Data Quality Assessment Report[1]:

OPAL Soil and Earthworm Survey

Prepared by the OPAL Soil Centre to accompany any data released to 3rd parties

[1] based on the first 2856 survey responses

LOTTERY FUNDED

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1 INTRODUCTION

1.1 BACKGROUND

The OPAL Soil and Earthworm Survey was launched in spring 2009, as the first of the five National Surveys under OPAL. The survey was completed by the general public utilising a field guide prepared by the Imperial College OPAL Soil Centre in collaboration with staff from the Natural History Museum (NHM), the Environment Agency (EA), the Field Studies Council (FSC), the University of Central Lancashire (UCL) and the British Geological Society (BGS). The survey data included information on the importance the respondent placed on environmental science, identification of the surveyed location, descriptions of environmental conditions encountered, basic soil property assessment, earthworm species identification and counts of earthworms and other macro-organisms.

The survey aimed to achieve both scientific and social beneficial outcomes. Many aspects of the survey were aimed at stimulating involvement of the general public in environmental science for educational purposes through providing an introduction to the process of observing, measuring and interpreting environmental variables.
The main objective was to develop a method to identify areas of soil degradation through data on soil conditions and earthworms collected by people of all ages and ability.

1.2 RECORDS RECEIVED AND SPATIAL DISTRIBUTION

The data quality assessment presented in this report has been based on records as of the 13 August 2009 when a total of 2,856 survey records had been submitted by respondents. The survey records provided spatial coverage of much of England; however a greater density of respondents were located in urban centres, primarily around London and Birmingham. OPAL operates over nine regions and the number of samples received from each of these regions up until 13 August is detailed in *Table 1.1* and *Figure 1.1* below. The only data that have been filtered out and excluded from our survey and therefore its quality assessment are from records where we have sufficient evidence that the location information has been incorrectly provided (explained in section 1.3).

1.3 LOCATION VALIDATION USING POSTCODES

Prior to all analysis, a ground-truthing exercise was completed to compare the postcode entered by respondents with the coordinates at which they placed their site marker when submitting their responses. The purpose of this was to exclude comparison of survey data with mapped reference data where there was uncertainty over the location at which the survey was completed.

The postcode for the site, where given by the participant, was geocoded to give latitude and longitude coordinates. This latitude and longitude from the site postcode was compared to the latitude and longitude recorded on the database from placement of the site marker. Comparison used the Haversine formula to calculate the distance between the two sets of coordinates.

As it was not mandatory to provide the postcode of the sampling location during the survey, a total of 1224 postcodes were supplied, representing 43% of responses. Of these records a total of 118 locations (4.13% of the entire dataset) were excluded from the quality assessment of the data as presented in this report. This was based on the submitted coordinates falling more than one kilometre from the submitted postcode.

Table 1.1 Number of Samples received by OPAL region up to 13th August 2009.

OPAL Region	Number of Samples
London	371
Yorkshire and The Humber	242
South East	399
North West	225
East Midlands	337
East of England	189
South West	273
West Midlands	708
North East	122

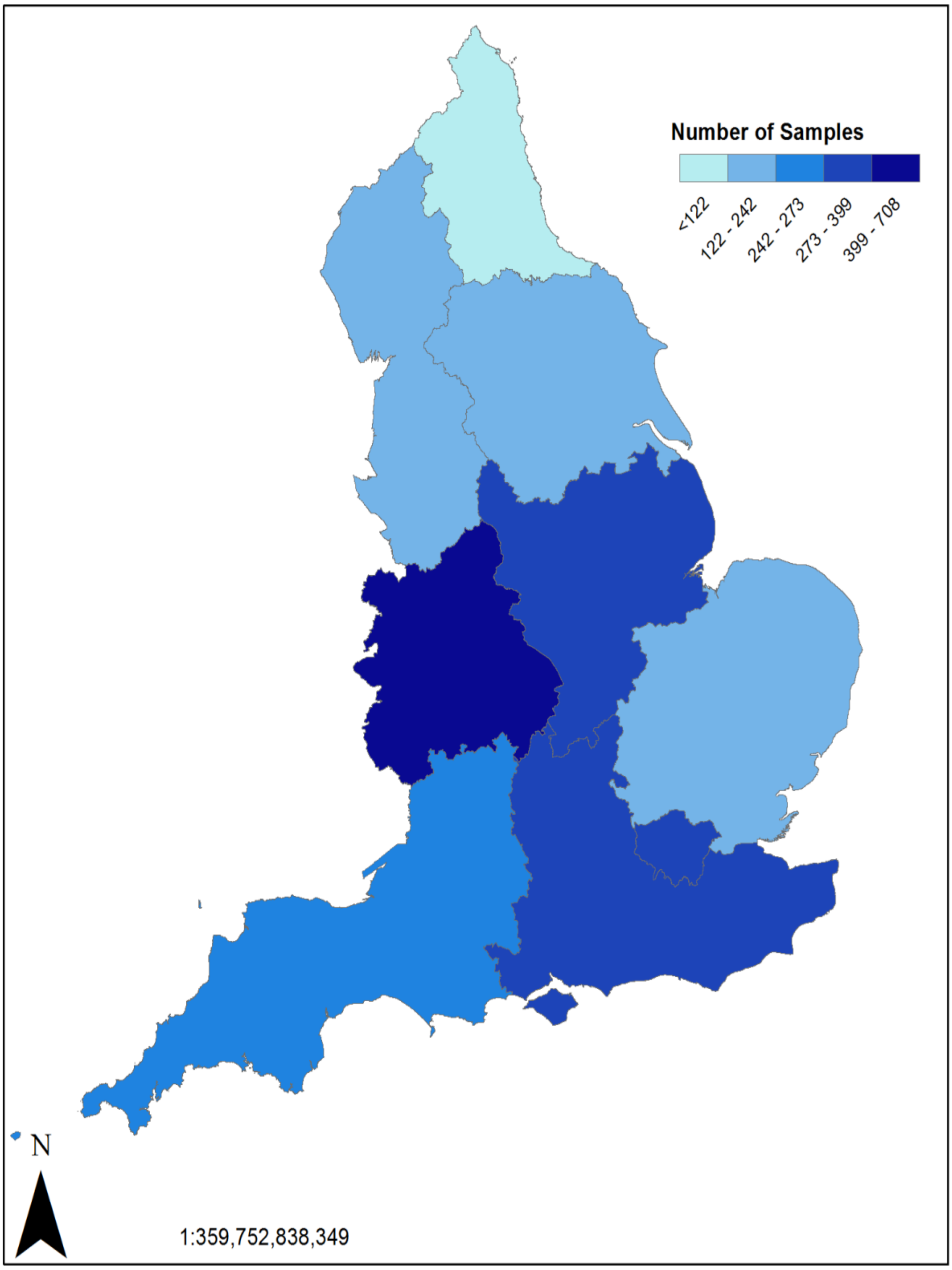


Figure 1.1 Choropleth map illustrating responses received within each of the OPAL regions up to 13 August 2009

1.4 DESCRIPTION OF SURVEY RECORDS

Within a single site (defined in the survey as an area with 5 m radius), survey respondents were prompted to collect information on a number of environmental variables. The survey records can be described as either *measurements* or *observations* depending on how the data was collected. To develop a robust baseline, the survey aimed to collect data with the minimum level of detail specified in *Table 1.2*.

Table 1.2 Survey data groups

Survey field	Desired Level of Detail
Quantitative or semi-quantitative (Measurements)	
Soil pH	Differentiate between acid, alkaline and neutral soils
Water drainage time	Differentiate between slow and fast drainage
Worm numbers	Accurate total count
Worm length	To fall within the recognised species body length
Distance to nearest road	<20m, 20-100m or >100m
Soil texture	Differentiate between sand, loamy sand and soils of increasing clay content
Vegetation coverage	Differentiate between no plant cover, 50% plant cover or 100% plant cover
Qualitative (Observations)	
Surrounding area	Differentiate between urban, suburban or rural areas
Sampling site	Identify land use by closest match to example image
Weather	Identify predominant weather condition
Plant roots	Identify presence or absence
Soil moisture	Differentiate between dry, moist or wet
Soil hardness	Differentiate between compacted or not compacted
Signs of pollution	Identify presence or absence of potential pollution sources
Soil objects	Identify presence or absence of anthropogenic inclusions
Soil fizz	Identify presence or absence of CO_3^{2-} reactivity to vinegar
Soil smell	Identify presence or absence of odour associated with high organic matter or chemical impacts to soil
Earthworm species identification	Differentiate between epigeic, endogeic or anecic species.
Soil colour	Differentiate between the major colour groups commonly observed

1.5 OBJECTIVES OF DATA QUALITY ASSESSMENT

The scientific objective of the survey was to develop a baseline understanding of the distribution of earthworm species and associated soil conditions in England. As well as providing the minimum resolution presented in *Table 1.2*, it was necessary that the data could be demonstrated to be: representative of previously established environmental conditions, reproducible following the established methodology, provide suitable spatial coverage and form a complete data set for future comparison. *Table 1.3* presents typical control measures employed to meet these data objectives and comments on how they were adopted in this investigation.

Table 1.3 Data Quality Targets

Control measures	Comments
Reproducibility	
Investigation conducted following a standard methodology.	A field guide was prepared to direct respondents. As typical respondents lacked formal training there was potential for individual deviation from the standard methodology. In some cases, respondents were supervised by community scientists, however variation from the formal procedures was not routinely documented.
Replicate measurements collected to assess standard deviation.	IC conducted a trial with repeat measurements of soil pH and texture at a single site to assess reproducibility within and between participants. Results used to establish acceptable limits for evaluating survey data. During the survey, respondents were asked to excavate two soil pits at each site.
Representativeness	
Investigation conducted following a standard methodology.	See above comment regarding standard methodology.
Control samples collected from locations with previously determined attributes.	IC conducted a trial to assess local variation in soil properties at a single sampling site. IC conducted targeted sampling at locations where soil conditions had previously been assessed by BGS. National soil and land use mapping provided by EA was used to compare survey records with existing data. NHM conducted cross checking of earthworm species identification and length measurement during a number of workshops.
Check measurements/identification performed by a second analyst.	No check measurements conducted for soil attributes.
Comparability	
Investigation conducted following a standard methodology.	See above comment regarding standard methodology.
All sampling conducted by an appropriately qualified and experienced sampler. Consistent types of samples collected.	Although respondents typically did not have formal training, the field guide is considered to have provided sufficient background understanding to complete the required tasks.
Completeness	
Acceptable spatial coverage achieved.	Community scientists established at key locations to achieve participation in major regional areas.
Investigation conducted following a standard methodology (including description of samples).	See above comment regarding standard methodology.
All sampling conducted by an appropriately qualified and experienced sampler.	See comment above.
Documentation of field works provided.	Survey results submitted via online portal.

The preparation of the standard field guide for the survey was therefore considered to be the primary means of meeting data quality targets for comparability of samples. The support provided by community scientists was considered a critical element in ensuring the completeness of the survey results, including spatial coverage and submittal of entire records.

The data quality assessment therefore focused on the reproducibility and representativeness elements described above. This assessment has been divided into a number of tasks to achieve this aim, as follows.

Task A: Assessment of soil pH and texture reproducibility at selected control sites.

Task B: Assessment of soil pH and texture representativeness using NSRI reference data.

Task C: Assessment of survey representativeness using BGS reference data.

Task D: Assessment of land use observation representativeness using LCM2000 reference data.

Task E: OPAL sampling event-based assessment of earthworm species identification.

2 TASK A: SOIL MEASUREMENT REPRODUCIBILITY

2.1 INTRODUCTION

During the survey a "site" was defined as an area of 5 m radius within which up to two soil pits would be excavated. Prior to comparing the results to reference data, two trials were conducted by IC to provide checks on the reproducibility of measurements within this area.

2.2 TRIAL 1

The first trial aimed to demonstrate that on a site with low soil heterogeneity, variability in repeat measurements taken by a single participant was not significantly different to variability in measurements between participants. The subject site for this trial was a playing field, selected for this trial based on a visual inspection that indicated a relatively homogenous soil type and uniform land management practices within the area. Over a nine-week period, two participants visited the site on a weekly basis and two soil pits were excavated each week within the defined area with a 5 m radius.

A total of 18 measurements were made by each participant, with soil pH and texture results presented in *Table 2.1*.

Table 2.1 Summary of Trial 1 Results

Measurement	**Number of responses: Participant 1**	**Number of responses: Participant 2**
Soil pH		
pH 5.0	2	0
pH 5.5	9	10
pH 6.0	7	8
Soil texture		
Silty clay	8	6
Sandy clay	1	0
Clay loam	2	2
Silty clay loam	7	9
Sandy clay loam	0	1

The pH values recorded ranged between 5 and 6 and all values fell within 0.5 pH units of the mean for each participant. The means for the two participants differed by approximately 0.1 pH units. A two-way analysis of variance with replication was conducted on this data, as summarised in the table below. As the F-value was less than the critical value for both sources of variation, there was no significant difference (at a 95% level of probability) identified in mean soil pH measurements either within or between samplers.

Table 2.2 ANOVA comparison of Trial 1 soil pH results

Source of Variation	SS	df	MS	F	P-value	F crit
Week	1.513889	8	0.189236	0.879032	0.551918	2.510158
Sampler	0.0625	1	0.0625	0.290323	0.596616	4.413873
Interaction	0.625	8	0.078125	0.362903	0.926824	2.510158
Within	3.875	18	0.215278			
Total	6.076389	35				

A comparison of soil texture observations indicated that in over 80% of assessments, both participants recorded the soil texture as silty clay or silty clay loam with the remainder identified as soil textures with the same range of clay content but differing sand/silt ratios.

Overall, the results of Trial 1 indicate that for repeat measurements made at a single site, no greater variability is expected for different samplers than for a single sampler.

2.3 TRIAL 2

The second trial aimed to identify the likely variability in survey results due to the inherent heterogeneity of soil conditions. A garden site (NHM Meadows) was selected as representative of conditions likely to be encountered during the survey and an area with 5 m radius designated for the trial. Over a nine-week period, a total of 18 participants visited the site and each completed the survey at two locations within the defined area.

Soil pH measurements ranged from 4.5 to 7 as presented in *Figure 2.1*, with a mean of 6.05 and standard deviation of 0.56 pH units. Overall, 86% of results fell within 0.5 pH units of the mean and 97% fell within 1 pH unit of the mean. The distribution of soil textures was examined in relation to their sand, silt and clay content, as illustrated below. Texture was predominantly described as a silty clay loam, with 91% of descriptions falling within neighbouring texture classes on the soil texture triangle (*Figure 2.2*).

These results are considered to indicate that site-based variation of soil pH by up to 1 pH unit should be considered likely when comparing results recorded in the survey to sources of reference data (*Section 3*).

Likewise, a variation in soil texture at a single site between adjacent classes on the soil texture triangle is considered feasible due to local heterogeneity. This is because each texture class represents a range of sand, silt and clay values and although boundaries between classes are defined on the soil texture triangle, in practice the transitions are much less distinct. Where the percentage of sand, silt and clay lie on or near the boundary between texture classes, it is therefore feasible that it may be described as either texture in the field. Furthermore, this is a subjective assessment which is informed by the experience of the assessor.

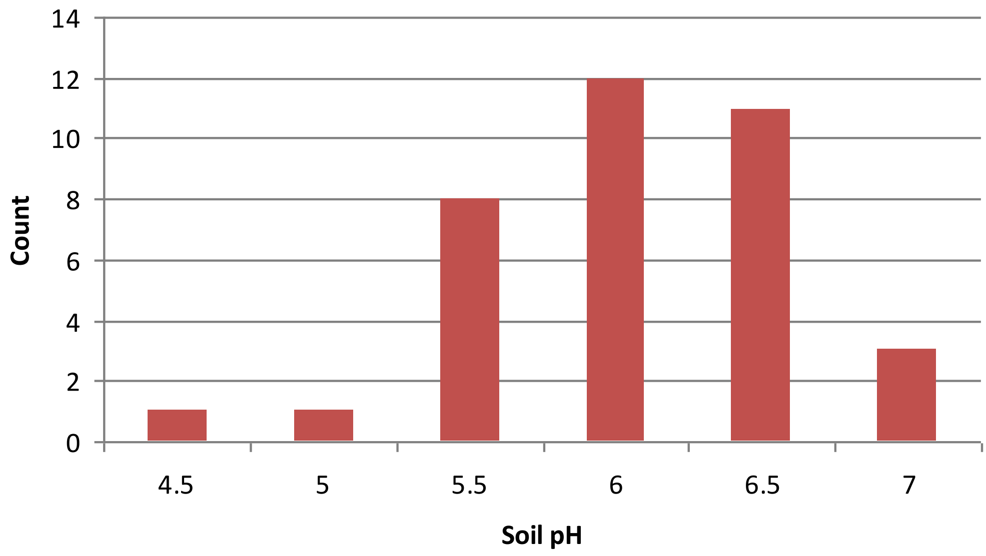


Figure 2.1 Trial 2 soil pH results

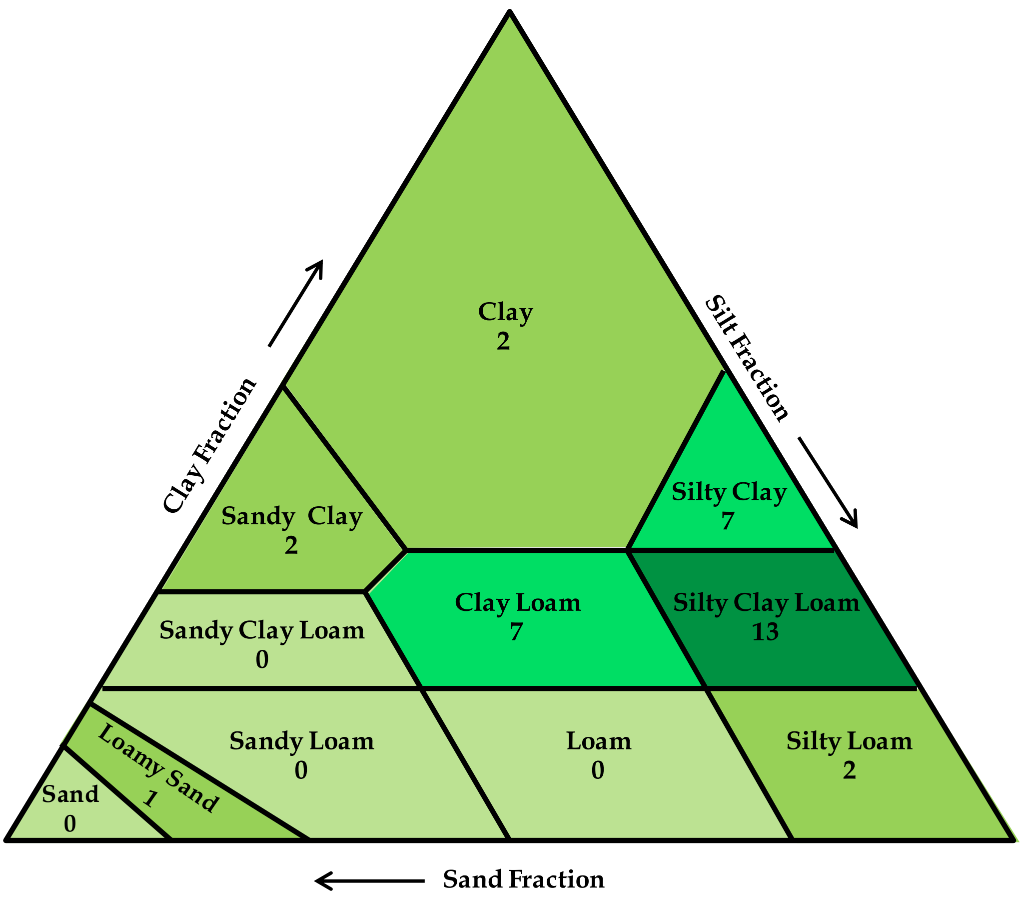


Figure 2.2 Trial 2 soil texture results

3 TASK B: SOIL PH AND TEXTURE REPRESENTATIVENESS

3.1 REFERENCE DATA SOURCE: NSRI NATIONAL SOIL MAP

The NSRI National Soil Map is a 1:250,000 scale vector map of geographic Soil Associations, based on published soil maps which cover a quarter of the land at scales of 1:25,000, 1:63,360 or 1:100,000 and on reconnaissance mapping of previously unsurveyed areas (Cranfield University, 2004).

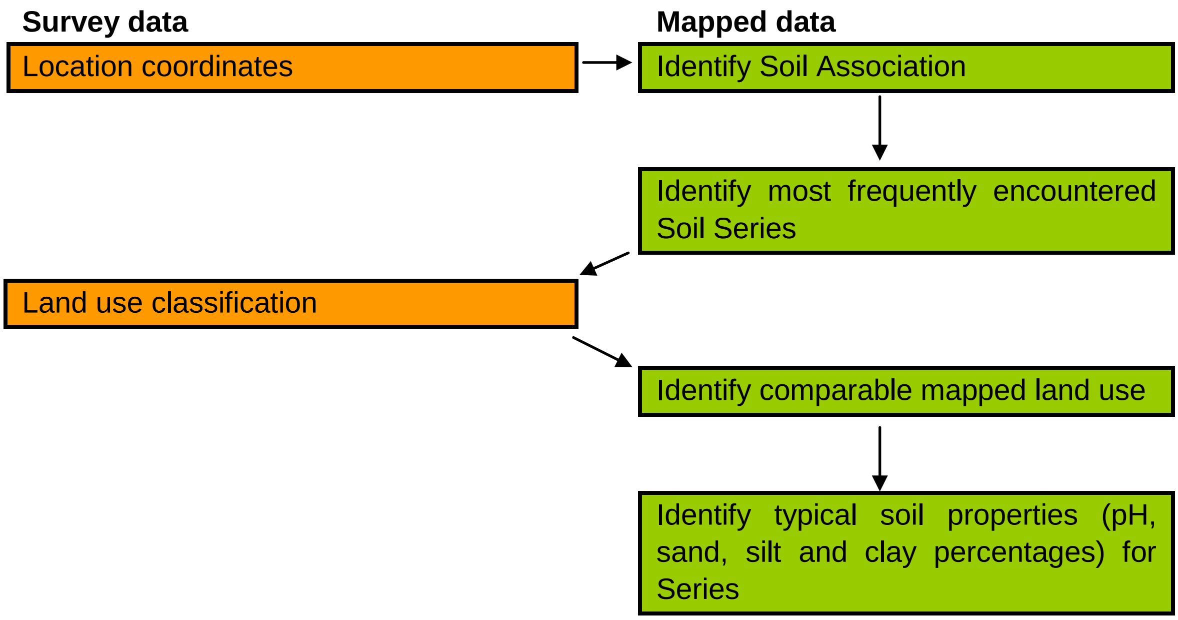
Each Soil Association comprised varying percentages of a number of Soil Series. The Soil Series forms the lowest division of the hierarchical system used to describe soil profile characteristics – in descending order these are *Major Group*, *Group*, *Subgroup* and *Series*. The three higher divisions are based on the pedogenic characteristics of the soil profile and the Soil Series is based on precisely defined particle-size subgroups, parent material type, colour and mineralogical characteristics[2]. Typical properties have been compiled for each horizon in each Soil Series under one of four land uses (Arable, Permanent Grassland, Ley Grassland or Other). Mapped land uses were considered comparable to the survey land use description as follows:

- *Arable*: “ploughed field”;
- *Permanent Grassland*: “grassy verge”, “heath or moorland”, “parkland” and “playing field”;
- *Ley Grassland*: “open grassy field”; and
- *Other*: “industrial”, “other”, “garden” and “wood or forest”.

These data therefore form a basis for understanding the spatial variation in soil properties within England.

For the purpose of comparison with the OPAL survey data, it is necessary to identify an expected or likely set of soil properties at each location. A deterministic approach was adopted for the initial comparison. Although the database supporting the NSRI map provides values for the percentage contribution of each Soil Series to the Soil Association, it does not provide similar information on the land use split within each Soil Series. A probabilistic approach to identifying soil properties was therefore not adopted. This identification of likely soil properties at each location involved the steps in the following flow chart:

[2] Clayden, B. and Hollis, J.M. (1984) Criteria for Differentiating Soil Series. Soil Survey Technical Monograph No. 17. Harpenden



3.2 SOIL PH

Soil pH was measured in the survey using universal indicator paper strips graduated from pH 4 to pH 9 in increments of 0.5 pH units. This measurement methodology was standardised across the survey. Soil pH was not reported by 53 respondents. Overall, the soil pH results appear to be close to normally distributed around a mean pH of 5.8, as shown in *Figure 3.1*.

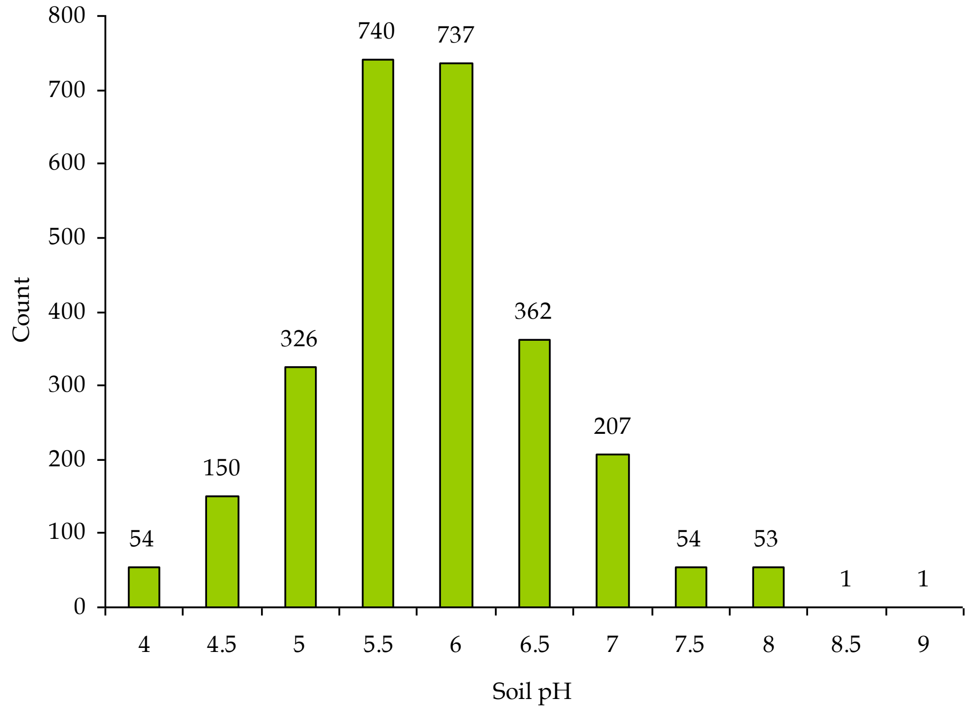


Figure 3.1 Distribution of Soil pH Values - Survey

A different trend was observed in the distribution of the mapped (NSRI) soil pH for the same locations, with a trend towards sites with more acidic soil pH. The mean pH for the mapped data was 5.5, as shown in *Figure 3.2*. A limitation of the methodology is apparent from this data, as the indicator strips did not allow identification of soil pH less than 4, however the NSRI indicates that only approximately 2% of locations have soil pH between 3.5 and 4. This high-level comparison indicates a tendency for many sites with mapped soil pH between 3.5 and 4.5 to have been reported in the survey with higher pH values.

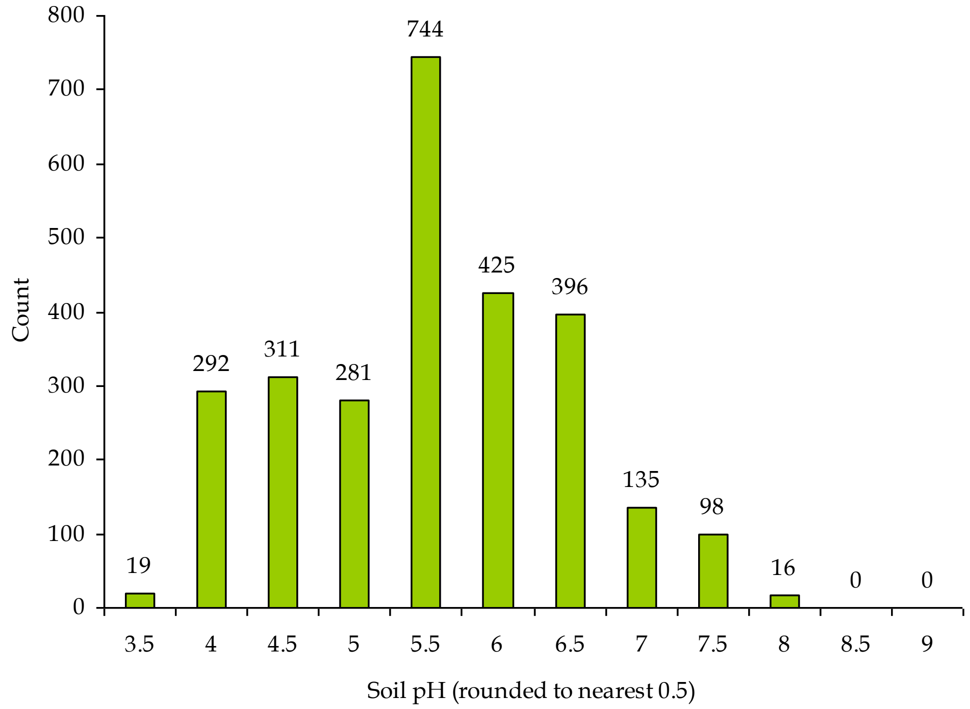


Figure 3.2 Distribution of Soil pH Values – NSRI Map

To further investigate the discrepancies between *Figures 3.1* and *3.2*, the mapped pH has been subtracted from the survey pH to obtain an “apparent error” for the survey results. A frequency histogram displaying this information is presented in *Figure 3.3*.

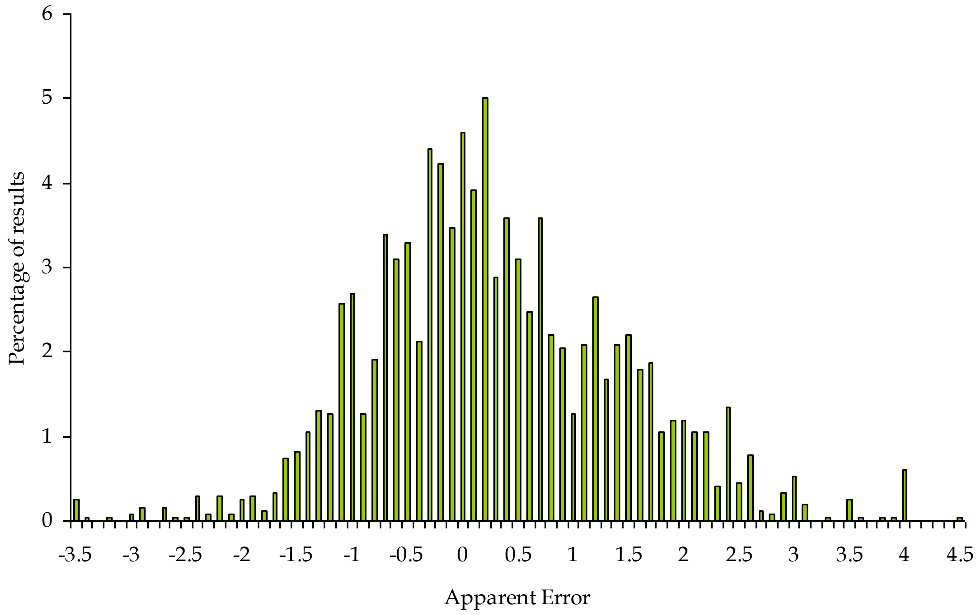


Figure 3.3 Apparent error frequency histogram

From this chart it is apparent that 40.6% of survey results were reported within 0.5 pH units of the expected value determined from the NSRI map. This is not considered to be problematic as the indicator paper used to measure pH in the field only allowed a resolution of 0.5 pH units. Within the remaining 59.4% of results, the majority of these were locations where the pH range was reported to be higher than that determined from the NSRI map.

The "apparent error" observed in the pH measurements is likely to be a result not only of the measurement technique but also as a limitation of the baseline data used to conduct the comparison. To investigate potential limitations in the NSRI map data, the dataset was divided into two groups, one with an "apparent error" less than or equal to 0.5 pH units and the second with an "apparent error" greater than 0.5 pH units. A comparison of the relative proportions of different land uses within each group was subsequently conducted, as illustrated in *Figures 3.4a & 3.4b*.

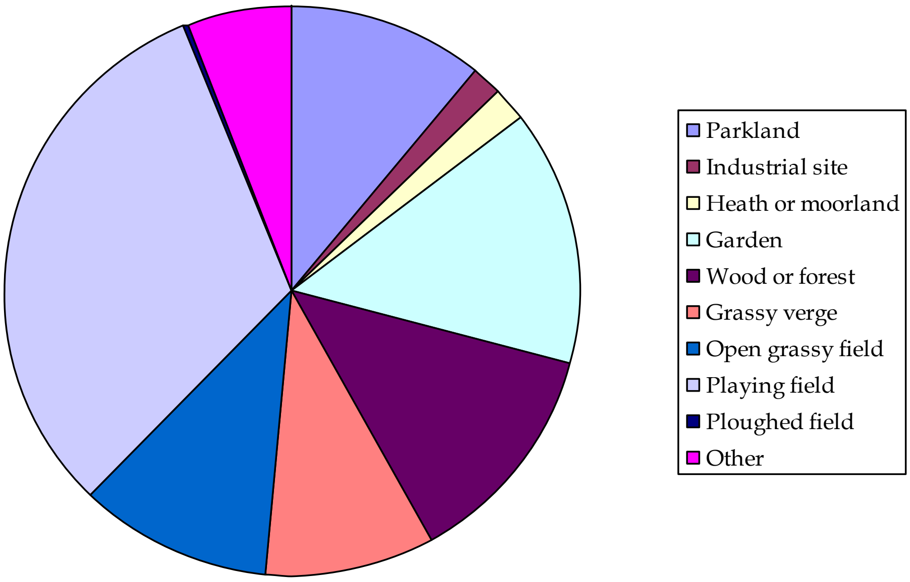


Figure 3.4a Land-use breakdown ("apparent error" <0.5 pH units)

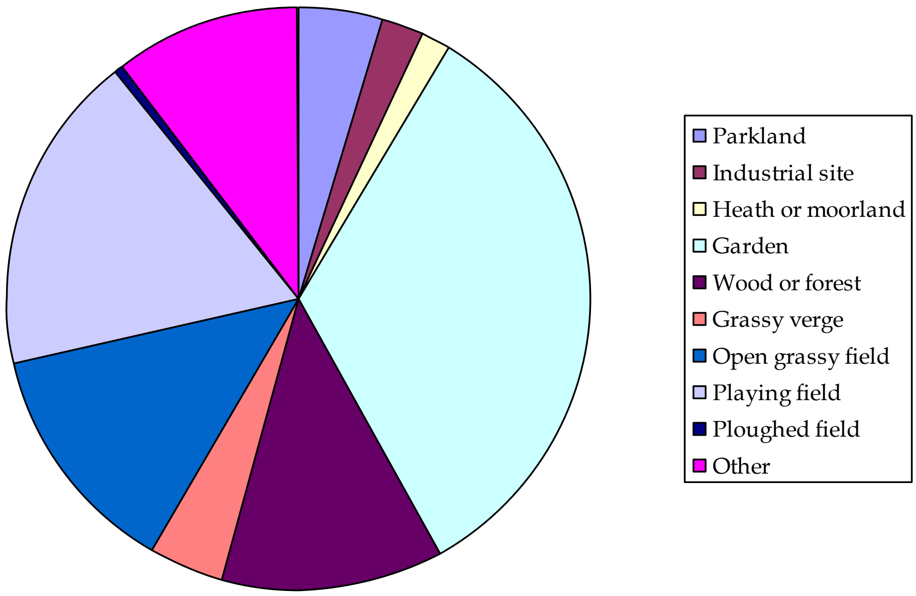


Figure 3.4b Land- use breakdown ("apparent error" >0.5 pH units)

It is apparent from this comparison that the locations described as gardens form a large proportion of the locations where the pH reported in the survey was more than 0.5 pH units different to that determined from the NSRI map. This indicates a limitation of the mapping in urban areas. It appears that the resolution of the mapping is poorer than the spatial variability in land-uses and soil conditions. Furthermore, surface soils in urban areas are typically highly disturbed and sourced from backfill not derived from the local area. As the Soil Series profiles are primarily derived in relation to the underlying geology, it is likely that surface soils in urban and suburban areas may not reflect the underlying natural soils.

To investigate this, locations identified as being in countryside areas (excluding gardens, industrial sites and "other") were selected and an "apparent error" frequency histogram produced for these survey results. This demonstrates a greater percentage (48.1%) of results falling within the 0.5 pH unit error range considered to be acceptable than in the previous comparison (*Figure 3.3*). The NSRI map is therefore considered to be a less suitable source of baseline data for urban and suburban areas, where soils are less likely to be indicative of the underlying parent material and local geology.

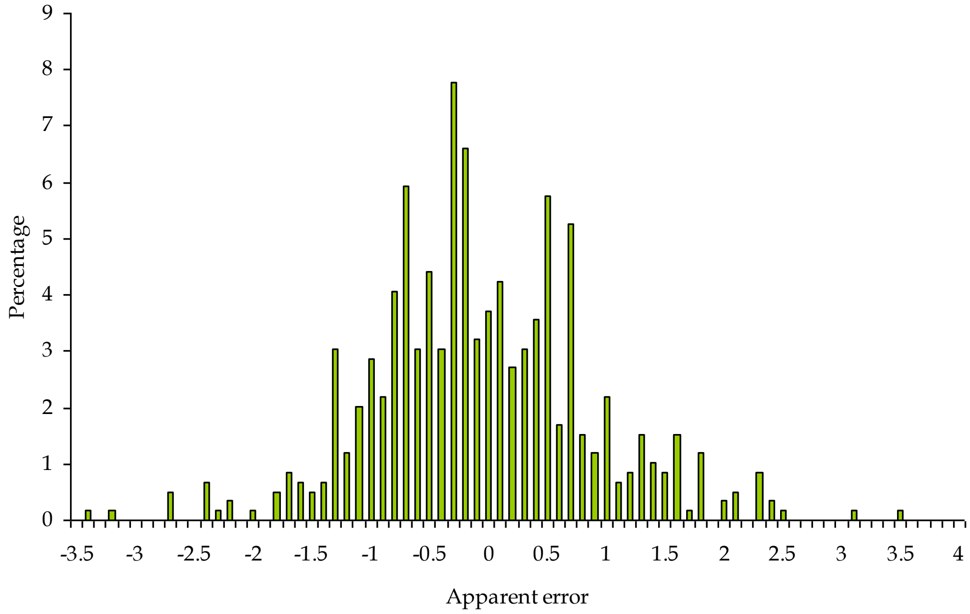


Figure 3.5 Apparent error frequency histogram – urban and suburban areas excluded

Overall, 78.0% of results fall within an error range of +/- 1 pH unit and 90.4% within an error range of +/- 1.5 pH units. Importantly the data appear to follow a normal distributed which indicates that the error was not solely associated with the more acidic soil locations, but was likely to be due to the low resolution of the mapped validation data, the selection of a single representative value for a naturally variable soil property and the limitations of the measurement methodology.

As the data quality objective was to reliably differentiate between acid, neutral and alkaline soils, the survey data for soil pH was therefore considered to be of acceptable quality. To investigate the representativeness of survey data in urban areas in more detail, Task C was completed using data sourced from the BGS.

3.3 SOIL TEXTURE

Soil textures were described during the survey based on a combination of attributes including the ability to form a coherent bolus and a ribbon, followed by measurement of ribbon length and evaluation of smoothness. Ribbon length is proportional to clay content; however the assessment is otherwise subjective. A total of 181 survey respondents did not report the soil texture.

The NSRI map provides typical percentage values for sand, silt and clay for each Soil Series. The procedure described in *Section 2.1* was followed to identify representative values for each mapped Soil Association. Utilising the soil texture triangle, each set of values was subsequently converted into a texture class.

As discussed in *Section 2.3*, where the percentage of sand, silt and clay lay on or near the boundary between texture classes, it was considered feasible that it may be described as either texture in the field. Therefore, for the purpose of evaluating the representativeness of the texture assessments reported in the survey, each texture class was assigned a set of corresponding mapped classes that would be considered consistent. This comparison matrix is presented in *Table 3.2*.

Table 3.1 Texture class comparison matrix

Mapped texture (NSRI)	Surveyed texture (OPAL) Silty loam	Silty clay loam	Silty clay	Sandy loam	Sandy clay loam	Sandy clay	Sand	Loamy sand	Loam	Clay loam	Clay
Sandy Clay	-	-	-	-	✓	✓	-	-	-	✓	✓
Silty Clay	-	✓	✓	-	-	-	-	-	-	✓	✓
Sandy Loam	-	-	-	✓	✓	-	✓	✓	✓	-	-
Clay Loam	✓	✓	✓	✓	✓	✓	-	-	✓	✓	✓
Clay	-	✓	✓	-	-	✓	-	-	-	✓	✓
Silty Clay Loam	✓	✓	✓	-	-	-	-	-	-	-	-
Loamy Sand	-	-	-	✓	✓	-	✓	✓	-	-	-
Loam	✓	✓	-	✓	✓	✓	✓	-	✓	✓	✓
Silt Loam	✓	✓	-	-	-	✓	✓	-	✓	✓	-
Sand	-	-	-	✓	✓	✓	✓	✓	-	-	✓
Sandy Clay Loam	-	-	-	✓	✓	✓	✓	✓	✓	✓	✓

The percentages of surveyed textures that were consistent with the texture derived from the NSRI map were subsequently calculated using this matrix and are illustrated in *Figure 3.6*.

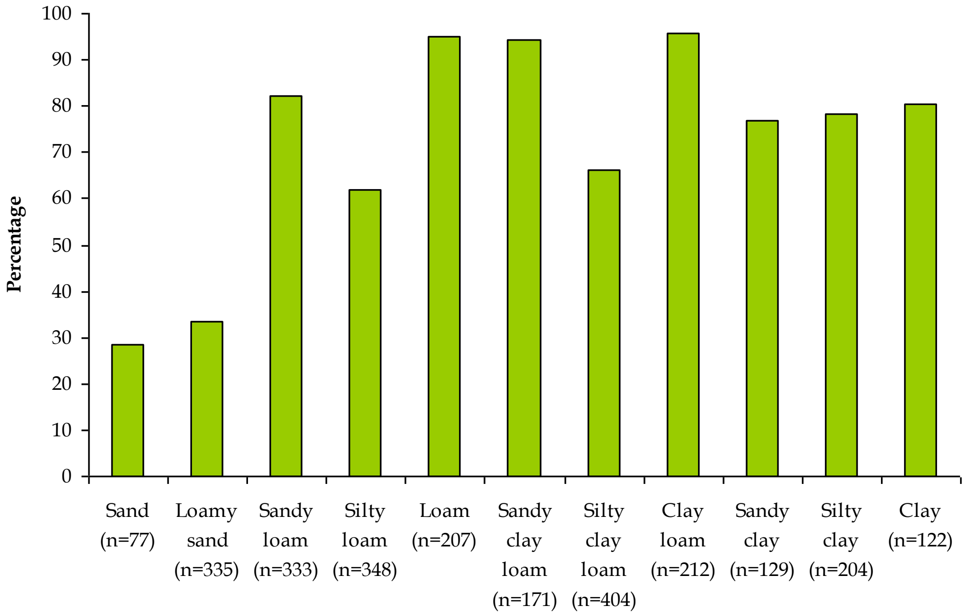


Figure 3.6 Percentage of survey texture classes matching mapped textures

Sand soil types were the least frequently reported and only 29% of these corresponded with similar textures determined from the NSRI map. It was considered likely that this error was due to a misapplication of the initial step of the methodology, as the use of insufficient water can prevent the formation of a coherent bolus. However, sites reported to have sand soil type were primarily also described as garden, open grassy field or playing field and the mismatch between the mapped texture and the surveyed texture could also be due to the presence of sand added as fill materials, for example, to improve drainage on sports fields.

Although a relatively high number of soils were described in the survey as loamy sand, only 33% of these corresponded to similar texture descriptions determined from the NSRI reference data. As discussed above for sand soils, it was likely that any error was due to misapplication of the methodology. Ribbon formation could be difficult if insufficient water was added or if the bolus was not worked for an adequate amount of time to break down the structure.

For the remaining texture classes, survey records were considered to be reasonably representative of texture as determined by ribbon length (which relates to clay content), with an average of 81% of reported textures corresponding with similar mapped attributes. It appears however that respondents were less accurate in distinguishing the soils with intermediate sand content, as silty loam and silty clay loam descriptions only corresponded with similar mapped textures at 62% and 66% of locations, respectively.

Overall, it was concluded that the results of the survey were suitably representative of the soil textures encountered, for the purpose of distinguishing between soils of increasing clay content but less representative of areas where sand or loamy sand soil types were present.

4 TASK C: SURVEY RECORD REPRESENTATIVENESS

4.1 REFERENCE DATA SOURCE: BGS SOIL SURVEY

The British Geological Survey Geochemical Baselines Survey of the Environment (G-BASE) project is a systematic survey to establish a geochemical baseline across the United Kingdom. The survey commenced in the 1960s at which time it was primarily used for mineral exploration. The survey has evolved into a multimedia, high resolution geochemical survey producing baseline data relevant to many environmental issues. The survey is described as high resolution because samples are collected at a high density averaging one sample every 1.5 to 2 square kilometres. The survey has included over 20 urban environments which are systematically mapped at a resolution of four samples per square kilometre.

A number of inorganic analytes, loss on ignition and pH were determined from laboratory analysis of collected soil and stream sediment samples as well as a number of observations made about the sample and the sampling site while in the field. Observations relevant to the OPAL Soil and Earthworm survey include the soil texture, soil colour and non-natural objects in the soil[3].

OPAL Soil and Earthworm survey responses were compared to data from the BGS G-BASE program. For soil pH, urban data was used for the areas of Coventry, Northampton and Derby[4]. For observational data, BGS data for the London part of the London Earth Project[5] was used. Characteristics compared are soil texture, soil colour, non-natural soil objects and land use. Sites sampled in the BGS London Earth sampling program were revisited in two areas, around Camden and Hammersmith in London. As the BGS survey had included a record of site geographic coordinates, high accuracy could be obtain in targeting the BGS locations for repeat sampling. At each sampling site in London the OPAL Soil and Earthworm survey was carried out.

4.2 SOIL PH

Urban soil pH collected in the high resolution G-BASE was compared to values collected in the OPAL Soil and Earthworm Survey. The G-BASE urban data was used as it has a higher resolution than the NSRI National Soil Map, and focuses on urban data where the majority of OPAL samples received so far occur.

The soil pH collected by the BGS from 5 - 20cm depth below ground level was used in three urban centres, Derby, Coventry and Northampton as shown in *Figure 4.1* below.

[3] Johnson, C.C. and Breward, N, 2004. G-BASE Geochemical Baseline Survey of the Environment. British Geological Survey, Keyworth, Commissioned Report, CR/04/016N.

[4] Scheib, A.J. and Nice, S.E., in press. Soil geochemical baseline data for the urban areas of Corby, Coventry, Derby, Leicester, Northampton, Nottingham and Peterborough in the East Midlands. British Geological Survey Open Report series, Keyworth, Nottingham. OR/08/075.

[5] Fordyce, F M, Brown, S E, Ander, E L, Rawlins, B G, O'donnell, K E, Lister, T R, Breward, N, and Johnson, C C. 2005. Urban geochemical mapping in Great Britain. *Geochemistry: Exploration, Environment, Analysis 5*, Vol. 4, 325-336

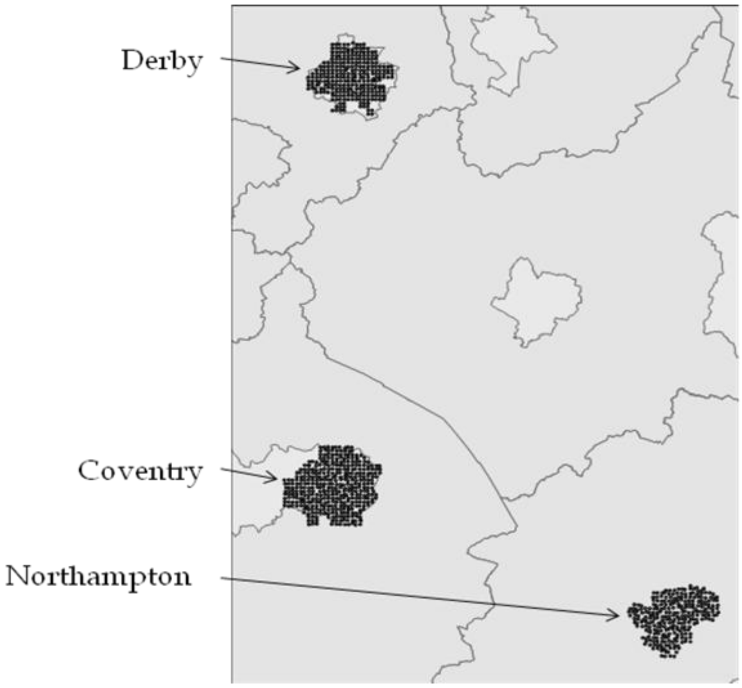


Figure 4.1 Urban areas sampled as part of the BGS GBASE sampling program and used for comparison to OPAL Soil and Earthworm Survey pH values

The number of BGS G-BASE samples within these urban areas as well as the number of OPAL Soil and Earthworm Survey Samples found within the BGS sampling area is detailed in *Table 4.1* below.

Table 4.1 Sample numbers from BGS and OPAL surveys in regional centers

Urban Area	BGS G-BASE Samples	OPAL Soil and Earthworm Survey Samples
Derby	276	46
Coventry	396	27
Northampton	275	3

The soil pH point data from the BGS G-BASE samples were Kriged to create raster plots of the soil pH in each of the urban areas as shown in *Figure 4.2* below.

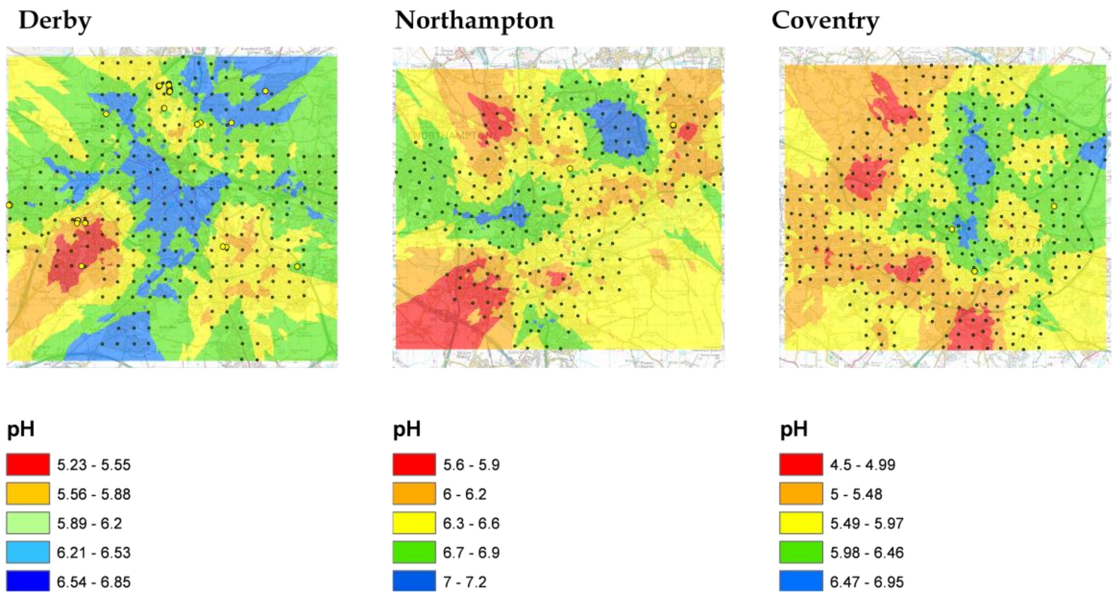


Figure 4.2 Plots for Derby, Northampton, and Coventry showing the raster created by Kriging BGS G-BASE samples (black points). OPAL Locations shown as yellow points

The value reported in the OPAL Soil and Earthworm Survey was compared with the raster value from the Kriged BGS G-BASE data at the location given.

The soil pH results from the OPAL Soil and Earthworm Survey for the three urban areas do not seem to follow a normal distribution as seen with results for the whole survey (*Figure 4.3*); this is likely due to the substantially lower number of samples in this dataset. The mean pH of this dataset is 5.7, very close to the mean pH of the national data set of 5.8.

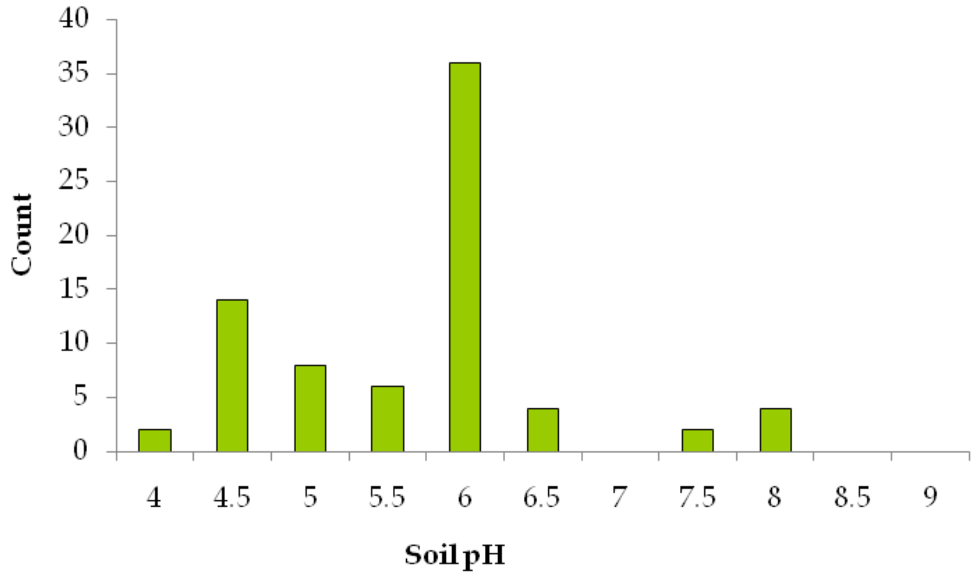


Figure 4.3 Distribution of Soil pH Values- OPAL Soil and Earthworm Survey

A different trend is seen in the distribution of soil pH from the Kriged BGS G-BASE data for the locations were the OPAL Soil and Earthworm Survey took place (*Figure 4.4*). The mean pH in the Kriged data was slightly higher than the survey at 6.1.

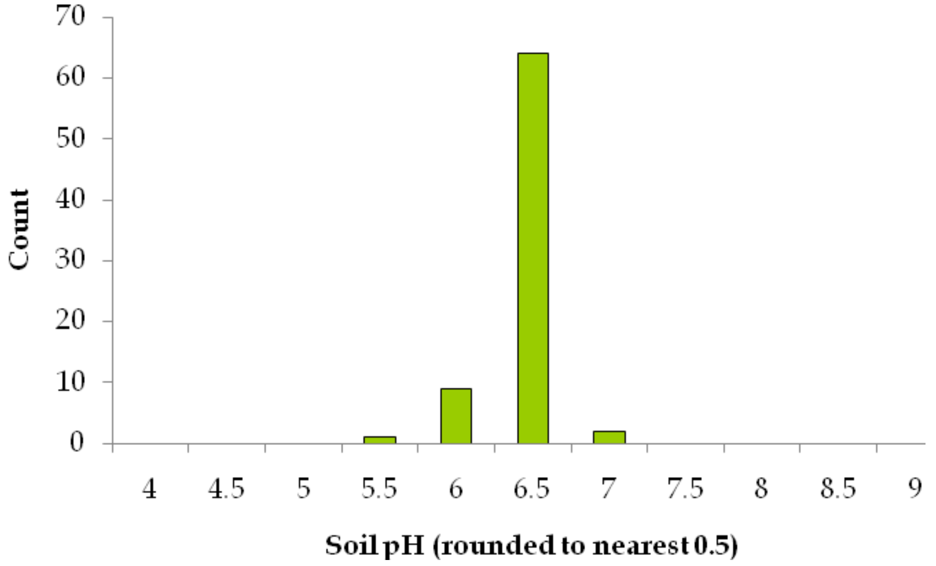


Figure 4.4 Distribution of expected soil pH values obtained from the Kriged raster plots

As for comparison between the survey pH and NSRI values an "apparent error" for the survey result was calculated using the BGS G-BASE data. A histogram displaying this information is presented in *Figure 4.5*.

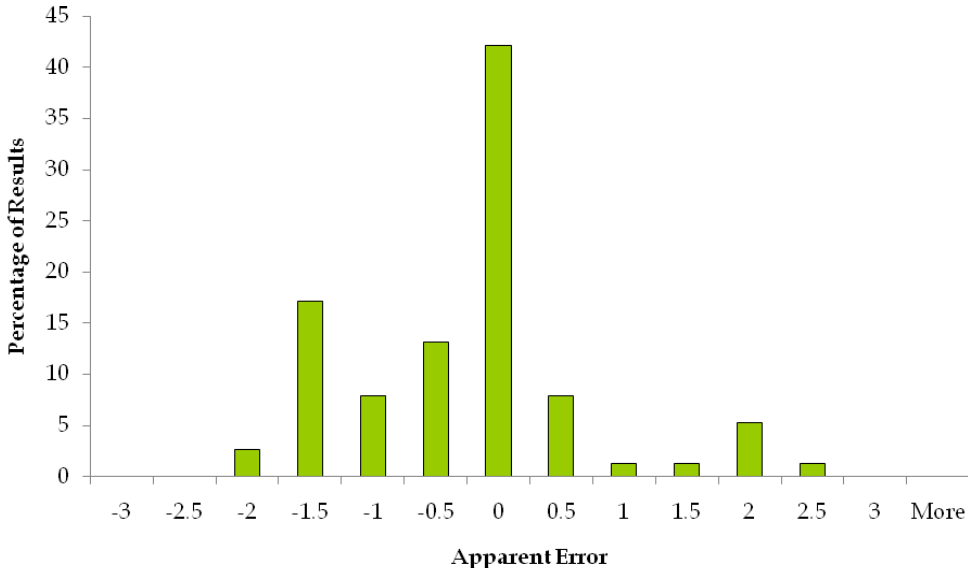


Figure 4.5 Histogram of apparent error between OPAL Soil and Earthworm values and Kriged values from BGS G-BASE samples

It is apparent that 50% of survey results were reported within 0.5 pH units of the expected value determined from the Kriged BGS G-BASE values. The remaining 50% of results were determined to have a different pH to that determined from the Kriged BGS G-BASE values. An apparent error of less than 1pH unit was found for 64.5% of samples and less than 1.5 pH units for 73.7% of samples. Contradictory to comparison with the NSRI, the majority of samples had a reported pH that is lower than the pH determined from the Kriged data.

If the two sets of samples are classed as Acid (<pH 5.6), Neutral (pH 5.6 – 7.5), Alkaline (>7.5) there is 50% agreement between the two datasets.

4.3 SOIL TEXTURE

The OPAL Survey had eleven soil texture classifications whilst the BGS had seven. The OPAL Soil Texture classifications were based on the USGS soil texture triangle whereas the BGS survey uses a simplified soil texture classification.

In order to compare the classifications of soil textures at each location it was necessary to standardise the soil texture classification. In order to do this, the USGS soil texture triangle was modified to form a generalised soil texture classification, into which both the BGS and IC OPAL soil classifications could be reclassified (*Figure 4.6*). For continuity, the principles used to design the generalised Soil Texture classification were the same as those applied by the Environment Agency.

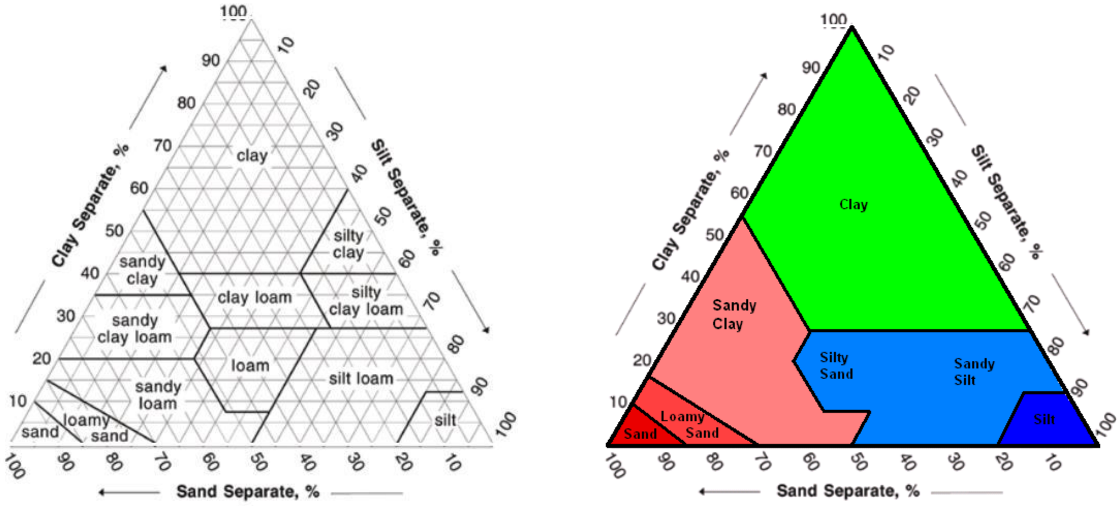


Figure 4.6 USGS Soil Texture Triangle (left) (Soil Survey Division Staff, 1993). Soil texture classifications to facilitate comparison of OPAL Soil and Earthworm and BGS London Earth data (right)

4.3.1 Exact Matches

The surveys were compared for exact soil texture matches at each location. Exact matches were those which appeared in both the OPAL Soil and Earthworm Survey and the BGS London Earth dataset. The list of exact matches being detailed in *Table 4.2* below.

Table 4.2 Table defining soil textures found in OPAL Soil and Earthworm survey and BGS London Earth survey which are defined as exact matches

BGS Soil Texture	OPAL Soil Texture
Sand	Sand
Sand	Loamy Sand
Silt	Silty Sand
Silt	Sandy Silt
Clay	Clay
Sandy Clay	Sandy Clay
Silty Sand	Silty Sand
Sandy Silt	Sandy Silt
Sandy Silt	Silty Sand

NB. *For the purpose of this comparison, “Loamy Sand” was treated as analogous to “Sand” whilst “Silt” was treated as analogous to “Sandy Silt/Silty Sand”.

4.3.2 Narrow Matches

The parameters for a match were then widened to include any location for which the major component of the soil texture was the same - the major component was identified by the noun within the soil texture. For example, in a Sandy Clay the major component is the noun “Clay” whilst the minor component is Sand as reflected by the adjective “Sandy”. The soil textures which matched under these criteria were identified as “narrow matches”.

4.3.3 Moderate Matches

A “moderate match” test carried out for soil texture wherein the parameters for a match were widened to include any location where either the major or minor component of the BGS and OPAL soil textures were the same. For example, for the soil texture Sandy Clay, any soil which was described as “Sandy” or named as “Clay” was considered to be a successful match such that both Sandy Silt and Clay would be considered matches.

The soil textures recorded in the BGS and OPAL surveys were compared to see how often they matched. The parameters of a match were varied and obviously the broader the parameters, the greater the number of matches which were identified.

Table 4.3 Percentage of soil texture matches between OPAL and BGS data

Match Class	Locations which matched
Exact	27 %
Narrow	36 %
Moderate	39 %

The match parameters were designed to compare the soil textures which could be considered as reasonably similar at varying levels of precision. This was carried out to allow for the inaccuracy that the variation in classification terminology used in the BGS and OPAL surveys would contribute to the comparison. By varying the parameters which determined a match, it was possible to negate, at least in part, the arbitrary nature of the soil texture reclassification. The fact that the number of matches did not increase greatly with the widening of the parameters suggest that in the cases where no match occurred, the soil texture descriptions were considerably different. This suggests that at these locations the soil textures were identified differently by the BGS and OPAL surveys for a reason other than the reclassification method used for comparison of soil textures in this research.

4.4 SOIL COLOUR

The OPAL survey had eleven options which could be used to identify the colour of a soil detailed in *Table 4.4*. The BGS Survey had eight colour options which could be used to classify a soil.

Table 4.4 Colours included in the OPAL Soil and Earthworm Survey

Colour Description	Colour Sample
Black	
Brownish Black	
Medium Brown	
Light Brown	
Reddish Brown	
Red	
Brown/Yellow	
Yellow	
Green	
Grey Green	
Blue/ Grey	
Grey/ White	

As the colour ranges were not the same for the two surveys, it was necessary to establish a principle for which colours could be considered as matches. This was achieved by identifying which of the BGS colours could be considered as an acceptable match for each OPAL colour. For example, for OPAL colour "a", the BGS colour Black would be considered an acceptable match; however the BGS colour Orange would not. Two types of matches were developed using this method, the first a "moderate match", in which only those BGS colours that are clearly and distinctly matches for the OPAL colours are considered. The second type of match was a "broader match", in which any colours which could be considered to be a shade of the OPAL colour were considered as matches, for example for Brownish Black, the most likely BGS match would be "Dark Brown", however "Black" was also considered a possibility in the "broader match" category.

Table 4.5 Moderate and Broader Matches between OPAL Soil and Earthworm Survey and BGS London Earth Survey Soil Colour Categories

Moderate Match		**Broader Match**	
BGS Soil Colour	IC OPAL Matches	BGS Soil Colour	IC OPAL Matches
Black	Black	Black	Black, Brownish Black
Dark Brown	Brownish Black, Medium Brown	Dark Brown	Brownish Black, Medium Brown
Light Brown	Light Brown	Light Brown	Light Brown, Brown/Yellow
Red	Reddish Brown, Red	Red	Reddish Brown, Red
Orange	Brown/Yellow	Orange	Brown/Yellow, Yellow
Yellow	Yellow	Yellow	Yellow
Green	Green, Grey Green	Green	Green, Grey Green
Grey	Blue/ Grey, Grey/ White	Grey	Blue/ Grey, Grey/ White

4.4.1 Results

Using the "moderate match" parameter for comparison, 73% of locations showed the same colour in the BGS and OPAL surveys. Very similar results were generated for the comparison using the "broad match" parameter 75% locations showing the same colour in both surveys.

If the non-matching locations that were within 1 colour category of a match were also considered to be a match, this increased the number of matches between the OPAL and BGS survey to 99%. Whilst these were not "exact matches", given the subjective nature of soil colour identification this could be considered to be well within an acceptable margin of error.

Overall, the OPAL identification of soil colour could be considered to be accurate as there were a high proportion of exact matches between the BGS and the OPAL survey. Similarly, the OPAL identification of soil colour could also be considered to be highly reliable as even when an exact match did not occur.

4.5 SOIL OBJECTS

The OPAL survey had six soil object categories, with cut wood not being found in the data set used for comparison. The BGS survey had thirty-two, however only 16 of these featured in the BGS dataset. Soil Object categories used in the survey were identified and the BGS Soil Object categories were reclassified under those OPAL categories which matched them most closely, as in *Table 4.6* below.

Table 4.6 Comparable non natural soil object categories in OPAL Soil and Earthworm and BGS London Earth Surveys

OPAL Soil Object Categories	BGS Soil Object Categories
Construction Material	Ceramic Waste Pottery Bricks Glazed China China Clay Tailings
Metal	Manufactured Metal Iron, Steel Wire Copper
Glass	Clear Glass Coloured Glass
Cut Wood (Not Found)	
Other	Plastic Fertiliser Sack Rubber Coal Tailings Slag (Furnace Waste)
None	Empty Record

The objects found in soil in the OPAL survey were compared to those found in the BGS survey. Because at some sites multiple objects were found the principle was applied that if one or more of the objects found at a site in the OPAL survey was the same as one or more of those found in the BGS survey this would be considered an "exact match".

The "exact match" comparison of the soil objects found at locations by the BGS survey and IC OPAL survey was 39%. Comparison of the presence of soil objects in the soil or not between locations sampled by the BGS and the OPAL soil and earthworm survey showed 65% agreement.

This suggests that the OPAL soil survey has fairly low reliability in identifying the same soil objects as identified in a soil by the BGS soil survey, increasing to a higher level when the presence or not of soil objects is considered. However, unlike other characteristics evaluated within the two surveys, soil objects is a category which would be expected to have a large amount of variability between small differences in sampling area.

4.6 LAND-USE

The OPAL survey had nine land-use categories while the BGS survey has 57, however only 20 of these were used in the Camden and Hammersmith London Earth data set. The breakdown of survey land-use descriptions compared to BGS observed land-uses are summarised in *Table 4.7*, with inconsistent land-use descriptions identified in bold. On average for all locations the survey land-use was consistent with the BGS land use observation at 96% of locations.

Table 4.7 Breakdown of survey site land-uses by BGS London Earth land use descriptions.

BGS Land use Classifications	Garden	Grassy verge	Heath or moorland	Industrial site	Open grassy field	Other	Parkland	Playing field	Ploughed field	Wood or forest
Domestic Garden (urban)	27	14	-	-	-	7	2	1	-	-
Park	4	2	5	-	-	1	21	-	-	5
Commercial and residential	10	7	-	-	-	-	**4**	1	-	-
Minor Roads/Verge	4	13	-	-	-	3	-	-	-	-
Urban Open Space	5	6	-	-	1	1	4	-	-	1
Recreational	1	3	2	-	-	-	4	3	-	2
Urban Open Space, tended but unproductive	8	2	-	-	-	-	4	-	-	-
Mature Deciduous Forest	**2**	1	1	-	**1**	1	1	-	-	6
Playing Field	1	1	2	-	-	1	1	3	-	-
Major Roads/Verge	-	3	-	-	1	-	-	-	-	-
Recent Deciduous Forest	**1**	-	-	-	-	-	-	-	-	2
Graveyard	1	1	-	-	-	1	-	-	-	-
Rough Grazing	-	1	-	-	-	-	-	-	-	1
School	1	-	-	-	-	-	-	1	-	-
Playground	-	1	-	-	-	-	1	-	-	-
Golf Course	-	1	-	-	-	-	1	-	-	-
Railway	-	-	-	-	-	-	-	-	-	**1**
Urban Open space, cleared, derelict	-	1	-	-	-	-	-	-	-	-
Crematorium	-	-	-	-	1	-	-	-	-	-

NB. Land-use descriptions not considered to be consistent are identified in bold type on a grey background.

In order to compare more closely the land-use identification at each location between the BGS and OPAL surveys it was necessary to first standardise the land-use categories as shown in *Table 4.8* below.

Table 4.8 Comparable land-use categories in OPAL Soil and Earthworm and BGS London Earth Surveys.

OPAL Land-use Categories	***BGS Land-use Categories***
Garden	Domestic Garden (urban)
Parkland	Park Urban Open Space Urban Open Space, tended but unproductive Recreational
Playing Field	Playground Playing Field School Golf Course
Heath or Moorland (Not Found)	
Open Grassy Field	Rough Grazing
Ploughed Field (Not Found)	
Grassy Verge	Major Road/ Verge Minor Road/Verge
Industrial Site	Commercial and residential Urban open space, cleared, derelict
Other	Railway Graveyard Crematorium

In addition to exact matches a comparison was made between moderate matches and broad matches. Land-uses were grouped into categories which reflected their similar characteristics (*Table 4.9*).

Table 4.9 Grouping of Similar Land Uses into Categories

Land-use	**Category**
Parkland Garden Playing Field Grassy Verge	1
Open Grassy Field Ploughed Field	2
Wood or Forest Heath or Moorland	3
Industrial Site Other	4

Category 1 contained all Land-uses that were predominantly grass with few to no trees, managed by people, used primarily for recreation and a common feature of the urban environment.

Category 2 contained all Land-uses that were predominantly grass with few to no trees and managed by people, but were not used primarily for recreation and were not a common feature of the urban environment.

Category 3 contained all Land-uses that were predominantly low growing, shrubs or woody vegetation and trees, semi-managed or unmanaged and an uncommon feature of the urban environment.

Category 4 contained all Land-uses that were associated with a commercial/industrial use or that were classified as “other”.

These categories were used to compare the BGS & IC OPAL Land-uses for matches using two different parameters, firstly “Moderate Matches” and secondly “Broad Matches”.

Under “Moderate Matches”, a match was defined as when the OPAL Land-use and any of the BGS Land-uses were within the same category. For example, an OPAL Land-use of Parkland and a BGS Land-use of Garden would be a match under the “Moderate Match” parameters.

In an analysis of exact matches, 54% of the OPAL land use classifications matched those of the BGS. This increased to 77% under “moderate match” parameters.

These results show that identifications of Land-use during the OPAL survey closely matched those identified during the BGS survey. Even under the most stringent parameters, more than half of all OPAL identifications were exact matches with the BGS.

5 TASK D: LAND-USE REPRESENTATIVENESS

5.1 REFERENCE DATA SOURCE: CEH LAND COVER MAP 2000

The Land Cover Map 2000 (LCM2000) is a digital vector map constructed using satellite data with knowledge based correction and is based on minimum mappable units of half a hectare. The map classifies land-use within one of 16 terrestrial and inshore groups of Broad Habitats. Divisions within some of these Broad Habitats results in 27 Subclasses, however the Broad Habitats provide sufficient detail for the purpose of comparison with the survey data. Each survey land-use could reasonably correspond with more than one Broad Habitat and vice versa.

5.2 LAND-USE COMPARISON

During the survey, respondents were prompted to assign the land-use at the site to one of ten descriptions, by matching the appearance of the area to photos of representative settings. To assess the degree to which these land use descriptions were representative of conditions encountered, the previously identified land-use at each location was identified on the LCM2000 reference map. The breakdown of survey land-use descriptions compared to mapped land-uses is summarised in *Table 5.1*, with inconsistent land use descriptions identified in bold. The percentage of survey land-use descriptions consistent with the mapped LCM2000 habitat are presented in *Figure 5.1*. On average, for all locations, the survey land use was consistent with the mapped land use at 90% of locations.

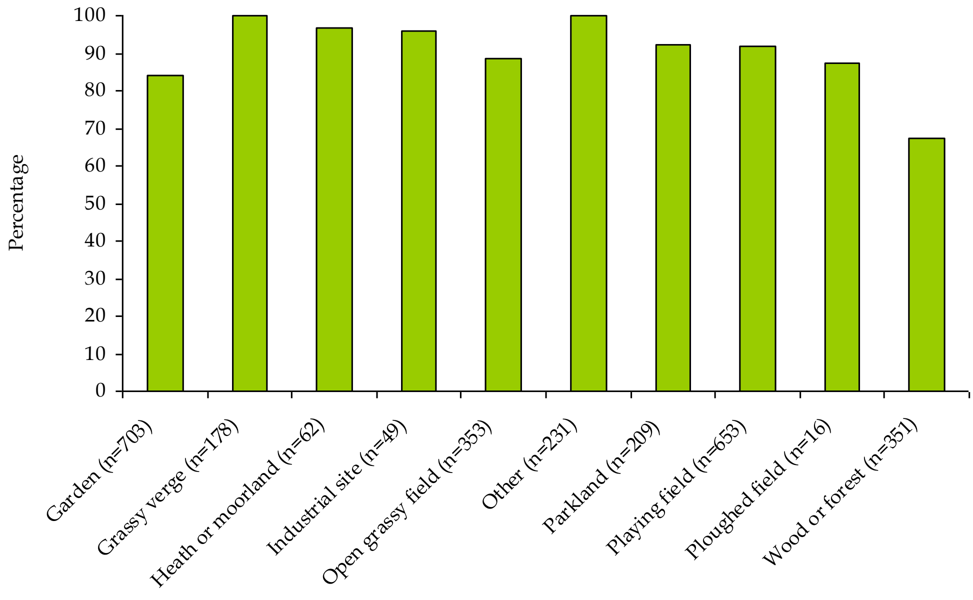


Figure 5.1 Percentage of land-use descriptions matching mapped habitats

Between 88% and 100% of individual land-use descriptions reported during the survey varied were considered to be consistent with LCM2000 mapped habitats, with the exception of the wood or forest areas, where 67% were considered to be consistent. This may be in part due to the limitations of the reference map, which classified land-use based on spectral reflectance data and may not differentiate well between grassland and evergreen woodland. Overall, it was concluded that the results of the survey were suitably representative of the land-uses encountered.

Table 5.1 Breakdown of survey site land-uses by LCM2000 land use description

LCM2000 Land-use description	Garden	Grassy verge	Heath or moorland	Industrial site	Open grassy field	Other	Parkland	Playing field	Ploughed field	Wood or forest
Broad leaved / mixed woodland	**38**	7	5	4	**27**	21	25	**16**	**1**	128
Continuous Urban	166	56	**1**	5	20	41	48	85	-	8
Suburban/rural developed	321	48	**1**	28	78	102	56	273	2	55
Improved grassland	52	19	1	7	130	29	39	132	9	**63**
Calcareous grass	16	12	2	2	24	11	10	48	-	**10**
Neutral grass	27	10	29	1	16	6	9	39	1	**11**
Arable horticulture	**50**	8	-	-	26	8	**11**	**31**	1	18
Arable cereals	**13**	6	-	**2**	4	5	**3**	**4**	1	**21**
Coniferous woodland	**8**	1	-	-	**11**	2	-	-	**1**	27
Setaside grass	2	-	4	-	1	1	2	14	-	**1**
Open dwarf shrub heath	1	-	7	-	-	-	-	-	-	-
Fen, marsh and swamp	1	-	3	-	-	-	1	**1**	-	-
Acid grass	2	9	9	-	12	1	-	5	-	**5**
Water (inland)	**3**	-	-	-	**3**	-	**2**	-	-	-
Dense dwarf shrub heath	2	-	-	-	-	-	1	-	-	-
Inland Bare Ground	1	2	-	-	-	3	1	5	-	**1**
Non-rotational arable and horticulture	-	-	-	-	1	-	-	-	-	-
Bogs (deep peat)	-	-	-	-	-	1	-	-	-	-
Bracken	-	-	-	-	-	-	1	-	-	**3**

NB. Land-use descriptions not considered to be consistent are identified in bold type on a grey background.

6 TASK E: OPAL SAMPLING EVENT-BASED ASSESSMENT OF EARTHWORM SPECIES IDENTIFICATION

6.1 OVERVIEW OF VALIDATION APPROACH

One of the main aims of the OPAL Soil and Earthworm survey is to encourage members of the general public, including school children, to collect and identify earthworms. This requires participants in the OPAL survey to use an identification guide. However, at the inception of the OPAL project the only identification guide to British earthworms was *Earthworms* by Sims & Gerard (1985). This is a technical book aimed at practicing biologists. Non-specialists find it difficult to use because of its reliance on unfamiliar terminology, and the fact that specimens must be well-preserved and examined with a microscope. One of the requirements of the OPAL survey was that participants should release the earthworms after identifying them. Therefore, a major challenge of the OPAL survey was to produce a user-friendly guide that would enable the general public to identify living earthworms. This presented two considerable obstacles: (1) to develop an identification guide that could be used by untrained individuals and deliver meaningful results, and (2) to base the guide on morphological characters that could be easily observed on live and moving earthworms.

The main scientific aims of the OPAL survey are (1) to map the distribution of earthworm species and soil properties across England, (2) to investigate the relationships between species distributions, soil properties and habitat type, and (3) to assess the ecological importance of earthworms in ecosystems by measuring their abundance, species density and functional group composition. OPAL participants were not asked to identify the functional group to which the specimens belonged. The functional groups consist of two or more species, and for the British species these have already between determined by previous research. Therefore functional group composition can be determined from species identifications even if these have a degree of error. The well-established ecological functional group classification given in Sims & Gerard (1985) was adopted: anecic species (heavily pigmented, very large, deep-burrowing earthworms that build permanent vertical burrows), endogeic species (pale earthworms that live in the topsoil, making horizontal tunnels and feeding on soil) and epigeic species (red earthworms that usually live in leaf-litter or the surface humus layer and feed on leaf-litter). In addition, a fourth functional group is recognised: compost species (red stripy earthworms that live almost exclusively in compost heaps and other similar accumulations of decaying vegetation).

As the OPAL survey data was collected by school children and members of the public, a precursor to any scientific analyses of the data is an assessment of its quality. It is essential to know the extent to which OPAL participants have correctly identified the earthworms they collected in the survey. As a large proportion of the OPAL participants were school children, we also needed to know whether there was a significant difference in the accuracy of identifications made by adults compared with children.

Two methods were available for assessing the identifications. The first involved an earthworm specialist (ES) examining directly a number of specimens collected by OPAL participants to check if their identifications were correct. The second method used other data recorded in the OPAL survey to assess the identifications. Participants were asked to record the length of the individual earthworms they identified, and these lengths were then compared with the known size ranges for each species.

The assessment produced by the first method was considered more reliable than the second because it was generated by an external expert. In contrast, the second method was considered less reliable because the quality of the verifying data (specimen length) was not independent or objective, as it relied on the competency of the OPAL participant.

6.2 Objectives of Data Quality Assessment

The overall aim was to assess how accurately the OPAL guide could be used by non-specialists. To achieve this, the specific objectives were:

1. to measure the proportion of OPAL earthworms that have been correctly identified to species, based on the direct examination of OPAL specimens;

2. to calculate the proportion of OPAL earthworms that can be correctly assigned to functional groups;

3. to test whether there was a significant difference in the levels of identification between adults and children;

4. to assess the usefulness of the specimen body lengths recorded by OPAL participants.

6.3 Identification methods

The Earthworm Specialist and/or OPAL Community Scientists attended numerous OPAL survey events across the country. The ES also organised similar earthworm sampling events in which non-specialist members of the public used the OPAL field guide to identify the specimens they found. Participants were observed while they were collecting earthworms and identifying them using the OPAL guide. After they had made their identifications, the earthworms were collected, preserved in vials of alcohol and labelled with the identification given by the participants. No assistance with identification was given to the participants until after they had recorded their final identifications. In total, earthworms were collected from 149 OPAL surveys or similar sampling events.

Participants were recorded as either adults or children (up to the age of sixteen). In a minority of cases the survey was done by family groups made up of adults and children. These groups were observed carefully to assess whether the adults guided the children to a taxonomic decision, or whether the adults deferred to the decisions of the children. Each group was then recorded as either adult or child depending on which had the biggest influence over the outcome of the identification process.

All specimens were identified at the Natural History Museum by the ES using a microscope and Sims & Gerard (1985). Fisher's exact test was used to compare the proportion of specimens correctly identified by adults versus children. The collated data were compared with the Natural History Museum's Soil Biodiversity Group (SBG) earthworm species database. The SBG database consisted of 5,281 verified species records collected by researchers and PhD students of the SBG during field work at 50+

localities across England. For the purposes of this study, SBG records from rare or extreme habitat types were excluded as these habitats were very unlikely to be sampled during the OPAL survey. The revised SBG dataset consisted mainly of earthworm samples from gardens, amenity grasslands, pasture, broadleaf woodlands and arable fields.

6.4 RESULTS

From the OPAL surveys and sampling events visited, a total of 595 earthworms were collected (hereafter called the OPAL control dataset). Sixteen specimens were excluded because they were too damaged to be identified. Of the remaining 579 specimens, 319 (53.6%) had been identified by adult participants and 260 (43.7%) had been identified by child participants.

6.4.1 Species distribution

All specimens in the OPAL control dataset were examined to verify their species identifications. The species distribution was then compared with the distribution of the SBG dataset (*Figure 6.1*). Overall, the distribution patterns given in *Figure 6.1* were very similar, with Spearman's rank correlation showing no significant difference in the ranked species distributions of the OPAL control and SBG datasets ($r_s = 0.933$, $P < 0.00001$). The 12 species of earthworm illustrated in the OPAL field guide represented 93% of all specimens in the SBG dataset. This proportion was not significantly different from the proportion (95%) in the OPAL control dataset (Fisher's exact test, $P = 0.279$), indicating that the field guide covered all the common species in most habitats in England.

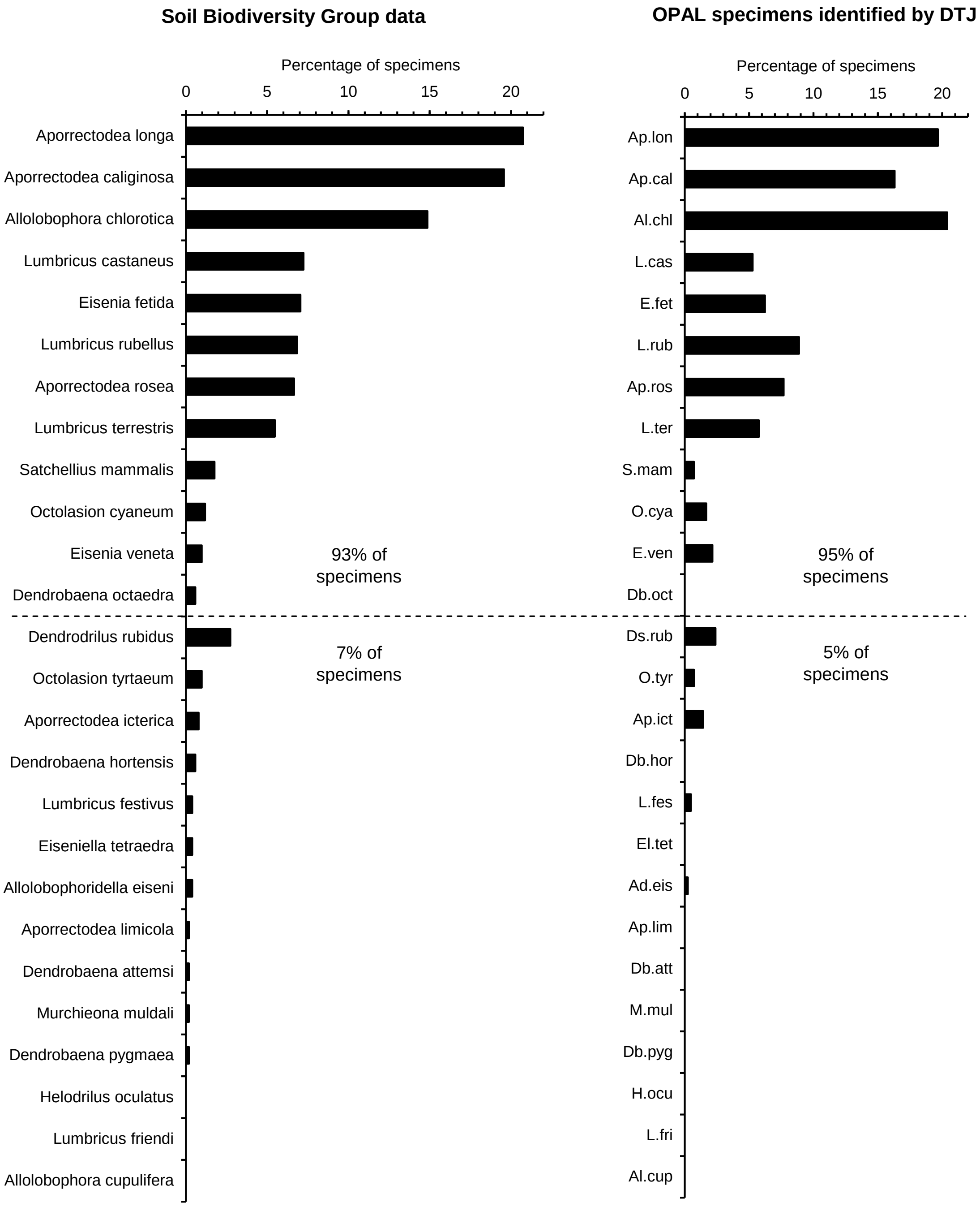


Figure 6.1 Species distributions of earthworm specimens in the SBG dataset and the OPAL control dataset. The species above the dotted line are the 12 species illustrated in the OPAL field guide.

6.4.2 Species identifications

Overall, participants identified 61.1% of specimens to species correctly. However, within this, some species were "easier" to identify than others (*Table 6.1*). At 86%, *Aporrectodea longa* had the highest proportion of correctly identified specimens.

Table 6.1 Percentage of earthworms correctly identified to species using the OPAL field guide.

All specimens	61.1%
Black-headed worm *Aporrectodea longa*	86%
Grey worm *Aporrectodea caliginosa*	69%
Green worm *Allolobophora chlorotica*	81%
Chestnut worm *Lumbricus castaneus*	42%
Brandling worm *Eisenia fetida*	48%
Redhead worm *Lumbricus rubellus*	58%
Rosy-tipped worm *Aporrectodea rosea*	74%
Lob worm *Lumbricus terrestris*	51%
Little tree worm *Satchellius mammalis*	60%
Blue-grey worm *Octolasion cyaneum*	19%
Compost worm *Eisenia veneta*	33%
Octagonal-tailed worm *Dendrobaena octaedra*	0%

Adults were significantly better than children at identifying earthworms (Fisher's exact test, $P = 0.0085$) with 66.2% of their specimens being correct, compared with the children who correctly identified only 53.3% of specimens. Considering individual species (*Table 6.2*), adults were significantly better than children at identifying *Aporrectodea longa* and *Aporrectodea rosea*.

Table 6.2 Percentages of earthworms correctly identified by adults and children using the OPAL field guide.

	Adults	Children
All specimens	66.2%**	53.3%
Black-headed worm *Aporrectodea longa*	98%***	64%
Grey worm *Aporrectodea caliginosa*	73%^{NS}	64%
Green worm *Allolobophora chlorotica*	78%^{NS}	84%
Chestnut worm *Lumbricus castaneus*	54%^{NS}	17%
Brandling worm *Eisenia fetida*	60%^{NS}	36%
Redhead worm *Lumbricus rubellus*	56%^{NS}	60%
Rosy-tipped worm *Aporrectodea rosea*	93%*	50%
Lob worm *Lumbricus terrestris*	50%^{NS}	55%
Little tree worm *Satchellius mammalis*	75%^{NS}	0%
Blue-grey worm *Octolasion cyaneum*	27%^{NS}	9%
Compost worm *Eisenia veneta*	50%^{NS}	11%
Octagonal-tailed worm *Dendrobaena octaedra*	0%^{NS}	0%

Note: * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$; NS = not significant

6.4.3 Functional group identifications

Based on the participants' species identifications, 82.3% of specimens could be assigned to their correct functional group. This varied from 92% for epigeic earthworms to only 60% for compost earthworms (*Table 6.3*).

Table 6.3 Percentage of earthworms that could be correctly assigned to functional group based on the species identifications made by participants using the OPAL field guide.

All specimens	82.3%
Anecic (deep burrowing) earthworms:	88.3%
Aporrectodea longa	
Lumbricus terrestris	
Epigeic (surface litter-feeding) earthworms:	67.1%
Lumbricus castaneus	
Lumbricus rubellus	
Lumbricus festivus	
Lumbricus friendi	
Dendrobaena octaedra	
Dendrobaena attemsi	
Dendrobaena pygmaea	
Dendrobaena hortensis	
Dendrodrilus rubidus	
Satchellius mammalis	
Endogeic (soil-feeding) earthworms:	92.0%
Allolobophora chlorotica	
Aporrectodea caliginosa	
Aporrectodea rosea	
Aporrectodea icterica	
Aporrectodea limicola	
Allolobophoridella eiseni	
Eiseniella tetraedra	
Octolasion cyaneum	
Octolasion tyrtaeum	
Murchieona muldali	
Compost earthworms:	60.0%
Eisenia fetida	
Eisenia veneta	

Overall, 88.1% of specimens identified to species by adult participants could be correctly assigned to functional group, which is significantly higher than the 73.4% of specimens identified by children (Fisher's exact test, P = 0.0002). This was due to the fact that adults were significantly better than children at identifying earthworm species (*Table 6.2*).

Comparing functional groups, adult identifications gave significantly higher proportions of correct assignments to three of the groups (anecic, epigeic and compost earthworms) than did the children's identifications (*Table 6.4*). There was no significant difference for endogeic earthworms between adults and children.

Table 6.4 Percentage of earthworms that can be correctly assigned to functional group based on the species identifications made by adults and children using the OPAL field guide.

Functional group	Adult	Children
All specimens	88.1%***	73.4%
Anecic (deep burrowing) earthworms	96%**	73%
Epigeic (surface litter-feeding) earthworms	79%**	45%
Endogeic (soil-feeding) earthworms	92%^{NS}	93%
Compost earthworms	74%*	44%

Note: * = P < 0.05; ** = P < 0.01; *** = P < 0.001; NS = not significant

6.4.4 Earthworm body lengths

The body lengths of adult earthworms collected and measured by OPAL participants and submitted to the OPAL website were compared with the size ranges given in Sims & Gerard (1985). For some species the size range was extended with the inclusion of additional information provided by the examination of preserved material in the Natural History Museum's collections and the SBG specimens. One third of all body lengths recorded by OPAL participants were outside the size range for the species identified. The individual species are given in *Table 6.5*.

Table 6.5 Percentage of OPAL earthworm specimen records that fall outside the known size range for adults of that species.

All specimens	33.3%
Black-headed worm *Aporrectodea longa*	51.8%
Grey worm *Aporrectodea caliginosa*	20.3%
Green worm *Allolobophora chlorotica*	35.4%
Chestnut worm *Lumbricus castaneus*	31.1%
Brandling worm *Eisenia fetida*	16.6%
Redhead worm *Lumbricus rubellus*	8.9%
Rosy-tipped worm *Aporrectodea rosea*	25.7%
Lob worm *Lumbricus terrestris*	52.8%
Little tree worm *Satchellius mammalis*	66.7%
Blue-grey worm *Octolasion cyaneum*	12.7%
Compost worm *Eisenia veneta*	26.9%
Octagonal-tailed worm *Dendrobaena octaedra*	50.9%

If the body lengths recorded by OPAL participants were accepted as being reliable, then rates of misidentification would be substantially higher than the levels of misidentification seen in the ES dataset. As the identification results observed in the ES dataset were considered more reliable, this suggests that many OPAL participants did not measure body length very accurately.

6.5 EARTHWORM QUALITY ASSESSMENT: CONCLUSIONS

The OPAL control dataset was very similar to the SBG dataset in its species distribution. The OPAL survey samples were therefore considered representative in that they captured all the common species and reflected the observed species assemblage structure in most English habitats. 95% of the adult specimens collected using the sampling method employed in the OPAL survey were illustrated on the OPAL field guide, indicating that they were highly suitable species to be included in the guide.

Overall, 61% of specimens were correctly identified to species. However, adults were significantly better than children at making correct identifications, with adults getting 66% of their specimens correct compared with only 53% by children. From observations at OPAL survey events, adults had a longer attention span than children and displayed more understanding of how the key worked. While both adults and children often expressed some uncertainty in their identifications, adults were more sophisticated in how they used the key, frequently exploring both the "yes" and the "no" answers in the guide to arrive at what they thought was a more likely identification. OPAL survey records of earthworms submitted by adults can therefore be considered more reliable than those submitted by children. Adults found some species "easy" to identify, such as *Aporrectodea longa* (98% correct) and *Aporrectodea rosea* (93% correct), whilst other species appeared to be more difficult and had lower levels of identification success.

Using species identifications to assign specimens to functional groups gave reasonable results, even when the species identifications contained a higher degree of error. Again, adult identifications gave a significantly higher level of correct functional group identification compared with the children's identifications. Functional group identification for specimens identified by adults varied from 74% for compost species, up to 96% for anecic species. If the compost worms were excluded (as they are rarely found outside of compost heaps and are not thought to have a significant ecological impact in other habitats), then the remaining functional group results for adults were considered acceptable for general analyses.

There was a high level of inconsistency for many species between the body length data and the species identifications. This reflects errors in measuring live earthworms that were observed during OPAL surveys, particularly by children. Measuring the length of wriggly earthworms is not an easy task, and appears to be a considerably greater source of error compared with the actual proportions of species misidentifications recorded in the OPAL control dataset. The submitted body length records were therefore not considered to be a reliable data source with which to verify species identifications.

7 CONCLUDING REMARKS

This report is intended to provide an assessment of data quality of the OPAL Soil and Earthworm National Survey. As the scientific objective of the survey was to develop a baseline understanding of the distribution of earthworm species and associated soil conditions in England, it was important to assess if the data collected could be demonstrated to be representative of previously established environmental conditions, reproducible following the established methodology, whether it could provide suitable spatial coverage and form a complete data set for comparability. The output of the assessment aims to provide a level of confidence that could reasonably be attained through analysis of the data. Subsequent analyses would then need to take these limitations into account when investigating the full survey dataset.

Overall, the quality assessment undertaken for this report demonstrated that levels of confidence in the data were of an acceptable level with variations depending on the final use of the data. The results of the quality assessment suggested that some outputs were more sensitive, for example to parameters such as the ability of members of the public to make detailed scientific measurements and observations and to understand the questions that were asked. Interesting findings included that the quality of data depended greatly on participant age group and their reasons for participating, and this is particularly true for identification of earthworms.

The analytical methods presented here did not aim to filter the dataset (with the exception of records with wrong location information) but to provide further information associated with its possible use. It aimed to inform users and enable them to identify whether the data was fit for the purpose they wish to use it for, and the likely levels of uncertainty they can place upon the data. For example for very specific hypothesis testing, targeted filtering could be used to maximise confidence levels in any findings based upon such analysis.