled in an area provided by the Contractor and agreed by the Resident Engineer.
- 8.5 All soft and compressible soils or existing fill shall be removed and run to spoil in dumps provided by the Contractor and agreed by the Resident Engineer. The works shall be accomplished in such a way that there is no undercutting of the sides of existing excavations.
- 8.6 Existing foundations or ledges of hard rock, roots of trees or former pipelines or services at the base of the area to be filled shall be excavated and replaced with compacted general fill which shall be compacted to the same specification as adopted for subsequent compaction works.

Note: No tree roots greater than 5mm diameter, no root balls and no masses of fibrous roots shall remain at the base of the excavation.

- 8.7 The base of the area to be filled shall be proof rolled with a dead weight roller and all soft materials replaced with compacted fill. Where unsuitable material has been excavated, the underlying natural ground shall be compacted to the same specification as adopted for subsequent compaction works.

9.0 Deposition of Fill

- 9.1 Where construction is required upon fill placed over sloping natural ground, and where fill thickness is less than 5m, the adjacent ground shall be benched, with the maximum vertical height of each bench not exceeding 500mm and providing that the fill depth below any building footprint does not vary by any more than 15%.
- 9.2 Where, because of the current method of working, previously engineered fill placed during the current works has to be benched as in Section 9.1 to allow new fill to be placed adjacent to it, then the benches only require to be 0.5m high by 1.0m wide, even where these occur beneath plots providing that the fill is the same material throughout the plot.
- 9.3 Where a development contains landscaped areas on which no structures are proposed, the underlying fill shall be selected, placed and compacted in the same way as the engineered fill, unless otherwise directed by the Resident Engineer. Where some relaxation of the specification for fill compaction underlying landscaped areas is permitted, there shall be a transition zone between the fill underlying the landscaped area and the fill underlying the structure. The dimensions of the transition zone will depend on the degree to which fill compaction was relaxed for the fill in the landscaped area. The location and extent of fill placed to a reduced standard of compaction shall be recorded.

Additional Requirements for Adoptable Highways

- 9.4 Recommendations provided within Sirius Settlement Report (dated July 2016) should be referred to for the requirements for adoptable highways.
- 9.5 The resultant excavation along the highway alignment shall be backfilled back to proposed formation level with suitable fill materials, which have been classified and compacted in accordance with this specification.

10.0 Placing and Compacting Fill

- 10.1 Clause 612 of MCHW Volume 1 applies. However, where there is conflict with the Clauses below, Clauses from this specification shall take precedence over Clause 612.
- 10.2 Fill shall be placed and compacted in the near-horizontal layers of the thickness required to achieve the specified end product or in accordance with the approved method specification, and shall, as far as practicable, be brought up at a uniform rate so that all parts of the site or particular sections of the site reach finished (formation) level at the same time.
- 10.3 The compaction plant selected, the number of passes made and the fill layer thickness and moisture content used shall have regard either to the specified end product and the means and manner of control testing or the specified method and the means and manner of control testing.
- 10.4 Where different types of fill material (all meeting the requirements of Section 3 of this specification) are to be employed, they shall be deposited in such a way that all parts or particular sections of the site receive roughly equal amounts of a given material, in roughly the same sequence, thus ensuring a uniform distribution of fill types over the whole fill thickness.
- 10.5 The Contractor shall take all necessary steps to ensure that the fill is placed at the moisture content necessary to achieve the specified level of compaction and shall, where necessary, add water to or dry the fill, in order to obtain this value. Where it is necessary to add water, this shall be done as a fine spray and in such a way that there is time for the water to be absorbed into the fill before being rolled by the plant.
- 10.6 Cobbles, boulders, rock or waste fragments, the largest dimension of which is greater than two-thirds of the compacted layer thickness, shall not be incorporated into the fill.
- 10.7 No fill shall be placed and left uncompacted at the end of the working day. Compacted fill shall be graded to falls to ensure free run-off of rainwater without ponding.
- 10.8 Compaction plant and compaction method shall be selected having regard to the proximity of existing trenches, excavations, retaining walls or other structures and all work shall be performed in such a way as to ensure that their existing stability is not impaired.
- 10.9 If weather conditions are such that the specified moisture content and density values cannot be achieved, the Contractor shall cease work until such time as the fill can be placed and compacted to meet specification requirements.

- 10.10 If the results of control tests (Section 11) indicate that the fill is being placed and compacted in such a way that the desired level of compaction is not being achieved, the Contractor shall further compact or, if necessary, shall excavate the affected work and replace with new fill, compacted to meet the specification requirements.
- 10.11 If the results of control tests (Section 11) indicate that antecedent weather conditions (such as frost or heavy rain) have caused the deterioration of finished work such that the work no longer meets with the specification, the Contractor shall, at his or her own cost, take such steps as are necessary to bring the fill to specification requirements.

11.0 **Control Testing**

11.1 Testing of end product compacted materials shall be in accordance with the schedule provided in Table 1.

- Moisture content and in-situ density determinations (BS1377:Part 2:1990:Section 3) shall be performed as soon as it is practical after placement,
- Control tests shall be performed by the Resident Engineer throughout the fill at such frequency and at such locations as shall be deemed necessary by the Resident Engineer.
- The minimum frequency of testing shall be as indicated within Table 1. Extra testing will be required in visually doubtful areas or previously failed areas.

11.2 The method specification requirements shall be controlled by in situ and laboratory testing as follows:-

- Moisture content determinations.
- The minimum frequency of testing shall be as shown within the schedule in Table 1. Extra testing will be required in visually doubtful areas or previously failed areas.
- Control tests shall be performed by the Resident Engineer throughout the fill at such frequency and at such locations as shall be deemed necessary by the Engineer. In this instance it is likely that method compaction shall be employed on granular cut materials. Control tests on method compacted fill shall comprise deformation type tests such as plate bearing tests (using minimum 600mm dia pate or DCPs).

11.3 For end product compaction, for example on cohesive materials, the Resident Engineer shall make available a plot of in situ dry densities against in situ moisture content results. Should any results indicate inadequate compaction (i.e. >5% air voids or <95% relative compaction), the Contractor shall agree with the Resident Engineer proposals for rectifying the existing situation and for improving future performance.

11.4 The compacted layer thickness shall be checked by the Resident Engineer.

11.5 The numbering system to be adopted for Quality Control testing shall be decided by the Resident Engineer at the start of works. The system adopted shall enable the location of each test to be identified in the works i.e. plan location and level beneath final formation level. The date of the test shall also be included. e.g. Plot 24/1.2/25May would indicate a test under Plot 24 at a depth of 1.2m below final formation level carried out on 25th May. The testing laboratory shall be informed of the number of each test they perform and shall report that number on the results sheet.

12.0 Monitoring of Fill Performance

12.1 If instructed by the Resident Engineer, the Contractor shall make arrangements for monitoring the performance of the fill, once placed. Monitoring may take one or more of the following forms:-

- Optical levelling of surface monuments;
- Standpipes or piezometers;
- Load tests (such as dummy foundation or skip load tests);
- Other methods as directed by the Resident Engineer and/or the Geotechnical Engineer.

12.2 The Contractor shall, within twenty one working days of receiving notification of the Resident Engineer's intention to monitor fill performance, arrange for the procurement and supply of the equipment to the Resident Engineer's written specification and shall inform the Resident Engineer of the date on which the equipment installation shall commence. The specification shall include:-

- A full description of the nature and type of instrument and the purpose it fulfils;
- The number required and the locations and/or depths at which it is to be installed;
- The frequency, accuracy and duration for which any readings are to be taken.

TABLE 6/1: (11/05) Acceptable Earthworks Materials: Classification and Compaction Requirements (See footnotes)

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability (In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631)				Compaction Requirements in Clause 612	Class				
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable Limits Within:			Lower	Upper	1	A	-
									Lower	Upper						
G E N E R A L	1	A	-	Well graded granular material	General Fill	Any material, or combination of materials, other than material designated as Class 3 in the Contract. (Properties (i), (ii) and (iv) in next column, shall not apply to chalk). Recycled aggregate	(i) grading	BS 1377 : part 2	Tab 6/2	Tab 6/2	Tab 6/4 Method 2	1	A	-		
							(ii) uniformity coefficient	See Note 5	10	-						
							(iii) mc	BS 1377 : Part 2	App 6/1	App 6/1						
							(iv) MCV	Clause 632	App 6/1	App 6/1						
							(v) IDD of chalk	Clause 634	-	App 6/1						
G R A N U L A R	1	B	-	Uniformly graded granular material	General Fill	Any material, or combination of materials, other than chalk. Recycled aggregate	(i) grading	BS 1377 : Part 2	Tab 6/2	Tab 6/2	Tab 6/4 Method 3	1	B	-		
							(ii) uniformity coefficient	See Note 5	-	10						
							(iii) mc	BS 1377 : Part 2	App 6/1	App 6/1						
							(iv) MCV	Clause 632	App 6/1	App 6/1						
F I L L	1	C	-	Coarse granular material	General Fill	Any material, or combination of materials, other than material designated as Class 3 in the Contract. (Properties (i) and (ii) in next column, shall not apply to chalk). Recycled aggregate	(i) grading	BS 1377 : Part 2	Tab 6/2	Tab 6/2	Tab 6/4 Method 5	1	C	-		
							(ii) uniformity coefficient	See Note 5	5	-						
							(iii) Los Angeles coefficient	Clause 635	-	50						

TABLE 6/1: (11/05) Acceptable Earthworks Materials: Classification and Compaction Requirements (See footnotes) (continued)

Class			General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability (In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631)				Compaction Requirements in Clause 612	Class			
						Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable Limits Within:						
								Lower	Upper					
G E N E R A L	2	A	-	Wet cohesive material	General Fill	Any material, or combination of materials, other than chalk.	(i) grading	BS 1377 : part 2	Tab 6/2	Tab 6/2	Tab 6/4 Method 1 except for materials with liquid limit greater than 50, determined by BS1377 : Part 2, only deadweight tamping or vibratory tamping rollers or grid rollers shall be used.	2	A	-
							(ii) plastic limit (PL)	BS 1377 : part 2	-	-				
							(iii) mc	BS 1377 : Part 2	PL -4%	App 6/1				
							(iv) MCV	Clause 632	App 6/1	App 6/1				
							(v) Undrained shear strength of remoulded material	Clause 633	App 6/1	App 6/1				
C O H E S I V E	2	B	-	Dry cohesive material	General Fill	Any material, or combination of materials, other than chalk	(i) grading	BS 1377 : Part 2	Tab 6/2	Tab 6/2	Tab 6/4 Method 2	2	B	-
							(ii) plastic limit (PL)	BS 1377 : Part 2	-	-				
							(iii) mc	BS 1377 : Part 2	App 6/1	PL -4%				
							(iv) MCV	Clause 632	App 6/1	App 6/1				
							(v) undrained shear strength of remoulded material	Clause 633	App 6/1	App 6/1				
F I L L														

TABLE 6/1: Acceptable Earthworks Materials: Classification and Compaction Requirements (See footnotes) (continued)

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability (In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631)				Compaction Requirements in Clause 612	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable Limits Within:					
									Lower	Upper				
G E N E R A L	2	C	-	Stony cohesive material	General Fill	Any material, or combination of materials, other than chalk	(i) grading	BS 1377 : part 2	Tab 6/2	Tab 6/2	Tab 6/4 Method 2	2	C	-
							(ii) plastic limit (PL)	BS 1377 : part 2	-	-				
							(iii) mc	BS 1377 : Part 2	App 6/1	App 6/1				
							(iv) MCV	Clause 632	App 6/1	-				
							(v) Undrained shear strength of remoulded material	Clause 633	App 6/1	-				
C O H E S I V E	2	D	-	Silty cohesive material	General Fill	Any material, or combination of materials, other than chalk	(i) grading	BS 1377 : Part 2	Tab 6/2	Tab 6/2	Tab 6/4 Method 3	2	D	-
							(ii) mc	BS 1377 : Part 2	App 6/1	App 6/1				
							(iii) MCV	Clause 632	App 6/1	App 6/1				
							(iv) undrained shear strength of remoulded material	Clause 633	App 6/1	App 6/1				
F I L L	2	E	-	Reclaimed pulverised fuel ash cohesive material	General Fill	Reclaimed material from lagoon or stockpile containing not more than 20% furnace bottom ash	(i) mc	BS 1377 : Part 2	To enable compaction to Clause 612	End product 95% of maximum dry density of BS 1377 : Part 4 (2.5 kg rammer method)	2	E	-	
							(ii) bulk density	BS 1377 : Part 9	App 6/1	App 6/1				

TABLE 6/1: (11/09) Acceptable Earthworks Materials: Classification and Compaction Requirements (See footnotes) (continued)

Class			General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability (In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631)				Compaction Requirements in Clause 612	Class			
						Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable Limits Within:			6	F	1	
Lower	Upper													
SELECTED GRANULAR	6	F	1	Selected granular material (fine grading)	Capping	Any material, or combination of materials - including recycled aggregates with not more than 50% by mass of recycled bituminous planings and granulated asphalt, but excluding materials that contain tar and tar-bitumen binders, unburnt colliery spoil, argillaceous rock and chalk. Property (vi) in the next column shall not apply if the Class Ra (asphalt) content of any recycled aggregate is 20% or less.	(i) grading	BS 1377 : Part 2	Tab 6/2	Tab 6/2	Tab 6/4 Method 6	6	F	1
							(ii) optimum mc	BS 1377 : Part 4 (vibrating hammer method)	-	-				
							(iii) mc	BS 1377 : Part 2	Optimum mc - 2%	Optimum mc				
							(iv) Los Angeles coefficient	Clause 635	-	60				
							(v) Class Ra (asphalt) content	Clause 710	-	50%				
							(vi) bitumen content	BS EN 12697-1 or BS EN 12697-39	-	2.0%				
FILL	6	F	2	Selected granular material (coarse grading)	Capping	Any material, or combination of materials - including recycled aggregates with not more than 50% by mass of recycled bituminous planings and granulated asphalt, but excluding materials that contain tar and tar-bitumen binders, unburnt colliery spoil and argillaceous rock. Property (i) in the next column shall not apply to chalk. Property (vi) in the next column shall not apply if the Class Ra (asphalt) content of any recycled aggregate is 20% or less.	(i) grading	BS 1377 : Part 2	Tab 6/2	Tab 6/2	Tab 6/4 Method 6	6	F	2
							(ii) optimum mc	BS 1377 : Part 4 (vibrating hammer method)	-	-				
							(iii) mc	BS 1377 : Part 2	Optimum mc - 2%	Optimum mc				
							(iv) Los Angeles coefficient	Clause 635	-	50				
							(v) Class Ra (asphalt) content	Clause 710	-	50%				
							(vi) bitumen content	BS EN 12697-1 or BS EN 12697-39	-	2.0%				

TABLE 6/1: (11/09) Acceptable Earthworks Materials: Classification and Compaction Requirements (See footnotes) (continued)

Class			General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability (In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631)				Compaction Requirements in Clause 612	Class			
						Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable Limits Within:			6	F	3	
Lower	Upper													
S E L E C T E D	6	F	3	Selected granular material	Capping	Any material, or combination of materials with not less than 50% by mass of recycled bituminous planings and granulated asphalt, but excluding materials that contain tar and tar-bitumen binders, unburnt colliery spoil and argillaceous rock	(i) grading	BS 1377 : Part 2 (On-site)	Tab 6/2	Tab 6/2	Tab 6/4 Method 6 Maximum Compacted layer thickness shall be 200 mm	6	F	3
								BS EN 933-2 (Off-site)	Tab 6/5	Tab 6/5				
							(ii) optimum mc	Clause 613	-	-				
							(iii) mc	Clause 613	Optimum mc - 2%	Optimum mc				
							(iv) Class Ra (asphalt) content	Clause 710	50%					
							(v) bitumen content	BS EN 12697-1 or BS EN 12697-39	-	10%				
G R A N U L A R	6	F	4	Selected granular material (fine grading) - imported on to the Site	Capping	Unbound mixture complying with BS EN 13285. Any material, or combination of materials - including recycled aggregates with not more than 50% by mass of recycled bituminous planings and granulated asphalt, but excluding materials that contain tar and tar-bitumen binders, unburnt colliery spoil, argillaceous rock and chalk. Property (x) in the next column shall not apply if the Class Ra (asphalt) content of any recycled aggregate is 20% or less.	(i) Size designation and overall grading category	BS EN 13285 - 0/31.5 and G_E	Tab 6/5	Tab 6/5	Tab 6/4 Method 6	6	F	4
							(ii) Maximum fines and oversize categories	BS EN 13285 - UF_{15} and OC_{75}	Tab 6/5	Tab 6/5				
							(iii) Los Angeles coefficient	BS EN 13242 - LA_{60}	-	60				
							(iv) Volume stability of blast furnace slag	BS EN 13242 - free from dicalcium silicate and iron disintegration	-	-				

TABLE 6/1: (11/05) Acceptable Earthworks Materials: Classification and Compaction Requirements (See footnotes) (continued)

Class			General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability (In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631)				Compaction Requirements in Clause 612	Class			
						Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable Limits Within:						
								Lower	Upper					
S E L E C T E D G R A N U L A R F I L L	6	I	-	Selected well graded granular material	Fill to reinforced soil and anchored earth structures	Natural gravel, natural sand, crushed gravel, crushed rock, crushed concrete, slag, chalk, well burnt colliery spoil or any combination thereof except that chalk shall not be combined with any other constituent. None of these constituents shall include any argillaceous rock. (Properties (i), (ii) and (v) in next column shall not apply to chalk.) (Properties (viii), (ix), (x), (xi), (xii), (xiii) and (xiv) only apply when metallic reinforcing or anchor elements, facing units or fastenings are used.) Recycled aggregate except recycled asphalt	(i) grading	BS 1377 : Part 2 (On-site)	Tab 6/2	Tab 6/2	Tab 6/4 Method 2	6	I	-
								BS EN 933-2 (Off-site)	Tab 6/5	Tab 6/5				
							(ii) uniformity coefficient	See Note 5	10	-				
							(iii) SMC of chalk	Clause 634	-	20%				
							(iv) mc	BS 1377 : Part 2	App 6/1	App 6/1				
							(v) MCV	Clause 632	App 6/1	App 6/1				
							(vi) effective angle of friction (ϕ') and effective cohesion (c')	Clause 636	App 6/1	-				
							(vii) coefficient of friction and adhesion (fill/elements)	Clause 639	App 6/1	-				
							(viii) pH value	BS 1377 : Part 3	Tab 6/3	Tab 6/3				
							(ix) chloride ion content	BS EN 1744-1	-	Tab 6/3				
							(x) water soluble (WS) sulfate content	TRL Report 447, Test No. 1	-	Tab 6/3				
							(xi) oxidisable sulfides (OS) content	TRL Report 447, Tests Nos. 2 and 4	-	Tab 6/3				
							(xii) resistivity	Clause 637	Tab 6/3	-				
							(xiii) redox potential	Clause 638	Tab 6/3	-				
							(xiv) organic content	BS 1377 : Part 3	-	Tab 6/3				
(xv) microbial activity index	Table 6/3	-	Tab 6/3											

TABLE 6/1: (11/05) Acceptable Earthworks Materials: Classification and Compaction Requirements (See footnotes) (continued)

Class	General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability (In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631)				Compaction Requirements in Clause 612	Class					
				Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable Limits Within:			6	J	-			
						Lower	Upper							
S E L E C T E D G R A N U L A R F I L L	6	J	-	Selected uniformly graded granular material	Fill to reinforced soil and anchored earth	Natural gravel, natural sand, crushed gravel, crushed rock, crushed concrete, slag, chalk, well burnt colliery spoil or any combination thereof, except that chalk shall not be combined with any other constituent. None of these constituents shall include any argillaceous rock. (Properties (viii), (ix), (x), (xi), (xii), (xiii) and (xiv) in next column only apply when metallic reinforcing or anchor elements, facing units or fastenings are used.) (Properties (i), (ii) and (v) in next column shall not apply to chalk.) Recycled aggregate except recycled asphalt	(i) grading	BS 1377 : Part 2 (On-site)	Tab 6/2	Tab 6/2	Tab 6/4 Method 3	6	J	-
								BS EN 933-2 (Off-site)	Tab 6/5	Tab 6/5				
							(ii) uniformity coefficient	See Note 5	5	10				
							(iii) SMC of chalk	Clause 634	-	20%				
							(iv) mc	BS 1377 : Part 2	App 6/1	App 6/1				
							(v) MCV	Clause 632	App 6/1	App 6/1				
							(vi) effective angle of friction (ϕ') and effective cohesion (c')	Clause 636	App 6/1	-				
							(vii) coefficient of friction and adhesion (fill/elements)	Clause 639	App 6/1	-				
							(viii) pH value	BS 1377 : Part 3	Tab 6/3	Tab 6/3				
							(ix) chloride ion content	BS EN 1744-1	-	Tab 6/3				
							(x) water soluble (WS) sulfate content	TRL Report 447, Test No. 1	-	Tab 6/3				
							(xi) oxidisable sulfides (OS) content	TRL Report 447, Tests Nos 2 and 4	-	Tab 6/3				
							(xii) resistivity	Clause 637	Tab 6/3	-				
							(xiii) redox potential	Clause 638	Tab 6/3	-				
							(xiv) organic content	BS 1377 : Part 3	-	Tab 6/3				
(xv) microbial activity index	Table 6/3	-	Tab 6/3											

TABLE 6/2: (05/04) Grading Requirements for Acceptable Earthworks Materials Other Than Classes 6F4, 6F5 and 6S

Percentage by Mass Passing the Size Shown																					
Class	Size (mm)		Size(mm) BS Series													Size (microns) BS Series				Size (microns)	Class
	500	300	125	90	75	37.5	28	20	14	10	6.3	5	3.35	2	1.18	600	300	150	63		
1A		100	95-100																<15		1A
1B			100																<15		1B
1C	100		10-95													0-25			<15		1C
2A & 2B			100											80-100					15-100		2A & 2B
2C			100											15-80					15-80		2C
2D			100																80-100	0-20	2D
6A	100								0-100		0-85					0-45			0-5		6A
6B	100		0-10																		6B
6C			100			0-100				0-100		0-35	0-10		0-2						6C
6D									100		89-100		60-100	30-100	15-80	5-48	0-15 except 0-20 for crushed rock				6D
6E & 6R			100	85-100					25-100							10-100			<15		6E & 2R
6F1					100	75-100			40-95		30-85					10-50			<15		6F1
6F2			100	80-100	65-100	45-100			15-60		10-45				0-25				0-12		6F2
6F3			100	80-100	65-100	45-100			15-60		10-45				0-25				0-12		6F3
6H								100			60-100			15-45	0-25			0-5			6H
6I & 6J			100		85-100				25-100					15-100		9-100			<15		6I & 6J
6K								100											0-10		6K
6L									100		89-100		60-100	30-100	15-100	5-70	0-15 except 0-20 for crushed rock				6L

TABLE 6/4: Method Compaction for Earthworks Materials: Plant and Methods (Method 1 to Method 6)
(This Table is to be read in conjunction with sub-Clause 612.10)

Type of Compaction Plant	Ref No.	Category	Method 1		Method 2		Method 3		Method 4		Method 5		Method 6		
			D	N#	D	N#	D	N#	D	N	D	N	N for D = 110 mm	N for D = 150 mm	N for D = 250 mm
Smoothed wheeled roller (or vibratory roller operating without vibration)	1	Mass per metre width of roll: over 2100 kg up to 2700 kg	125	8	125	10	125	10*	175	4	unsuitable		unsuitable	unsuitable	unsuitable
	2	over 2700 kg up to 5400 kg	125	6	125	8	125	8*	200	4	unsuitable		16	unsuitable	unsuitable
	3	over 5400 kg	150	4	150	8	unsuitable		300	4	unsuitable		8	16	unsuitable
Grid roller	1	Mass per metre width of roll: over 2700 kg up to 5400 kg	150	10	unsuitable		150	10	250	4	unsuitable		unsuitable	unsuitable	unsuitable
	2	over 5400 kg up to 8000 kg	150	8	125	12	unsuitable		325	4	unsuitable		20	unsuitable	unsuitable
	3	over 8000 kg	150	4	150	12	unsuitable		400	4	unsuitable		12	20	unsuitable
Deadweight tamping roller	1	Mass per metre width of roll: over 4000 kg up to 6000 kg	225	4	150	12	250	4	350	4	unsuitable		12	20	unsuitable
	2	over 6000 kg	300	5	200	12	300	3	400	4	unsuitable		8	12	20
Pneumatic-tyred roller	1	Mass per wheel: over 1000 kg up to 1500 kg	125	6	unsuitable		150	10*	240	4	unsuitable		unsuitable	unsuitable	unsuitable
	2	over 1500 kg up to 2000 kg	150	5	unsuitable		unsuitable		300	4	unsuitable		unsuitable	unsuitable	unsuitable
	3	over 2000 kg up to 2500 kg	175	4	125	12	unsuitable		350	4	unsuitable		unsuitable	unsuitable	unsuitable
	4	over 2500 kg up to 4000 kg	225	4	125	10	unsuitable		400	4	unsuitable		unsuitable	unsuitable	unsuitable
	5	over 4000 kg up to 6000 kg	300	4	125	10	unsuitable		unsuitable		unsuitable		12	unsuitable	unsuitable
	6	over 6000 kg up to 8000 kg	350	4	150	8	unsuitable		unsuitable		unsuitable		12	unsuitable	unsuitable
	7	over 8000 kg up to 12000 kg	400	4	150	8	unsuitable		unsuitable		unsuitable		10	16	unsuitable
	8	over 12000 kg	450	4	175	6	unsuitable		unsuitable		unsuitable		8	12	unsuitable
Vibratory tamping roller	1	Mass per metre width of a vibrating roll: over 700 kg up to 1300 kg	100	12	100	12	150	12	100	10	unsuitable		unsuitable	unsuitable	unsuitable
	2	over 1300 kg up to 1800 kg	125	12	125	12	175	12*	175	8	unsuitable		12	unsuitable	unsuitable
	3	over 1800 kg up to 2300 kg	150	12	150	12	200	12*	unsuitable		unsuitable		8	12	unsuitable
	4	over 2300 kg up to 2900 kg	150	9	150	9	250	12*	unsuitable		400	5	6	10	unsuitable
	5	over 2900 kg up to 3600 kg	200	9	200	9	275	12*	unsuitable		500	6	6	10	unsuitable
	6	over 3600 kg up to 4300 kg	225	9	225	9	300	12*	unsuitable		600	6	4	8	unsuitable
	7	over 4300 kg up to 5000 kg	250	9	250	9	300	9*	unsuitable		700	6	3	7	12
	8	over 5000 kg	275	9	275	9	300	7*	unsuitable		800	6	3	6	10

TABLE 6/4: Method Compaction for Earthworks Materials: plant and Methods (Method 1 to Method 6)
(This Table is to be read in conjunction with sub-Clause 612.10)

Type of Compaction Plant	Ref No.	Category	Method 1		Method 2		Method 3		Method 4		Method 5		Method 6			
			D	N#	D	N#	D	N#	D	N	D	N	N for D = 110 mm	N for D = 150 mm	N for D = 250 mm	
Vibratory roller	1	Mass per metre width of a vibratory roll: over 270 kg up to 450 kg over 450 kg up to 700 kg over 700 kg up to 1300 kg over 1300 kg up to 1800 kg over 1800 kg up to 2300 kg over 2300 kg up to 2900 kg over 2900 kg up to 3600 kg over 3600 kg up to 4300 kg over 4300 kg up to 5000 kg over 5000 kg	unsuitable	75	16	150	16	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	
	2		unsuitable	75	12	150	12	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable
	3		100	12	125	10	150	6	125	10	unsuitable	16	unsuitable	unsuitable	unsuitable	unsuitable
	4		125	8	150	8	200	10*	175	4	unsuitable	6	16	unsuitable	unsuitable	unsuitable
	5		150	4	150	4	225	12*	unsuitable	unsuitable	4	6	12	unsuitable	unsuitable	unsuitable
	6		175	4	175	4	250	10*	unsuitable	400	5	3	5	11	unsuitable	unsuitable
	7		200	4	200	4	275	8*	unsuitable	500	5	3	5	10	unsuitable	unsuitable
	8		225	4	225	4	300	8*	unsuitable	600	5	2	4	8	unsuitable	unsuitable
	9		250	4	250	4	300	6*	unsuitable	700	5	2	4	7	unsuitable	unsuitable
	10		275	4	275	4	300	4*	unsuitable	800	5	2	3	6	unsuitable	unsuitable
Vibrating plate compactor	1	Mass per m ² of base plate: over 880 kg up to 1100 kg over 1100 kg up to 1200 kg over 1200 kg up to 1400 kg over 1400 kg up to 1800 kg over 1800 kg up to 2100 kg over 2100 kg	unsuitable	unsuitable	75	6	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	
	2		unsuitable	75	10	100	6	75	10	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	
	3		unsuitable	75	6	150	6	150	8	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	
	4		100	6	125	6	150	4	unsuitable	unsuitable	8	unsuitable	unsuitable	unsuitable	unsuitable	
	5		150	6	150	5	200	4	unsuitable	unsuitable	5	8	unsuitable	unsuitable	unsuitable	
	6		200	6	200	5	250	4	unsuitable	unsuitable	3	6	12	unsuitable	unsuitable	
Vibro-tamper	1	Mass: over 50 kg up to 65 kg over 65 kg up to 75 kg over 75 kg up to 100 kg over 100 kg	100	3	100	3	150	3	125	3	unsuitable	4	8	unsuitable	unsuitable	
	2		125	3	125	3	200	3	150	3	unsuitable	3	6	12	unsuitable	
	3		150	3	150	3	225	3	175	3	unsuitable	2	4	10	unsuitable	
	4		225	3	200	3	225	3	250	3	unsuitable	2	4	10	unsuitable	
Power rammer	1	Mass: 100 kg up to 500 kg over 500 kg	150	4	150	6	unsuitable	200	4	unsuitable	5	8	unsuitable	unsuitable	unsuitable	
	2		275	8	275	12	unsuitable	400	4	unsuitable	5	8	14	unsuitable	unsuitable	
Dropping-weight compactor	1	Mass of rammer over 500 kg weight drop: over 1 m up to 2 m over 2 m	600	4	600	8	450	8	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	
	2		600	2	600	8	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	unsuitable	

TABLE 6/4: Method Compaction for Earthworks Materials: Plant and Methods (Method 7)
(This Table is to be read in conjunction with sub-Clause 612.10)

Type of Compaction Plant	Ref No.	Category	Method 7	
			N for D = 150 mm	N for D = 250 mm
Smooth wheeled roller (or vibratory roller operating without vibration)	1	Mass per metre width of roll: over 2100 kg up to 2700 kg	unsuitable	unsuitable
	2	over 2700 kg up to 5400 kg	unsuitable	unsuitable
	3	over 5400 kg	12	unsuitable
Grid roller	1	Mass per metre width of roll: over 2700 kg up to 5400 kg	unsuitable	unsuitable
	2	over 5400 kg up to 8000 kg	16	unsuitable
	3	over 8000 kg	8	unsuitable
Deadweight tamping roller	1	Mass per metre width of roll: over 4000 kg up to 6000 kg	4	8
	2	over 6000 kg	3	6
Pneumatic-tyred roller	1	Mass per wheel: over 1000 kg up to 1500 kg	unsuitable	unsuitable
	2	over 1500 kg up to 2000 kg	12	unsuitable
	3	over 2000 kg up to 2500 kg	6	unsuitable
	4	over 2500 kg up to 4000 kg	5	unsuitable
	5	over 4000 kg up to 6000 kg	4	16
	6	over 6000 kg up to 8000 kg	unsuitable	8
	7	over 8000 kg up to 12000 kg	unsuitable	4
	8	over 12000 kg	unsuitable	4
Vibratory tamping roller	1	Mass per metre width of vibrating roll: over 700 kg up to 1300 kg	unsuitable	unsuitable
	2	over 1300 kg up to 1800 kg	unsuitable	unsuitable
	3	over 1800 kg up to 2300 kg	16	unsuitable
	4	over 2300 kg up to 2900 kg	12	unsuitable
	5	over 2900 kg up to 3600 kg	10	unsuitable
	6	over 3600 kg up to 4300 kg	8	16
	7	over 4300 kg up to 5000 kg	7	14
	8	over 5000 kg	6	12
Vibratory roller	1	Mass per metre width of vibrating roll: over 270 kg up to 450 kg	unsuitable	unsuitable
	2	over 450 kg up to 700 kg	unsuitable	unsuitable
	3	over 700 kg up to 1300 kg	unsuitable	unsuitable
	4	over 1300 kg up to 1800 kg	unsuitable	unsuitable
	5	over 1800 kg up to 2300 kg	12	unsuitable
	6	over 2300 kg up to 2900 kg	10	unsuitable
	7	over 2900 kg up to 3600 kg	10	unsuitable
	8	over 3600 kg up to 4300 kg	8	unsuitable
	9	over 4300 kg up to 5000 kg	8	unsuitable
	10	over 5000 kg	6	12
Vibratory plate compactor	1	Mass per m ² of base plate: over 880 kg up to 1100 kg	unsuitable	unsuitable
	2	over 1100 kg up to 1200 kg	unsuitable	unsuitable
	3	over 1200 kg up to 1400 kg	unsuitable	unsuitable
	4	over 1400 kg up to 1800 kg	10	unsuitable
	5	over 1800 kg up to 2100 kg	8	unsuitable
	6	over 2100 kg	6	unsuitable
Vibro-tamper	1	Mass: over 50 kg up to 65 kg	unsuitable	unsuitable
	2	over 65 kg up to 75 kg	unsuitable	unsuitable
	3	over 75 kg up to 100 kg	unsuitable	unsuitable
	4	over 100 kg	8	unsuitable
Power rammer	1	Mass: 100 kg up to 500 kg	8	unsuitable
	2	over 500 kg	6	10
Dropping weight compactor	1	Mass of rammer over 500 kg height drop: over 1 m up to 2 m	unsuitable	unsuitable
	2	over 2 m	unsuitable	unsuitable

APPENDIX B
EARTHWORKS TESTING TO BE CARRIED OUT BY THE CONTRACTOR AND
REQUIREMENTS FOR CLAUSE 612 COMPACTION OF MATERIALS

- 1.0 Testing required by the Resident Engineer to be carried out by the Contractor to assess compliance with the Sirius Specification for Engineered Fill is listed in this Appendix.
- 2.0 The Contractor shall allow in his rates for the testing listed. Where test certificates are identified these shall be produced prior to the incorporation of that item into the Works.
- 3.0 Notes:
 - 1 (N) indicates that a NAMAS / UKAS test report or certificate is required.
 - 2 Unless otherwise shown in this Appendix tests and certificates for work, goods or materials as scheduled under any one Clause are required for all such work, goods or materials in the Works.

Table 1: Testing to be carried out by Contractor and requirements for Clause 612 compaction of materials

Clause	Work, Goods or Material		Test	Frequency of Testing	Test Certificate	Comments
601, 631 to 637, 640	Acceptable material					
	Class	General Description				
	1	General granular fill	Grading/uniformity coefficient (N) and mc (natural) (N)	1 every 500m ³	Required	UKAS Accredited Laboratory. Results to be cross referenced by RE with Table 6/1 in Appendix A.
			Dry density/mc relationship (4.5kg rammer) (N) Particle density (N)	Each site trial (where possible).		
			1C only Los Angeles Coefficient (N) OR 10% fines value (N)	Each sub class of material.		
	2	General cohesive fill	Grading (N) mc (natural) and LL & PL (N)	1 per 500m ³	Required	UKAS Accredited Laboratory. Results to be cross referenced by RE with Table 6/1 in Appendix A.
Dry density/mc relationship (2.5kg rammer) (N) Particle density (N)			Each class or sub class of material			
6F	Selected granular fill	Grading/uniformity coefficient (N)	1 every 500m ³	Required	UKAS Accredited Laboratory. Results to be cross referenced by RE with Table 6/1 in Appendix A.	
		6F1 & 6F2 only Los Angeles Coefficient (N) OR 10% fines value (N)	Each class or sub class of material			
		Water soluble sulphate and pH (N)				
		Oxidisable sulphides and total potential sulphate				

		Dry density/mc relationship* (vibrating rammer Clause 612) (N)	Each class or sub class of material		<i>*[Or based on site trials as required]</i>
--	--	----------------------------------------------------------------	-------------------------------------	--	-----------------------------------------------

Table 1: Testing to be carried out by Contractor and requirements for Clause 612 compaction of materials (cont'd)

612	Compaction of fills	End product compaction	Field dry density (N) (by calibrated nuclear density gauge, sand replacement test or corecutter as appropriate)	1 per 900m ² and on approx. every second layer	Required	Results to be plotted on graph by RE to establish relative compaction and air voids content achieved by compaction.
			Undrained shear strength	Daily hand shear vanes at an approx. rate of one per 400m ² and on each lift.		Tested in-situ by RE after compaction.
		Method compaction	Plate load tests using 600mm diam plate (N)	Once a week during earthwork activities.	Required	RE to review results relative to recorded settlement. CBR to be calculated when test undertaken on highway formation.
			TRL dynamic cone penetrometer	Approx daily during earthwork activities and at a rate of each lift and one per plot footprint and at approx. 25m centres along all adoptable highways.		Tested in-situ by RE after compaction. CBR to be calculated.



APPENDIX D

CLEAN COVER GUIDANCE VALUES

The Sirius Group

Stage 1 Threshold Concentrations for Clean Cover Material for Use in Gardens of Private Residential Properties

Parameter	Threshold Concentration (mg/kg, unless otherwise stated)			Comment
	1% SOM [*]	2.5% SOM	5% SOM	
Metals/Metalloids				
Arsenic (inorganic)	37			
Cadmium	11			Soil pH 6-9
Chromium (III)	910			
Copper	200			Based on phytotoxic effect
Lead	200			
Mercury (inorganic)	40			
Nickel	130			
Selenium	250			
Zinc	450			Based on phytotoxic effect
Other Inorganics				
pH	<5 or >9			Must be in range 5-9
Water-Soluble Sulphate	0.5 g/l			
Organics				
PAHs^{**}				
Total 16 PAHs	100	100	100	Professional judgement
Benzo(a)pyrene	2.1	2.1	2.2	Genotoxic surrogate
Naphthalene	1.0	2.3	4.6	
TPH[†]				
Sum of TPH fractions EC5-35	500	500	500	Professional judgement
Aliphatic EC 5-6	24	41	68	
Aliphatic EC >6-8	53	110	210	
Aliphatic EC >8-10	13	31	61	
Aliphatic EC >10-12	62	150	300	
Aliphatic EC >12-16	510	1200	2300	
Aliphatic EC >16-35	41000	70000	90000	
Aromatic EC >5-7	53	110	200	
Aromatic EC >7-8	100	240	460	
Aromatic EC >8-10	20	48	94	
Aromatic EC >10-12	63	150	290	
Aromatic EC >12-16	140	320	570	
Aromatic EC >16-21	260	540	840	
Aromatic EC >21-35	1100	1500	1700	
TPH Hazard Index (no units)	<1	<1	<1	
BTEX[‡]				
Benzene	0.063	0.13	0.24	
Miscellaneous Organics				
Phenol	110	190	330	
Other Parameters				
Asbestos	Unsuitable if any fibres present			

Based on sandy soil at a range of soil organic matter contents and assuming a standard residential with gardens land use. Alternative criteria may be specified for other soil types and SOM contents, for soils placed at depth, or for other land uses.

Notes:

* Soil organic matter; %SOM = 1.724 * %TOC.

** Soils must meet the specified criteria for each component AND the sum of 16 PAHs. The total is specified to prevent unsuitable materials being placed as cover. Where an individual PAH is not shown, then its criterion is greater than that for the sum or it is a genotoxic PAH assessed by using benzo(a)pyrene as a surrogate marker.

† Soils must meet the specified criteria for each component and the Hazard Index for TPH must be <1.0. The sum of TPH fractions must also be met to prevent unsuitable materials being placed as cover. Where an individual TPH fraction has a criterion greater than that for the sum of TPH fractions, the value is solely provided for the calculation of the Hazard Index.

‡ Components other than benzene are not genotoxic carcinogens and therefore assessed as part of the TPH mixture.

Soils must have no visual or olfactory evidence of contamination.

The Sirius Group

Stage 1 Threshold Concentrations for Clean Cover Soils for Use in Areas of Soft Landscaping

Parameter	Threshold Concentration (mg/kg, unless otherwise stated)			Comment
	1% SOM [*]	2.5% SOM	5% SOM	
Metals/Metalloids				
Arsenic (inorganic)	79			
Cadmium	120			Soil pH 6-9
Chromium (III)	1500			
Copper	200			Based on phytotoxic effect
Lead	630			
Mercury (inorganic)	120			
Nickel	230			
Selenium	1100			
Zinc	450			Based on phytotoxic effect
Other Inorganics				
pH	<5 or >9			pH to be in range 5-9
Water-Soluble Sulphate	0.5 g/l			
Organics				
PAHs^{**}				
Total 16 PAHs	100	100	100	Professional judgement
Benzo(a)pyrene	4.2	4.2	4.2	Genotoxic surrogate
TPH[†]				
Sum of TPH fractions EC5-35	500	500	500	Professional judgement
Aliphatic EC 5-6	520000	550000	570000	
Aliphatic EC >6-8	560000	580000	600000	
Aliphatic EC >8-10	12000	12000	12000	
Aliphatic EC >10-12	13000	13000	13000	
Aliphatic EC >12-16	13000	13000	13000	
Aliphatic EC >16-35	250000	250000	250000	
Aromatic EC >5-7	55000	55000	55000	
Aromatic EC >7-8	55000	55000	55000	
Aromatic EC >8-10	5000	5000	5000	
Aromatic EC >10-12	5000	5000	5000	
Aromatic EC >12-16	5000	5000	5000	
Aromatic EC >16-21	3800	3800	3800	
Aromatic EC >21-35	3800	3800	3800	
TPH Hazard Index (no units)	<1	<1	<1	
BTEX[‡]				
Benzene	71	72	72	
Miscellaneous Organics				
Phenol	440	440	440	440mg/kg is the skin irritation threshold
Other Parameters				
Asbestos	Fibres present			

Based on sandy soil at a range of soil organic matter contents for areas of vegetated landscaping in residential or commercial land uses. Alternative criteria may be specified for other soil types and SOM contents, for soils placed at depth, or for other land uses.

Notes:

* Soil organic matter; %SOM = 1.724 * %TOC.

** Soils must meet the specified criteria for each component AND the sum of 16 PAHs. The total is specified to prevent unsuitable materials being placed as cover. Where an individual PAH is not shown, then its criterion is greater than that for the sum or it is a genotoxic PAH assessed by using benzo(a) pyrene as a surrogate marker.

† Soils must meet the specified criteria for each component and the Hazard Index for TPH must be <1.0. The sum of TPH fractions must also be met to prevent unsuitable materials being placed as cover. Where an individual TPH fraction has a criterion greater than that for the sum of TPH fractions, the value is solely provided for the calculation of the Hazard Index.

‡ Components other than benzene are not genotoxic carcinogens and therefore assessed as part of the TPH mixture.

Soils must have no visual or olfactory evidence of contamination.



The Sirius Group

Generic Assessment Criteria for PAHs in Soils When Surrogate Marker Approach is Invalid

Parameter	Residential (mg/kg)						Commercial / Industrial (mg/kg)			Note
	With Homegrown Produce			Without Homegrown Produce			1% SOM	2.5% SOM	5% SOM	
	1% SOM	2.5% SOM	5% SOM	1% SOM	2.5% SOM	5% SOM				
Acenaphthene	200	490	920	2000	3600	4900	75000	92000	100000	
Acenaphthylene	170	400	760	2000	3600	4900	76000	93000	100000	
Anthracene	2300	5300	9400	30000	34000	36000	520000	540000	540000	
Benzo(a)anthracene	7.5	11	13	12	14	15	170	170	180	
Benzo(a)pyrene	2.2	2.7	2.9	3.2	3.2	3.2	35	35	36	
Benzo(b)fluoranthene	2.6	3.3	3.6	4.0	4.0	4.1	45	45	45	
Benzo(k)fluoranthene	77	93	99	110	110	110	1200	1200	1200	
Benzo(g,h,i)perylene	320	340	350	360	360	360	3900	4000	4000	
Chrysene	15	22	26	30	31	32	350	350	360	
Dibenzo(a,h)anthracene	0.24	0.28	0.30	0.31	0.32	0.32	3.5	3.6	3.6	
Fluoranthene	280	560	820	1500	1600	1600	23000	23000	23000	
Fluorene	170	390	730	2200	3400	4000	60000	67000	70000	
Indeno(1,2,3-c,d)pyrene	27	36	40	45	46	46	510	510	510	
Naphthalene	1.0	2.3	4.6	1.0	2.4	4.7	110	260	510	
Phenanthrene	95	220	380	1300	1400	1500	22000	22000	23000	
Pyrene	620	1200	1900	3700	3800	3800	54000	54000	54000	

All concentration-based criteria are rounded to 2 significant figures.

The criteria assume a sandy soil type, which will be conservative for the great majority of soils (including made ground) encountered on historically contaminated sites.

Criteria have been derived by Sirius using CLEA version 1.06. Parameters for the land use cases are consistent with those given in Environment Agency (2009) "Updated Technical Background to the CLEA Model", report SC050021/SR3 but updated (where relevant) for respiration rate, exposure frequency for dermal contact outdoors, soil adherence factors for children, and plant uptake concentration factors given in CL:AIRE (2014) and Nathanail et al., (2015). No correction has been made for the "Top Two" crop types in the Residential with Homegrown Produce land use and the criteria will therefore be conservative in this regard.

Health Criteria Values (HCVs) and (except where specifically noted) chemical property data were obtained from Nathanail et al. (2015).



APPENDIX E

SIRIUS GENERIC ASSESSMENT CRITERIA



SIRIUS GENERIC ASSESSMENT CRITERIA

Context

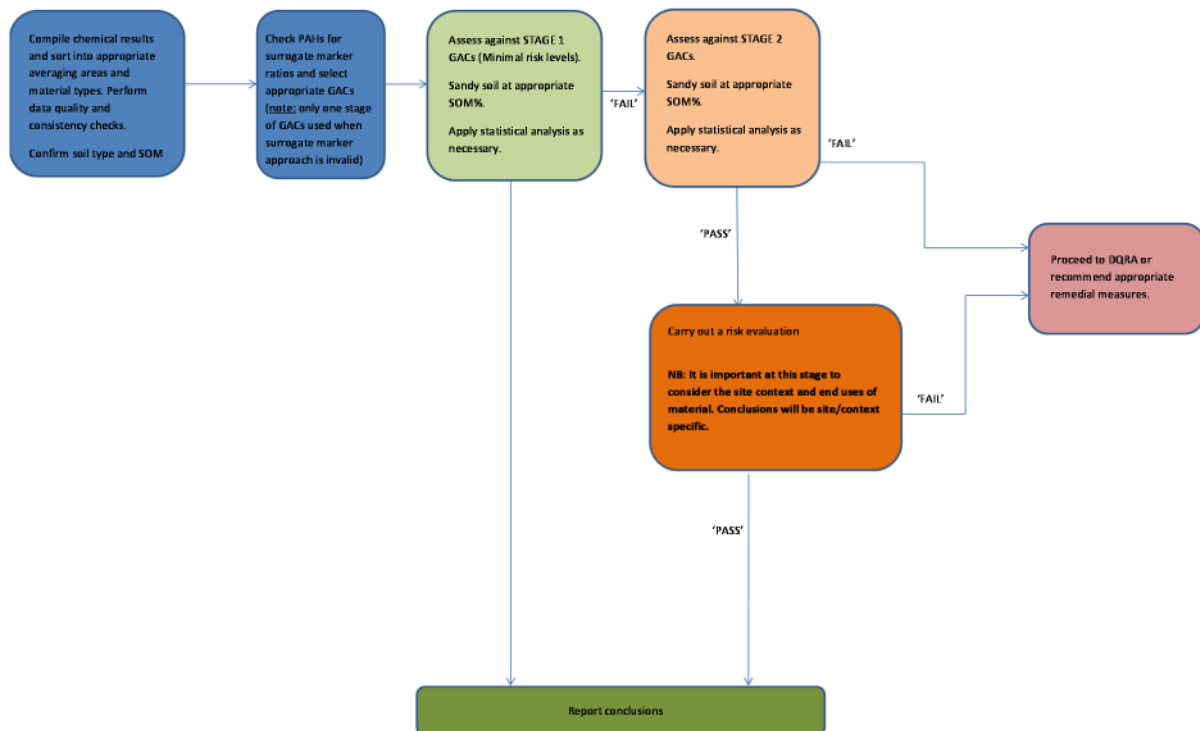
The framework for conducting site investigations, risk assessments and undertaking any necessary remedial works in the UK is provided by Environment Agency report CLR11 “Model Procedures for the Management of Contaminated Land”. This presents a phased approach to risk assessment, involving: identification and qualitative assessment of potential pollutant linkages (source-pathway-receptor relationships) by means of a Conceptual Site Model; Generic Quantitative Risk Assessment (GQRA) of potentially significant pollutant links by comparing contaminant concentrations with appropriate Generic Assessment Criteria (GAC) values; and, if required, a Detailed Quantitative Risk Assessment (DQRA) based on site-specific conditions.

Assessment of Risk to Human Health

Introduction

A staged approach to GQRA has been adopted by Sirius for the evaluation of soil concentration data, as shown schematically in Figure 1.

Figure 1. GQRA Process.





The first stage of GQRA comprises assessment of the data against GAC values derived using toxicological parameter values based on “minimum risk”. Any contaminants exceeding their GACs at this stage are further assessed against Stage 2 GACs, which have been derived using Low Level of Toxicological Concern (LLTC) criteria, where these are available.

With appropriate justification, a contaminant concentration that does not exceed the relevant Stage 2 GAC value may be considered to indicate that the land is “suitable for use”. The appropriate use of LLTC-based criteria within the planning regime is considered reasonable by government agencies, as most recently highlighted in the letter (dated 3rd September 2014) to all local authorities from Lord de Mauley, Parliamentary Under Secretary at DEFRA.

A narrative “risk evaluation” must therefore accompany any Stage 2 assessment to justify the conclusions drawn. Where appropriate, this may provide a basis for eliminating from further consideration those contaminants whose concentrations do not exceed the applicable Stage 2 GAC value.

For the specific case of lead, the Category 4 Screening Level criteria given in CL:AIRE (2014)¹ have been adopted directly as GACs, as these are considered to be based on expert interpretation of current toxicological evidence.

In some areas, background concentrations of lead, other metals and metalloids, and/or individual PAHs may exceed their respective GACs and it may be appropriate to consider relative site and background concentration data as part of a more detailed assessment of the data.

Derivation of GACs

Except where otherwise stated, GACs have been derived by Sirius using CLEA version 1.071.

The GAC values have been derived for a sandy soil type, which will be conservative for the majority of soils (including made ground) encountered on historically contaminated sites. For organic contaminants of concern, criteria have been derived for a number of Soil Organic Matter (SOM) contents.

Genotoxic PAHs are assessed by the “Surrogate Method” using benzo(a)pyrene. Further information on this approach is given below.

Unless specifically stated, chemical properties and Health Criteria Values (HCVs) were obtained from:

- Environment Agency Science Report SC050021 series;
- Nathanail *et al.* (2009) “The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment”, 2nd edition, Land Quality Press, Nottingham;
- CL:AIRE - AGS - EIC (2010) “Soil Generic Assessment Criteria for Human Health Risk Assessment”. CL:AIRE, London.

GACs for arsenic, benzene, benzo(a)pyrene, cadmium and chromium (VI) have been derived using the

¹ CL:AIRE (2014) “Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination”, Report SP1010, rev. 2.



Low Level of Toxicological Concern (LLTC) criteria given in CL:AIRE (2013). These criteria are considered a reasonable basis for assessment as they are still highly precautionary and definitely do not approach an intake level that could be defined as approaching Significant Possibility of Significant Harm to human health in the context of Part 2A of the Environmental Protection Act 1990. It must be further understood that the GACs derived will still incorporate a residual level of conservatism resulting from the exposure parameters used and the assumptions inherent in the model algorithms.

GACs for Genotoxic PAHs

Our approach to the assessment of genotoxic PAHs retains the use of benzo(a)pyrene as a surrogate marker. This approach for genotoxic PAHs is recommended by the HPA (2010)², which we consider to be the authoritative current guidance produced by a UK expert body and note that it was retained in the DEFRA Category 4 Screening Levels project (CL:AIRE, 2014).

The surrogate marker approach allows the assessment of the combined carcinogenic risk associated with all genotoxic PAHs³ present as a mixture within soil, even though detailed toxicological information for many of the individual compounds may be lacking. The approach is based on determining the risk posed by the genotoxic PAH mixture using the concentration of benzo(a)pyrene present as an indicator.

To use the GAC for benzo(a)pyrene as a surrogate marker, a number of requirements must be met (HPA, 2010):

- Benzo(a)pyrene must be present in all soil samples containing genotoxic PAHs for which this method of assessment is being used;
- A similar profile of the genotoxic PAHs relative to benzo(a)pyrene should be present in all of the samples being assessed;
- The PAH profile of PAHs in the soil samples should be similar to that present in the pivotal toxicity study on which toxicological criterion for benzo(a)pyrene was based (Culp et al., 1998⁴). Table 1 provides the basis for defining the acceptable range.

Data indicate that contaminated soils in the UK generally meet these criteria⁵ but the assessor must review their dataset before adopting this approach. If the above criteria are not met, then the surrogate marker approach must not be adopted and individual GAC or SSAC values are to be applied.

² HPA (2010) "Risk Assessment Approaches for Polycyclic Aromatic Hydrocarbons (PAHs)", version 5.

³ The genotoxic PAHs included in the USEPA PAH 16 analysis reported by analytical labs are: benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, benzo(a)pyrene, chrysene, dibenz[a,h]anthracene and indeno[1,2,3-c,d]pyrene.

⁴ Culp, S. *et al.* (1998) *Carcinogenesis*, 19, 117-124.

⁵ Bull, S. & Collins, C. (2013) *Environ. Geochem. Health*, 31, 101-109.



Table 1. Profile of Genotoxic PAHs Relative to Benzo(a)pyrene that are Considered Acceptable for Application of Benzo(a)pyrene as a Surrogate Marker.

PAH	Acceptable Ratio of PAH Concentration to Benzo(a)pyrene for Application of Surrogate Marker Assessment	
	Lower Limit	Upper Limit
Benz[a]anthracene	0.12	12.43
Benzo[b]fluoranthene	0.11	10.85
Benzo[k]fluoranthene	0.04	3.72
Benzo[g,h,i]perylene	0.08	8.22
Chrysene	0.12	11.61
Dibenz[a,h]anthracene	0.01	1.38
Indeno[1,2,3-c,d]pyrene	0.07	7.27

For further information see: HPA (2010).

Soil Criteria Set for Purposes Other Than Human Health Protection

The Sirius GACs for sulphate, total organic carbon (TOC) and calorific value are set on basis of risks other than human health and their exceedance does not indicate a potential risk to future site users:

- The GAC for sulphate content is based on potential detrimental effects on buried concrete⁶ and must be assessed with reference to the soil pH;
- The GAC for TOC content is provided for indicative assessment of disposal options if off-site landfill of soil were to be considered. This GAC is set at the 'Inert' waste threshold and should be considered as being applied for information purposes only;
- The GAC for calorific value is set to assist in an initial assessment of the potential fire risk posed by made ground or natural soils containing elevated concentrations of potentially combustible organic matter.

Assessment criteria more stringent than those for human health may be set for specific purposes, for example, elimination of nuisance odours or ensuring that potentially mobile free-phase organic products are not present.

Controlled Waters

The Environment Agency's "Remedial Targets Methodology" (2006) provides a framework for assessing the potential for pollution of controlled waters and for deriving remedial target concentrations in soil and groundwater.

There are no generic groundwater or surface water quality standards that are applicable to all sites. Drinking Water Standards and Environmental Quality Standards (EQS) are used by Sirius as assessment criteria where they are appropriate to the contaminant linkages under consideration. Given that these standards apply at the receptor point, this is a conservative approach for samples collected at a source or along a transport pathway.

⁶ BRE (2005) "Concrete in Aggressive Ground", Special Digest No. 1; 3rd Edition.



Soil Leachability

Sirius specifies that the analytical laboratory undertakes leachate preparation by BS EN 12475-2:2002. Where specific circumstances require a different method to be used, then this will be explained and justified within the report body text.

The results of leachate analysis are compared to the relevant GAC values for controlled waters.

The Sirius Group Stage 1 Generic Assessment Criteria for Soils

Revision:

20th August 2015

Parameter	Residential (mg/kg, unless otherwise stated)						Commercial / Industrial (mg/kg, unless otherwise stated)			Note
	With Homegrown Produce			Without Homegrown Produce			1% SOM	2.5% SOM	5% SOM	
	1% SOM	2.5% SOM	5% SOM	1% SOM	2.5% SOM	5% SOM				
Metals/Metalloids										
Arsenic (inorganic)	37			40			630			[1]
Cadmium	11			85			190			[2]
Chromium (III)	910			4000			8600			
Chromium (VI)	6.0			6.1			33			[3]
Copper	200			7100			68000			[4]
Lead	200			310			2300			[5]
Mercury (inorganic)	40			56			1100			[6]
Nickel	130			180			980			[7]
Selenium	250			430			12000			
Vanadium	410			1200			9000			
Zinc	450			40000			750000			[4]
Other Inorganics										
pH	<5 or >9			<5 or >9			<5 or >9			
Total Sulphate	2400			2400			2400			[8]
Water-Soluble Sulphate	0.5 g/l			0.5 g/l			0.5 g/l			[8]
Free Cyanide	34			34			1400			[9]
Organics										
PAHs										
Acenaphthene	200	490	920	2000	3600	4900	75000	92000	100000	
Acenaphthylene	170	400	760	2000	3600	4900	76000	93000	100000	
Anthracene	2300	5300	9400	30000	34000	36000	520000	540000	540000	[10]
Benzo(a)anthracene	Assessed using benzo(a)pyrene as a surrogate marker									[10]
Benzo(a)pyrene	2.1	2.1	2.2	2.3	2.3	2.3	27	27	27	[11]
Benzo(b)fluoranthene	Assessed using benzo(a)pyrene as a surrogate marker									[10]
Benzo(k)fluoranthene	Assessed using benzo(a)pyrene as a surrogate marker									[10]
Benzo(g,h,i)perylene	Assessed using benzo(a)pyrene as a surrogate marker									[10]
Chrysene	Assessed using benzo(a)pyrene as a surrogate marker									[10]
Dibenzo(a,h)anthracene	Assessed using benzo(a)pyrene as a surrogate marker									[10]
Fluoranthene	280	560	820	1500	1600	1600	23000	23000	23000	
Fluorene	170	390	730	2200	3400	4000	60000	67000	70000	
Indeno(1,2,3-c,d)pyrene	Assessed using benzo(a)pyrene as a surrogate marker									[10]
Naphthalene	1.0	2.3	4.6	1.0	2.4	4.7	110	260	510	
Phenanthrene	95	220	380	1300	1400	1500	22000	22000	23000	
Pyrene	620	1200	1900	3700	3800	3800	54000	54000	54000	
BTEX and related										
Benzene	0.063	0.13	0.24	0.16	0.30	0.38	15	28	49	
Toluene	100	240	460	370	830	1100	33000	68000	110000	
Ethylbenzene	26	62	120	34	81	110	3200	7400	14000	
Xylenes (total)	28	67	130	33	78	110	3200	7700	15000	[12]
1,2,4-trimethylbenzene	0.22	0.53	1.1	0.24	0.58	1.2	39	93	170	
Iso-propylbenzene	6.6	16	32	6.8	17	33	1300	3100	6100	
Propylbenzene	21	51	100	23	57	110	3800	9100	17000	
Styrene	6.9	16	32	21	49	93	3100	6100	9500	
TPH										
Aliphatic EC 5-6	24	41	68	24	41	48	2400	4100	6900	
Aliphatic EC >6-8	53	110	210	53	110	150	5300	11000	21000	
Aliphatic EC >8-10	13	31	61	13	31	43	1300	3100	6000	
Aliphatic EC >10-12	62	150	300	62	150	220	6100	15000	28000	
Aliphatic EC >12-16	510	1200	2300	510	1200	1700	43000	72000	85000	
Aliphatic EC >16-35	41000	70000	90000	42000	70000	80000	>1E6	>1E6	>1E6	[13]
Aromatic EC >5-7	53	110	200	150	300	380	15000	28000	48000	
Aromatic EC >7-8	100	240	460	370	820	1100	33000	68000	110000	
Aromatic EC >8-10	20	48	94	22	54	75	2200	5200	9800	
Aromatic EC >10-12	63	150	290	120	290	400	11000	22000	30000	
Aromatic EC >12-16	140	320	570	1100	1900	2100	35000	37000	37000	
Aromatic EC >16-21	260	540	840	1800	1900	1900	28000	28000	28000	
Aromatic EC >21-35	1100	1500	1700	1900	1900	1900	28000	28000	28000	
Chlorinated Organics										
Chlorobenzene	0.19	0.44	0.86	0.19	0.45	0.87	31	71	140	
Dichloromethane (DCM)	0.47	0.78	1.2	1.2	1.7	2.4	250	340	470	
1,1-dichloroethane (DCA)	1.4	2.4	4.0	1.4	2.4	4.1	260	420	690	
1,2-dichloroethane (DCA)	0.0031	0.0048	0.0076	0.0035	0.0053	0.0084	0.34	0.51	0.81	
1,1-dichloroethene (DCE)	0.15	0.26	0.45	0.15	0.26	0.46	24	43	74	
cis-1,2-dichloroethene (DCE)	0.066	0.12	0.20	0.069	0.12	0.21	14	23	38	
trans-1,2-dichloroethene (DCE)	0.11	0.21	0.38	0.12	0.22	0.39	21	37	65	
Pentachlorophenol	0.21	0.52	1.0	27	30	31	400	400	400	
1,1,1,2-tetrachloroethane	0.56	1.3	2.6	0.63	1.5	2.9	59	140	270	
1,1,2,2-tetrachloroethane	0.98	2.1	4.0	1.6	3.4	6.3	150	310	570	

The Sirius Group Stage 1 Generic Assessment Criteria for Soils

Parameter	Residential (mg/kg, unless otherwise stated)						Commercial / Industrial (mg/kg, unless otherwise stated)			Note
	With Homegrown Produce			Without Homegrown Produce			1% SOM	2.5% SOM	5% SOM	
	1% SOM	2.5% SOM	5% SOM	1% SOM	2.5% SOM	5% SOM				
Tetrachloroethene (PCE)	0.074	0.17	0.32	0.07	0.17	0.33	10	23	45	
Tetrachloromethane (CT)	0.011	0.024	0.046	0.011	0.024	0.046	1.6	3.6	6.9	
1,1,1-trichloroethane (TCA)	3.7	7.8	15	3.8	7.9	15	370	770	1400	
1,1,2-trichloroethane (TCA)	0.39	0.85	1.6	0.51	1.1	2.0	89	180	320	
Trichloroethene (TCE)	0.0070	0.015	0.028	0.0071	0.015	0.68	1.5	2.8	44	
Trichloromethane (CF)	0.43	0.80	1.4	0.48	0.89	53	98	170	300	
Vinyl Chloride	0.00034	0.00045	0.00062	0.00037	0.00048	0.00066	0.038	0.049	0.068	
Miscellaneous Organics										
Carbon disulphide	0.066	0.13	0.25	0.066	0.13	0.25	6.7	14	25	
Di-(2-ethylhexyl)-phthalate	290	660	1100	3900	4000	4100	85000	85000	8600	
MTBE	31	55	94	39	68	120	7400	12000	19000	
Phenol	110	190	330	420	440	440	440			[14]
Methylphenols (cresols), total	78	170	330	5600	8200	9900	160000	170000	18000	[15]
2,4-dimethylphenol (m-xylene)	18	43	82	200	430	720	15000	23000	28000	
Other Parameters										
TOC	3% w/w			3% w/w			3% w/w			[16]
Calorific Value	2 MJ/kg			2 MJ/kg			2 MJ/kg			[17]
Asbestos	Fibres present			Fibres present			Fibres present			

All concentration-based criteria are rounded to 2 significant figures.

The criteria assume a sandy soil type, which will be conservative for the great majority of soils (including made ground) encountered on historically contaminated sites.

Except where otherwise stated, criteria have been derived by Sirius using CLEA version 1.06. Parameters for the land use cases are consistent with those given in Environment Agency (2009) "Updated Technical Background to the CLEA Model", report SC050021/SR3 but updated (where relevant) for respiration rate, exposure frequency for dermal contact outdoors, soil adherence factors for children, and plant uptake concentration factors given in CL:AIRE (2014) and Nathanail *et al.*, (2015). No correction has been made for the "Top Two" crop types in the Residential with Homegrown Produce land use and the criteria will therefore be conservative in this regard.

Health Criteria Values (HCVs) and (except where specifically noted) chemical property data were obtained from:

- Environment Agency Science Report SC050021 Series;
- Nathanail *et al.* (2015);
- CL:AIRE-AGS-EIC (2010).

Footnotes

[1] Based on oral GAC as this is the lower GAC and reflects a cancer risk many orders of magnitude greater than for inhalation.

[2] Determined for lifetime exposure. Plant uptake concentration factors applied were as given in CL:AIRE (2014). The GAC values are based on data for soils having a pH value in the range 6-8; caution should be applied in applying them at pH values outside this range, especially at pH values <5.

[3] Both oral and inhalation HCVs are based on local toxicological effects and therefore the lowest (oral) GAC value is adopted.

[4] For the Residential with Homegrown Produce land use, the GAC values for Cu and Zn are based on potential phytotoxic effects and have been set at the maximum allowable concentrations for sewage sludge-amended soils presented in the "Sludge (Use in Agriculture) Regulations" (SI 1263/1989); these criteria may also be applied in any land use where plants are to be grown. The equivalent GAC values for human health protection in the Residential with Homegrown Produce land use are around an order of magnitude greater.

[5] The Category 4 Screening Levels for lead defined in CL:AIRE (2013) have been adopted directly to provide an acceptable basis for initial assessment of data. Where background concentrations of lead exceed the GAC value, then site-specific evaluation will be required.

[6] The SGV for mercury is based on inorganic mercury which represents the most common form encountered within the environment. This is considered appropriate for most sites as: "...the SGV for inorganic mercury can normally be compared with chemical analysis for total mercury content because the equilibrium concentrations of elemental and methylmercury compounds are likely to be very low" (Environment Agency report SC050021/Mercury SGV). Analysis and specific assessment for elemental or methylated forms of mercury will need to be considered if historical land use or site-specific factors indicate that these forms of mercury are likely to be present.

[7] Toxicological effects by inhalation are localised, therefore the lower of the GAC values for oral and inhalation HCVs have been adopted.

[8] BRE (2005). Sulphate is not considered to pose a potential risk to human health under normal circumstances – this GAC applies to construction cases only and is set at the upper limit for DS-1 Design Sulphate Class concrete.

[9] GAC calculated for acute risk. Further information can be provided upon request.

[10] The genotoxic PAHs (benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene) are routinely assessed using benzo(a)pyrene as a surrogate (HPA (2010) "Risk Assessment Approaches for Polycyclic Aromatic Hydrocarbons (PAHs)", version 5). Separate information on this approach is provided.

[11] Calculated using a 'minimum risk' oral index dose derived from the application of a 10,000x safety factor to the BMD10 presented in CL:AIRE (2014) for benzo(a)pyrene as a surrogate marker and the inhalation index dose specified in CL:ARE (2014) and Nathanail *et al.* (2015). As a conservative measure, the GAC is based on combined exposure pathways to account for systemic carcinogenic effects. Further information on the derivation can be provided upon request.

[12] For screening purposes, a single GAC has been set for total xylene. This is the lowest of the values calculated for the three individual xylene isomers.

[13] "No GAC" indicates that no value has been specified for this land use as the TDSI cannot be exceeded at achievable soil concentrations.

[14] 440mg/kg is the minimum concentration that is protective for direct skin contact with phenol (See Environment Agency SR050021/Phenol SGV) and is adopted where GACs for chronic exposure are higher.

[15] For screening purposes, a single GAC has been set for total methylphenol. This is the lowest of the values calculated for the three individual methylphenol isomers.

[16] The Hazardous Waste (England and Wales) Regulations 2005. TOC content in itself does not represent a potential risk to human health. This GAC is provided for indicative assessment of disposal options, in the case that off-site landfill of soil is undertaken. This GAC is specified at the "Inert" waste threshold and should be considered as for information purposes only.

[17] ICRL (1986) Guidance Note 61/84, 2nd Edition, Notes on the Fire Hazards of Contaminated Land. Calorific value is not an indication of direct human health risk but may be useful in assessment of the potential fire risk posed by made ground or natural soils containing elevated concentrations of potentially combustible organic matter.

The Sirius Group Stage 2 Generic Assessment Criteria for Soils

Revision:

20th August 2015

Parameter	Residential (mg/kg, unless otherwise stated)						Commercial / Industrial (mg/kg, unless otherwise stated)			Note
	With Homegrown Produce			Without Homegrown Produce			1% SOM	2.5% SOM	5% SOM	
	1% SOM	2.5% SOM	5% SOM	1% SOM	2.5% SOM	5% SOM				
Metals/Metalloids										
Arsenic (inorganic)	37			40			630			[1]
Cadmium	18			150			410			[2]
Chromium (III)	910			4000			8600			
Chromium (VI)	21			21			49			[3]
Copper	200			7100			68000			[4]
Lead	200			310			2300			[5]
Mercury (inorganic)	40			56			1100			[6]
Nickel	130			180			980			[7]
Selenium	250			430			12000			
Vanadium	410			1200			9000			
Zinc	450			40000			750000			[4]
Other Inorganics										
pH	<5 or >9			<5 or >9			<5 or >9			
Total Sulphate	2400			2400			2400			[8]
Water-Soluble Sulphate	0.5 g/l			0.5 g/l			0.5 g/l			[8]
Free Cyanide	34			34			1400			[9]
Organics										
PAHs										
Acenaphthene	200	490	920	2000	3600	4900	75000	92000	100000	
Acenaphthylene	170	400	760	2000	3600	4900	76000	93000	100000	
Anthracene	2300	5300	9400	30000	34000	36000	520000	540000	540000	[10]
Benzo(a)anthracene	Assessed using benzo(a)pyrene as a surrogate marker									
Benzo(a)pyrene	4.9	4.9	4.9	5.3	5.3	5.3	76	76	76	[11]
Benzo(b)fluoranthene	Assessed using benzo(a)pyrene as a surrogate marker									
Benzo(k)fluoranthene	Assessed using benzo(a)pyrene as a surrogate marker									
Benzo(g,h,i)perylene	Assessed using benzo(a)pyrene as a surrogate marker									
Chrysene	Assessed using benzo(a)pyrene as a surrogate marker									
Dibenzo(a,h)anthracene	Assessed using benzo(a)pyrene as a surrogate marker									
Fluoranthene	280	560	820	1500	1600	1600	23000	23000	23000	
Fluorene	170	390	730	2200	3400	4000	60000	67000	70000	
Indeno(1,2,3-c,d)pyrene	Assessed using benzo(a)pyrene as a surrogate marker									
Naphthalene	1.0	2.3	4.6	1.0	2.4	4.7	110	260	510	[10]
Phenanthrene	95	220	380	1300	1400	1500	22000	22000	23000	
Pyrene	620	1200	1900	3700	3800	3800	54000	54000	54000	
BTEX and related										
Benzene	0.13	0.27	0.50	0.37	0.71	1.30	15	29	51	[12]
Toluene	100	240	460	370	830	1100	33000	68000	110000	
Ethylbenzene	26	62	120	34	81	110	3200	7400	14000	
Xylenes (total)	28	67	130	33	78	110	3200	7700	15000	[13]
1,2,4-trimethylbenzene	0.22	0.53	1.1	0.24	0.58	1.2	39	93	170	
Iso-propylbenzene	6.6	16	32	6.8	17	33	1300	3100	6100	
Propylbenzene	21	51	100	23	57	110	3800	9100	17000	
Styrene	6.9	16	32	21	49	93	3100	6100	9500	
TPH										
Aliphatic EC 5-6	24	41	68	24	41	48	2400	4100	6900	
Aliphatic EC >6-8	53	110	210	53	110	150	5300	11000	21000	
Aliphatic EC >8-10	13	31	61	13	31	43	1300	3100	6000	
Aliphatic EC >10-12	62	150	300	62	150	220	6100	15000	28000	
Aliphatic EC >12-16	510	1200	2300	510	1200	1700	43000	72000	85000	
Aliphatic EC >16-35	41000	70000	90000	42000	70000	80000	>1E6	>1E6	>1E6	[14]
Aromatic EC >5-7	53	110	200	150	300	380	15000	28000	48000	
Aromatic EC >7-8	100	240	460	370	820	1100	33000	68000	110000	
Aromatic EC >8-10	20	48	94	22	54	75	2200	5200	9800	
Aromatic EC >10-12	63	150	290	120	290	400	11000	22000	30000	
Aromatic EC >12-16	140	320	570	1100	1900	2100	35000	37000	37000	
Aromatic EC >16-21	260	540	840	1800	1900	1900	28000	28000	28000	
Aromatic EC >21-35	1100	1500	1700	1900	1900	1900	28000	28000	28000	
Chlorinated Organics										
Chlorobenzene	0.19	0.44	0.86	0.19	0.45	0.87	31	71	140	
Dichloromethane (DCM)	0.47	0.78	1.2	1.2	1.7	2.4	250	340	470	
1,1-dichloroethane (DCA)	1.4	2.4	4.0	1.4	2.4	4.1	260	420	690	
1,2-dichloroethane (DCA)	0.0031	0.0048	0.0076	0.0035	0.0053	0.0084	0.34	0.51	0.81	
1,1-dichloroethene (DCE)	0.15	0.26	0.45	0.15	0.26	0.46	24	43	74	
cis-1,2-dichloroethene (DCE)	0.066	0.12	0.20	0.069	0.12	0.21	14	23	38	
trans-1,2-dichloroethene (DCE)	0.11	0.21	0.38	0.12	0.22	0.39	21	37	65	
Pentachlorophenol	0.21	0.52	1.0	27	30	31	400	400	400	
1,1,1,2-tetrachloroethane	0.56	1.3	2.6	0.63	1.5	2.9	59	140	270	
1,1,1,2-tetrachloroethane	1.0	2.1	4.0	1.6	3.4	6.3	150	310	570	
Tetrachloroethene (PCE)	0.074	0.17	0.32	0.074	0.17	0.33	10	23	45	
Tetrachloromethane (CT)	0.011	0.024	0.046	0.011	0.024	0.046	1.6	3.6	7	

The Sirius Group Stage 2 Generic Assessment Criteria for Soils

Parameter	Residential (mg/kg, unless otherwise stated)						Commercial / Industrial (mg/kg, unless otherwise stated)			Note
	With Homegrown Produce			Without Homegrown Produce			1% SOM	2.5% SOM	5% SOM	
	1% SOM	2.5% SOM	5% SOM	1% SOM	2.5% SOM	5% SOM				
1,1,1-trichloroethane (TCA)	3.7	7.8	15	3.8	7.9	15	370	770	1400	
1,1,2-trichloroethane (TCA)	0.39	0.85	1.6	0.51	1.1	2.0	89	180	320	
Trichloroethene (TCE)	0.0070	0.015	0.028	0.0071	0.015	0.68	1.5	2.8	44	
Trichloromethane (CF)	0.43	0.80	1.4	0.48	0.89	53	98	170	300	
Vinyl Chloride	0.00034	0.00045	0.00062	0.00037	0.00048	0.00066	0.038	0.049	0.07	
Miscellaneous Organics										
Carbon disulphide	0.066	0.13	0.25	0.066	0.13	0.25	6.7	14	25	
Di-(2-ethylhexyl)-phthalate	290	660	1100	3900	4000	4100	85000	85000	8600	
MTBE	31	55	94	39	68	120	7400	12000	19000	
Phenol	110	190	330	420	440	440	440			[15]
Methylphenols (cresols), total	78	170	330	5600	8200	9900	160000	170000	18000	[16]
2,4-dimethylphenol (m-xylene)	18	43	82	200	430	720	15000	23000	28000	
Other Parameters										
TOC	3% w/w			3% w/w			3% w/w			[17]
Calorific Value	2 MJ/kg			2 MJ/kg			2 MJ/kg			[18]
Asbestos	Fibres present			Fibres present			Fibres present			

All concentration-based criteria are rounded to 2 significant figures.

The criteria assume a sandy soil type, which will be conservative for the great majority of soils (including made ground) encountered on historically contaminated sites.

Except where otherwise stated, criteria have been derived by Sirius using CLEA version 1.06. Parameters for the land use cases are consistent with those given in Environment Agency (2009) "Updated Technical Background to the CLEA Model", report SC050021/SR3 but updated (where relevant) for respiration rate, exposure frequency for dermal contact outdoors, soil adherence factors for children, and plant uptake concentration factors given in CL:AIRE (2014) and Nathanail et al. (2015). No correction has been made for the "Top Two" crop types in the Residential with Homegrown Produce land use and the criteria will therefore be conservative in this regard.

Health Criteria Values (HCVs) and (except where specifically noted) chemical property data were obtained from:

- Environment Agency Science Report SC050021 Series;
- CL:AIRE (2014)
- Nathanail et al. (2015);
- CL:AIRE-AGS-EIC (2010).

Footnotes

[1] Determined using LLTC value and plant uptake concentration factors given in CL:AIRE (2014). The oral GAC is adopted as this is the lower value and reflects a cancer risk many orders of magnitude greater than for inhalation.

[2] Determined for lifetime exposure using the LLTC value and plant uptake concentration factors given in CL:AIRE (2014). The GAC values are based on data for soils having a pH value in the range 6-8; caution should be applied in applying them at pH values outside this range, especially at pH values <5.

[3] Determined using LLTC value and plant uptake concentration factors given in CL:AIRE (2014). Both oral and inhalation LLTCs are based on local toxicological effects and therefore the lowest (oral) GAC value is adopted.

[4] For the Residential with Homegrown Produce land use, the GAC values for Cu and Zn are based on potential phytotoxic effects and have been set at the maximum allowable concentrations for sewage sludge-amended soils presented in the "Sludge (Use in Agriculture) Regulations" (SI 1263/1989); these criteria may also be applied in any land use where plants are to be grown. The equivalent GAC values for human health protection in the Residential with Homegrown Produce land use are around an order of magnitude greater.

[5] The Category 4 Screening Levels for lead defined in CL:AIRE (2013) have been adopted directly to provide an acceptable basis for initial assessment of data. Where background concentrations of lead exceed the GAC value, then site-specific evaluation will be required.

[6] The SGV for mercury is based on inorganic mercury which represents the most common form encountered within the environment. This is considered appropriate for most sites as: "...the SGV for inorganic mercury can normally be compared with chemical analysis for total mercury content because the equilibrium concentrations of elemental and methylmercury compounds are likely to be very low" (SC050021/Mercury SGV). Analysis and specific assessment for elemental or methylated forms of mercury will need to be considered if historical land use or site-specific factors indicate that these forms of mercury are likely to be present.

[7] Toxicological effects by inhalation are localised, therefore the lower of the GAC values for oral and inhalation HCVs have been adopted.

[8] BRE (2005). Sulphate is not considered to pose a potential risk to human health under normal circumstances – this GAC applies to construction cases only and is set at the upper limit for DS-1 Design Sulphate Class concrete.

[9] GAC calculated for acute risk. Further information can be provided upon request.

[10] The genotoxic PAHs (benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene) are routinely assessed using benzo(a)pyrene as a surrogate (HPA (2010) "Risk Assessment Approaches for Polycyclic Aromatic Hydrocarbons (PAHs)", version 5). Separate information on this approach is provided.

[11] Determined using oral LLTC value (CL:AIRE, 2014) for assessment of all pathways to determine systemic carcinogenic effect; inhalation HCV and LLTC values are based on local pulmonary effects only and result in a less conservative GAC.

[12] Calculated using LLTC value (CL:AIRE, 2014).

[13] For screening purposes, a single GAC has been set for total xylene. This is the lowest of the values calculated for the three individual xylene isomers.

[14] "No GAC" indicates that no value has been specified for this land use as the TDSI cannot be exceeded at achievable soil concentrations.

[15] 440mg/kg is the minimum concentration that is protective for direct skin contact with phenol (See Environment Agency SR050021/Phenol SGV) and is adopted where GACs for chronic exposure are higher.

[16] For screening purposes, a single GAC has been set for total methylphenol. This is the lowest of the values calculated for the three individual methylphenol isomers.

[17] The Hazardous Waste (England and Wales) Regulations 2005. TOC content in itself does not represent a potential risk to human health. This GAC is provided for indicative assessment of disposal options, in the case that off-site landfill of soil is undertaken. This GAC is specified at the 'Inert' waste threshold and should be considered as for information purposes only.

[18] ICRCL (1986) Guidance Note 61/84, 2nd Edition, Notes on the Fire Hazards of Contaminated Land. Calorific value is not an indication of direct human health risk but may be useful in assessment of the potential fire risk posed by made ground or natural soils containing elevated concentrations of potentially combustible organic matter.

The Sirius Group

Stage 1 Generic Assessment Criteria for Soils in Public Open Space Settings

Revision: 20th August 2015

Parameter	Informal POS in Residential Setting (mg/kg, unless otherwise stated)			Park POS (mg/kg, unless otherwise stated)			Note
	1% SOM	2.5% SOM	5% SOM	1% SOM	2.5% SOM	5% SOM	
Metals/Metalloids							
Arsenic (inorganic)	79			170			[1]
Cadmium	120			560			[2]
Chromium (III)	1500			33000			
Chromium (VI)	7.7			220			[3]
Copper	200			200			[4]
Lead	630			1300			[5]
Mercury (inorganic)	120			240			[6]
Nickel	230			800			[7]
Selenium	1100			1800			
Vanadium	2000			5000			
Zinc	450			450			[4]
Other Inorganics							
pH	<5 or >9			<5 or >9			
Total Sulphate	2400			2400			[8]
Water-Soluble Sulphate	0.5 g/l			0.5 g/l			[8]
Free Cyanide	34			34			[9]
Organics							
PAHs							
Acenaphthene	15000	15000	15000	30000	30000	30000	
Acenaphthylene	15000	15000	15000	30000	30000	30000	
Anthracene	74000	74000	74000	150000	150000	150000	[10]
Benzo(a)anthracene	Assessed using benzo(a)pyrene as a surrogate marker						[10]
Benzo(a)pyrene	4.2	4.2	4.2	10	10	10	[11]
Benzo(b)fluoranthene	Assessed using benzo(a)pyrene as a surrogate marker						[10]
Benzo(k)fluoranthene	Assessed using benzo(a)pyrene as a surrogate marker						[10]
Benzo(g,h,i)perylene	Assessed using benzo(a)pyrene as a surrogate marker						[10]
Chrysene	Assessed using benzo(a)pyrene as a surrogate marker						[10]
Dibenzo(a,h)anthracene	Assessed using benzo(a)pyrene as a surrogate marker						[10]
Fluoranthene	3100	3100	3100	6300	6300	6400	
Fluorene	9900	9900	9900	20000	20000	20000	
Indeno(1,2,3-c,d)pyrene	Assessed using benzo(a)pyrene as a surrogate marker						[10]
Naphthalene	3500	3800	4000	1300	1800	2400	
Phenanthrene	3100	3100	3100	6300	6300	6300	
Pyrene	7400	7400	7400	15000	15000	15000	
BTEX and related							
Benzene	71	72	72	94	100	110	
Toluene	55000	56000	56000	90000	97000	100000	
Ethylbenzene	23000	24000	24000	18000	23000	28000	
Xylenes (total)	38000	40000	41000	19000	26000	33000	[12]
1,2,4-trimethylbenzene	240	240	240	220	280	320	
Iso-propylbenzene	24000	24000	24000	14000	20000	24000	
Propylbenzene	24000	24000	25000	27000	33000	37000	
Styrene	3000	3000	3000	5600	5800	5900	
TPH							
Aliphatic EC 5-6	520000	550000	570000	120000	150000	200000	
Aliphatic EC >6-8	560000	580000	600000	170000	250000	330000	
Aliphatic EC >8-10	12000	12000	12000	16000	19000	22000	
Aliphatic EC >10-12	13000	13000	13000	22000	24000	24000	
Aliphatic EC >12-16	13000	13000	13000	25000	25000	26000	
Aliphatic EC >16-35	250000	250000	250000	470000	480000	490000	
Aromatic EC >5-7	55000	55000	55000	78000	87000	93000	
Aromatic EC >7-8	55000	55000	55000	89000	97000	100000	
Aromatic EC >8-10	5000	5000	5000	7700	8800	9300	
Aromatic EC >10-12	5000	5000	5000	9400	9800	10000	
Aromatic EC >12-16	5000	5000	5000	10000	10000	10000	
Aromatic EC >16-21	3800	3800	3800	7700	7800	7800	
Aromatic EC >21-35	3800	3800	3800	7800	7900	7900	
Chlorinated Organics							
Chlorobenzene	8800	10000	12000	1500	2200	3000	
Dichloromethane (DCM)	750	750	750	1400	1400	1400	
1,1-dichloroethane (DCA)	42000	43000	45000	11000	14000	17000	
1,2-dichloroethane (DCA)	28	28	28	22	25	28	
1,1-dichloroethene (DCE)	9200	9600	10000	1900	2500	3200	
cis-1,2-dichloroethene (DCE)	1200	1200	1300	390	490	610	
trans-1,2-dichloroethene (DCE)	3500	3700	3800	910	1200	1500	
Pentachlorophenol	180	180	180	250	270	280	
1,1,1,2-tetrachloroethane	1400	1400	1400	1600	1900	2100	
1,1,1,2,2-tetrachloroethane	1400	1400	1400	1900	2100	2300	
Tetrachloroethene (PCE)	1300	1400	1400	900	1200	1500	
Tetrachloromethane (CT)	790	850	890	210	310	410	
1,1,1-trichloroethane (TCA)	120000	130000	130000	63000	84000	100000	

The Sirius Group

Stage 1 Generic Assessment Criteria for Soils in Public Open Space Settings

Parameter	Informal POS in Residential Setting (mg/kg, unless otherwise stated)			Park POS (mg/kg, unless otherwise stated)			Note
	1% SOM	2.5% SOM	5% SOM	1% SOM	2.5% SOM	5% SOM	
1,1,2-trichloroethane (TCA)	960	970	980	760	950	1100	
Trichloroethene (TCE)	110	120	120	76	98	120	
Trichloromethane (CF)	2400	2500	2500	2700	2900	3100	
Vinyl Chloride	3.5	3.5	3.5	5.0	5.2	5.5	
Miscellaneous Organics							
Carbon disulphide	9000	10000	11000	1500	2100	2800	
Di-(2-ethylhexyl)-phthalate	9700	9700	9700	16000	16000	16000	
MTBE	73000	73000	73000	70000	81000	92000	
Phenol	440			440			[13]
Methylphenols (cresols), total	25000	25000	25000	47000	49000	50000	[14]
2,4-dimethylphenol (m-xyleneol)	5000	5000	5000	8700	9200	9600	
Other Parameters							
TOC	3% w/w			3% w/w			[15]
Calorific Value	2 MJ/kg			2 MJ/kg			[16]
Asbestos	Fibres present			Fibres present			

The POS cases defined are based on the specific Conceptual Site Models given in CL:AIRE (2014). For these GACs to be applied, the relevant conceptual model must be valid for the site under assessment.

All concentration-based criteria are rounded to 2 significant figures.

The criteria assume a sandy soil type, which will be conservative for the great majority of soils (including made ground) encountered on historically contaminated sites.

Except where otherwise stated, criteria have been derived by Sirius using CLEA version 1.06. Parameters for the land use cases are consistent with those given in Environment Agency (2009) "Updated Technical Background to the CLEA Model", report SC050021/SR3 but updated (where relevant) for respiration rate, exposure frequency for dermal contact outdoors, soil adherence factors for children, and plant uptake concentration factors given in CL:AIRE (2014) and Nathanail et al. (2015). No correction has been made for the "Top Two" crop types in the Residential with Homegrown Produce land use and the criteria will therefore be conservative in this regard.

Health Criteria Values (HCVs) and (except where specifically noted) chemical property data were obtained from:

- Environment Agency Science Report SC050021 Series;
- Nathanail et al. (2015);

Footnotes

- [1] Based on oral GAC as this is the lower GAC and reflects a cancer risk many orders of magnitude greater than for inhalation.
- [2] Determined for lifetime exposure. Plant uptake concentration factors applied were as given in CL:AIRE (2014). The GAC values are based on data for soils having a pH value in the range 6-8; caution should be applied in applying them at pH values outside this range, especially at pH values <5.
- [3] Both oral and inhalation HCVs are based on local toxicological effects and therefore the lowest (oral) GAC value is adopted.
- [4] The GAC values for Cu and Zn are based on potential phytotoxic effects and have been set at the maximum allowable concentrations for sewage sludge-amended soils presented in the "Sludge (Use in Agriculture) Regulations" (SI 1263/1989); these criteria may also be applied in any land use where plants are to be grown. The GAC values for human health protection are significantly higher.
- [5] The Category 4 Screening Levels for lead defined in CL:AIRE (2014) have been adopted directly to provide an acceptable basis for initial assessment of data. Where background concentrations of lead exceed the GAC value, then site-specific evaluation will be required.
- [6] The SGV for mercury is based on inorganic mercury which represents the most common form encountered within the environment. This is considered appropriate for most sites as: "...the SGV for inorganic mercury can normally be compared with chemical analysis for total mercury content because the equilibrium concentrations of elemental and methylmercury compounds are likely to be very low" (Environment Agency report SC050021/Mercury SGV). Analysis and specific assessment for elemental or methylated forms of mercury will need to be considered if historical land use or site-specific factors indicate that these forms of mercury are likely to be present.
- [7] Toxicological effects by inhalation are localised; consistent with the SGV for nickel, the lower of the GAC values for oral and inhalation HCVs have been adopted in each case.
- [8] BRE (2005). Sulphate is not considered to pose a potential risk to human health under normal circumstances – this GAC applies to cases where concrete structures may be constructed within the soil and is set at the upper limit for DS-1 Design Sulphate Class concrete.
- [9] GAC calculated for acute risk. Further information can be provided upon request.
- [10] The genotoxic PAHs (benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene) are routinely assessed using benzo(a)pyrene as a surrogate (HPA (2010) "Risk Assessment Approaches for Polycyclic Aromatic Hydrocarbons (PAHs)", version 5). Separate information on this approach is provided.
- [11] Calculated using a 'minimum risk' oral index dose derived from the application of a 10,000x safety factor to the BMD10 presented in CL:AIRE (2014) for benzo(a)pyrene as a surrogate marker and the inhalation index dose specified in CL:AIRE (2014) and Nathanail et al. (2015). As a conservative measure, the GAC is based on combined exposure pathways to account for systemic carcinogenic effects. Further information on the derivation can be provided upon request.
- [12] For screening purposes, a single GAC has been set for total xylene. This is the lowest of the values calculated for the three individual xylene isomers.
- [13] 440mg/kg is the minimum concentration that is protective for direct skin contact with phenol (See Environment Agency SR050021/Phenol SGV) and is adopted where GACs for chronic exposure are higher.
- [14] For screening purposes, a single GAC has been set for total methylphenol. This is the lowest of the values calculated for the three individual methylphenol isomers.
- [15] The Hazardous Waste (England and Wales) Regulations 2005. TOC content in itself does not represent a potential risk to human health. This GAC is provided for indicative assessment of disposal options, in the case that off-site landfill of soil is undertaken. This GAC is specified at the 'Inert' waste threshold and should be considered as for information purposes only.
- [16] ICRCL (1986) Guidance Note 61/84, 2nd Edition, Notes on the Fire Hazards of Contaminated Land. Calorific value is not an indication of direct human health risk but may be useful in assessment of the potential fire risk posed by made ground or natural soils containing elevated concentrations of potentially combustible organic matter.

The Sirius Group

Stage 2 Generic Assessment Criteria for Soils in Public Open Space Settings

Revision: 20th August 2015

Parameter	Informal POS in Residential Setting (mg/kg, unless otherwise stated)			Park POS (mg/kg, unless otherwise stated)			Note
	1% SOM	2.5% SOM	5% SOM	1% SOM	2.5% SOM	5% SOM	
Metals/Metalloids							
Arsenic (inorganic)	79			170			[1]
Cadmium	220			840			[2]
Chromium (III)	1500			33000			
Chromium (VI)	23			250			[3]
Copper	200			200			[4]
Lead	630			1300			[5]
Mercury (inorganic)	120			240			[6]
Nickel	230			800			[7]
Selenium	1100			1800			
Vanadium	2000			5000			
Zinc	450			450			[4]
Other Inorganics							
pH	<5 or >9			<5 or >9			
Total Sulphate	2400			2400			[8]
Water-Soluble Sulphate	0.5 g/l			0.5 g/l			[8]
Free Cyanide	34			34			[9]
Organics							
PAHs							
Acenaphthene	15000	15000	15000	30000	30000	30000	
Acenaphthylene	15000	15000	15000	30000	30000	30000	
Anthracene	74000	74000	74000	150000	150000	150000	[10]
Benzo(a)anthracene	Assessed using benzo(a)pyrene as a surrogate marker						[10]
Benzo(a)pyrene	10	10	10	21	21	22	[11]
Benzo(b)fluoranthene	Assessed using benzo(a)pyrene as a surrogate marker						[10]
Benzo(k)fluoranthene	Assessed using benzo(a)pyrene as a surrogate marker						[10]
Benzo(g,h,i)perylene	Assessed using benzo(a)pyrene as a surrogate marker						[10]
Chrysene	Assessed using benzo(a)pyrene as a surrogate marker						[10]
Dibenzo(a,h)anthracene	Assessed using benzo(a)pyrene as a surrogate marker						[10]
Fluoranthene	3100	3100	3100	6300	6300	6400	
Fluorene	9900	9900	9900	20000	20000	20000	
Indeno(1,2,3-c,d)pyrene	Assessed using benzo(a)pyrene as a surrogate marker						[10]
Naphthalene	3500	3800	4000	1300	1800	2400	
Phenanthrene	3100	3100	3100	6300	6300	6300	
Pyrene	7400	7400	7400	15000	15000	15000	
BTEX and related							
Benzene	140	140	140	140	160	180	[12]
Toluene	55000	56000	56000	90000	97000	100000	
Ethylbenzene	23000	24000	24000	18000	23000	28000	
Xylenes (total)	38000	40000	41000	19000	26000	33000	[13]
1,2,4-trimethylbenzene	240	240	240	220	280	320	
Iso-propylbenzene	24000	24000	24000	14000	20000	24000	
Propylbenzene	24000	24000	25000	27000	33000	37000	
Styrene	3000	3000	3000	5600	5800	5900	
TPH							
Aliphatic EC 5-6	520000	550000	570000	120000	150000	200000	
Aliphatic EC >6-8	560000	580000	600000	170000	250000	330000	
Aliphatic EC >8-10	12000	12000	12000	16000	19000	22000	
Aliphatic EC >10-12	13000	13000	13000	22000	24000	24000	
Aliphatic EC >12-16	13000	13000	13000	25000	25000	26000	
Aliphatic EC >16-35	250000	250000	250000	470000	480000	490000	
Aromatic EC >5-7	55000	55000	55000	78000	87000	93000	
Aromatic EC >7-8	55000	55000	55000	89000	97000	100000	
Aromatic EC >8-10	5000	5000	5000	7700	8800	9300	
Aromatic EC >10-12	5000	5000	5000	9400	9800	10000	
Aromatic EC >12-16	5000	5000	5000	10000	10000	10000	
Aromatic EC >16-21	3800	3800	3800	7700	7800	7800	
Aromatic EC >21-35	3800	3800	3800	7800	7900	7900	
Chlorinated Organics							
Chlorobenzene	8800	10000	12000	1500	2200	3000	
Dichloromethane (DCM)	750	750	750	1400	1400	1400	
1,1-dichloroethane (DCA)	42000	43000	45000	11000	14000	17000	
1,2-dichloroethane (DCA)	28	28	28	22	25	28	
1,1-dichloroethene (DCE)	9200	9600	10000	1900	2500	3200	
cis-1,2-dichloroethene (DCE)	1200	1200	1300	390	490	610	
trans-1,2-dichloroethene (DCE)	3500	3700	3800	910	1200	1500	
Pentachlorophenol	180	180	180	250	270	280	
1,1,1,2-tetrachloroethane	1400	1400	1400	1600	1900	2100	
1,1,1,2,2-tetrachloroethane	1400	1400	1400	1900	2100	2300	
Tetrachloroethene (PCE)	1300	1400	1400	900	1200	1500	
Tetrachloromethane (CT)	790	850	890	210	310	410	
1,1,1-trichloroethane (TCA)	120000	130000	130000	63000	84000	100000	

The Sirius Group

Stage 2 Generic Assessment Criteria for Soils in Public Open Space Settings

Parameter	Informal POS in Residential Setting (mg/kg, unless otherwise stated)			Park POS (mg/kg, unless otherwise stated)			Note
	1% SOM	2.5% SOM	5% SOM	1% SOM	2.5% SOM	5% SOM	
1,1,2-trichloroethane (TCA)	960	970	980	760	950	1100	
Trichloroethene (TCE)	110	120	120	76	98	120	
Trichloromethane (CF)	2400	2500	2500	2700	2900	3100	
Vinyl Chloride	3.5	3.5	3.5	5.0	5.2	5.5	
Miscellaneous Organics							
Carbon disulphide	9000	10000	11000	1500	2100	2800	
Di-(2-ethylhexyl)-phthalate	9700	9700	9700	16000	16000	16000	
MTBE	73000	73000	73000	70000	81000	92000	
Phenol	440			440			[14]
Methylphenols (cresols), total	25000	25000	25000	47000	49000	50000	[15]
2,4-dimethylphenol (m-xyleneol)	5000	5000	5000	8700	9200	9600	
Other Parameters							
TOC	3% w/w			3% w/w			[16]
Calorific Value	2 MJ/kg			2 MJ/kg			[17]
Asbestos	Fibres present			Fibres present			

The POS cases defined are based on the specific Conceptual Site Models given in CL:AIRE (2014). For these GACs to be applied, the relevant conceptual model must be valid for the site under assessment.

All concentration-based criteria are rounded to 2 significant figures.

The criteria assume a sandy soil type, which will be conservative for the great majority of soils (including made ground) encountered on historically contaminated sites.

Except where otherwise stated, criteria have been derived by Sirius using CLEA version 1.06. Parameters for the land use cases are consistent with those given in Environment Agency (2009) "Updated Technical Background to the CLEA Model", report SC050021/SR3 but updated (where relevant) for respiration rate, exposure frequency for dermal contact outdoors, soil adherence factors for children, and plant uptake concentration factors given in CL:AIRE (2014) and Nathanail et al. (2015). No correction has been made for the "Top Two" crop types in the Residential with Homegrown Produce land use and the criteria will therefore be conservative in this regard.

Health Criteria Values (HCVs) and (except where specifically noted) chemical property data were obtained from:

- Environment Agency Science Report SC050021 Series;
- CL:AIRE (2014);
- Nathanail et al. (2015);
- CL:AIRE-AGS-EIC (2010).

Footnotes

[1] Determined using LLTC value and plant uptake concentration factors given in CL:AIRE (2014). The oral GAC is adopted as this is the lower value and reflects a cancer risk many orders of magnitude greater than for inhalation.

[2] Determined for lifetime exposure using the LLTC value given in CL:AIRE (2014).

[3] Determined using LLTC value given in CL:AIRE (2014). Both oral and inhalation LLTCs are based on local toxicological effects and therefore the lowest (oral) GAC value is adopted.

[4] The GAC values for Cu and Zn are based on potential phytotoxic effects and have been set at the maximum allowable concentrations for sewage sludge-amended soils presented in the "Sludge (Use in Agriculture) Regulations" (SI 1263/1989); these criteria may also be applied in any land use where plants are to be grown. The GAC values for human health protection are significantly higher.

[5] The Category 4 Screening Levels for lead defined in CL:AIRE (2014) have been adopted directly to provide an acceptable basis for initial assessment of data. Where background concentrations of lead exceed the GAC value, then site-specific evaluation will be required.

[6] The SGV for mercury is based on inorganic mercury which represents the most common form encountered within the environment. This is considered appropriate for most sites as: "...the SGV for inorganic mercury can normally be compared with chemical analysis for total mercury content because the equilibrium concentrations of elemental and methylmercury compounds are likely to be very low" (SC050021/Mercury SGV). Analysis and specific assessment for elemental or methylated forms of mercury will need to be considered if historical land use or site-specific factors indicate that these forms of mercury are likely to be present.

[7] Toxicological effects by inhalation are localised; consistent with the SGV for nickel, the lower of the GAC values for oral and inhalation HCVs have been adopted in each case.

[8] BRE (2005). Sulphate is not considered to pose a potential risk to human health under normal circumstances – this GAC applies to cases where concrete structures may be constructed within the soil and is set at the upper limit for DS-1 Design Sulphate Class concrete.

[9] GAC calculated for acute risk. Further information can be provided upon request.

[10] The genotoxic PAHs (benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene) are routinely assessed using benzo(a)pyrene as a surrogate (HPA (2010) "Risk Assessment Approaches for Polycyclic Aromatic Hydrocarbons (PAHs)", version 5). Separate information on this approach is provided.

[11] Determined using oral LLTC value (CL:AIRE, 2014) for assessment of all pathways to determine systemic carcinogenic effect; inhalation HCV and LLTC values are based on local pulmonary effects only and result in a less conservative GAC.

[12] Calculated using LLTC value (CL:AIRE, 2014).

[13] For screening purposes, a single GAC has been set for total xylene. This is the lowest of the values calculated for the three individual xylene isomers.

[14] The GAC is based on the threshold protective for acute effects of skin contact with phenol (See SR050021/Phenol SGV). The chronic exposure GAC is significantly higher.

[15] For screening purposes, a single GAC has been set for total methylphenol. This is the lowest of the values calculated for the three individual methylphenol isomers.

[16] The Hazardous Waste (England and Wales) Regulations 2005. TOC content in itself does not represent a potential risk to human health. This GAC is provided for indicative assessment of disposal options, in the case that off-site landfill of soil is undertaken. This GAC is specified at the 'Inert' waste threshold and should be considered as for information purposes only.

[17] ICRCCL (1986) Guidance Note 61/84, 2nd Edition, Notes on the Fire Hazards of Contaminated Land. Calorific value is not an indication of direct human health risk but may be useful in assessment of the potential fire risk posed by made ground or natural soils containing elevated concentrations of potentially combustible organic matter.



GAC VALUES FOR CONTROLLED WATERS IN ENGLAND AND WALES

Parameter	GAC (µg/l, unless stated)			Notes
	Inland waters		Coastal and transition waters	
	EQS	DWS	EQS	
Metals and metalloids (dissolved)				
Arsenic	50	10	25	1
Cadmium	See separate table	5	0.2	1, 2
Chromium (total)	4.7	50	N.A.	1, 3
Copper	1.0 (bioavailable)	2000	3.76	1, 4
Lead	1.2 (bioavailable)	10	1.3	1, 4
Mercury	0.07	1.0	0.07	1, 4, 5
Nickel	4.0 (bioavailable)	20	8.6	1, 4
Zinc	10.9 (bioavailable) + background	5000	6.8 + background	1, 4, 6
Misc. inorganics				
Ammonia (total, as N)	See separate table	N.A.	N.A.	7
Ammonia (total, as NH ₄ ⁺)	N.A.	500	N.A.	
Ammonia (un-ionised (NH ₃), as N)	N.A.	N.A.	21	7
Cyanide (free)	10	50	10	
Sulphate	N.A.	250 mg/l	N.A.	8
Petroleum hydrocarbons and related				
TPH (speciated analysis) <i>per fraction</i>	10	10	10	9, 10
Benzene	10	1.0	8	
Toluene	74	700	74	11
Xylenes (sum)	N.A.	500	N.A.	11
MTBE	2600	200	2600	12, 13
PAHs				
Anthracene	0.1	N.A.	0.1	
Benzo(b)fluoranthene + Benzo(k)fluoranthene (sum)	N.A.	Sum of 4 = 0.1	N.A.	
Benzo(g,h,i)perylene + indeno(1,2,3-c,d)pyrene (sum)	N.A.		N.A.	
Benzo(a)pyrene	1.7E-04	0.01	1.7E-04	
Fluoranthene	0.0063	N.A.	0.0063	
Naphthalene	2.0	N.A.	2.0	
Phenol				
Phenol	7.7	N.A.	7.7	
Chlorinated organics				
Dichloromethane	20	N.A.	20	
Trichloromethane (chloroform)	2.5	100	2.5	14
Tetrachloromethane (carbon tetrachloride)	12	3.0	12	
1,2-dichloroethane (1,2-DCA)	10	3.0	10	

Cadmium - inland waters EQS	
Hardness (as mg/l CaCO ₃)	EQS (µg/l)
<40	0.08
40-50	0.08
50-100	0.09
100-200	0.15
>=200	0.25

Ammonia - inland waters EQS		
Alkalinity (as mg/l CaCO ₃)	Altitude	EQS (µg/l)
<10	Any	300
10-50	Any	300
50-100	<80m	600
50-100	>80m	300
100-200	<80m	600
100-200	>80m	300
>200	Any	600



Parameter	GAC (µg/l, unless stated)			Notes
	Inland waters		Coastal and transition waters	
	EQS	DWS	EQS	
1,1,1-trichloroethane (1,1,1-TCA)	100	N.A.	100	
1,1,2-trichloroethane (1,1,2-TCA)	400	N.A.	300	
Trichloroethene (TCE)	10	Sum of 2 = 10	10	
Tetrachloroethene (PCE)	10		10	
Vinyl chloride	N.A.	0.5	N.A.	

Notes referenced in table:

1. Metals and metalloid EQS relate to dissolved contamination only (i.e. analysis of filtered samples).
2. Inland waters EQS for cadmium is dependent upon hardness or alkalinity of the receiving surface water. See separate table.
3. Separate EQS standards exist for Cr III and CrVI in fresh water. The fresh water Cr III has been value adopted as the screening value for total Cr analysis as it is normally the predominant form in solution. Specific EQS for Cr VI (3.4µg/l in freshwater; 0.6µg/l in transition and coastal waters) must be applied where relevant.
4. The bioavailable concentration of copper, nickel and zinc in fresh water is dependent upon the pH, DOC and calcium data for the receiving surface water. These data should be collected whenever possible to calculate an equivalent GAC for total metal concentration using the UKTAG m-BAT spreadsheet model. Although the standard indicates that lead should be assessed on a bioavailable basis, no tool is currently available and this criterion should be applied as-is for screening purposes.
5. The value for mercury is the Maximum Acceptable Concentration (MAC) as no annual average EQS is specified in the legislation.
6. The EQS for zinc may be adjusted for the ambient uncontaminated background concentration in the receiving surface water where data are available.
7. EQS for ammonia in inland waters depends on the hardness and altitude of the receiving water body - see separate table. The criteria given here are based on the attainment of "good" chemical quality in the water body.
8. No EQS for sulphate appears in the referenced legislation.
9. No concentration-based EQS values currently exist for TPH. In the absence of specific criteria, our recent discussions with the Environment Agency have led us to adopt 10µg/l for each individual fraction determined by speciated TPH (TPHCWG) analysis.
10. No concentration-based DWS exists for TPH. A sum TPH concentration of 200µg/l defines the DW2 Class threshold limit in the Surface Water (Abstraction for Drinking Water) (Classification) Regulations 1996; DW2 waters are generally suitable for abstraction as drinking water supplies, subject to standard filtration and chemical treatment. We therefore consider that the 10µg/l criterion for each fraction provides a reasonable and proportionate basis for the initial assessment of risk posed to off-site groundwater and/or surface water potable abstractions that may be impacted at a downgradient abstraction point by TPH contamination originating from the site.
11. The drinking water-based criteria are from World Health Organisation (WHO) Guidelines for Drinking Water Quality, 2008. Taint may result at lower concentrations.
12. The "EQS" given here for MTBE is the PNEC value for fresh and sea water life given in: EU Risk Assessment Report (2002) MTBE, 3rd Priority List, volume 19.
13. DWS for MTBE is a 5-fold dilution of the USEPA (1997) Drinking Water Advisory value for taint, EPA-822-F-97-009. Toxicological thresholds are significantly higher.
14. Sum trihalomethanes limit for drinking water is 100µg/l but chloroform is only compound of this class normally encountered at contaminated sites.

Sources and general comments

Unless otherwise stated, EQS-based GACs are annual average surface water quality criteria given in Table 1 within Part 3 (Priority Substances) or long-term average criteria given in Table 1 within Part 2 (Specific Pollutants) of The Water Framework Directive (Standards and Classification) Directions (England and Wales), 2015.

Unless otherwise stated, drinking water standard-based GACs are taken from the Water Supply (Water Quality) Regulations 2016, and relate to concentration at the supply point and/or consumers' taps.

This list presents recommended GAC values for commonly monitored analytes but is not exhaustive. See the above-referenced legislation for the full lists of criteria.