Hounslow Heath Site Investigation
Technical Report

2 April 2009

Prepared by Victoria Butler for Hounslow Borough Council

Pollution Assessment & Remediation

PARC Consultants

Executive summary

Contents

1 Background information

1.1 Location

Hounslow Heath is a designated Local Nature Reserve and Site of Metropolitan Importance for Nature Conservation. located in the south of Hounslow Borough, bordered by the A315 (Staines Road) to the north, the River Crane to the west, railway track to the south and a residential area, including Hounslow Heath Junior School to the east. There is a car park, marked “P” on the map, and entrance points, indicated by red squares (Figure 1).

Figure 1. Map of Hounslow Heath showing entrances, car park and fenced off area.

1.2 History

The heath has had many diverse uses throughout history, including First World War air defences, a firing range at the north-west corner, extraction of sand and gravel through the 19th-20th centuries and unregulated landfill for domestic waste in the 1960s-70s. The landfill was eventually capped and the heath was designated a Local Nature Reserve in 1991.

1.3 Current use

Hounslow Heath currently covers 110 hectares, including ericaceous heathland (approximately 5 hectares) and acid grassland, both of which are National Biodiversity Action Plan (BAP) habitats, and 0.5 hectares of reed bed. The heath supports Many Red Data Book and Nationally notable species of invertebrates, some of which are found nowhere else in Greater London (Hounslow Borough Council, no date).

1.4 Contamination

Contamination concerns arise mainly from the firing range, potentially leading to high concentrations of lead in the soil, and the unregulated landfill, which may be responsible for other heavy metal contamination.

2 Introduction to project

2.1 Project brief

The brief supplied by Hounslow Borough Council is to analyse the concentrations and distribution of heavy metal contamination across Hounslow Heath in order to assess the suitability of the site for its current use as a Local Nature Reserve and to determine the most suitable location for a new school on the site.

2.2 Scope of study

In accordance with the brief, the heavy metals to be tested for were limited to:

arsenic (As)
cadmium (Cd)
lead (Pb)
— toxic to humans

copper (Cu)
nickel (Ni)
zinc (Zn)
— phytotoxic

The soil pH and calcium carbonate concentrate was also tested, because many heavy metals are soluble only at low pH. This affects their mobility in the soil and the potential for them to enter into groundwater. Samples were taken of soil, groundwater, river water and earthworms on the site.

2.3 Previous studies

A study carried out by Chin (1995) provided background information on sampling methods and showed concentrations of lead which exceed the Soil Guideline Values.

2.4 Soil Guideline Values – maybe to go in methodology

The concentrations of heavy metals were compared with Soil Guideline Values (SGV), determined by the Environment Agency. These are scientifically based generic criteria to help assess long-term risks to human health from exposure to contamination in soil. SGVs are set very low because they are cautionary and take into account the most vulnerable residents. The purpose of SGVs is to indicate whether further site-specific investigation is necessary. This means that concentrations exceeding the SGV are not necessarily a risk to health.

2.5 Legislative and policy context

Contaminated land is defined by Defra as land containing contaminants which pose a significant harm to human health and/or the environment (Defra 2008). Wherever possible, the Government encourages voluntary remediation of contaminated land, but where this is not carried out, contaminated land legislation may be used. The legislation was introduced by Defra in 1995 as Part 2A of the Environmental Protection Act 1990. This has since been supplemented by the Contaminated Land (England) Regulations 2006. These documents have been developed to ensure that contaminated land is remediated to the point at which it is suitable for its use.

3 Methodology

3.1 Limitations

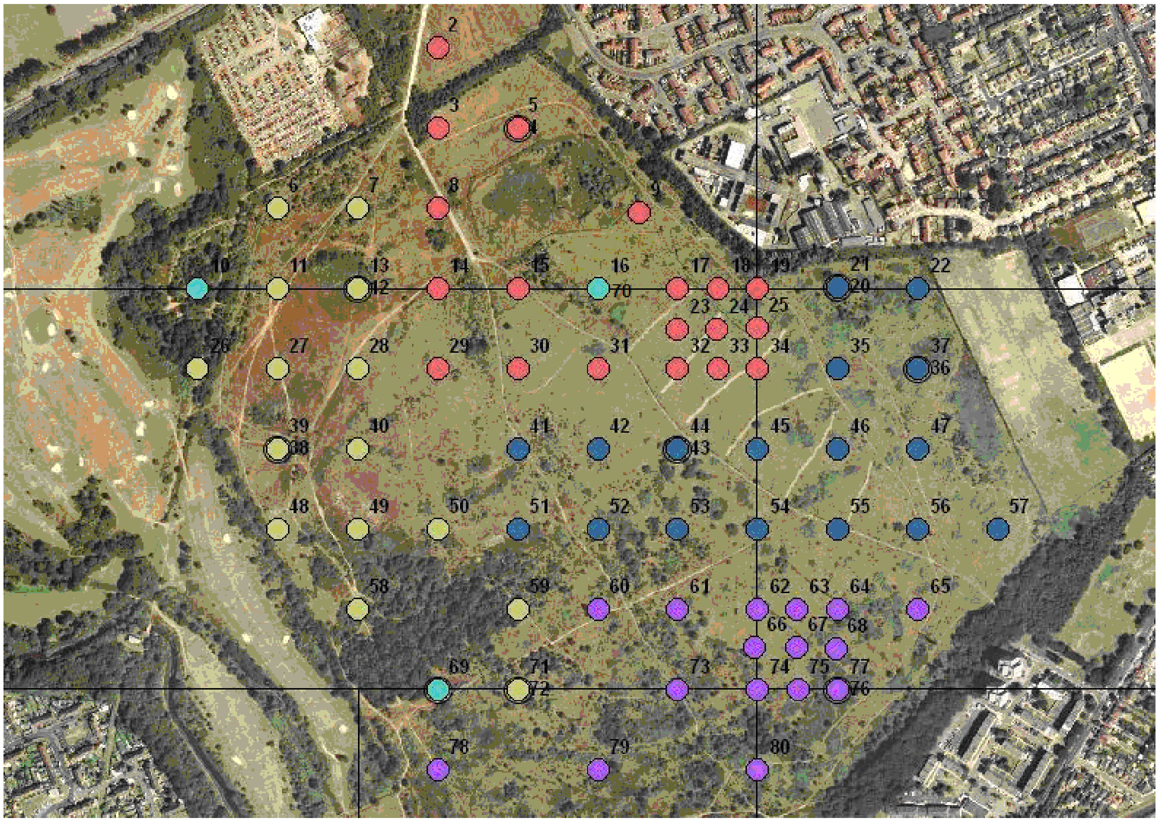
The project budget allowed for one day of sampling and analysis of 80 soil samples, 14 water samples and 4 earthworm samples. No samples could be taken from the fenced off area marked in blue on the map (Figure 1).

3.2 Sampling method

In order to get an overview of contamination throughout the heath, a 100 x 100 metre grid sampling strategy was chosen, ensuring an even distribution of samples and complete coverage of the site. Two areas of intensive sampling (50 x50 metres) were selected in areas showing high contamination in the Chin (1995) study in order to determine the level of heterogeneity of soil contamination and to ascertain that a 100 x 100 metre grid was sufficiently representative of the overall site(Figure 2). The limited number of samples meant that a few points on the grid had to be omitted, which were chosen on the basis of showing low contamination in the Chin (1995) study (Figure 2).

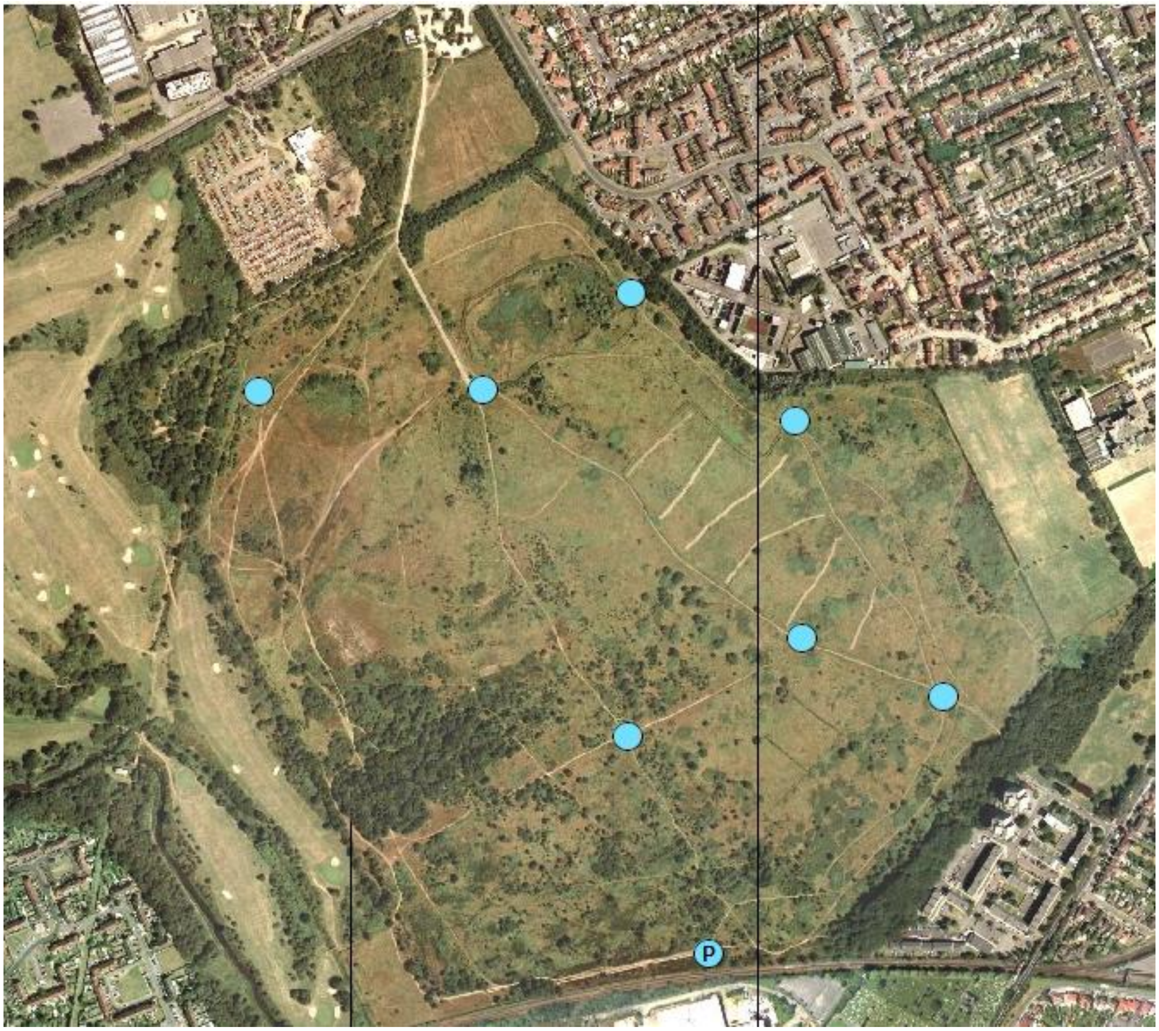
At each point, a composite soil sample was collected, a field measurement of pH taken and soil type determined. Soil samples were taken from the top 30 cm using a hand auger or spade (in the case of points at which earthworms were collected). Only mature earthworms were collected. These were identified and sent to the laboratory for analysis.

Figure 2. Grid for soil and earthworm sampling points on Hounslow Heath. Soil samples were taken from all points marked by a circle. Earthworm samples were taken at points shown by light blue circles. Duplicates were taken at circles labelled with two numbers.



Groundwater samples were taken from existing covered boreholes shown in Figure 3. Water samples were taken at two different points of the River Crane and one from a puddle (marked by P in Figure 3). The pH was tested in the field.

Figure 3. Groundwater sampling points on Hounslow Heath.



3.3 Lab analysis

Heavy metal concentrations in the soil and earthworm samples was determined using ICP-AES. The pH of soil and water samples was measured using a glass combination electrode probe.

4 Quality control

4.1 Accuracy and precision

Table 1. Precision of sampling and laboratory analysis

	As	Ca	Cd	Cu	Ni	Pb	Zn
Sampling Precision	93%	88%	78%	90%	93%	86%	86%
Lab Precision	100%	100%	100%	100%	100%	100%	100%

Overall Precision	93%	88%	78%	90%	93%	86%	86%

Table 2. Accuracy of laboratory analysis

	As	Ca	Cd	Cu	Ni	Pb	Zn
HRM 1	71%	63%	0%	41%	60%	99%	100%
HRM 2	78%	96%	70%	84%	99%	92%	85%
NBS2711	85%	73%	77%	99%	77%	81%	70%
Lab Accuracy	78%	78%	74%	75%	79%	91%	86%

4.2 Grid size

Results were compared for the following grid sizes of 50 x 50 metres, 100 x 100 metres and 200 x 200 metres. No significant differences between mean concentrations of heavy metal concentration were found. From this it can be concluded that the 100 x 100 metre grid size was appropriate.

5 Results

5.1 Soil

Figure 4a. Arsenic concentrations by sampling point

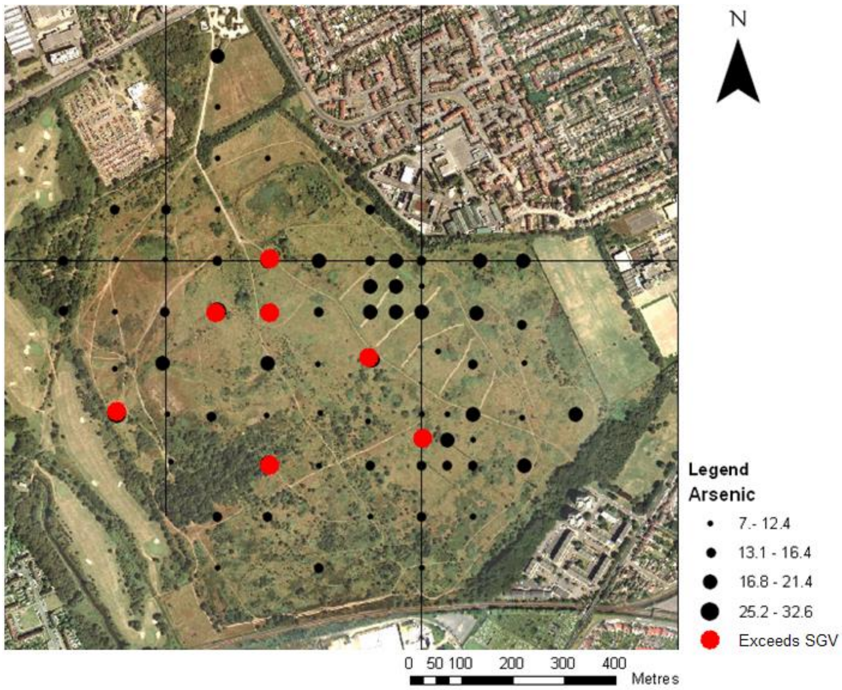


Figure 4b. Arsenic concentrations extrapolated

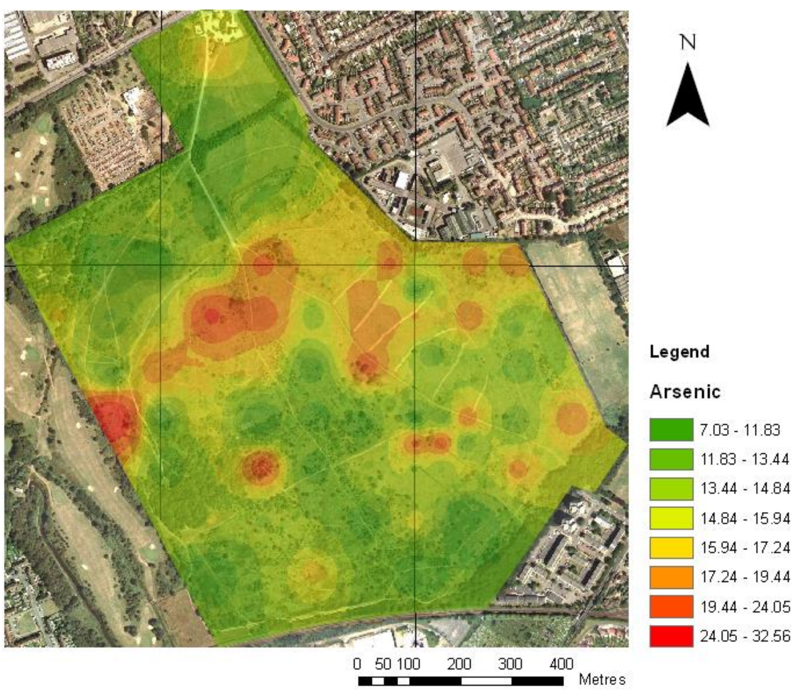


Figure 5a. Copper concentrations by sampling point

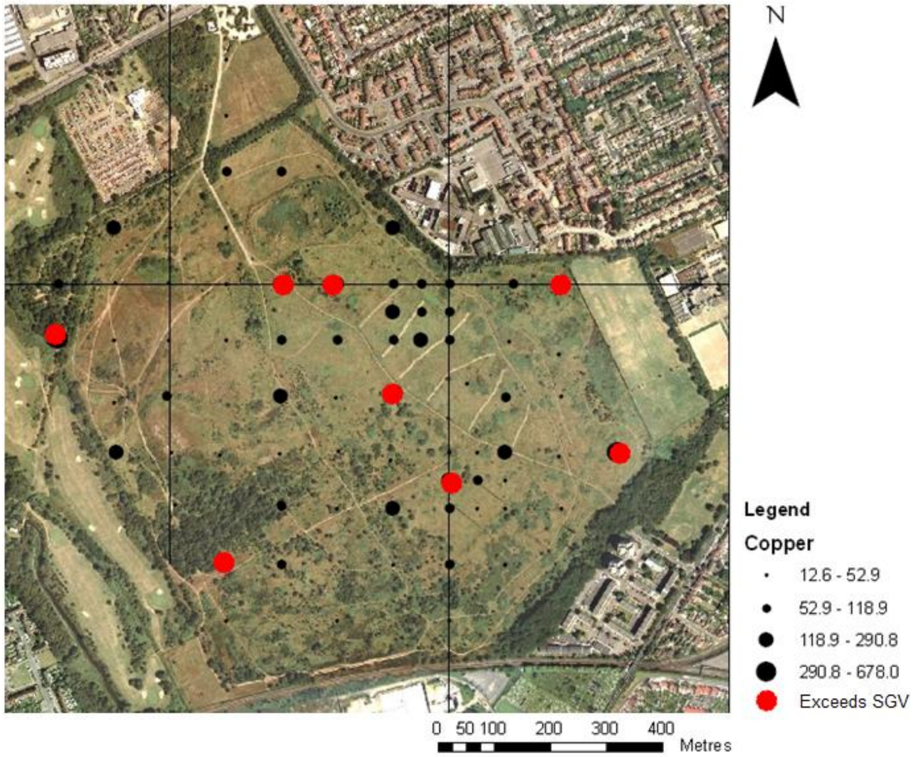


Figure 5b. Copper concentrations extrapolated

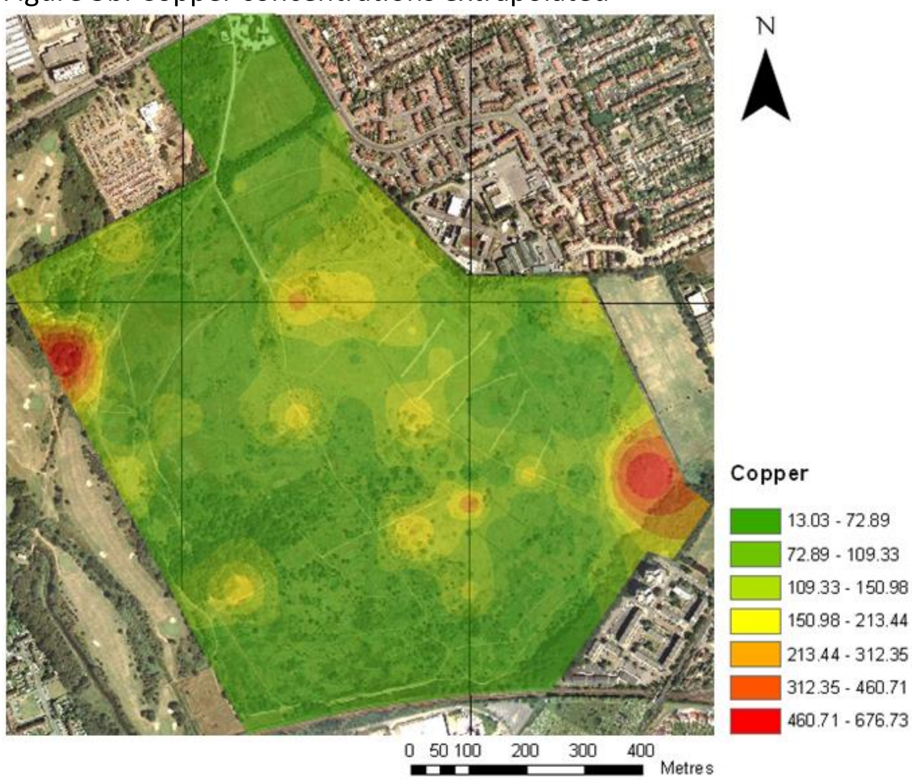


Figure 6a. Lead concentrations by sampling point

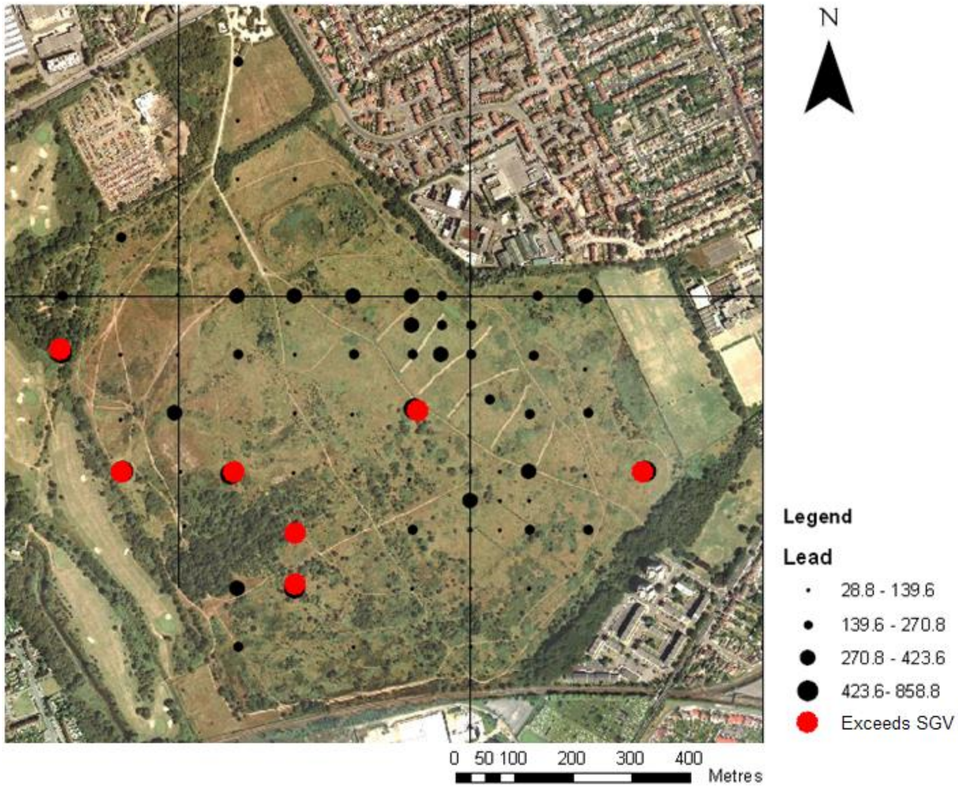


Figure . Lead concentrations extrapolated

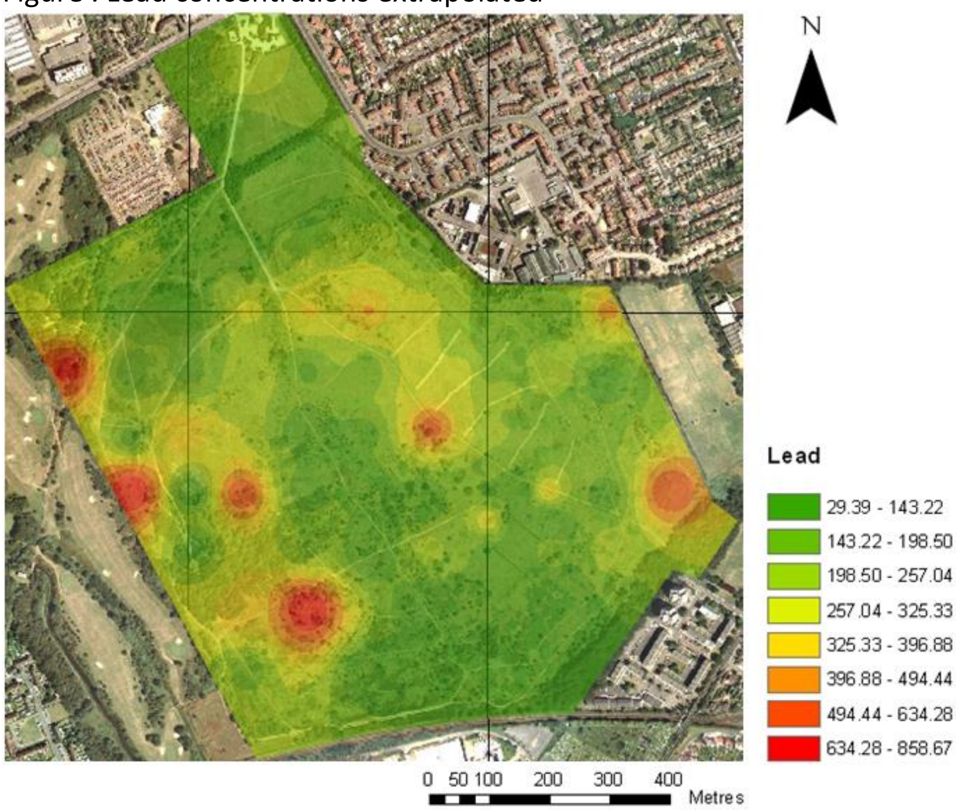


Figure . Zinc concentrations by sampling point

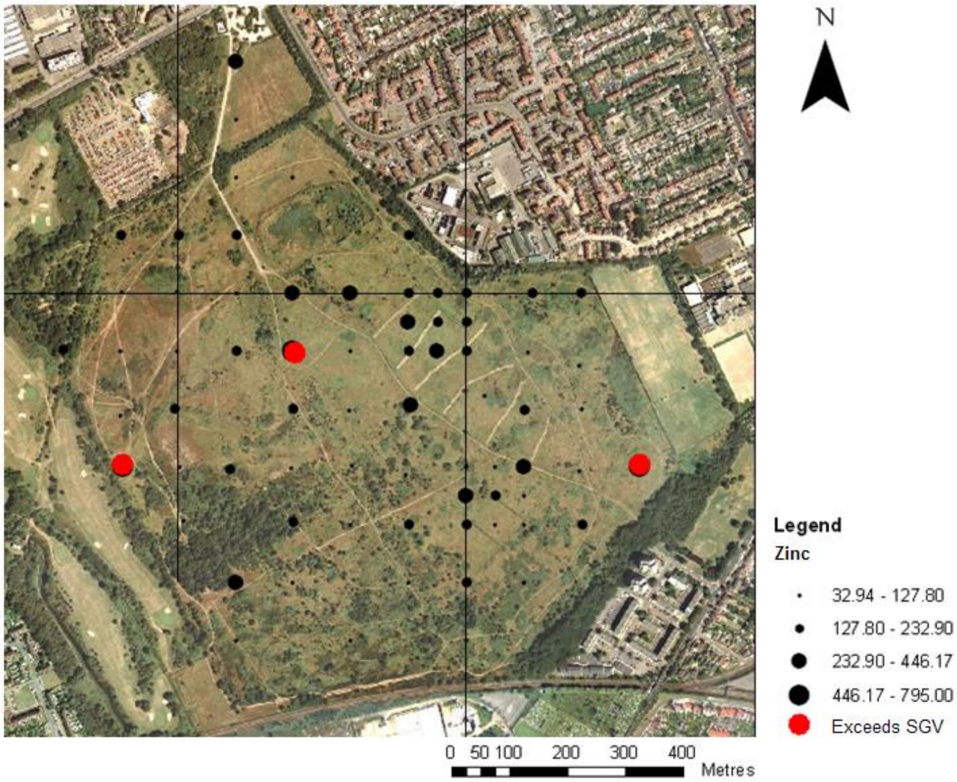


Figure . Zinc concentrations extrapolated

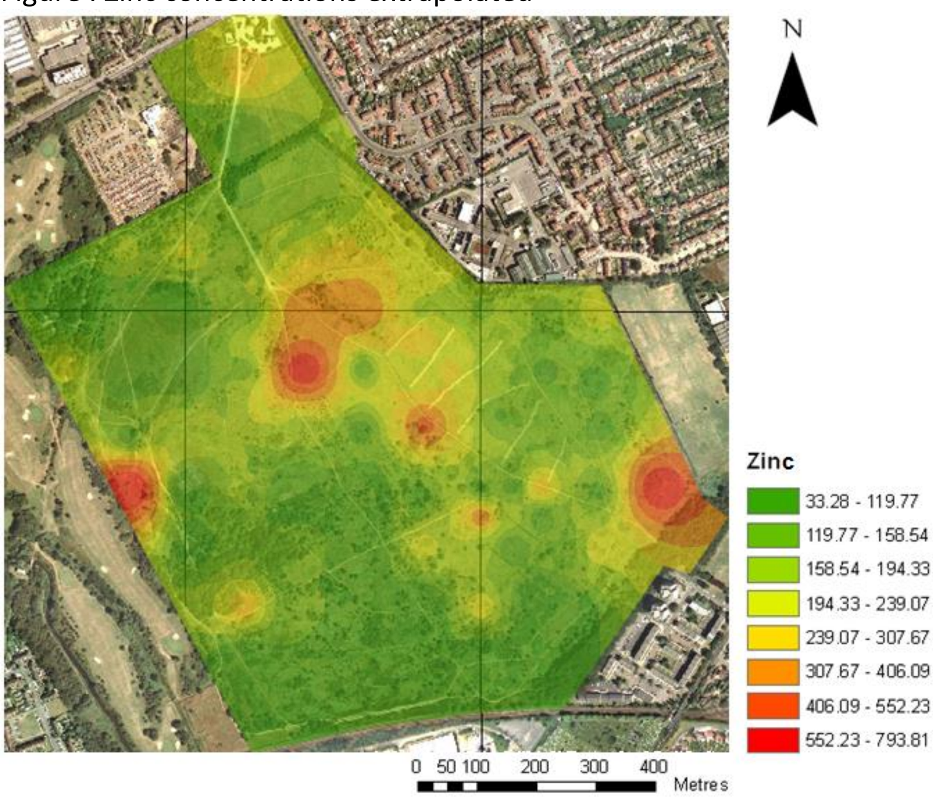


Figure . Nickel concentrations by sampling point

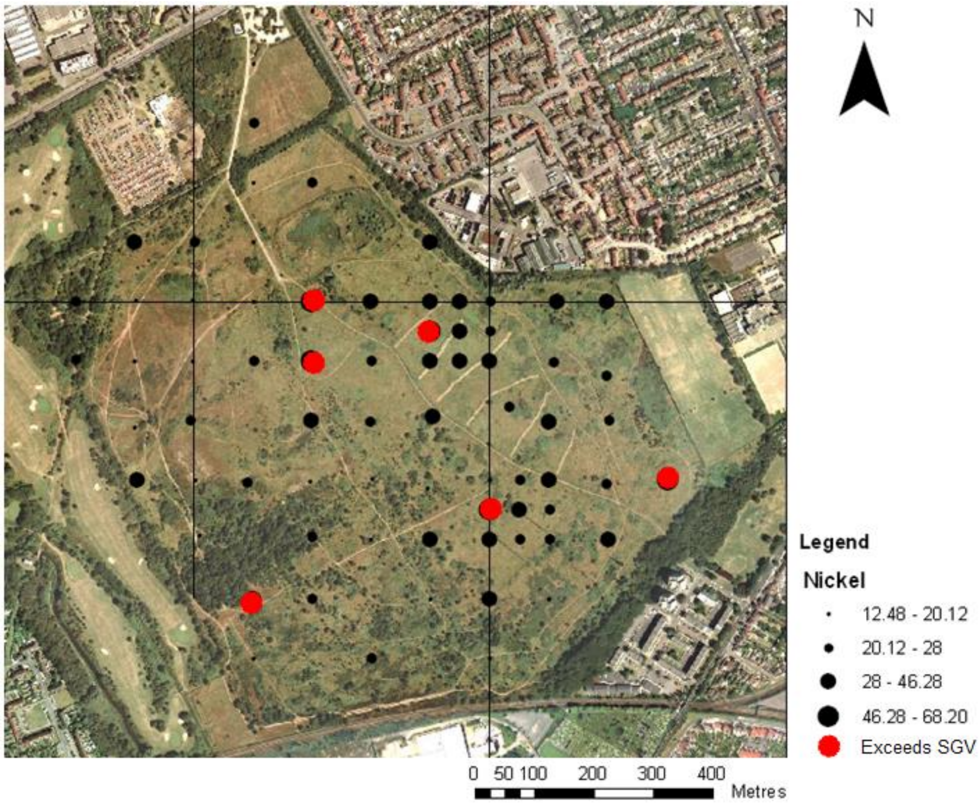


Figure . Nickel concentrations extrapolated

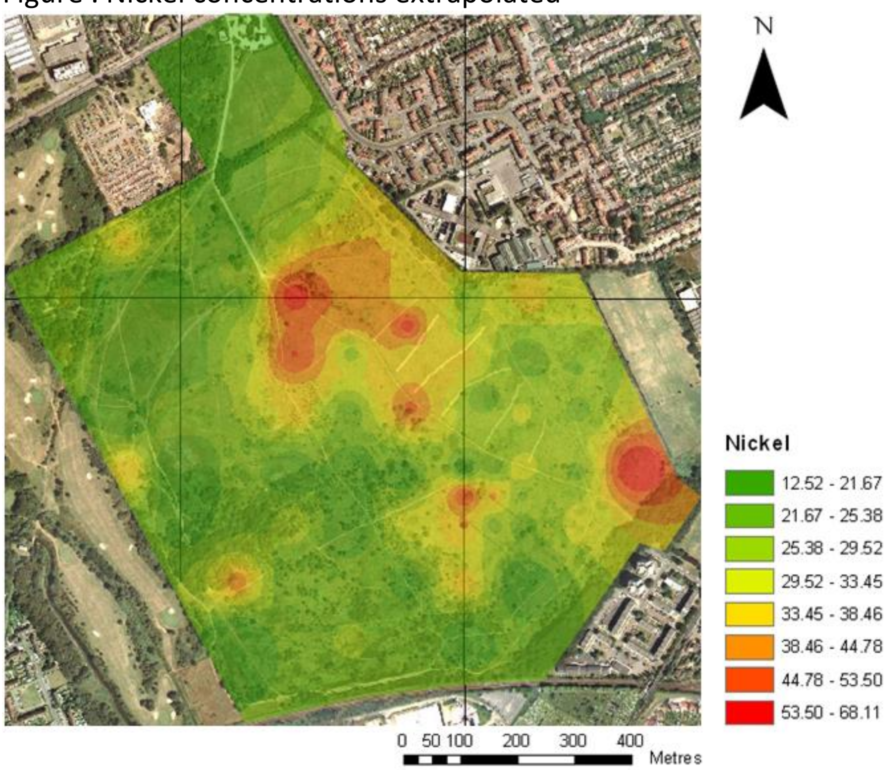


Figure . Cadmium concentrations by sampling point

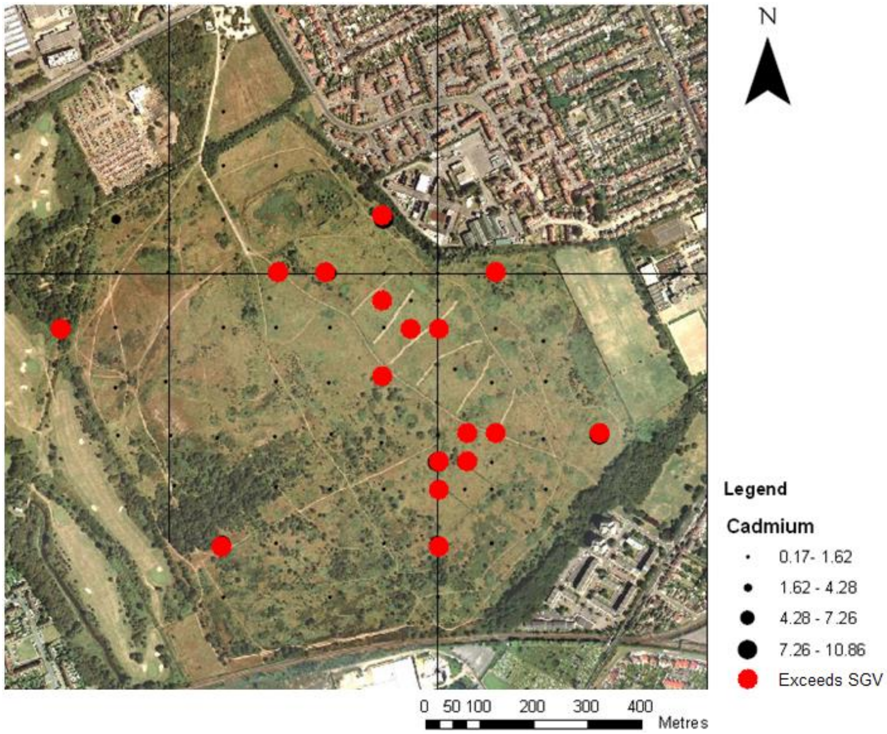


Figure . Cadmium concentrations extrapolated

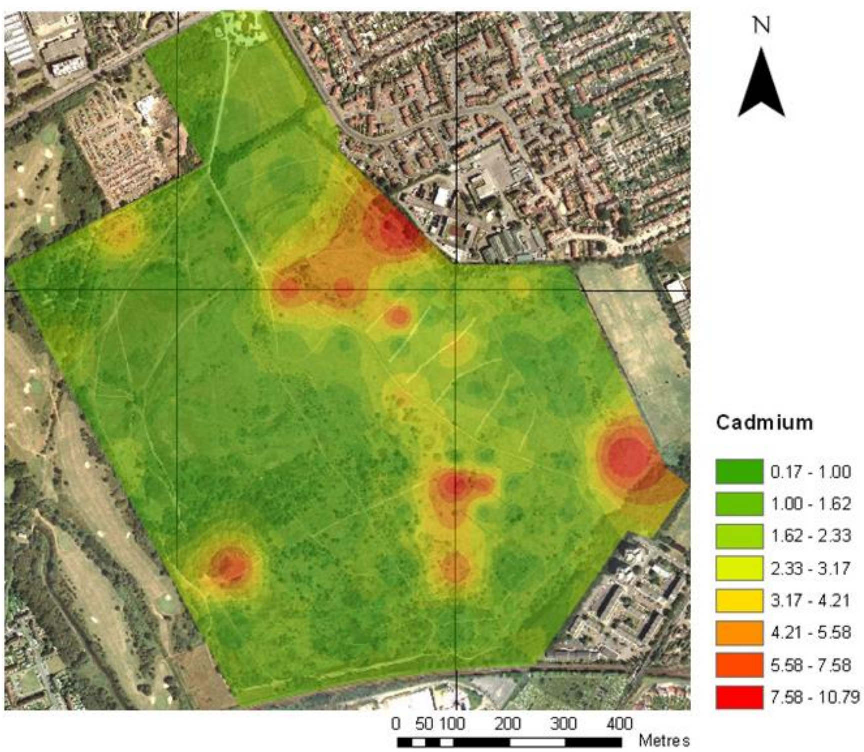


Figure . Soil pH

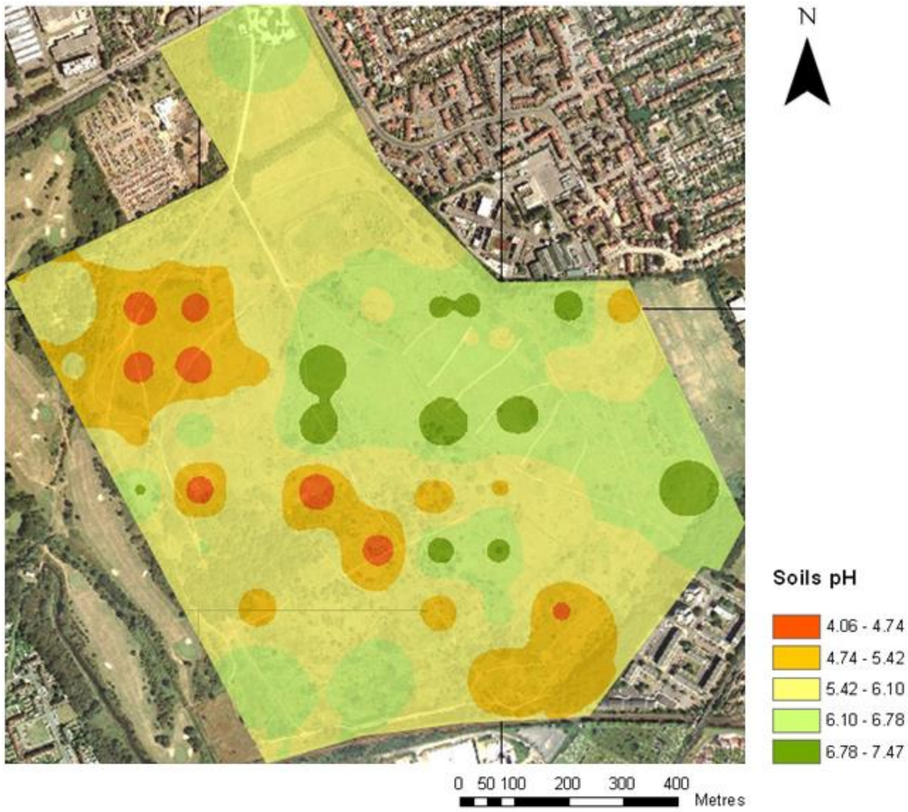
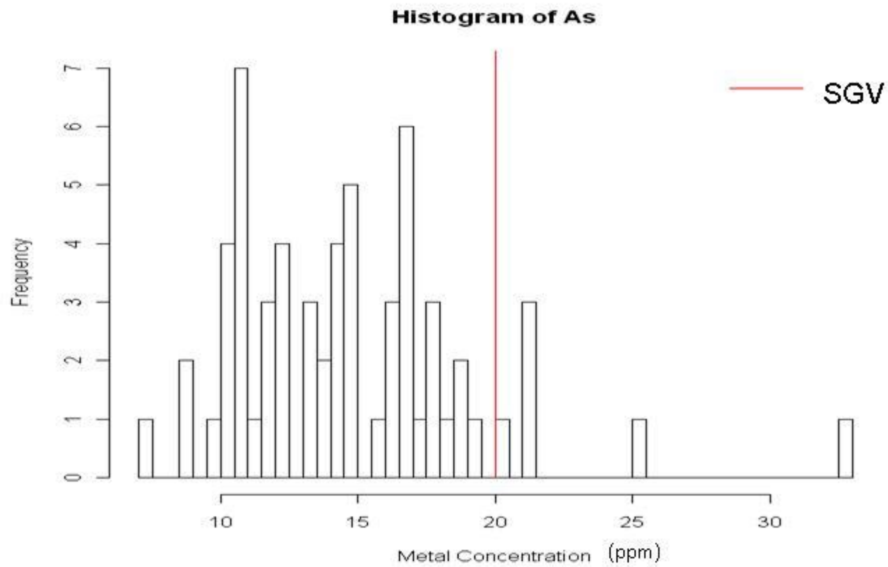
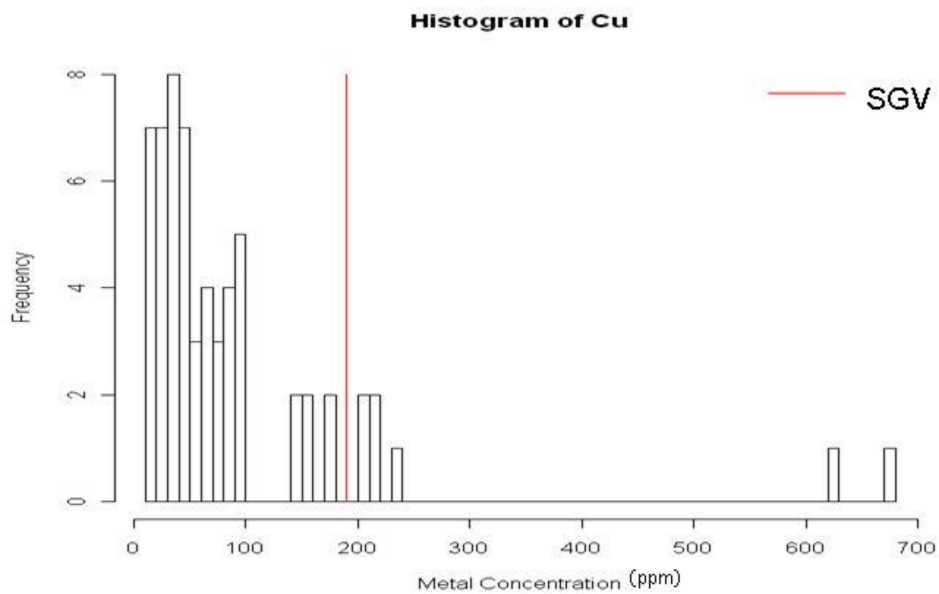
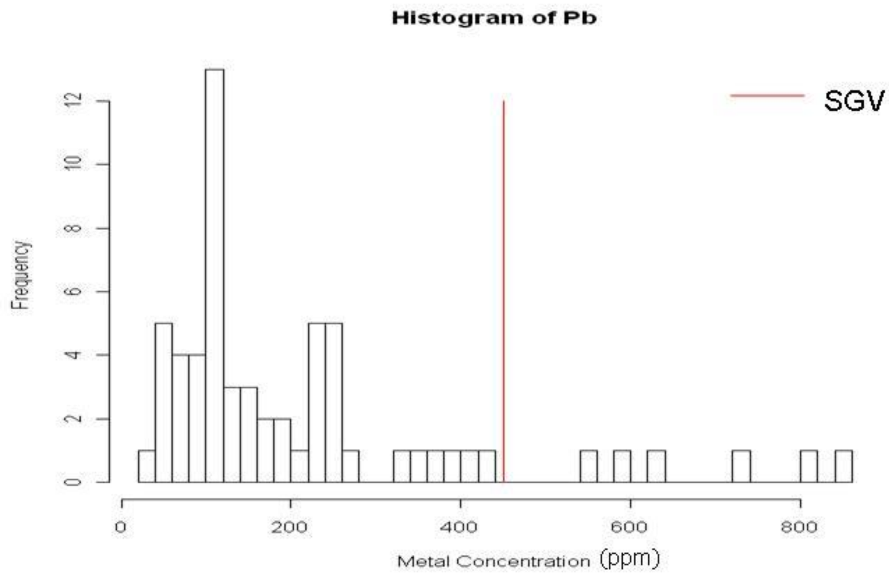


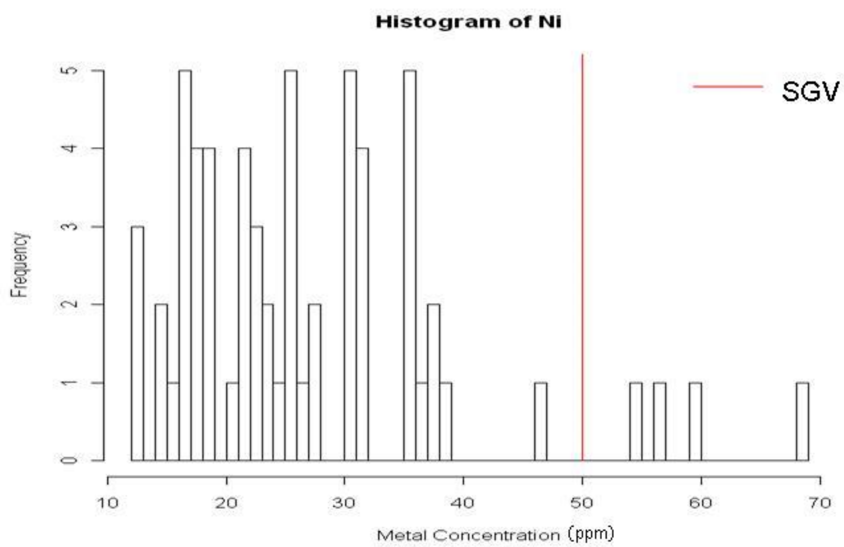
Table . Mean heavy metal concentrations on Hounslow Heath

Metal	Mean concentration ppm	Standard deviation ppm	Soil Guideline Value (SGV) ppm
Arsenic	17.3	4.3	20
Copper	109.1	119.2	190*
Lead	256.2	188.5	450
Zinc	205.8	158.5	720*
Nickel	31.8	11.7	50
Cadmium	1.9	2.3	1 or 2 (pH dependent)

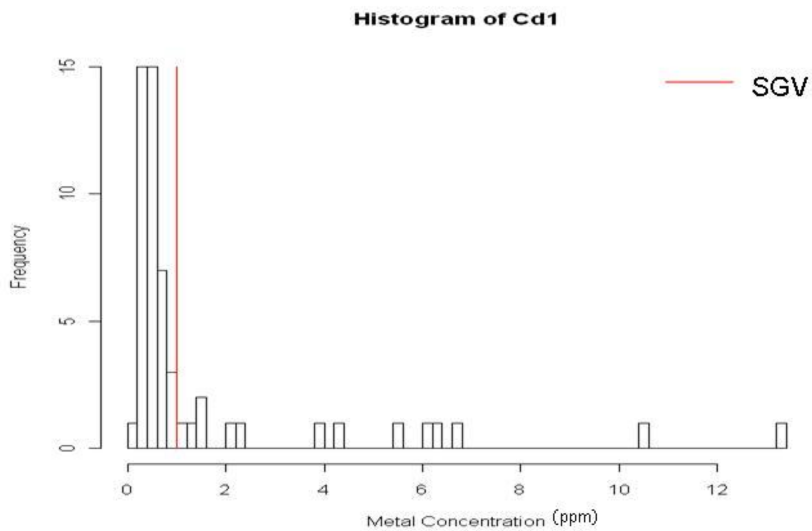

Histogram of As
SGV
Frequency
0
1
2
3
4
5
6
7
10
15
20
25
30
Metal Concentration (ppm)


Histogram of Cu
SGV
Frequency
0
2
4
6
8
0
100
200
300
400
500
600
700
Metal Concentration (ppm)

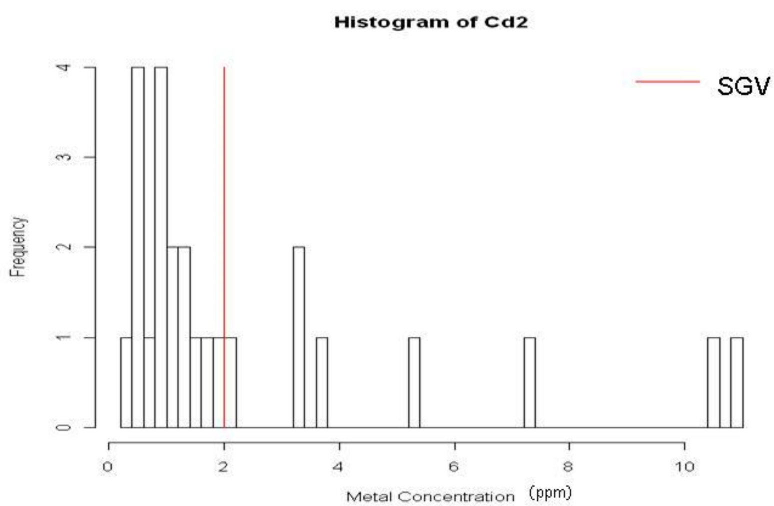


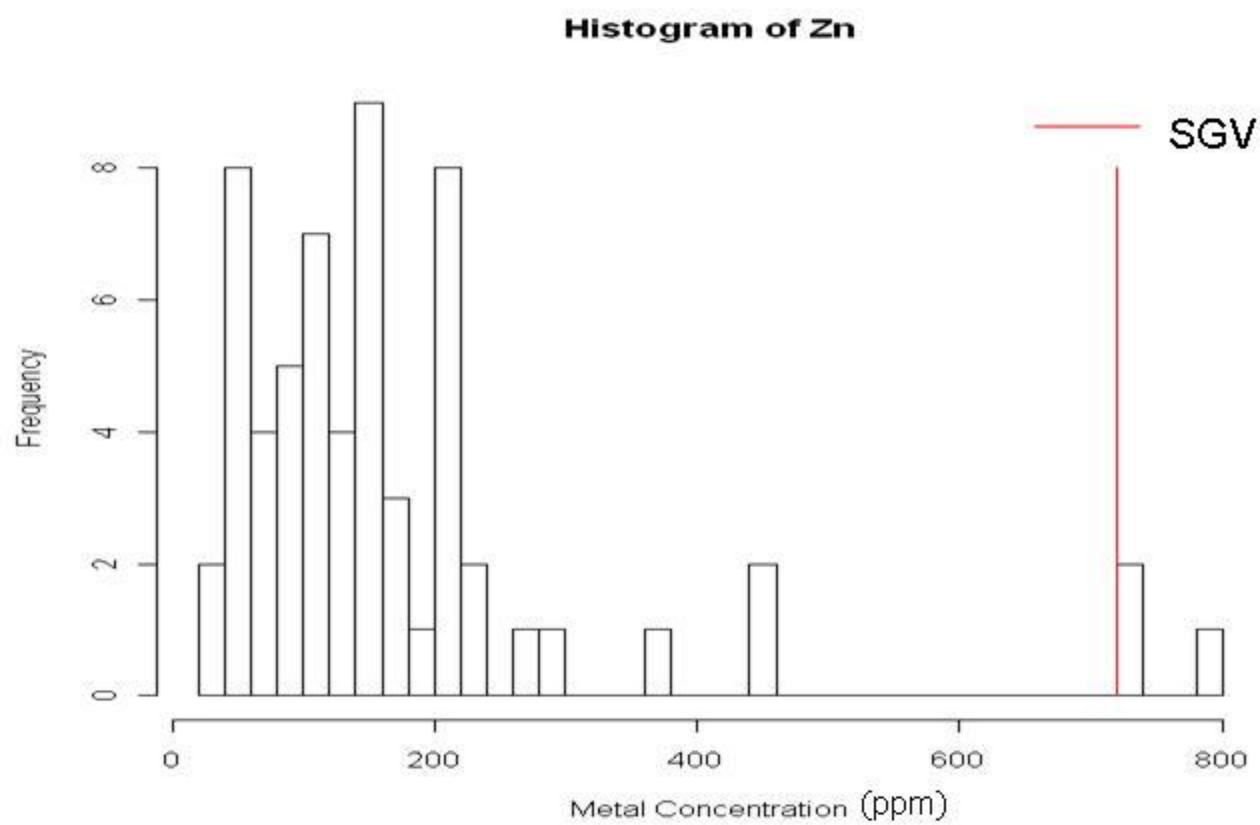


Cadmium low pH (Cd1)



Cadmium high pH (Cd2)




Histogram of Zn
SGV
Frequency
0
2
4
6
8
0
200
400
600
800
Metal Concentration (ppm)

What the results mean

Earthworms

- Earthworms are important in soil processes
- burrowing: mix in organics, drain, aerate soil
  - dermal contact with metals in soil
- feeding on soil
  - intestinal exposure to and uptake of metals in soil
- can pass metals to organisms further up food chain
  - an indicator of bioavailability to e.g. birds

- Function 1: Biomonitoring of contamination
  - Indicators of contamination in site assessment
  - Chemical analyses not enough for risk assessment
    - Don't show bioavailability to receptors
    - Compound effects unaccounted for
    - Toxicological and community level assessment to supplement RA
- Function 2: Bioremediation (supplement to microbial)
  - Inexpensive, effective, environmentally harmless
  - Worms can help in physical recovery
  - Improve biodiversity of soil ecosystem through nutrient cycling
  - Actually consume some of the toxicants
- Function 3: Assessment of remediation
  - Goal of remediation should include ecological recovery
  - Remediation may only achieve chemical transformation, not biological risk reduction.
    - Chemical concentrations vary from bioavailable amounts
  - Can indicate bioavailability (and risk) to organisms further up food chain.
- New methodology designed for OPAL
  - Record: depth, number, species, location (note mobility)

- Analyse HM concentration in dry weight of samples

- Compare with corresponding soil sample

- Earthworms analysed accumulated certain metals to a higher degree than their surrounding soil (red line = SGV):
  - Cd
  - As
  - Zn
- If medium risk of Cd suggests further investigation:
- Combine toxicological and community level studies
  - A. caliginosa (Grey worm) artificial intro
  - Potentially L. rubellus also

- Develop an integrated risk assessment for better knowledge of receptors
    - Chemical + biological
- Consider earthworms as supplementary bioremediators

Risk assessment
Significance of risk = magnitude of consequence x probability of consequence
Semi quantitative
Qualitative
Uses principles of CLR11 – Model Procedures for the Management of Land Contamination available from Environment Agency
Figure . Conceptual model for risk assessment of heavy metal contamination on Hounslow Heath.

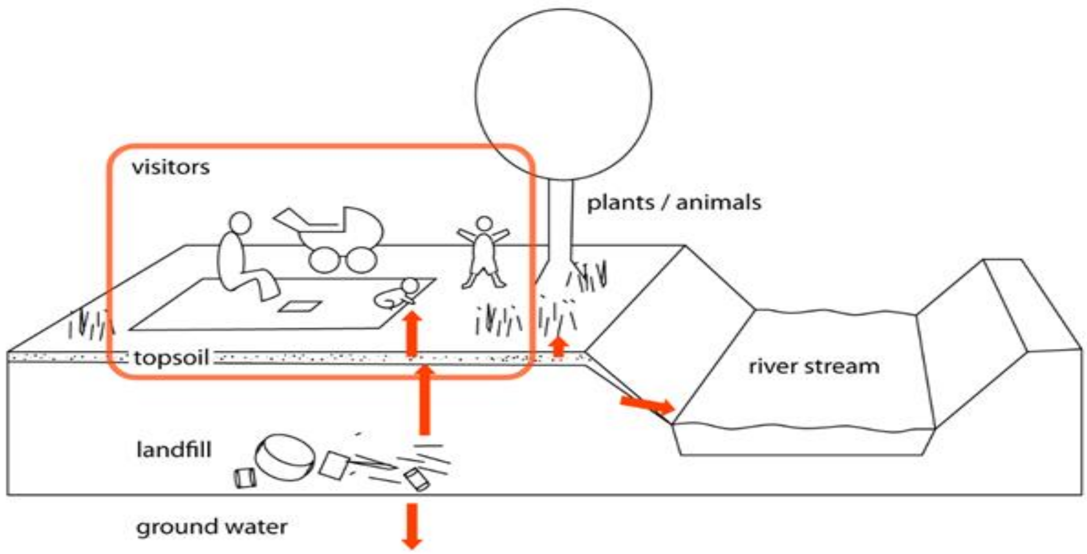


Table . Sources, pathways and receptors for heavy metal contamination on Hounslow Heath.

Source	**Pathway**	**Receptor**
• Topsoil Contamination • Vegetation	• Direct ingestion of soil • Eating fruit (e.g. berries) that have taken up the contamination	• Humans • Critical Group: Young child age between 0 - 6
• Topsoil contamination • Vegetation	• Inhalation of soil particles • Dermal contact with soil • Eating vegetation	• Visiting animals, e.g. dogs, cows
• Soil contamination	• Plant uptake through roots	• Vegetation e.g. bushes, shrubs, trees
• Soil contamination • Vegetation	• Contamination in the food chain, e.g. birds feeding on invertebrates	• Wildlife on site e.g. rabbits, foxes, birds and earthworms

Risk assessment charts.

Figure . Risk assessment chart for arsenic.

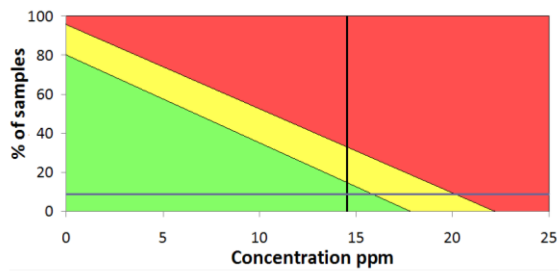


Figure . Risk assessment chart for cadmium.

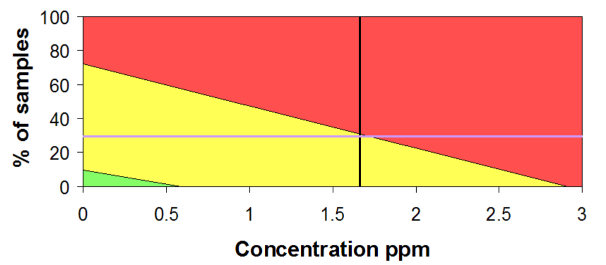


Figure . Risk assessment chart for lead.

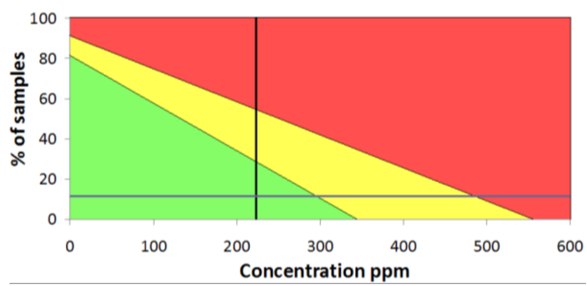


Figure . Risk assessment chart for copper.

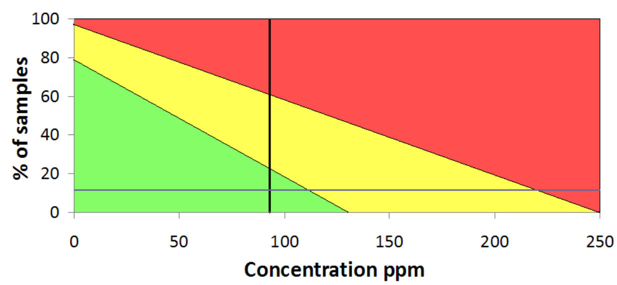


Figure . Risk assessment chart for nickel.

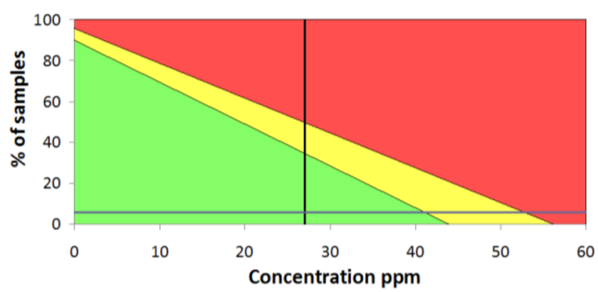
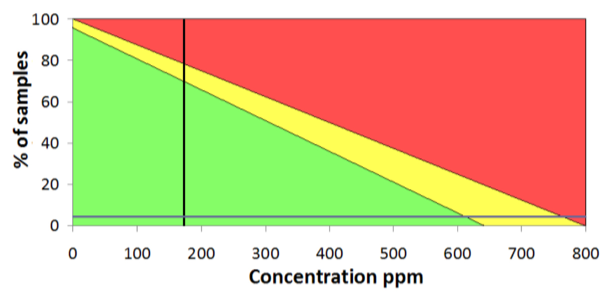


Figure . Risk assessment chart for zinc.



Low risk
Medium risk
High risk

% of samples over SGV
Average concentration on heath

Metal	SGV	Average concentration	Standard deviation	Significance of risk
Arsenic	20	14.72	4.33	Low
Cadmium	1/2	1.66	2.33	Medium
Lead	450	218.38	188.53	Low
Copper	190	93.04	119.21	Low

Nickel	50	27.15	11.73	Low
Zinc	720	175.48	159.84	Low

Figure . Consequence map for phytotoxic metals (copper, nickel, zinc).

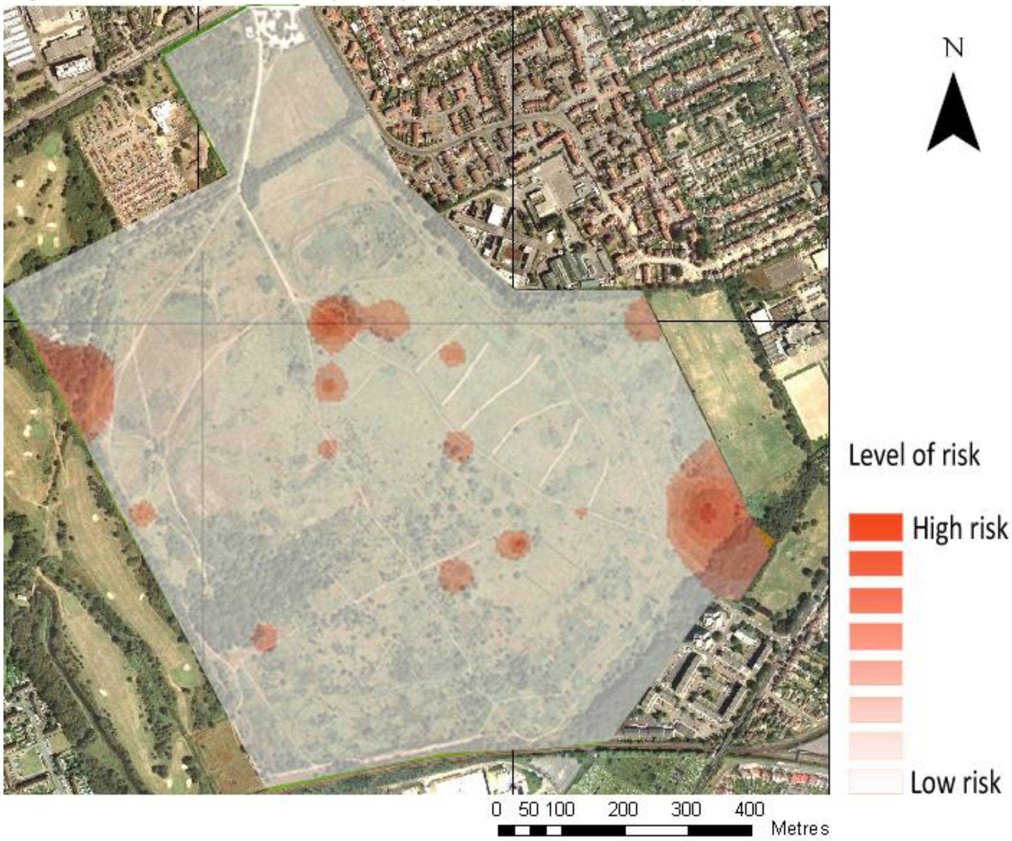
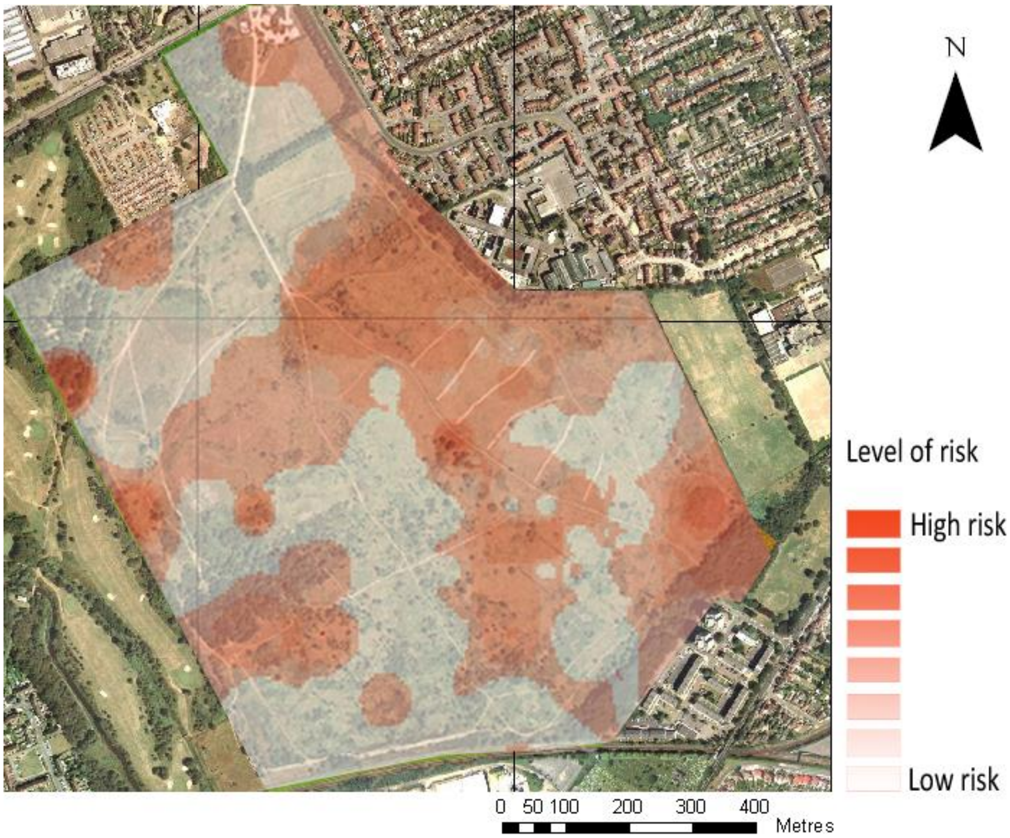


Figure . Consequence map for human toxic metals (arsenic, cadmium, lead).



Groundwater contamination risk

Figure . Consequence map for contamination of groundwater.

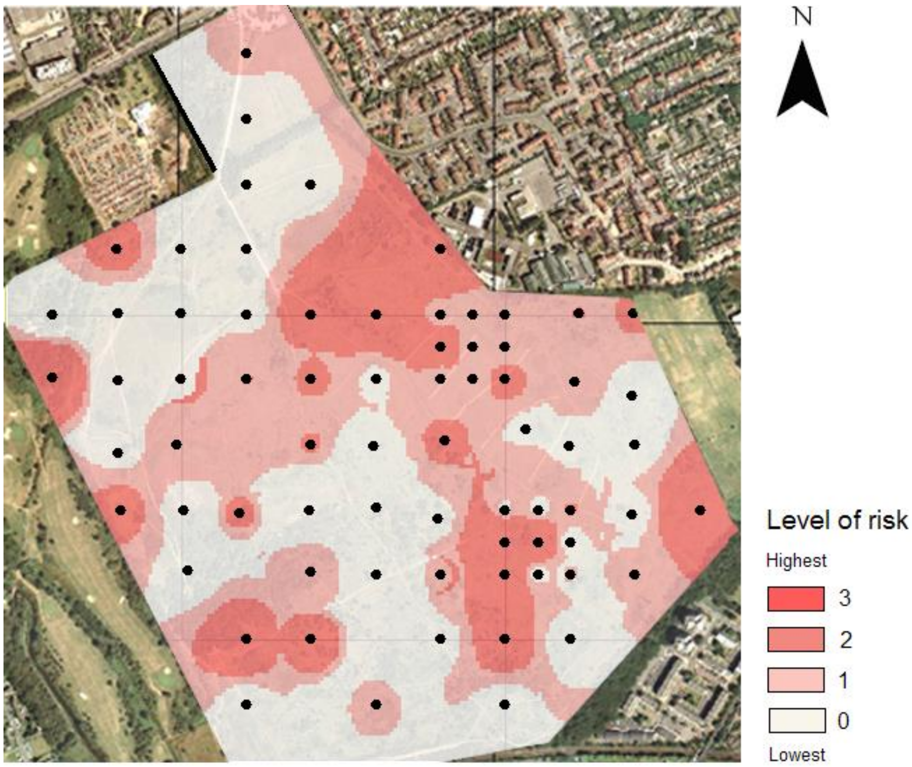


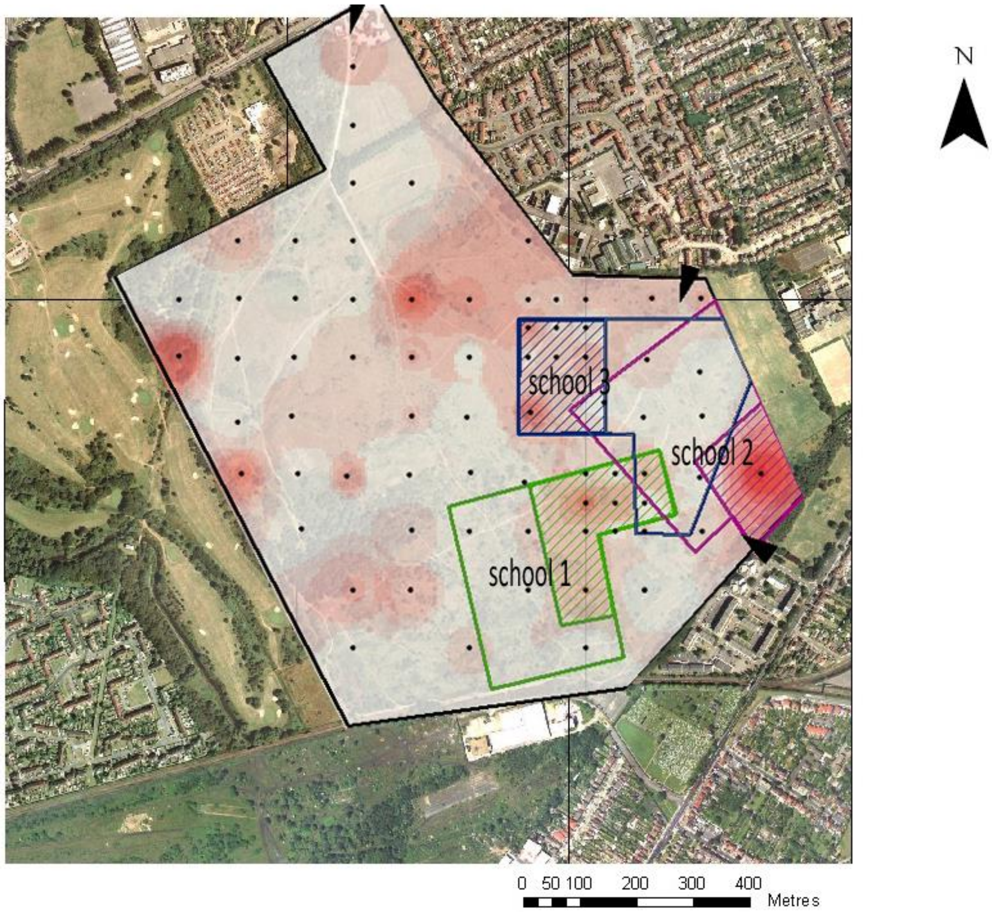
Table . Risk assessment results for groundwater contamination.

Heavy Metal	Mean concentration (ppm)	Standard deviation	Risk (Drinking Water Directive)
Arsenic	0.06	0.05	High
Cadmium	>0.01	0.00	Low
Lead	0.02	0.00	Low
Copper	0.01	0.01	Low
Nickel	0.05	0.01	High
Zinc	0.28	0.55	Low

Recommendations

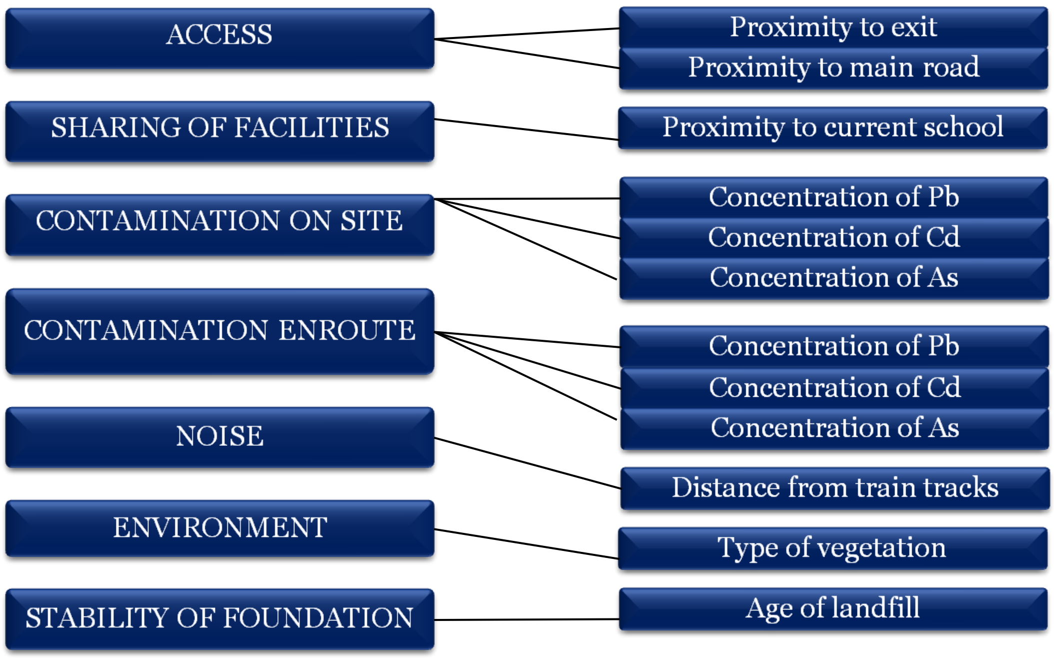
Location of school

Potential sites considered



Option	Overall Performance
1	43
2	30
3	8

MCA criteria



Recommendations

- Further investigation required for Cd levels and their distribution
  - Potential remediation requirement
  - Use earthworms as bioindicators to supplement chemical analysis
- Locate the school at site 1
  - Both options may require some remediation of the other site

References

Hounslow Borough Council (no date) *Hounslow Heath Nature Reserve: About the heath*. Online <http://www.hounslow.info/parks/hounslowheath/HounslowHeathAboutTheHeath.htm> accessed [23 March 2009]

Environment Agency (2008) *Soil Guideline Values.* Online <http://www.environment-agency.gov.uk/research/planning/33734.aspx> accessed [23 March 2009]

Defra (2008) *Guidance on the Legal Definition of Contaminated Land.* Defra (© Crown)

Chin S.Y. (1995) *Reconnaissance survey of potential heavy metal contamination of soils on Hounslow Heath, West London*. MSc thesis, Imperial College London.