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

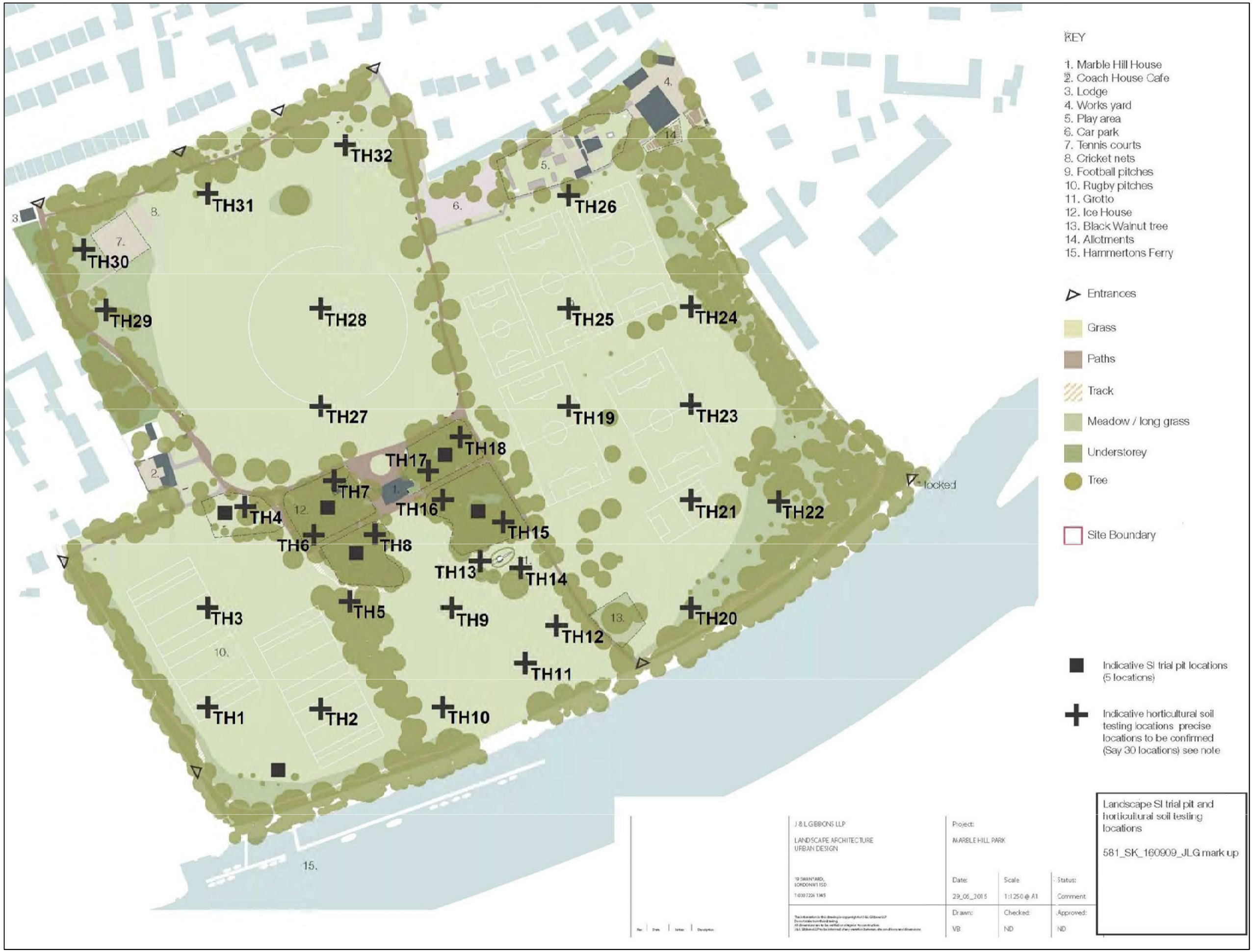
Report Qualifications

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



= Trial Hole Location (approx.)

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Project: MARBLE HILL PARK

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

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