British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

UK Baseline Geochemistry: A Key Environmental Yardstick

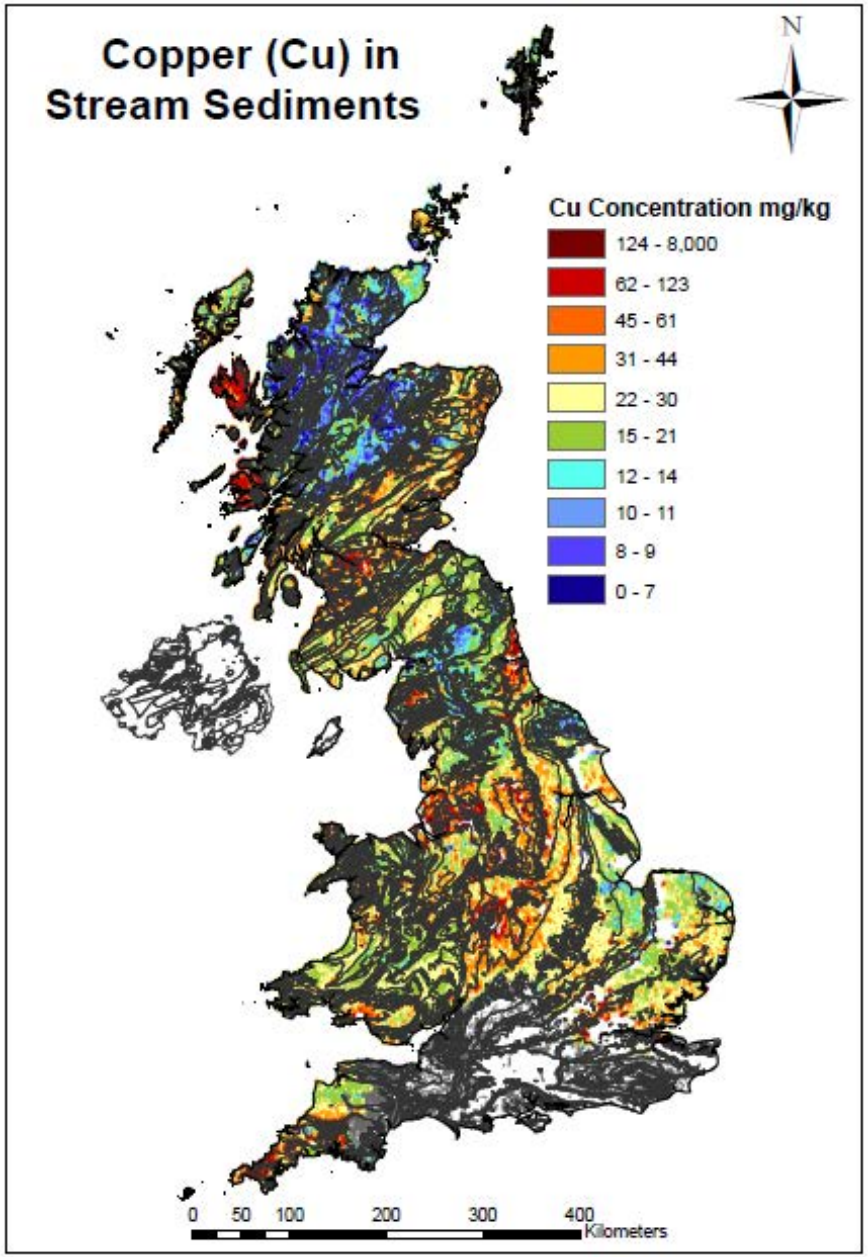
Geochemical Baselines and Medical Geology Team

Content

- Geochemical baselines → G-BASE project
- Applications → how the data have been used and what can be done in the south west

G-BASE in Great Britain

- **G**eochemical **Ba**seline **S**urvey of the **E**nvironment
- Systematic, high density, geochemical survey of UK
- Original survey – stream sediment
- Later - soil, stream water
- Urban surveys – soil only as standard
- Improved analytical techniques – more elements, lower detection limits



Drainage sample site

- Wet sieve sediment to <150 µm
- Pan – heavy mineral concentrate (<2mm >150µm)
- Filtered and unfiltered water samples

Soil sample collection

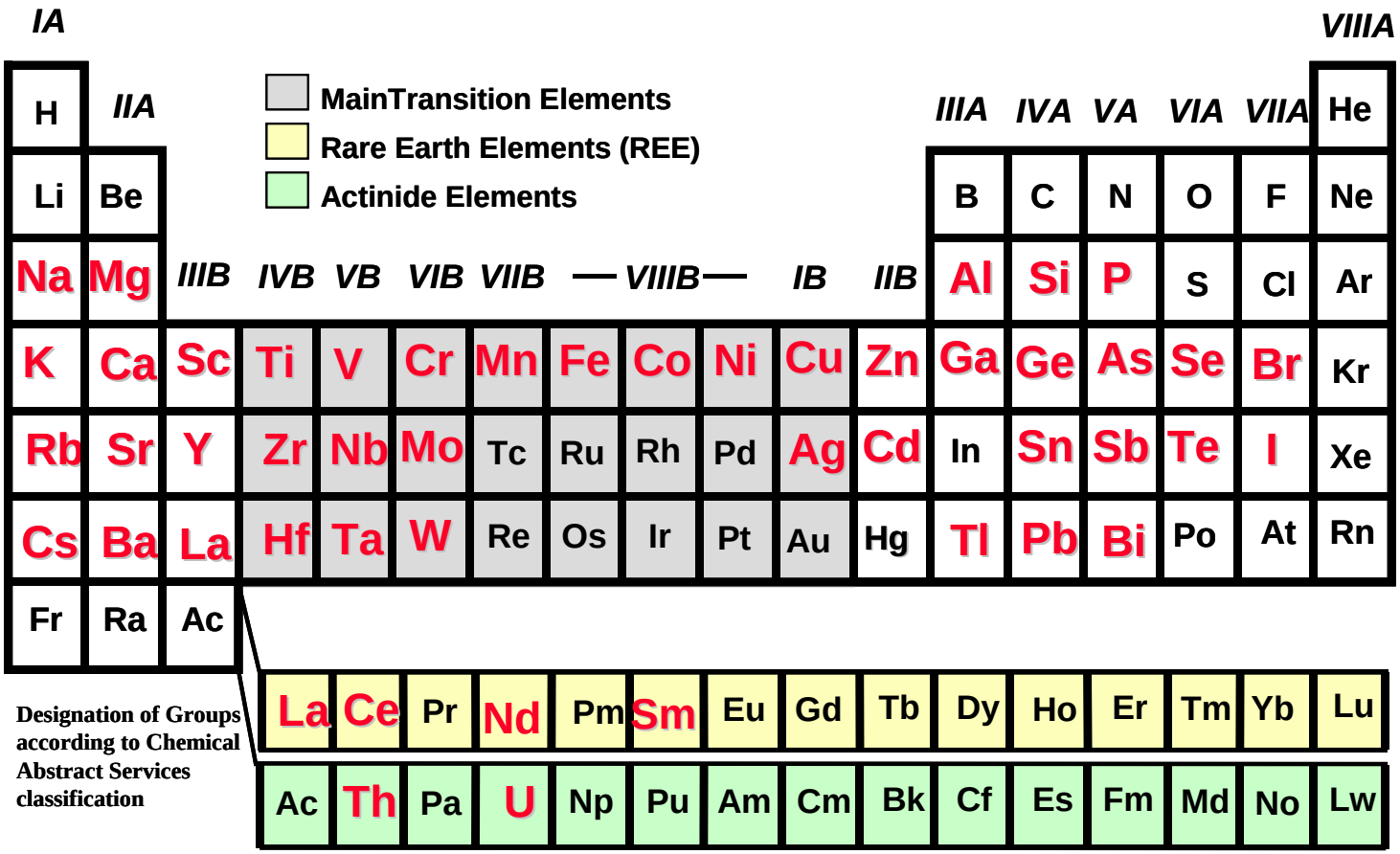
Use a hand held Dutch soil auger

Surface sample 5-20 cm

Deep sample 35-50 cm

Each sample is a composite

G-BASE soil and stream sediment analytes



G-BASE stream water analytes

Blue: ICP-MS. Green: IC.

Additional determinands: **conductivity, pH, bicarbonate, DOC**

H																He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	*La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	**Ac														

*Lanthanides	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
**Actinides	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Who does the sampling?

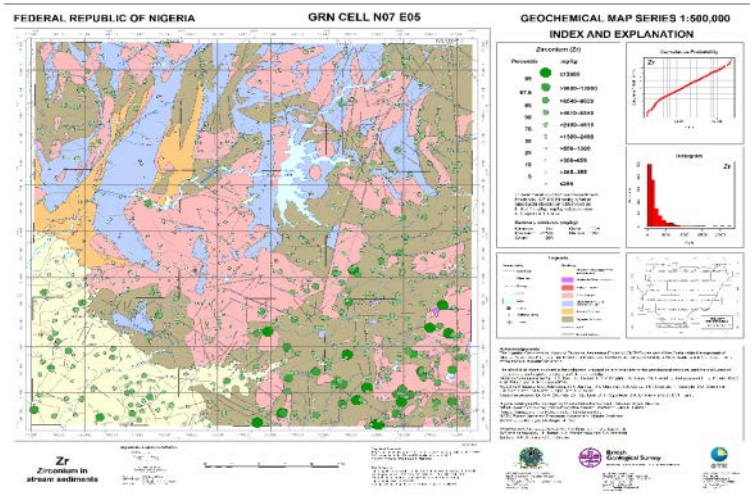
- Voluntary workforce
- Undergraduate geology/ earth science students

Consistent methodology

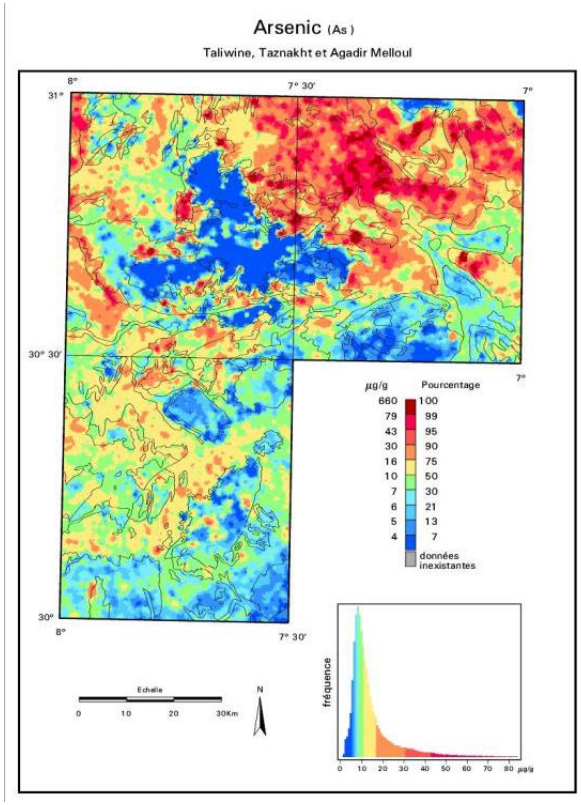
- Focus of project changed, but methodology consistent
- Training – staff and students
- Capability in UK, exported worldwide

G-BASE underpinning of overseas projects

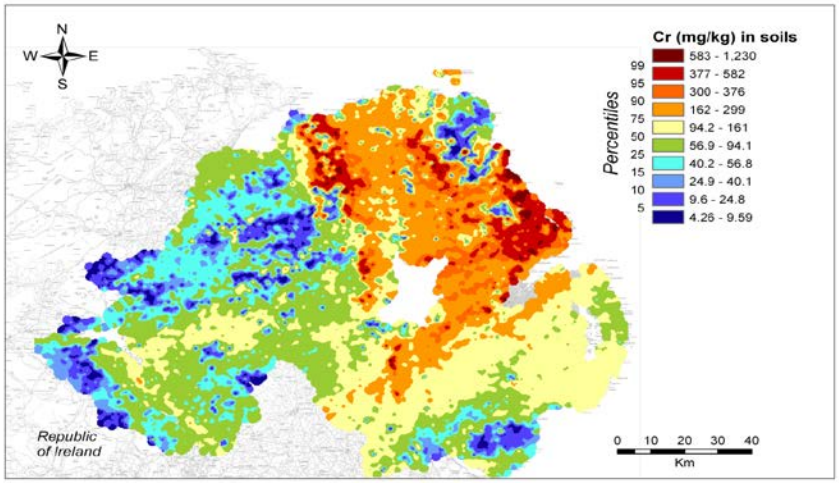
Madagascar 2005 -2006



Nigeria 2009 - 2011



Morocco 1998-1999



Tellus 1993-1994, 2004-2006

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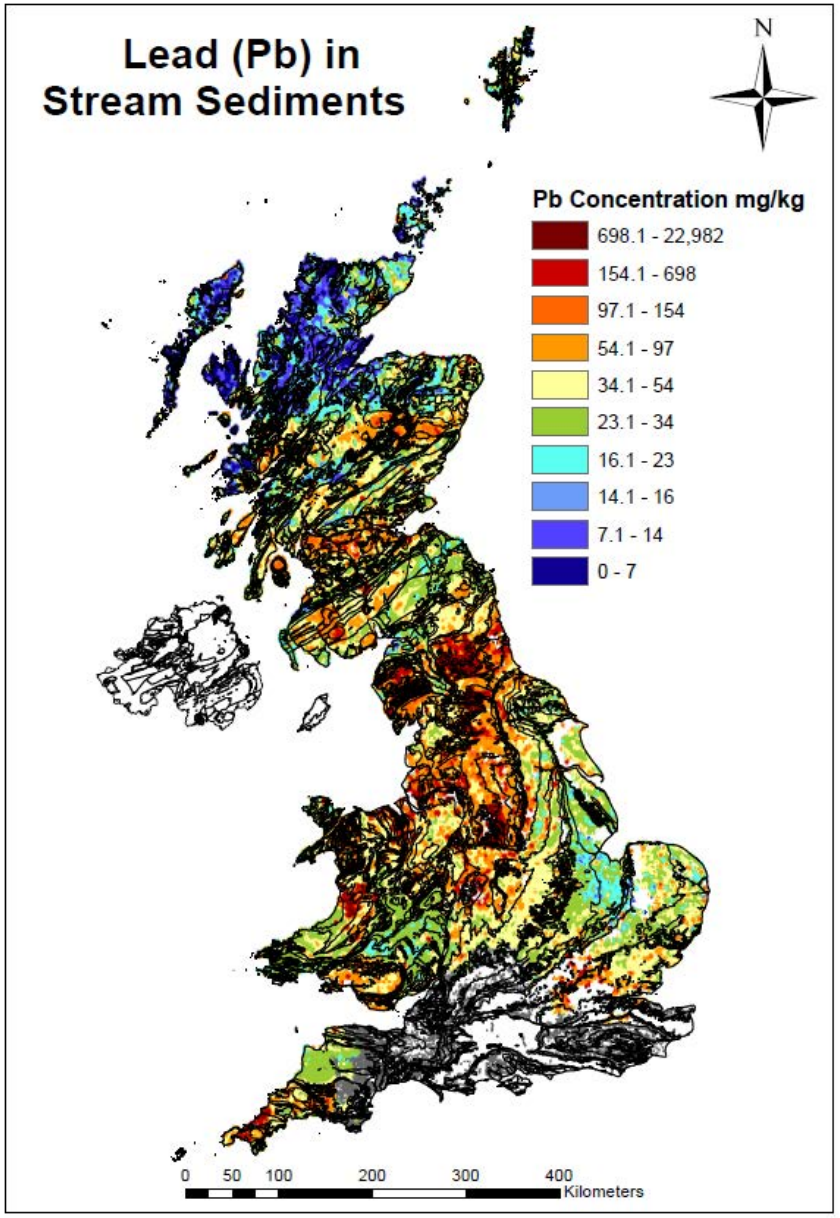
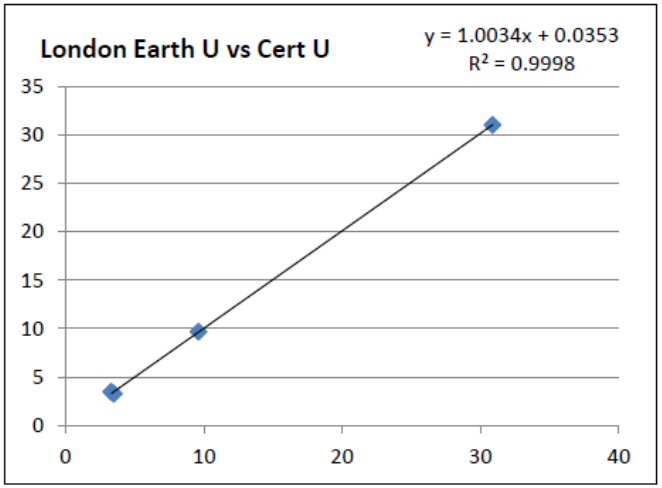
Valuable data set

- Completed coverage of Great Britain September 2013 for stream sediment sample media
- 109,644 drainage sites in total
- Same techniques from beginning to end
- Uniqueness of project → consistency = Robust data set



Quality control

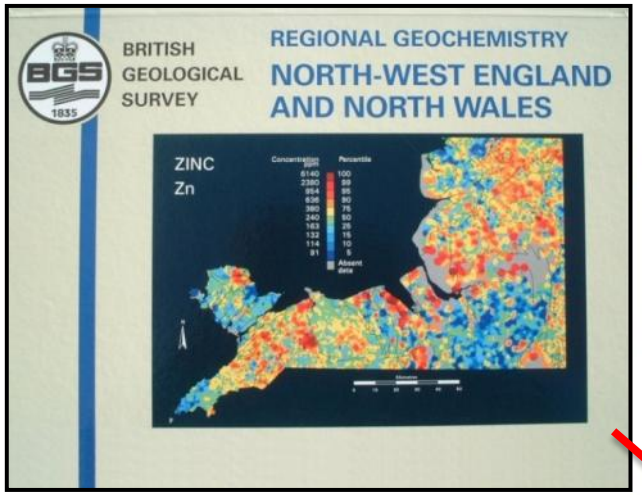
- rigorous QC procedures → seamless coverage
- Control samples:
  - Duplicates
  - Subsamples
  - Blanks
  - Certified reference materials (CRMs)
  - Secondary reference materials (SRMS)

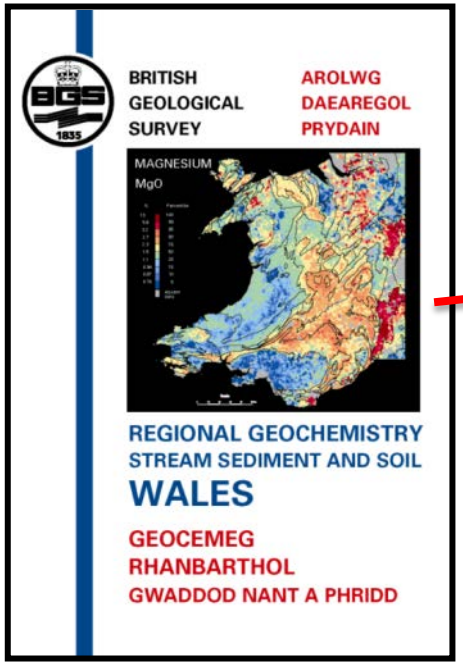


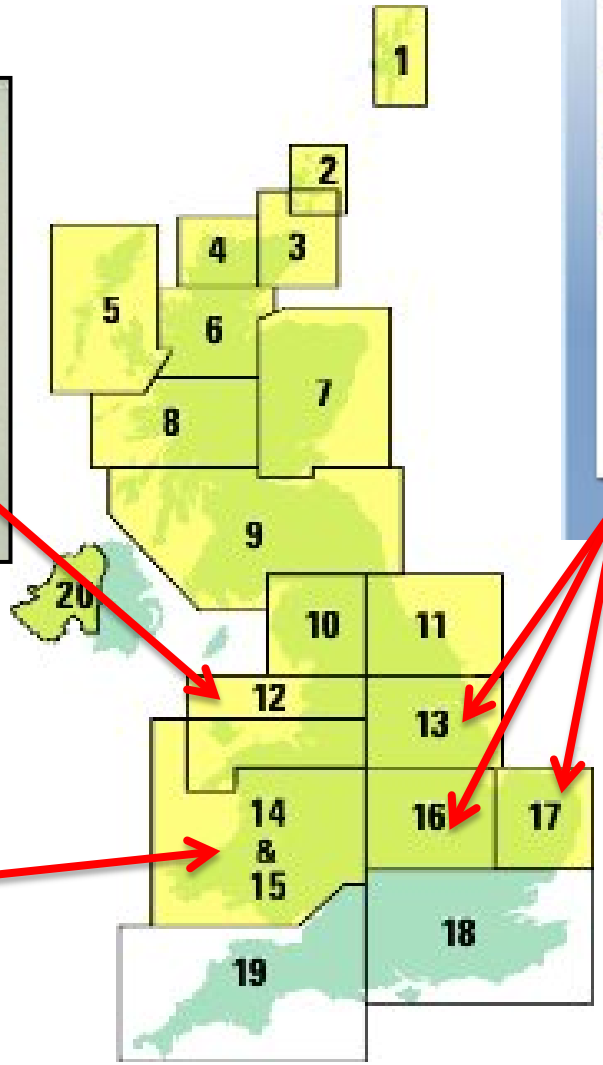
Regression Plots for XRF-ED 2005

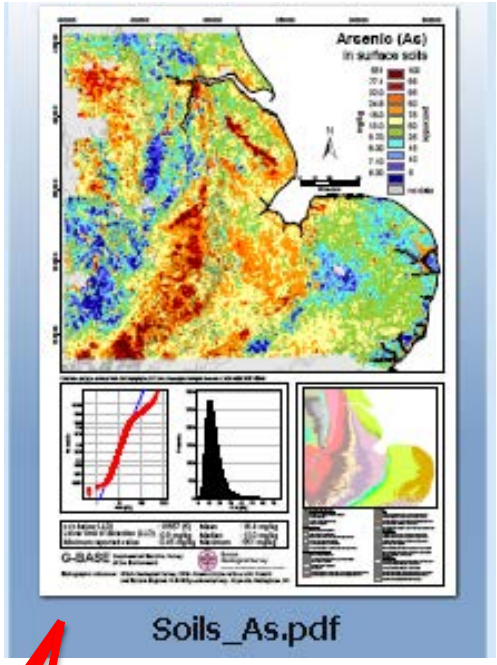
CRM ID	U	Cert U
GSD-7	3.3	3.5
GSS-1	3.5	3.3
LKSD-1	9.6	9.7
LKSD-4	30.9	31

Products





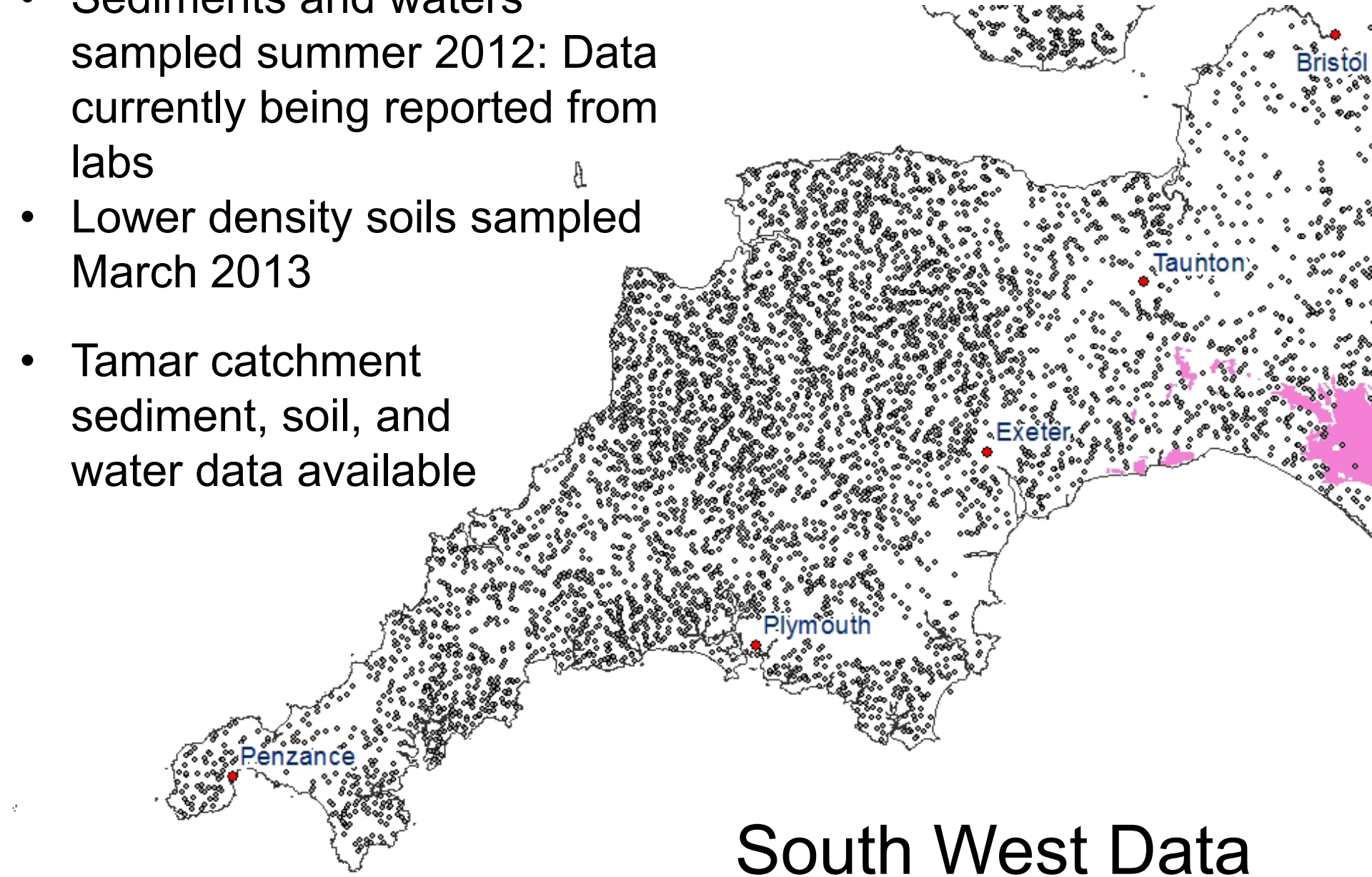




http://www.bgs.ac.uk/gbase

- Sediments and waters sampled summer 2012: Data currently being reported from labs
- Lower density soils sampled March 2013

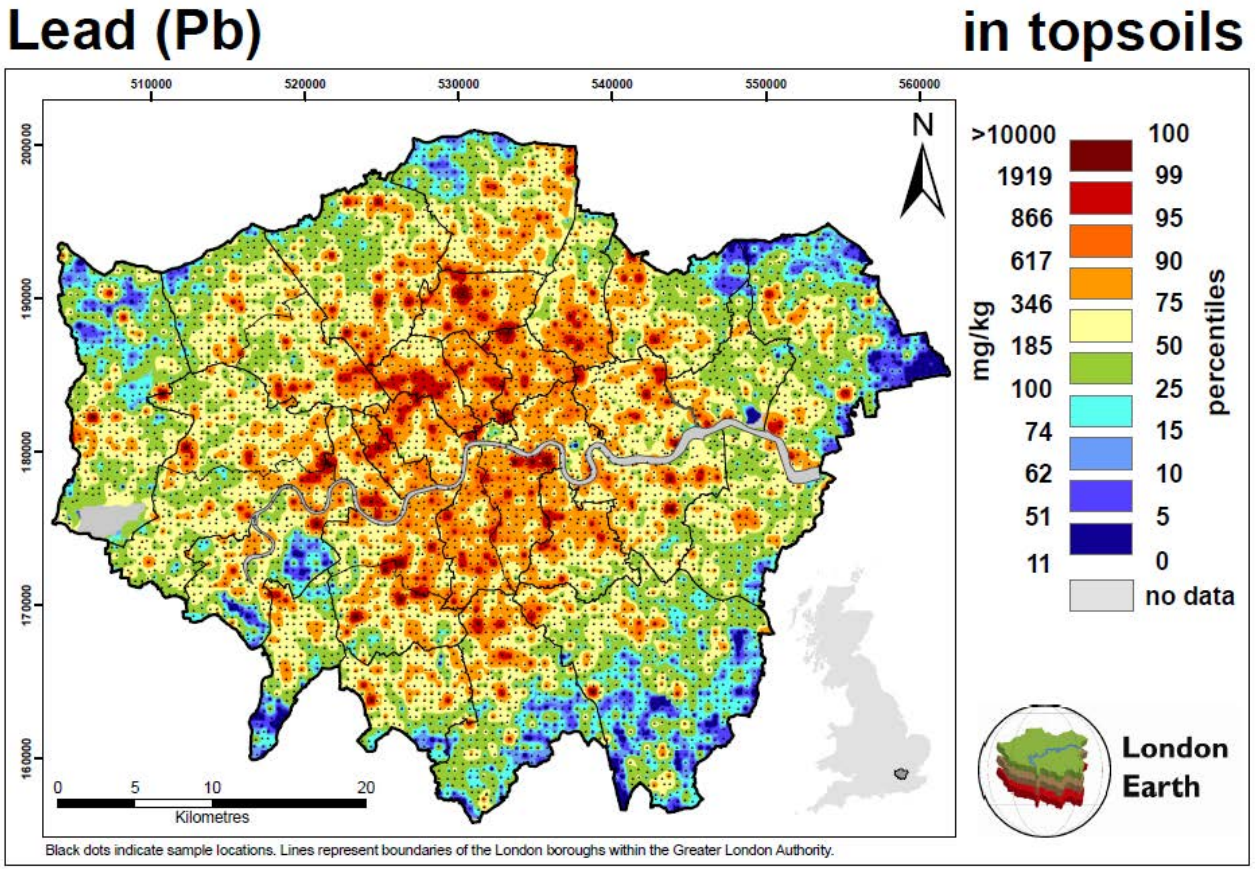
- Tamar catchment sediment, soil, and water data available



South West Data

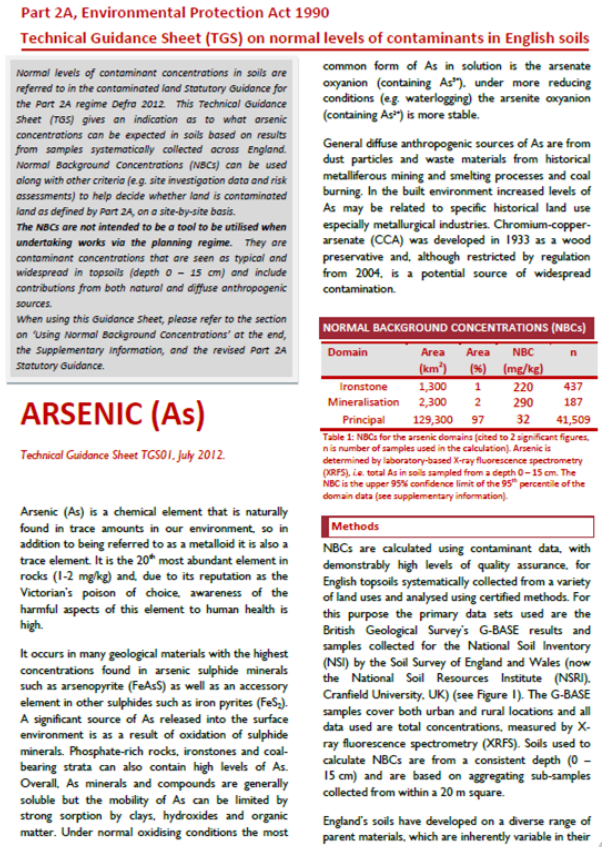
Current uses of G-BASE data

- Chemical composition of UK land surface
- Underpin resource assessment
- Support policy development
- Support research into hazards and human and agricultural health
- Identify anthropogenic modifications



Normal Background Concentrations (NBC)

- BGS commissioned by DEFRA (Department for Food and Rural Affairs)
- Define boundary between natural and anthropogenic and mineralisation domains
- High soil concentrations may be natural or diffuse pollution sources
- Potentially reduce need for excessive remediation – reuse existing site materials
  - Reduce remediation costs (£3.75million at 1 site)
  - 3750 lorry trips avoided
  - Saved 105 tonnes CO_2



Part 2A, Environmental Protection Act 1990

Technical Guidance Sheet (TGS) on normal levels of contaminants in English soils

Normal levels of contaminant concentrations in soils are referred to in the contaminated land Statutory Guidance for the Part 2A regime Defra 2012. This Technical Guidance Sheet (TGS) gives an indication as to what arsenic concentrations can be expected in soils based on results from samples systematically collected across England. Normal Background Concentrations (NBCs) can be used along with other criteria (e.g. site investigation data and risk assessments) to help decide whether land is contaminated land as defined by Part 2A, on a site-by-site basis.

The NBCs are not intended to be a tool to be utilised when undertaking works via the planning regime. *They are contaminant concentrations that are seen as typical and widespread in topsoils (depth 0 – 15 cm) and include contributions from both natural and diffuse anthropogenic sources.*

When using this Guidance Sheet, please refer to the section on 'Using Normal Background Concentrations' at the end, the Supplementary Information, and the revised Part 2A Statutory Guidance.

ARSENIC (As)

Technical Guidance Sheet TGS01, July 2012.

Arsenic (As) is a chemical element that is naturally found in trace amounts in our environment, so in addition to being referred to as a metalloid it is also a trace element. It is the 20th most abundant element in rocks (1-2 mg/kg) and, due to its reputation as the Victorian's poison of choice, awareness of the harmful aspects of this element to human health is high.

It occurs in many geological materials with the highest concentrations found in arsenic sulphide minerals such as arsenopyrite (FeAsS) as well as an accessory element in other sulphides such as iron pyrites (FeS_2). A significant source of As released into the surface environment is as a result of oxidation of sulphide minerals. Phosphate-rich rocks, ironstones and coal-bearing strata can also contain high levels of As. Overall, As minerals and compounds are generally soluble but the mobility of As can be limited by strong sorption by clays, hydroxides and organic matter. Under normal oxidising conditions the most common form of As in solution is the arsenate oxyanion (containing As^{5+}), under more reducing conditions (e.g. waterlogging) the arsenite oxyanion (containing As^{3+}) is more stable.

General diffuse anthropogenic sources of As are from dust particles and waste materials from historical metalliferous mining and smelting processes and coal burning. In the built environment increased levels of As may be related to specific historical land use especially metallurgical industries. Chromium-copper-arsenate (CCA) was developed in 1933 as a wood preservative and, although restricted by regulation from 2004, is a potential source of widespread contamination.

NORMAL BACKGROUND CONCENTRATIONS (NBCs)

Domain	Area (km^2)	Area (%)	NBC (mg/kg)	n
Ironstone	1,300	1	220	437
Mineralisation	2,300	2	290	187
Principal	129,300	97	32	41,509

Table 1: NBCs for the arsenic domains (cited to 2 significant figures, n is number of samples used in the calculation). Arsenic is determined by laboratory-based X-ray fluorescence spectrometry (XRFS), *i.e.* total As in soils sampled from a depth 0 – 15 cm. The NBC is the upper 95% confidence limit of the 95th percentile of the domain data (see supplementary information).

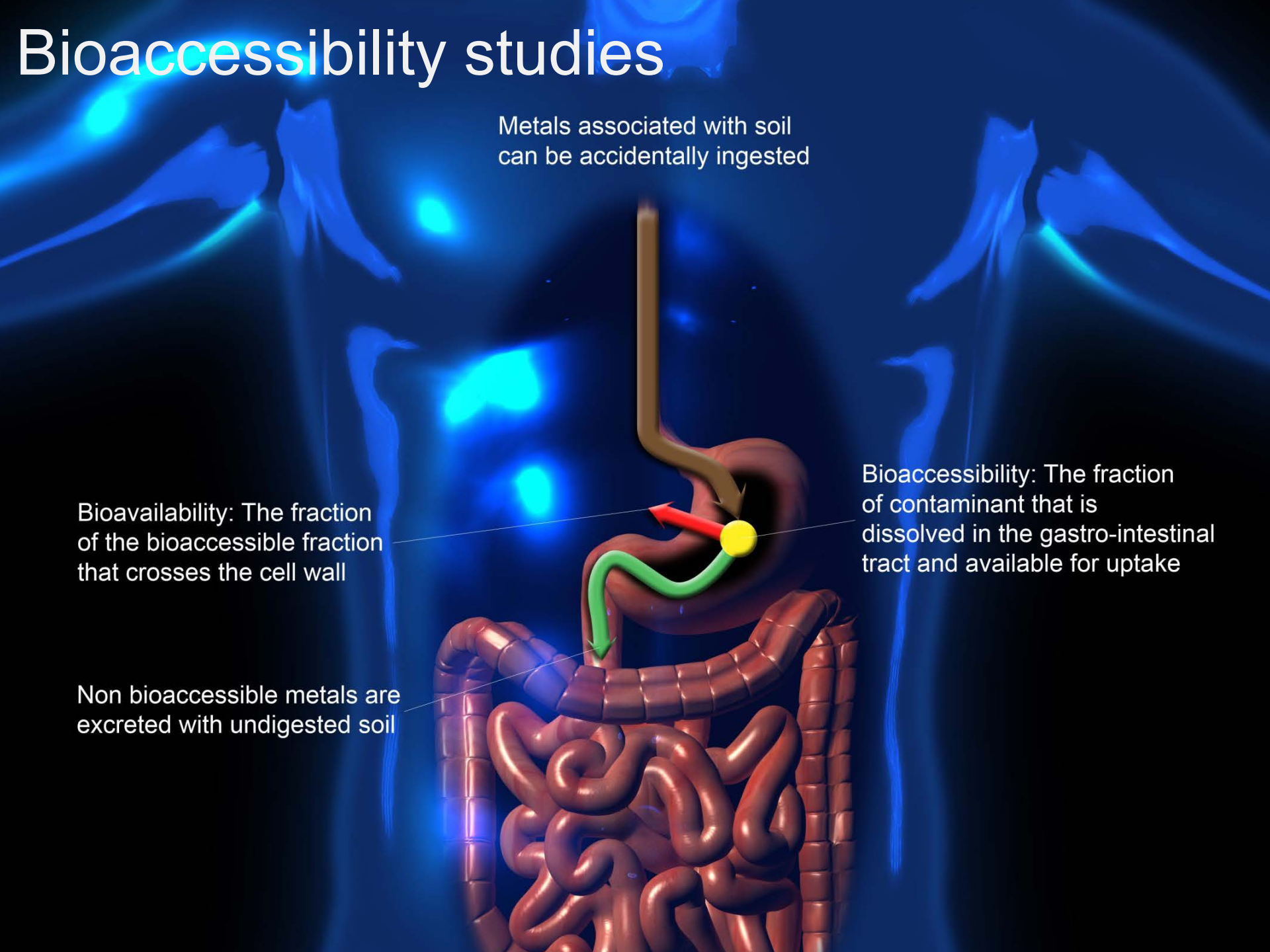
Methods

NBCs are calculated using contaminant data, with demonstrably high levels of quality assurance, for English topsoils systematically collected from a variety of land uses and analysed using certified methods. For this purpose the primary data sets used are the British Geological Survey's G-BASE results and samples collected for the National Soil Inventory (NSI) by the Soil Survey of England and Wales (now the National Soil Resources Institute (NSRI), Cranfield University, UK) (see Figure 1). The G-BASE samples cover both urban and rural locations and all data used are total concentrations, measured by X-ray fluorescence spectrometry (XRFS). Soils used to calculate NBCs are from a consistent depth (0 – 15 cm) and are based on aggregating sub-samples collected from within a 20 m square.

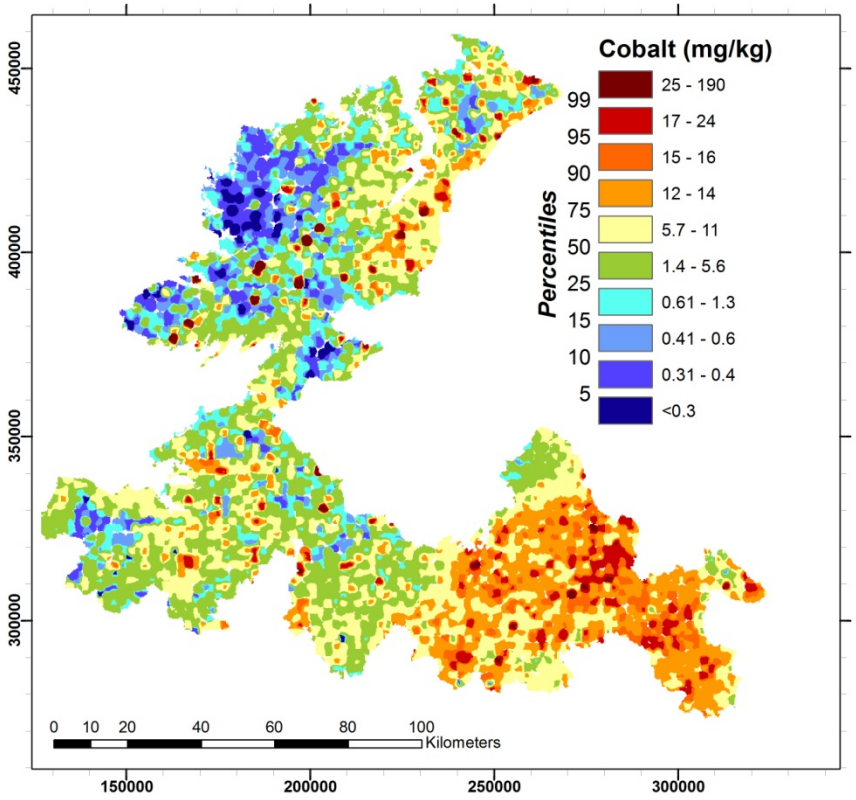
England's soils have developed on a diverse range of parent materials, which are inherently variable in their

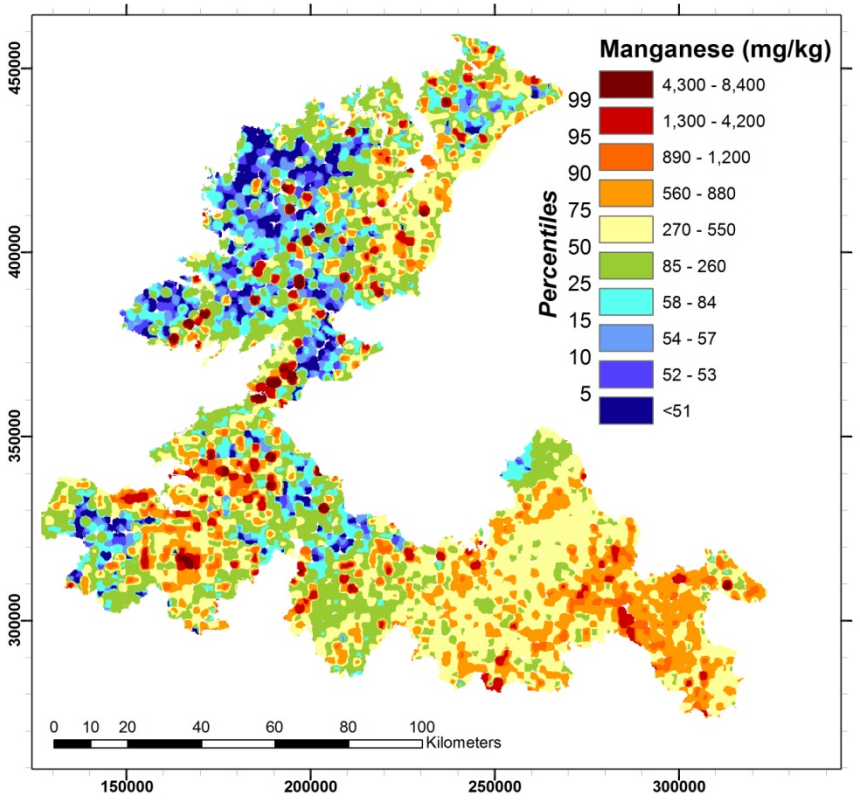
http://www.bgs.ac.uk/gbase/NBCDefraProject.html

Bioaccessibility studies



Soil cobalt and manganese data for assessing cobalt deficiency risk, Republic of Ireland





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Understanding Underground

European Union
European Regional Development Fund
Investing in your future

A project supported by the EU's INTERREG IVA Programme managed by the Special EU Programmes Body

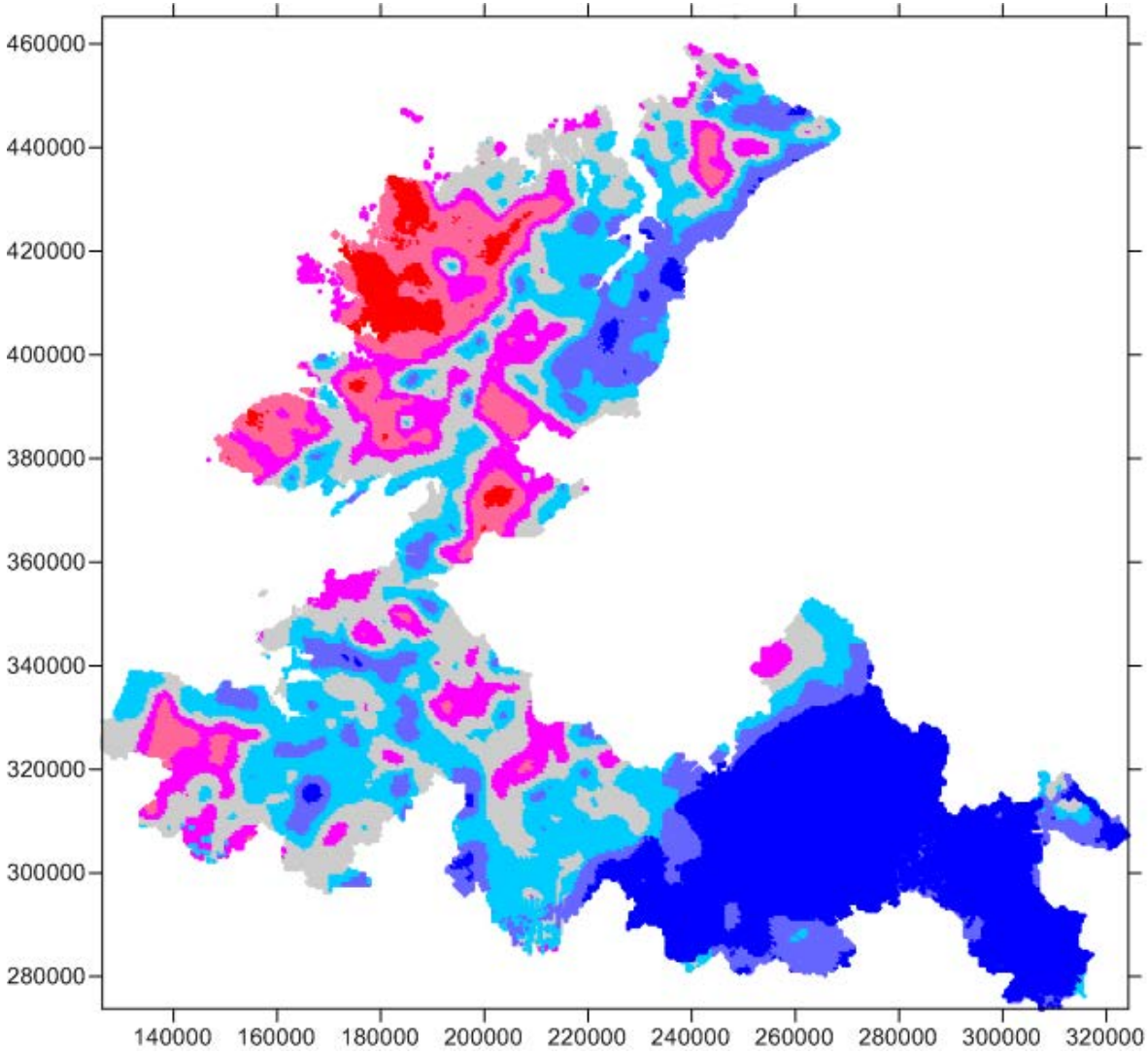
Agricultural advisory service guidance

Soil cobalt index	Upper soil cobalt concentration (mg/kg)	Upper soil manganese concentration (mg/kg)		
		600	1000	>1000
1	3	High risk Treat soil[1]		
2	5	Low risk Treat soil[2]	High risk Treat animal[3]	
3	10	No risk	No risk	Low risk Treat animal[3]
4	>10	No risk	No risk	No risk

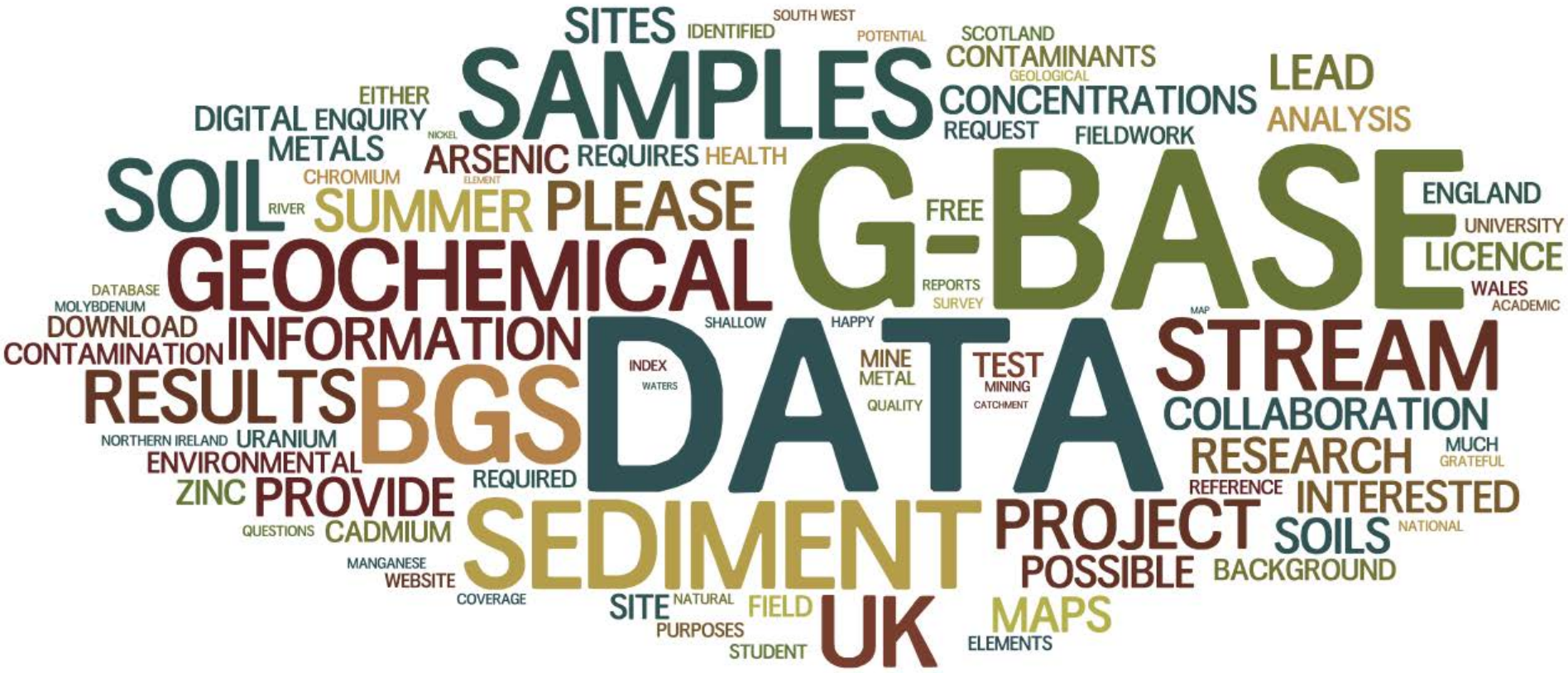
[1]Apply cobalt sulphate (21% cobalt) at 3 kg/ha to ¼ of grassland every four years[4]
[2]Apply cobalt sulphate (21% cobalt) at 2 kg/ha to ¼ of grassland every four years[4]
[3]Treat animals directly by oral cobalt drench, cobalt bullet or vitamin B12 injection
[4]Annually if high pH soil

Taken from Table 8-2 of Coulter, B.S., Lalor, S., 2008. Major and Micro Nutrient Advice for Productive Agricultural Crops (3rd Ed). Teagasc, Johnstown Castle, Co. Wexford, Ireland.

Mapping probability of specific outcomes



Exceptionally unlikely	0 to 1
Very unlikely	1 to 10
Unlikely	10 to 33
About as likely as not	33 to 66
Likely	66 to 90
Very likely	90 to 99
Virtually certain	99 to 100




Thank you for listening
Any Questions?
www.bgs.ac.uk/gbase