8.16 SOIL RESOURCE SURVEY

SOIL RESOURCE SURVEY

MARBLE HILL PARK

TWICKENHAM, LONDON

Prepared on behalf of:

ENGLISH HERITAGE

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CONTENTS

1.0 INTRODUCTION

Tim O'Hare Associates LLP was commissioned by English Heritage to undertake a Soil Resource Survey at Marble Hill Park, Twickenham, London.

Our authority to carry out the work is contained in email correspondence from Ndai Halisch of English Heritage, dated 30/09/2016.

1.1 Purpose

In accordance with the supplied *Soil Resource Survey: Specification* produced by J&L Gibbons LLP, on behalf of English Heritage, a Soil Resource Survey was required within Marble Hill Park to inform the landscape design development. The survey was to ascertain the nature and horticultural quality of the existing site soils in selected locations, together with the provision of advice on how to improve the soils for landscape works as necessary. The survey was to provide information to support the emerging design for the Park and to highlight areas where more detailed investigation will be required.

1.2 Actions

Tim O'Hare Associates LLP has evaluated the nature of the soils by firstly conducting a desk study review of available information (soil and geological maps). This was followed by assessing a number of key chemical and physical soil properties by a combination of on-site investigation and laboratory analysis.

This report issues the findings of the soil survey in accordance with the requirements of Clause 2.2 of the supplied specification, including:

- site observations and soil descriptions;
- results and interpretation of all analyses;
- discussion on soil quality and suitability for planting;
- recommendations for tree planting, including specifications for imported materials.

2.0 DESK STUDY REVIEW

The following sources of information were consulted for the desk study review:

- British Geological Survey website – Geology of Britain;
- Soil Map of England and Wales – Sheet 6 South East England (1:250,000).

2.1 Geology

The *British Geological Survey* website (*Geology of Britain 1:50,000*) describes the site geology (Bedrock and Superficial Deposits) as described below.

Bedrock

The bedrock was described as *London Clay Formation – Clay and Silt*. This consists of sedimentary bedrock formed approximately 34 to 56 million years ago in the Palaeogene Period in a local environment previously dominated by deep seas.

Superficial Deposits

Superficial deposits described as *Langley Silt Member – Clay and Silt* are located over the majority of the site. These are predominantly wind-blown deposits formed up to 2 million years ago in the Quaternary Period.

In the southern part of the site towards the River Thames, superficial deposits of *Alluvium – Clay, Silty, Peaty and Sandy* are recorded. These are deposits formed up to 2 million years ago in the Quaternary Period in local environments dominated by rivers.

2.2 Soil Map of England and Wales

The Soil Map of England and Wales (1:250,000 scale) classifies the soils of this site as:

Unsurveyed	Mainly urban and industrial areas.

Soils within urban and industrial areas are potentially subject to a wide range of natural and anthropologic influences and impacts, and can include building materials and soils which have been imported from outside of the subject site. In horticultural terms, this can result in variable soil conditions with regards to soil chemistry, fertility status and physical condition, including compaction and the presence of foreign matter within the soil matrix.

3.0 SITE ASSESSMENT

3.1 Site Visit and Location

We visited Marble Hill Park on the 19th October 2016. The site work was undertaken by soil scientists Ceri Spears and Rebecca Hollands.

The park is situated to the east of Twickenham (approximate National Grid Reference of centre: TQ1734573656), adjacent to the River Thames.

3.2 The Site

The park comprises an area of public open space surrounding the 18th century Marble Hill House.

Roads and predominantly residential properties lie alongside most of the site boundaries, with the A305 Richmond Road to the North, Orleans Road to west and Meadowside to the east. The River Thames forms the southern boundary.

Sports pitches are laid out over the majority of the park, with football pitches in the eastern section, rugby pitches in the southwestern part and a cricket field to the north of the House, with an artificial wicket. Surfaced tennis courts are located in the north-western corner. An amenity grass area is situated to the south of the House, which is understood to be in use for events periodically.

The majority of the park is vegetated with amenity grass, with areas of rough mown grass and mature trees around the edges or beside pathways. Mature woodland areas with predominantly ivy groundcover are situated adjacent to the House, all of which are surrounded with chestnut pale fencing. Groups of semi-mature trees are present in a number of locations.

The topography of the site is relatively level, with terracing to the south of the House, together with raised pathways. There appears to have been some reworking of levels within the eastern section, possibly to provide even grades for the football pitches.

Plate 1: Grassed football pitches in eastern section of the park (facing south)

Plate 2: Grass area to south of Marble Hill House

Plate 3: Grassed rugby pitches in southwestern part of park

Plate 4: Grass area to north of Marble Hill House – part of which is in use as a cricket field

Plate 5: Artificial cricket wicket

Plate 6: Woodland area surrounding the House

Plate 7: Mature trees alongside grass area

Plate 8: Rough mown grass and semi-mature trees

3.3 Soil Sampling and Examination Protocol

A series of trial holes (32 no.) were constructed in accordance with the required distribution of sampling locations on the supplied site plan produced by J&L Gibbons (ref. 581_SK_160909_JLG mark-up).

All trial holes were excavated by hand using a spade and/or soil auger to a maximum depth of 1.0m. The locations of our trial holes are indicated on a site plan presented in Appendix 1.

At certain locations, excavation beyond a depth of 400-450mm was not possible on account of the compacted and stony nature of the soil (see trial hole record in Appendix 2 for indication of locations).

At each trial hole the soils were examined with reference to the Soil Survey Field Handbook (Soil Survey Technical Monograph No.5 (3rd Edition) SILSOE 1997). Important physical soil properties were recorded, including texture, structure, Munsell colour, compaction, drainage and aeration characteristics, topsoil depths and the presence of deleterious materials. At the same time, representative soil samples were taken for laboratory analysis. Where the soils were consistent in visual appearance, the samples were combined to form representative composite samples for laboratory analysis.

The findings from this exercise are summarised in Section 4.0 below.

4.0 SOIL TYPES

The site assessment found the soils to be variable in texture over the site, with 3 typical soil profiles encountered, as outlined below:

- *Profile 1 – Light to Medium Textured Soils.* Sandy loam topsoil over sandy loam or sandy clay loam subsoil. This was the most commonly recorded profile and was found at TH1 – TH4, TH19 and TH21 – TH32.
- Profile 2 – *Woodland Soils.* Similar to *Profile 1*, including a distinct surface humic layer. Observed within the areas of woodland at TH5 – TH8 and TH15 – TH18.
- *Profile 3 – Heavy Textured Soils.* Clay loam topsoil over clay loam or clay subsoil. Recorded within the southern part of the site towards the River Thames at TH9 – TH11 and TH20.

These soil profiles are described in further detail below and identified for each trial hole (with recorded horizon depths) within the outline trial hole record given in Appendix 2.

Profile 1

Profile 1 – Light to Medium Textured Soils is described as:

P1 Topsoil	Dark brown (Munsell Colour 10YR 3/3) to brown (Munsell Colour 10 YR 4/3), dry to slightly moist, friable, non-calcareous SANDY LOAM. The topsoil typically had a moderately defined but weakly developed, fine to medium granular structure, occasionally with a blocky structure. Slightly stony with subangular to subrounded, small to medium sized (20-50mm) stones and occasional large stones (>50mm). Occasional small brick fragments recorded, with no further foreign matter observed.
P1 Subsoil	Yellowish brown (Munsell Colour 10YR 5/4) to strong brown (Munsell Colour 7.5YR 5/8), dry to slightly moist, non-calcareous to slightly calcareous SANDY LOAM to SANDY CLAY LOAM. Virtually stone-free to slightly stony. Slight mottling was observed within the subsoil at TH24, TH29 and TH30. No other evidence of impeded drainage was observed. The proportion of clay within the subsoil generally increased from depths c. 850-900mm bgl. Note, at TH3, TH12 and TH21, the subsoil was heavier in texture, comprising a CLAY LOAM ("Profile 3 Subsoil").

Plate 9: *Profile 1 Topsoil* at TH26

Plate 10: *Profile 1 Topsoil* arisings – dry friable consistency

Plate 11: *Profile 1 Topsoil* at TH2 in rugby pitch

Plate 12: Subangular and subrounded, small to medium sized stones within *Profile 1 Topsoil*

Plate 13: Yellowish brown *Profile 1 Subsoil*

Plate 14: Strong brown *Profile 1 Subsoil*

Profile 2

Profile 2 – Woodland Soils is described as:

P2 Topsoil	**Humus Layer**	Very dark brown to black, (Munsell Colour 10YR 2/2 to 10YR 2/1) partially to fully decomposed litter.
	Mineral Layer	Brown (Munsell Colour 10YR 5/3), dry to slightly moist, friable, non-calcareous, fine SANDY LOAM, with a weakly-developed, fine to medium granular structure. Slightly stony. Occasional glass fragments were recorded within the woodland topsoil.
P2 Subsoil		Dark yellowish brown to strong brown (Munsell Colour 10YR 4/4 to 7.5YR 4/6), slightly moist, non-calcareous, fine SANDY LOAM with a single grain and weakly developed granular structure. Slightly stony. No evidence of impeded drainage was observed.

Plate 15: *Profile 2 Topsoil* with darker coloured humic layer on surface

Plate 16: *Profile 2 Subsoil*

Plate 17: Glass fragment observed within *Profile 2 Topsoil* at TH18

Profile 3

Profile 3 – Heavy Textured Soils is described as:

P3 Topsoil	Very dark greyish brown (Munsell Colour 10YR 3/2) to dark greyish brown (Munsell Colour 10YR 4/2), slightly moist to moist, firm to plastic, slightly calcareous HEAVY CLAY LOAM. The topsoil typically has a moderately-developed blocky structure. Virtually stone-free to slightly stony. No foreign matter observed.
P3 Subsoil	Dark yellowish brown to strong brown (Munsell Colour 10YR 5/4 to 10YR 5/6), slightly moist, firm to plastic, slightly calcareous HEAVY CLAY LOAM to CLAY with a moderately developed structure. Virtually stone-free. Common ochreous mottling was recorded, indicating impeded drainage and seasonal waterlogging.

Plate 18: *Profile 3 Topsoil* (left) and *Subsoil* (right) at TH10

Plate 19: *Profile 3 Subsoil* at TH11

5.0 LABORATORY ANALYSIS

5.1 Analytical Schedule

Representative samples of topsoil and subsoil were submitted to the laboratory for analysis.

The samples were analysed in accordance with the following schedule:

- particle size analysis (% sand, silt, clay)
- stone content (2-20mm, 20-50mm, >50mm);
- pH value;
- electrical conductivity values;
- exchangeable sodium percentage (topsoil only);
- major plant nutrients - N, P, K, Mg (topsoil only);
- organic matter content;
- C:N ratio (topsoil only).

The results are presented on the Certificates of Analyses in Appendix 3 and an interpretation of the results is given below.

5.2 Results of Topsoil Analysis

Particle Size Analysis

The majority of the topsoil samples (*Profile 1* and *Profile 2*) fell into the *sandy loam* texture class. Further detailed particle size analysis indicated that the topsoil contained significant quantities of 'fines (clay, silt, very fine sand and fine sand) and this soil would be considered to have a slightly *broad* particle size distribution.

The *Profile 3* topsoil sample comprising a composite of topsoil from TH10, TH11 and TH20 fell into the *clay loam* texture class and would be described as heavy in texture.

Stone Content

The stone contents of the samples were low to moderate.

pH and Electrical Conductivity

The topsoil samples were strongly acid to alkaline in reaction (pH 4.9 – 7.9). The most acidic topsoil sample was associated with the *Profile 2, Woodland Topsoil*, whilst the most alkaline topsoil was associated with the heavier textured *Profile 3 Topsoil.*

The electrical conductivity (salinity) values were all low, indicating that soluble salts were not present at levels that would be harmful to plants.

Organic Matter and Nutrient Status

The topsoil samples contained sufficient reserves of organic matter.

The topsoil samples were all adequately supplied with total nitrogen and extractable magnesium. The majority of the samples were deficient in extractable potassium and extractable phosphorus (except the samples from TH5 and TH22).

5.3 Results of Subsoil Analysis

Particle Size Analysis and Stone Content

The majority of the subsoil samples were found to be light to medium in texture (*Profile 1* and *Profile 2*), falling into the *sandy loam* and *sandy clay loam* classes. Further detailed particle size analysis indicated that these subsoils have a slightly *broad* particle size distribution. The sand sized fraction of these samples (0.05 – 2.0mm) comprised mainly *very fine sand* (0.05 – 0.15mm), *fine sand* (0.15 – 0.25mm) and *medium sand* (0.25 – 0.50mm).

The *Profile 3* subsoil samples fell into the *clay loam* and *clay* texture classes and would be described as heavy in texture.

The stone content of the subsoil samples was low.

pH and Electrical Conductivity

The pH range of the subsoil samples was broad, ranging from acid to strongly alkaline (pH 5.5 – 8.4). The acid to slightly acid subsoil samples mostly correspond with the sandier textured soils, whilst the heavier textured subsoils tend to be more alkaline.

The electrical conductivity (salinity) values of the subsoil samples were low, indicating that soluble salts were not present at levels that would be harmful to plants.

Organic Matter and Nutrient Status

The majority of the subsoil samples contained low levels of organic matter, which is considered typical of subsoil.

The subsoil samples from TH2, TH3 and TH11 contained moderate levels of organic matter, above levels typically recorded in subsoil material. These trial holes were constructed within areas that are understood to flood periodically and as such, the increased levels are likely to be due to accumulation of organic matter within the flooded alluvial environment.

6.0 DISCUSSION

The purpose of this survey was to ascertain the nature and horticultural quality of the existing site soils in selected locations in Marble Hill Park, together with the provision of advice on how to improve the soils for landscape works as necessary. The survey information is to support the emerging design for the Park and to highlight areas where more detailed investigation will be required.

6.1 Soil Conditions

From our visual examinations, three distinct soil profile types were observed and the subsequent laboratory analysis confirmed that the chemical properties were reasonably consistent within the profile types.

These soil profiles are identified for each trial hole within the trial hole record given in Appendix 2.

The characteristics of the three soil profiles are summarised in Table 1 below:

Table 1: Soil Profile Characteristics

Profile 1 – Light to Medium Textured Soils	***Profile 2 – Woodland Soils***	***Profile 3 – Heavy Textured Soils***
• Sandy loam to sandy clay loam soil textures • Fine textures – significant proportions of 'fines' (very fine sand, clay, silt) • Slightly broad particle size distribution • Virtually stone-free to slightly stony • Acid to slightly alkaline soil reaction • Non-calcareous, with occasionally slightly calcareous subsoil • Non-saline • Topsoil has sufficient reserves of organic matter, nitrogen and magnesium • Topsoil is deficient in phosphorus and potassium	• Humic surface layer – 40-50mm thick • Sandy loam soil texture • Fine textures – significant proportions of 'fines' (very fine sand, clay, silt) • Slightly stony • Strongly acid soil reaction • Non-calcareous • Non-saline • Topsoil has sufficient reserves of organic matter, and all major plant nutrients	• Heavy clay loam to clay soil textures • Virtually stone-free to slightly stony • Alkaline to strongly alkaline soil reaction • Slightly calcareous • Non-saline • Topsoil has sufficient reserves of organic matter, nitrogen and magnesium • Topsoil is slightly deficient in phosphorus and potassium

The soil considerations for future landscape works are discussed in Section 6.2 below.

6.2 Re-Use of the Site Soils

Physical Considerations

Profile 1 and 2 Soils

The 'fineness' and slightly broad particle size distribution of the *Profile 1* and *Profile 2* soils will make them particularly prone to structural degradation during all phases of soil handling. This would be especially so during and after intensive operations such as topsoil stripping or stockpiling, which are not necessarily going to take place as part of this project, but also includes compaction during initial vegetation removal, cultivation and planting work (e.g. tree pit excavation). At present in their undisturbed state, the soils have sufficient soil structure to enable satisfactory drainage and aeration. However, these structures can easily be lost once such fine textured soil is disturbed.

Provided their physical condition is satisfactory and suitable species are selected, the *texture* of the *Profile 1* and *Profile 2 Soils* should be suitable for most general landscape applications, including shrub planting, native transplants and grass establishment. The *Profile 1* and *Profile 2 Topsoils* should also be suitable for smaller sized rootballed tree planting, provided they their physical condition is maintained. A suitable imported topsoil would be recommended for larger rootballed trees (e.g. extra heavy standard or semi-mature).

The *Profile 1* and *Profile 2 Subsoils* could be prone to self-compaction if placed below the weight of a tree root ball and so are not considered suitable for use as backfill in tree pits for large rootballed trees. An appropriate free-draining, coarser textured sand or sandy subsoil is recommended for backfilling the lower portion of these tree pits.

The presence of glass within the *Profile 2 Topsoil* inspected could present a safety risk to end users. Appropriate safety precautions would need to be adhered to with regard to presence of glass during any vegetation clearance and subsequent cultivation/planting works. If any of these areas are to be converted to amenity grass, the presence of glass should be considered as the risk of injury to end users may be higher in such areas.

Profile 3 Soils

The heavy texture of the *Profile 3* soils and presence of mottling in the subsoil indicates that this soil profile type will be prone to seasonal waterlogging following periods of prolonged or heavy rainfall. It is also likely that these soils will be prone to structural degradation during landscape preparation and planting works which will further reduce their permeability, particularly if they are handled when wet and plastic in consistency. As such, the physical condition of these soils will need to be maintained by careful handling and sensitive soil management to ensure they are fit for planting or seeding.

Provided the soils are left with a satisfactory soil structure, they should be suitable for a range of planting types, provided species tolerant of moisture retentive soils are selected. However, if the structure of the soils is damaged during the landscape works, their usage potential will be reduced significantly.

The heavy texture of the *Profile 3 Soils* is not ideal for large rootballed tree planting and as such, suitable imported soils are recommended for this purpose.

Chemical Characteristics

Soil Reaction

The strongly acid to slightly acid (occasionally slightly alkaline) soil reaction of the *Profile 1* and *Profile 2* samples (topsoil and subsoil) means that the species selected should ideally have a wide pH tolerance, or have a preference for acidic soils. If it is desired to plant species that prefer or require alkaline soils, a suitable application of lime may be required in the locality of these specimens. However, it would not be practical to amend the pH of the subsoil and therefore, the planting of species that specifically demand alkaline soil is not recommended within the majority of the Park.

The *Profile 3* soils were alkaline to strongly alkaline in reaction and, as such, specimens planted in the locality of these soils should be tolerant of alkaline soil conditions.

Fertility Status

The topsoils across the site contained sufficient reserves of organic matter and as such, no applications of organic ameliorant (e.g. compost) would be required.

The samples contained sufficient levels of total nitrogen and magnesium, with significant deficiencies in extractable phosphorus and potassium recorded within the majority of the samples. The *Profile 2 Topsoil* contained sufficient levels of all major plant nutrients. The nutrient deficiencies may be addressed by routine fertiliser applications where required.

If it is desired to establish species-rich wildflower grassland habitats as part of landscape improvements, the soil fertility should be considered. Species-rich wildflower grasslands typically require low-nutrient soils, and in particular low phosphorus levels, so that aggressive weeds and grasses such as dandelion, nettle and rye-grass cannot dominate the sward. Moderate to high organic matter and total nitrogen content is desirable to support healthy seed growth. Appropriate management practices (e.g. periodic mowing and collection of cuttings to prevent seed head development) are often necessary to maximise diversity in the sward.

In this instance, the majority of the site topsoils (except *P2 Topsoil*) have reasonably low or occasionally moderate phosphorus levels (MAFF Index – mostly 1, occasionally 2), with good reserves of organic matter and nitrogen. As such, the topsoils have potential for re-use for this purpose. However, the topsoil will have an inherent weed / grass seed bank and therefore, an appropriate weed management regime (e.g. periodic mowing and collection of cuttings to prevent seed head development) is likely to be required to maximise diversity in the sward.

Sports and Events Use

The fine or heavy texture of the site topsoils means that some form of amelioration is likely to be necessary within the sports pitches and event spaces to improve wear tolerance and surface water infiltration, particularly if higher usage levels are envisaged. Further investigation into the soil physical properties in relation to these purposes is recommended (see Section 7.0 below).

6.3 Re-Use Summary

The following section considers the potential to re-use the available soils for a range of general landscape types. It is important to note that for all planting and seeding, the soils must have an adequate structural condition and suitable plant species should be selected.

The suitability of the site soils is summarised in Table 2 (*topsoil*) and Table 3 (*subsoil*) below.

Table 2: Topsoil Suitability

Planting Environment	***P1 Topsoil***	***P2 Topsoil***	***P3 Topsoil***	***Amelioration / Notes***
Larger rootballed trees (extra heavy standard to semi mature)	X	X	X	--
Small rootballed trees (up to heavy standard)	✓	✓	✓	Fertiliser application
Containerised shrubs	✓	✓	✓	Fertiliser application
Bare root specimens (e.g. trees, shrubs, hedging)	✓	✓	✓	Fertiliser application
Amenity grass (not including sports pitches / event spaces)	✓*	X#	✓*	Fertiliser application
Species-rich wildflower seeding	✓	X	✓	Post-seeding management recommended

✓ = *Topsoil* suited to this landscape type provided the topsoil and subsoil are adequately structured, aerated and drained, suitable species are selected and any nutrient deficiencies are remedied through application of an appropriate fertiliser where necessary.

X = *Topsoil* not suited to this landscape type.

* Assuming a low to moderate level of foot-traffic

\# Note, glass present in *P2 Topsoil*, which is not suitable for grass areas

Table 3: Subsoil Suitability

Planting Environment	*P1 Subsoil*	*P2 Subsoil*	*P3 Subsoil*	*Amelioration / Notes*
Larger rootballed trees (extra heavy standard to semi mature)	X	X	X	Drainage assistance may be required depending on species requirements and soil physical condition. To be confirmed by soakage tests
Small rootballed trees (up to heavy standard)	O	O	X	
Containerised shrubs	✓	✓	✓	
Bare root specimens (e.g. trees, shrubs, hedging)	✓	✓	✓	--
Amenity grass (not including sports pitches / event spaces)	✓	✓	✓	--
Species-rich wildflower seeding	✓	✓	✓	--

✓ = *Subsoil* suited to this landscape type provided the soil is adequately structured, aerated and drained and suitable species are selected.

O = *Subsoil* may be suitable for this landscape type, provided consideration is given to improving the drainage potential.

X = *Subsoil* not suited to this landscape type.

6.4 Soil Ameliorants

Fertiliser Application for Planting

To address the nutrient deficiencies and to help promote effective plant establishment, we recommend applying and incorporating the compound, slow release fertiliser *Everris Enmag CRF* (11%N:22%P_2O_5:9%K_2O:6%MgO) at a rate of 90 g/m^2 and to a depth of 200mm.

Amenity Grass Fertiliser

For amenity grass establishment, we recommend applying and incorporating the pre-seeding grass fertiliser *Everris Sportsmaster Pre-seeder* (8%N:12%P_2O_5:8%K_2O+3%MgO) prior to seeding or turfing at a rate of 50 g/m^2 and to a depth of 100mm.

6.5 Imported Soils

Imported topsoil and/or subsoil will be required for certain landscape types for which the site-won soils are not suitable (see Section 6.3 above). An indicative specification for suitable imported topsoil and subsoil has been included in Appendix 4.

This specification is intended as a guide at this stage and would be governed by the specific requirements of the proposed landscape scheme once this has been produced (e.g. selected species, stock sizes etc).

As indicated in the suggested specification, we recommend that the imported soils are predominantly sandy in texture, with a narrow particle size distribution to enable them to have good drainage characteristics together with high workability and resistance to compaction. At this stage, the chemical characteristics, including pH, salinity and fertility status have been based on the ranges typically considered suitable for many species and planting types commonly used within public open space landscape schemes.

6.6 Tree Pit Construction and Backfilling

The following recommendations are provided to prepare appropriate soil conditions for planting new trees.

Tree Pit Dimensions

Individual pits or planting trenches should be excavated for planting rootballed trees. The pits/trenches should be at least 250mm wider than the rootball on all sides. The depth of the tree pit should allow for the required depth of topsoil and subsoil and dimensions of the rootball, together with any drainage media (see 'Drainage Considerations' and 'Soil Depths' below).

For rootballed smaller trees (e.g. standards and light standards) planted in areas of *Profile 1* or *Profile 2* soil, the depth of the pit could be reduced, i.e. dug out to the depth of the rootball only, leaving the existing subsoil largely undisturbed.

Bare-root specimens could be 'notch' planted into existing topsoil and subsoil, thereby reducing disturbance to the soil profile.

Pit Preparation

The base of each pit/trench should be thoroughly loosened to a minimum depth of 300mm and the sides decompacted to eliminate any smearing, using the teeth of an excavator bucket for example.

Drainage Considerations

Given the heavy texture of the *Profile 3* soils and presence of prominent mottling within this soil profile, the drainage performance of the soil profile is restricted. Furthermore, the drainage performance of the fine textured *Profile 1* and *Profile 2* soils may be reduced following disturbance from pit excavation. As such, there is a risk of tree pits acting as sumps for surface draining water. To avoid this, appropriate modifications should be incorporated into their design. This may including mounding around trees or groups of trees, or installing soakage layers / positive drainage (piped drainage) as necessary / feasible. It should be noted that positive drainage will require a suitable outfall.

Soakage tests are recommended to confirm the soakage performance of the soil profiles and to ascertain whether a gravel attenuation layer (aka 'soakage layer') at the base of the tree pits would be necessary / effective or whether installation of positive drainage (piped drainage) is necessary.

Soil Depths

The tree pits should be backfilled with suitable depths of topsoil and subsoil. Topsoil should not be placed to the full depth of the pit/trench because the organic component of topsoil needs to maintain a sufficient level of gaseous exchange with the atmosphere (aeration) in order to provide an adequate supply of oxygen for soil microbes and plant roots, and to release exchanged gasses. Placement of topsoil to greater depths increases the risk that the topsoil will be insufficiently aerated, which could lead to the generation of oxygen depleted or 'anaerobic' soil conditions, which are inhospitable to plant growth.

We would recommend that topsoil is not placed deeper than 300mm if *site-won topsoil* is used or 400mm if a predominantly sand-based, imported topsoil is used. The lower part of the tree pit should be backfilled with suitable subsoil with a low organic matter content.

6.7 Soil Structure & Physical Degradation

It is essential to provide a structured, uncompacted soil profile for the successful establishment and subsequent growth of plants and grass. Adequate soil structure is a key element for healthy plant growth to ensure aeration and drainage within the rootzone. Any damage to soil structure will reduce the drainage rate of the site topsoil and subsoil.

The potential quality and the ultimate suitability of the soils for re-use will depend on how well their soil structure is preserved during the landscape work. The site soils will be particularly prone to structural damage if handled when wet. In this situation, the larger (air containing) soil pores are destroyed and replaced by smaller (water retentive) pores. This will restrict gaseous exchange with the atmosphere and cause the topsoil to become anaerobic (oxygen depleted). In addition, the lack of larger pores prevents effective drainage and results in an increased risk of waterlogging.

Waterlogged and anaerobic conditions, if they persist, can be severely detrimental to plants in two main ways. Firstly, aerobic bacteria are replaced by anaerobic bacteria that produce ammonia and methane gases which are harmful to plants. Secondly, without oxygen plant roots are unable to take up water and nutrients.

7.0 FURTHER WORK

In light of our findings, there are a number of areas which would warrant further investigations and/or input. These include the following.

- An additional soil investigation is recommended for the grass areas that are used for events to identify what measures can be taken to improve the physical properties and wear tolerance of the soils. This could also provide input into a grass management plan for these areas.
- The sports pitches do not currently exhibit signs of significant wear, with the exception of occasional 'hot spots' within some of the goal mouths. This indicates that they appear to be withstanding the current usage levels. However, if a better standard of pitch and / or greater levels of usage are desirable, a number of improvements could potentially be made. In order to determine the current pitch quality in more detail and determine what improvements may be necessary / feasible, we recommend carrying out a detailed agronomic assessment. This would involve a technical site investigation of the sports pitches to evaluate their existing condition (e.g. evenness, gradients, turf quality), together with an evaluation of the soil profile specifically in relation to sports use (e.g. fertility, drainage characteristics).

  This assessment could be conducted in conjunction with a usage survey that will consider the types of sports catered for, the age groups of the players, the frequency of use and the standard required. An understanding of the on-going maintenance plans of the pitches is also useful when compiling recommendations.
- Soakage tests are recommended for any zones of new tree planting to determine any necessary drainage requirements, particularly if large semi-mature specimens or demanding species are to be selected.

If you would like to pursue any of these items, we will be happy to discuss the relevant issues in further detail.

We would like to thank English Heritage for entrusting our practice with this commission. We trust this report meets with your approval and provides the necessary information. Please do not hesitate to contact the undersigned if we can be of further assistance.

Ceri Spears
BSc MSc MISoilSci
Senior Associate

For and on behalf of Tim O'Hare Associates LLP

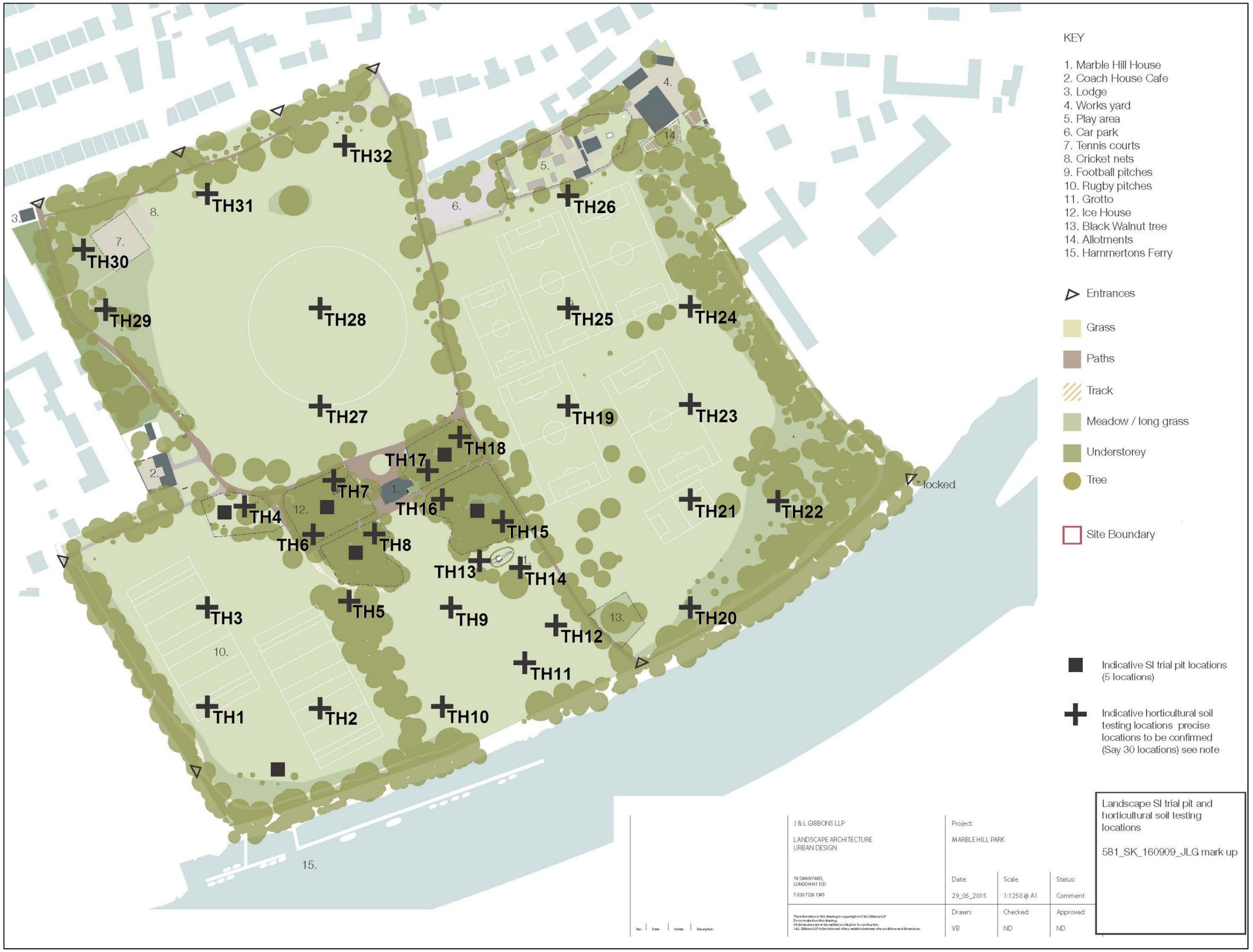
Report Qualifications

Our interpretation of the soil conditions at Marble Hill Park is based on observations made during our site investigation and the results of laboratory tests. This report presents our site observations and test results and our interpretation of those observations and results. On any site there may be variations in soil conditions between these exploratory positions. We can therefore not accept any responsibility for soil conditions that have not been exposed by this investigation.

This investigation provides a record of baseline soil conditions at Marble Hill Park, Twickenham, in relation to future landscape design development. It should not therefore be relied on for alternative end-uses or for other schemes. This report has been prepared solely for the benefit of our client English Heritage. No warranty is provided to any third party and no responsibility or liability will be accepted for any loss or damage in the event that this report is relied upon by a third party or is used in circumstances for which it was not originally intended.

Appendix 1

Site Plan – Trial Hole Locations



KEY

1. Marble Hill House
2. Coach House Cafe
3. Lodge
4. Works yard
5. Play area
6. Car park
7. Tennis courts
8. Cricket nets
9. Football pitches
10. Rugby pitches
11. Grotto
12. Ice House
13. Black Walnut tree
14. Allotments
15. Hammertons Ferry

Entrances

Grass

Paths

Track

Meadow / long grass

Understorey

Tree

Site Boundary

Indicative SI trial pit locations (5 locations)

Indicative horticultural soil testing locations precise locations to be confirmed (Say 30 locations) see note

+ = Trial Hole Location (approx.)

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URBAN DESIGN

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Project:
MARBLE HILL PARK

Date:	Scale	Status:
29_05_2015	1:1250 @ A1	Comment
Drawn:	Checked:	Approved:
VB	ND	ND

Rev | Date | Initials | Description

Landscape SI trial pit and horticultural soil testing locations

581_SK_160909_JLG mark up

TIM O'HARE ASSOCIATES
SOIL & LANDSCAPE CONSULTANCY

Client:	English Heritage
Project:	Marble Hill Park, Twickenham
Job ref no.:	TOHA/16/3995/CS
Drawing no.:	3995/1
Drawing title	Soil Resource Survey – Trial Hole Locations

Date:	Oct '16	Scale:	NTS
Drawn by:	CS	Checked by:	TOH

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Appendix 2

Outline Trial Hole Record

TIM O'HARE ASSOCIATES
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Trial Hole Record

Client: **English Heritage**
Site: **Marble Hill Park**
Job: **Soil Resource Survey**
Date: **November 2016**
Our Ref: **TOHA/16/3995/CS**

TH1 (*Profile 1*)

GL – 0.20m	P1 Topsoil
0.20 – 0.70m	P1 Subsoil
0.70m	No further progress

TH2 (*Profile 1*)

GL – 0.21m	P1 Topsoil
0.21 – 0.45m	P1 Subsoil
0.45m	No further progress

TH3 (*Profile 1 with Profile 3 Subsoil*)

GL – 0.51m	P1 Topsoil
0.51 – 1.0m	P3 Subsoil

TH4 (*Profile 1*)

GL – 0.21m	P1 Topsoil
0.21 – 0.38m	P1 Subsoil
0.38m	No further progress

TH5 (*Profile 2*)

GL – 0.04m	Humic Layer
0.04 – 0.19m	P2 Topsoil
0.19 – 0.40m	P2 Subsoil
0.40m	No further progress

TH6 (*Profile 2*)

GL – 0.06m	Humic Layer
0.06 – 0.18m	P2 Topsoil
0.18 – 1.0m	P2 Subsoil

TH7 (*Profile 2*)

GL – 0.06m	Humic Layer
0.06 – 0.14m	P2 Topsoil
0.14 – 1.0m	P2 Subsoil

TH8 (*Profile 2*)

GL – 0.06m	Humic Layer
0.06 – 0.18m	P2 Topsoil
0.18 – 1.0m	P2 Subsoil

TH9 (*Profile 3*)

GL – 0.38m	P3 Topsoil
0.38 – 1.0m	P3 Subsoil

TH10 (*Profile 3*)

GL – 0.20m	P3 Topsoil
0.20 – 1.0m	P3 Subsoil

TH11 (*Profile 3*)

GL – 0.39m	P3 Topsoil
0.39 – 1.0m	P3 Subsoil

TH12 (*Profile 1 with Profile 3 Subsoil*)

GL – 0.40m	P1 Topsoil
0.40 – 1.0m	P3 Subsoil

TH13 (*Profile 1*)

GL – 0.28m	P1 Topsoil
0.28 – 0.40m	P1 Subsoil
0.40m	No further progress

TH14 (*Profile 1*)

GL – 0.28m	P1 Topsoil
0.28 – 0.40m	P1 Subsoil
0.40m	No further progress

TH15 (*Profile 2*)

GL – 0.05m	Humic Layer
0.05 – 0.10m	P2 Topsoil
0.10 – 1.0m	P2 Subsoil

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TIM O'HARE ASSOCIATES
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Trial Hole Record

Client: **English Heritage**
Site: **Marble Hill Park**
Job: **Soil Resource Survey**
Date: **November 2016**
Our Ref: **TOHA/16/3995/CS**

TH16 (*Profile 2*)

GL – 0.05m	Humic Layer
0.05 – 0.22m	P2 Topsoil
0.22 – 1.0m	P2 Subsoil

TH17 (*Profile 2*)

GL – 0.05m	Humic Layer
0.05 – 0.29m	P2 Topsoil
0.29 – 1.0m	P2 Subsoil

TH18 (*Profile 2*)

GL – 0.05m	Humic Layer
0.05 – 0.26m	P2 Topsoil
0.26 – 1.0m	P2 Subsoil

TH19 (*Profile 1*)

GL – 0.22m	P1 Topsoil
0.22 – 0.60m	P1 Subsoil
0.60m	No further progress

TH20 (*Profile 3*)

GL – 0.29m	P3 Topsoil
0.29 – 1.0m	P3 Subsoil

TH21 (*Profile 1 with Profile 3 Subsoil*)

GL – 0.33m	P1 Topsoil
0.33 – 1.0m	P3 Subsoil

TH22 (*Profile 1*)

GL – 0.35m	P1 Topsoil
0.35 – 0.60m	P1 Subsoil
0.60m	No further progress

TH23 (*Profile 1*)

GL – 0.23m	P1 Topsoil
0.23 – 0.70m	P1 Subsoil
0.70m	No further progress

TH24 (*Profile 1*)

GL – 0.32m	P1 Topsoil
0.32 – 1.0m	P1 Subsoil

TH25 (*Profile 1*)

GL – 0.36m	P1 Topsoil
0.36 – 1.0m	P1 Subsoil

TH26 (*Profile 1*)

GL – 0.22m	P1 Topsoil
0.22 – 0.43m	P1 Subsoil
0.43m	No further progress

TH27 (*Profile 1*)

GL – 0.39m	P1 Topsoil
0.39 – 1.0m	P1 Subsoil

TH28 (*Profile 1*)

GL – 0.36m	P1 Topsoil
0.36 – 1.0m	P1 Subsoil

TH29 (*Profile 1*)

GL – 0.31m	P1 Topsoil
0.31 – 1.0m	P1 Subsoil

TH30 (*Profile 1*)

GL – 0.23m	P1 Topsoil
0.23 – 1.0m	P1 Subsoil

TH31 (*Profile 1*)

GL – 0.34m	P1 Topsoil
0.34 – 1.0m	P1 Subsoil

TH32 (*Profile 1*)

GL – 0.36m	P1 Topsoil
0.36 – 0.40m	P1 Subsoil
0.40m	No further progress

Appendix 3

Laboratory Analysis Results

TIM O'HARE ASSOCIATES
SOIL & LANDSCAPE CONSULTANCY

Client:	**English Heritage**
Project:	**Marble Hill Park, Twickenham**
Job:	**Soil Resource Survey**
Soil Type:	**Topsoil**
Date:	**November 2016**
Job Ref No:	**TOHA/16/3995/CS**

Sample Reference			**TH1+2+3**	**TH5+17**	**TH9+10+11+20**	**TH12+13+14**	**TH19+21+23+26**	**TH24+25**	**TH29+30+31**
Soil Type			Profile 1 Topsoil	Profile 2 Topsoil	Profile 3 Topsoil	Profile 1 Topsoil	Profile 1 Topsoil	Profile 1 Topsoil	Profile 1 Topsoil
		Accreditation							
Clay (<0.002mm)	%	UKAS	15	11	32	16	14	12	10
Silt (0.002-0.063mm)	%	UKAS	14	15	27	17	17	15	15
Sand (0.063-2.00mm)	%	UKAS	71	74	41	67	69	73	75
Texture Class (UK Classification)	--	UKAS	SL	SL	CL	SL	SL	SL	SL
Stones (2-20mm)	% DW	GLP	4	4	1	6	1	4	1
Stones (20-50mm)	% DW	GLP	7	0	0	5	2	5	3
Stones (>50mm)	% DW	GLP	4	0	0	14	3	0	0
pH Value (1:2.5 water extract)	units	UKAS	5.9	4.9	7.9	6.8	7.1	5.5	6.3
Electrical Conductivity (1:2.5 water extract)	uS/cm	UKAS	64	117	261	215	232	74	99
Electrical Conductivity (1:2 $CaSO_4$ extract)	uS/cm	UKAS	2011	2088	2102	2079	2092	2023	2044
Exchangeable Sodium Percentage	%	UKAS	0.4	1.4	0.4	0.4	0.4	1.2	0.7
Organic Matter (LOI)	%	UKAS	5.4	7.4	7.6	6.8	5.3	4.8	3.8
Total Nitrogen (Dumas)	%	UKAS	0.23	0.31	0.36	0.31	0.25	0.22	0.18
C : N Ratio	ratio	UKAS	14	14	12	13	12	13	12
Extractable Phosphorus	mg/l	UKAS	10	60	14	13	13	22	10
Extractable Potassium	mg/l	UKAS	92	190	107	79	68	55	49
Extractable Magnesium	mg/l	UKAS	104	82	76	69	47	62	50

SL = SANDY LOAM
CL= CLAY LOAM

Ceri Spears
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Senior Associate

Results of analysis should be read in conjunction with the report they were issued with

TIM O'HARE ASSOCIATES
SOIL & LANDSCAPE CONSULTANCY

Client:	**English Heritage**
Project:	**Marble Hill Park, Twickenham**
Job:	**Soil Resource Survey**
Soil Type:	**Topsoil**
Date:	**November 2016**
Job Ref No:	**TOHA/16/3995/CS**

Sample Reference			**TH4+27+28**
Soil Type			Profile 1 Topsoil
		Accreditation	
Clay (<0.002mm)	%	UKAS	14
Silt (0.002-0.05mm)	%	UKAS	14
Very Fine Sand (0.05-0.15mm)	%	UKAS	23
Fine Sand (0.15-0.25mm)	%	UKAS	24
Medium Sand (0.25-0.50mm)	%	UKAS	19
Coarse Sand (0.50-1.0mm)	%	UKAS	4
Very Coarse Sand (1.0-2.0mm)	%	UKAS	2
Total Sand (0.05 - 2.00mm)	%	UKAS	72
Texture Class (UK Classification)	--	UKAS	SL
Stones (2-20mm)	% DW	GLP	1
Stones (20-50mm)	% DW	GLP	0
Stones (>50mm)	% DW	GLP	0

pH Value (1:2.5 water extract)	units	UKAS	5.0
Electrical Conductivity (1:2.5 water extract)	uS/cm	UKAS	68
Electrical Conductivity (1:2 $CaSO_4$ extract)	uS/cm	UKAS	2005
Exchangeable Sodium Percentage	%	UKAS	1

Organic Matter (LOI)	%	UKAS	4.4
Total Nitrogen (Dumas)	%	UKAS	0.20
C : N Ratio	ratio	UKAS	13
Extractable Phosphorus	mg/l	UKAS	13
Extractable Potassium	mg/l	UKAS	69
Extractable Magnesium	mg/l	UKAS	76

SL = SANDY LOAM

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Results of analysis should be read in conjunction with the report they were issued with

TIM O'HARE ASSOCIATES
SOIL & LANDSCAPE CONSULTANCY

Client:	**English Heritage**
Project:	**Marble Hill Park, Twickenham**
Job:	**Soil Resource Survey**
Soil Type:	**Subsoil**
Date:	**November 2016**
Job Ref No:	**TOHA/16/3995/CS**

Sample Reference			**TH1+2+4**	**TH3**	**TH9+12**	**TH10+11+20**	**TH21**	**TH23+25**	**TH24+27+28**	**TH29+30**	**TH31**
Soil Type			Profile 1 Subsoil	Profile 3 Subsoil	Profile 3 Subsoil	Profile 3 Subsoil	Profile 3 Subsoil	Profile 1 Subsoil	Profile 1 Subsoil	Profile 1 Subsoil	Profile 1 Subsoil
		Accreditation									
Clay (<0.002mm)	%	UKAS	13	24	34	42	29	19	16	13	12
Silt (0.002-0.063mm)	%	UKAS	14	27	29	37	27	25	20	21	18
Sand (0.063-2.00mm)	%	UKAS	73	49	37	21	44	56	64	66	70
Texture Class (UK Classification)	--	UKAS	SL	CL	CL	C	CL	SCL	SL	SL	SL
Stones (2-20mm)	% DW	GLP	3	1	1	1	0	5	1	1	0
Stones (20-50mm)	% DW	GLP	0	0	0	0	0	2	0	0	1
Stones (>50mm)	% DW	GLP	0	0	0	0	0	0	0	0	0
pH Value (1:2.5 water extract)	units	UKAS	5.5	6.7	7.9	8.3	8.4	7.9	6.4	6.6	6.3
Electrical Conductivity (1:2.5 water extract)	uS/cm	UKAS	56	52	159	175	135	169	56	58	57
Organic Matter (LOI)	%	UKAS	3.1	3.2	2.7	3.3	2.1	2.2	2.0	2.1	1.8

SL = SANDY LOAM
CL = CLAY LOAM
C = CLAY

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Results of analysis should be read in conjunction with the report they were issued with

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Client:	**English Heritage**
Project:	**Marble Hill Park, Twickenham**
Job:	**Soil Resource Survey**
Soil Type:	**Subsoil**
Date:	**November 2016**
Job Ref No:	**TOHA/16/3995/CS**

Sample Reference			**TH5+8+15**	**TH19+22+26**
Soil Type			Profile 2 Subsoil	Profile 1 Subsoil
		Accreditation		
Clay (<0.002mm)	%	UKAS	18	17
Silt (0.002-0.05mm)	%	UKAS	18	17
Very Fine Sand (0.05-0.15mm)	%	UKAS	27	24
Fine Sand (0.15-0.25mm)	%	UKAS	19	17
Medium Sand (0.25-0.50mm)	%	UKAS	14	17
Coarse Sand (0.50-1.0mm)	%	UKAS	3	5
Very Coarse Sand (1.0-2.0mm)	%	UKAS	1	3
Total Sand (0.05 - 2.00mm)	%	UKAS	64	66
Texture Class (UK Classification)	--	UKAS	SL	SL
Stones (2-20mm)	% DW	GLP	5	6
Stones (20-50mm)	% DW	GLP	0	0
Stones (>50mm)	% DW	GLP	0	0
pH Value (1:2.5 water extract)	units	UKAS	4.6	7.4
Electrical Conductivity (1:2.5 water extract)	uS/cm	UKAS	89	266
Organic Matter (LOI)	%	UKAS	2.1	2.2

SL = SANDY LOAM

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Results of analysis should be read in conjunction with the report they were issued with

Appendix 4

Indicative Imported Topsoil and Subsoil Specification

1.0 INTRODUCTION

This Imported Soil Specification document sets out the suggested requirements for imported topsoil and washed sand (subsoil), and the measures and techniques for sampling and testing soils to be sourced for soft landscape purposes at Marble Hill Park, Twickenham, London.

All imported soil should be obtained which complies with both the horticultural requirements (as detailed in Section 2.0) and environmental requirements (as detailed in Section 3.0).

This document specifies the imported soil requirements for soft landscape works construction only. The soil requirements for any associated sports pitch or event space improvement works are outside the scope of this specification.

This specification are intended as a guide at this stage and would be governed by the specific requirements of the proposed landscape scheme once this has been produced (e.g. selected species, stock sizes etc).

1.1 Soil Types

The soil materials covered by this specification document are:

- Imported Topsoil
- Imported Washed Sand (*subsoil*)

1.2 Soil Materials Generally

Purity: Free of pests, disease, and fungus.

Foreign matter: On visual inspection, free from non-soil or sand material, brick, wire/rebar and other building materials and wastes, sharps, hydrocarbons, plant matter, invasive weeds, and any other foreign matter or material or substance that would render the soil or sand unsuitable for landscape use.

Contamination: Do not use topsoil or sand contaminated with rubbish or other materials that are:

- Corrosive, explosive or flammable.
- Hazardous to human or animal life.
- Detrimental to healthy plant growth.

Give notice: If any evidence or symptoms of soil contamination are discovered on the site or in soils, sand or compost or other planting media to be imported.

Soil Structure: all soils shall have sufficient soil structure once placed and settled to enable healthy root growth and adequate soil function (drainage and aeration capacity)

2.0 HORTICULTURAL SOIL REQUIREMENTS

2.1 Imported Topsoil

Imported Topsoil should meet the following criteria:

Visual Examination

The topsoil shall be free from non-soil material, brick, wire/rebar and other building materials and wastes, sharps, hydrocarbons, plant matter, invasive weeds, and any other foreign matter or material or substance that would render the topsoil unsuitable for landscape use.

Parameter	Unit	Lower Limit	Upper Limit
Clay (<0.002mm)	%	5	18
Silt (0.002-0.05mm)	%	5	35
Sand (0.05-2.0mm) Of which at least 45% shall fall into fine sand (0.15-0.25mm) to medium sand (0.25-0.50mm) range	%	55	85
Stones (2-20mm)	%DW	--	15
Stones (20-50mm)	%DW	--	10
Stones (>50mm)		--	0
pH Value	Unit	6.0	8.5
Electrical Conductivity (1:2.5 water extract)	µS/cm	--	1500
Electrical Conductivity ($CaSO_4$ extract)	µS/cm	--	3300
Exchangeable Sodium Percentage	%	--	9
Organic Matter	%	4.0	8.0
Total Nitrogen	%	0.20	--
Extractable Phosphorus	mg/l	26	140
Extractable Potassium	mg/l	240	1500
Extractable Magnesium	mg/l	50	600
Calcium Carbonate	%	--	5

2.2 Imported Washed Sand

Imported Washed Sand for use as subsoil should comprise a quarried washed sand material that should meet the following criteria. It should not comprise a marine-dredged sand or recycled sand.

Visual Examination

The washed sand shall be free from non-sand material, topsoil, other subsoil types, brick, wire/rebar and other building materials and wastes, sharps, hydrocarbons, plant matter, invasive weeds, and any other foreign matter or material or substance that would render the sand unsuitable for landscape use.

Parameter	Unit	Lower Limit	Upper Limit
Clay & Silt (less than 0.05mm)	%	0	0
Very Fine Sand (0.05 – 0.15mm)	%	0	5
Fine Sand (0.15 – 0.25mm)	%	5	15
Medium Sand (0.25 – 0.50mm)	%	50	75
Coarse Sand (0.50 – 1.0mm)	%	25	45
Very Coarse Sand (1.0 – 2.0mm)	%	0	5
Stones (2-10mm)	%DW	0	10
Stones (>10mm)	%DW	0	0
Saturated Hydraulic Conductivity	mm/hr	150	--
pH Value	Unit	5.0	8.5
Electrical Conductivity (1:2.5 water extract)	µS/cm	--	600
Calcium Carbonate	%	--	2

3.0 ENVIRONMENTAL REQUIREMENTS

The following Generic Assessment Criteria (GAC) shall be used as Tier 1 screening values for the assessment of *imported topsoil* to be used, unless Site-Specific Assessment Criteria (SSAC) are available for the site where the soil(s) is to be used.

In circumstances where any of these values are exceeded, further risk assessment and/or testing should be undertaken to confirm the significance of the non-compliance.

Parameter	Unit	GAC*
Inorganic Arsenic	mg/kg	37
Boron (soluble)	mg/kg	290
Cadmium	mg/kg	11
Chromium (III)	mg/kg	910
Chromium (IV)	mg/kg	6
Copper	mg/kg	100
Lead	mg/kg	200
Mercury	mg/kg	1.2
Nickel	mg/kg	60
Selenium	mg/kg	250
Zinc	mg/kg	200
Phenol	mg/kg	280
Benzene	mg/kg	0.087
Toluene	mg/kg	130
Ethylbenzene	mg/kg	47
Xylene - m	mg/kg	59
Xylene - o	mg/kg	60
Xylene - p	mg/kg	56
Aliphatics C5-C6	mg/kg	42
Aliphatics C6-C8	mg/kg	100
Aliphatics C8-C10	mg/kg	27
Aliphatics C10-C12	mg/kg	130
Aliphatics C12-C26	mg/kg	1100
Aliphatics C16-C35	mg/kg	65,000
Aromatics C5-C7	mg/kg	70
Aromatics C7-C8	mg/kg	130
Aromatics C8-C10	mg/kg	34
Aromatics C10-C12	mg/kg	74
Aromatics C12-C16	mg/kg	140
Aromatics C16-C21	mg/kg	260
Aromatics C21-C35	mg/kg	1100
Acenaphthene	mg/kg	210
Acenaphthylene	mg/kg	170
Anthracene	mg/kg	2400
Continued…		

Parameter	Unit	GAC*
Benzo(a)anthracene	mg/kg	7.2
Benzo[a]pyrene	mg/kg	2.2
Benzo(b)fluoranthene	mg/kg	2.6
Benzo(g,h,i)perylene	mg/kg	320
Benzo(k)fluoranthene	mg/kg	77
Chrysene	mg/kg	15
Dibenzo[a,h]anthracene	mg/kg	0.24
Fluoranthene	mg/kg	280
Fluorene	mg/kg	170
Indeno(1,2,3-cd)pyrene	mg/kg	27
Naphthalene	mg/kg	2.3
Phenanthrene	mg/kg	95
Pyrene	mg/kg	620
Asbestos screen	Detected / Not Detected	Not Detected

* GAC values derived from LQM CIEH S4ULs (2015), DEFRA SP1010, BS3882:2015 and HSE Control of Asbestos Regulations 2012. Based on SOM of 1% and pH of 6.0 where applicable.

4.0 SOIL SAMPLING AND TESTING

The topsoil and sand material considered for importation shall be independently sampled, tested and approved while stockpiled off site at their source or manufacture location.

4.1 Sampling Protocol

The samples shall be truly representative of the soil/sand to be offered. One *Composite Sample* shall be taken for every **250m^3** of soil to be used, with a minimum of 3 No. samples per source.

Each composite sample should be made up of **10 No. sub-samples** taken from evenly spaced locations across the stockpile. The sub-samples shall be mixed together and quartered down to form a **5kg** composite sample. Each composite sample shall be placed in a clean, strong plastic bag and a 500ml brown glass, wide-necked jar (for organics testing) and each labelled with the source reference and date of sampling. Glass jar samples shall be stored and delivered to the laboratory in a cool box within 24hrs of sampling.

Soils/sands of different types should never be mixed to form a composite sample.

The samples should be analysed on a 6 working day turnaround and the Contractor should incorporate this into their programme.

The sampled soil/sand materials shall be temporarily stockpiled at the source location while the Contractor awaits receipt of the soil/sand analysis results and written approval is provided by the Client's representative on its suitability for use within the project.

4.2 Testing Schedule

The composite samples shall be sent to a UKAS and MCERTS accredited laboratory(s) with a request for each sample to be analysed strictly in accordance with the *Testing Schedules* given below in Clauses 4.2.1 (Topsoil) and 4.2.2 (Washed Sand).

4.2.1 Imported Topsoil Testing Schedule

The following testing parameters shall be requested for the composite *Imported Topsoil* samples (methods in accordance with BS3882:2015 or as indicated):

1. Visual examination to record the presence of any deleterious materials
2. pH Value (1:2.5 soil/water extract)
3. Electrical Conductivity (1:2.5 soil/water extract)
4. Electrical Conductivity (1:2.5 soil/$CaSO_4$ extract)
5. Exchangeable Sodium Percentage
6. Detailed Particle Size Analysis (clay, silt, 5 sands)
7. Stone Content by % weight (2-20mm, 20-50mm, >50mm)
8. Total Nitrogen (% - Dumas Method)
9. Extractable Phosphorus, Potassium & Magnesium (RB427 Method)
10. Organic Matter (%)
11. Calcium Carbonate (% BS7755:3:10:1995)
12. **Potential Contaminants** – See parameters in **Section 3.0**

4.2.2 Imported Washed Sand Testing Schedule

The following testing parameters shall be requested for the composite *Imported Washed Sand* samples (methods in accordance with BS8601:2013 or as indicated):

1. Visual examination to record the presence of any deleterious materials
2. pH Value (1:2.5 soil/water extract)
3. Electrical Conductivity (1:2.5 soil/water extract)
4. Detailed Particle Size Analysis (clay, silt, 5 sands)
5. Stone Content by % weight (2-10mm, >10mm)
6. Calcium Carbonate (% BS7755:3:10:1995)
7. Saturated Hydraulic Conductivity (*ASTM F1815:2011*. Percolation Test – 40cm tension)

4.3 Reporting

The results of analysis for each proposed source of topsoil and washed sand shall be presented in an interpretive report. Each report shall contain the following information:

- Source name and location
- Date of sampling;
- Description of the soil or sand (and components used if a manufactured topsoil);
- Photographs of the stockpile and the soil / sand;
- Visual examination;
- Certificates of Analysis.
- Interpretation of all results with comments on the suitability of the material for use in the proposed scheme.

5.0 SOIL MANAGEMENT

The following measures for soil handling and amelioration shall be adhered to.

5.1 Soil Handling

For the duration of the soiling and playing field construction works, the following soil handling measures shall be adhered to:

- It is important to avoid physical degradation during all phases of soil handling (e.g. spreading, cultivation, amelioration and seeding). As a consequence, soil handling operations should be carried out when soil is non-plastic (friable) in consistency.
- In particular, it is important to ensure that the soils are not unnecessarily compacted by trampling or trafficking by site machinery. In addition, soil handling should be stopped during and after heavy rainfall, and not continue until the soil has regained a non-plastic (friable) consistency.
- If, during the course of the soiling and playing field construction works, the soil is compacted, it will be important to ensure that it is suitably cultivated to relieve the compaction and restore the structure prior to seeding.
- Ensure that the topsoil and sand are not mixed with each other or other building materials during importation, handling and temporary storage.

5.2 Soil Ameliorants

The use of fertilisers or any other soil ameliorants is dependent on the findings of the soil tests and the recommendations provided within the interpretive report.

SPECIFICATION QUALIFICATIONS

This document considers the proposal to use imported topsoil and imported subsoil for soft landscape purposes for the Marble Hill Park project, Twickenham, London. This document should not therefore be relied on for alternative end-uses or for other schemes.

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