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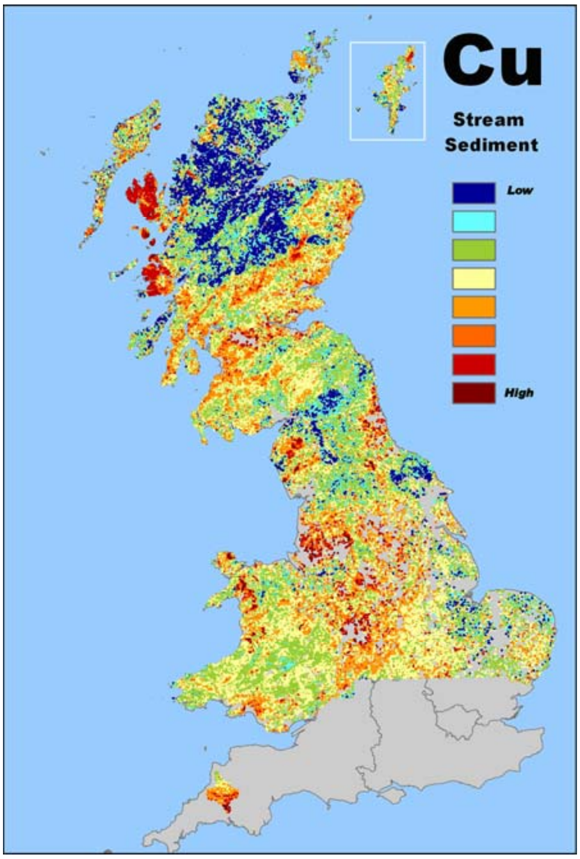
Finishing Off G-BASE: A strategy for completing the Geochemical Baseline Survey of Great Britain

Chemical and Biological Hazards Programme

Internal Report IR/07/005



BRITISH GEOLOGICAL SURVEY

WHATEVER PROGRAMME

INTERNAL REPORT IR/07/005

Finishing Off G-BASE: A strategy for completing the Geochemical Baseline Survey of Great Britain

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Front cover

Image of Cu in stream sediments for samples collected to the end of 2004.

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Summary

G-BASE has 37,400 km^2 of southern England left to sample before a complete national geochemical baseline map can be produced, this represents 16% of the British land area. Approximately one fifth of this remaining area is underlain by Chalk.

With the current sampling strategy of collecting drainage and soil samples it is estimated that there are still 38,900 sites remaining to be sampled (Plan A). This will take 210 weeks to complete or 10 years with two sampling teams collecting for 10.5 weeks each summer.

It is recommended that in order to speed up the sampling the project returns to its prime objective of creating a geochemical baseline from the drainage samples, collecting soils only where the drainage system is poorly developed or absent (i.e. over the chalk) (Plan B). This will reduce the number of sites to be sampled down to 23,750. This would take 126 weeks to complete or two teams sampling for 10.5 weeks per year over a period of six years. In order to complete the work in three years 4 teams would need to sample for 10.5 weeks each summer or two teams could, extending the field season to a period March – October, work for 21 weeks per year. We currently have staff resources that are capable of running two teams for 10.5 weeks per year.

Total estimated costs are **£5.3m** and **£3.7m** respectively for Plans A & B.

Plan	Details	Number of sites to be sampled	Time required for one sampling team at std sampling rate	Estimated Cost of Sampling	Estimated breakdown of sampling costs (£k)	Lab. Costs (£k)	Additional staff/IS/ OR costs (£k)	**TOTALS (£K)**
A	Carry on as we are collecting drainage and soils samples	38,900	210 weeks	£1,230,250	**Staff** 369		383	752
					OR 800		9	809
					IS 62	3,628	3	3,693
					Total 1,231	3,628	395	**5,254**
B	Only collect drainage samples (soils only in chalk areas)	23,750	126 weeks	£731,250	**Staff** 219		255	474
					OR 475		8	483
					IS 38	2,739	3	2,780
					Total 732	2,739	266	**3,737**

Table 1: Table summarising estimated costs for Plans A and B (calculated at 2006 costs). These costs are for carrying out the sampling and analytical programmes up to the point of producing raw analytical data. They exclude estimates for the data QC, levelling and interpretation.

Sampling costs for Plan A and Plan B are **£1,230,250** and **£731,250** respectively, with 30% of these costs being staff costs, 5% internal services (vehicle use) and 65% OR.

Laboratory costs (sample preparation and analysis) for Plan A and Plan B are **£3.6m** and **£2.7m** respectively, though it would be hoped that with a greater throughput of samples lower analytical costs could be negotiated. Water sample analyses represent the largest proportion of analytical costs (£1.5m) and the value of including waters needs to be debated if there are budget restrictions.

Additional staff resources will be needed to manage the project, plan, and administer the samples and data. Whilst the project should be responsible for verifying data received from the labs, the data conditioning procedures should be done from a project within the Information Management Programme as part of preparing national maps. Additional staff costs based in 2006-7 staff rates are estimated to be **£383k** (Plan A) or **£255k** (Plan B), though these estimates will change according the length of time to complete the project. It is more efficient in terms of other costs if the project is completed more quickly.

G-BASE equipment store had become very depleted in recent years due to the sharp decline in OR. If more teams are to be sent out sampling then more equipment will need to be purchased (e.g. GPSs, sieve sets, rucksacs etc.). This will require an initial outlay of **£5k** and provision needs to be made in the budget to annually replace broken equipment. Stocks of secondary reference materials are also very depleted and will need to be replenished at an estimated cost of **£4k.**

It is suggested that the soil baseline maps could be completed by obtaining existing soil samples from other organisations (e.g. samples from the National Soils Inventory held by Rothamsted Research). Analytical methodology and IPR issues would need to be resolved but to complete England and Wales by reanalysing NSI soils at a density of 1 sample per $25km^2$ is estimated to cost **£261k**.

There will be staff resource issues if the project is to be accelerated. We currently have the capability of running 2 teams concurrently for 10.5 weeks per year. Field team leaders are a very valued resource and require at least 3 months of G-BASE sampling experience before they are anywhere near capable of leading a team. The Tellus project has taught us many useful lessons regarding the staffing of teams during years of intensive sampling.

The project would deliver raw geochemical data to the Geochemistry Database and samples archived to the NGDC. Other important deliverables of the current G-BASE project such as the urban sampling, geochemical data interpretation for recently sampled areas, university collaboration, publication writing and co-funded projects also need to be accounted for in any future planning.

1 Introduction

This report sets out a strategy for completing the Baseline Geochemical Mapping of Great Britain by the Geochemical Baseline Survey of the Environment (G-BASE). It reports on what remains to be done and the resources required for getting to a point where we can say we have complete national geochemical baseline coverage.

The geochemical mapping of Great Britain is one of BGS's longest running national strategic surveys. Its longevity demonstrates its ability to adapt to changing user requirements. What was principally a mineral exploration activity is now strongly aligned with NERC's environmental objectives. We are the only organisation in the country undertaking such a systematic high density survey.

Organisational change has impacted on the ability of the project to deliver complete coverage within a reasonable period of time. Since the introduction of the matrix in 2000 the project has been moved in and out of three Programmes and resided in two different Directorates. This has resulted in a loss of focus to get the work finished, compounded by the big success in geochemical mapping attracting CR funds both nationally (e.g. Tellus project, in N Ireland) and internationally (e.g. Morocco). To a large extent the ability of a Science Budget project to defer objectives when high-income CR projects are available has been a benefit to BGS bringing in income, sustaining expertise in our sampling and interpretative skills, maintaining a high international profile, and also maintaining important services such as the BGS chemistry laboratories. However, the continued deferment to commissioned work has greatly impinged on our credibility to deliver complete national coverage within a reasonable length of time as had been promised in several generations of five year science plans. **In order to complete the G-BASE more rapidly, BGS management must assign a priority status equal or higher than that of CR projects**

In the mid-1990s, when G-BASE had the resources to field two sampling teams for a twelve week period (i.e. 24 weeks sampling) completion was scheduled for 2012. The significant reduction in resources caused by the matrix reorganisation reduced progress to less than 10 weeks sampling per year and pushed back the estimated completion date to 2021. From the mid-1990s the project also started to collect and analyse a greater range of media, notably soil samples, and started an urban soilsampling programme. This had significant resource implications and slowed down the national baseline mapping. A defining point in the national mapping progress was the scientifically successful Morocco Geochemical Mapping project (1998-2000) which decimated the G-BASE sampling teams and caused an analytical backlog that took five years to recover from. A complete sampling season was lost due to the foot-and-mouth outbreak in 2001, but the project approached the 2005 - 2010 Science Programme with optimism proposing the completion of SE England in by 2010 and SW England by 2015. However, the start of the 2005-2010 period coincided with G-BASE involvement in the N Ireland Tellus project and a significant drop on OR budget for the project. **Even if G-BASE had been given the financial resources to accelerate sampling, it did not have the staff resources available to do so**. The decline in the number of drainage samples collected is clear from the histogram showing the number of samples collected since 1969 (Figure 1).

The Tellus project has been a valuable learning exercise for the G-BASE project. It has demonstrated how large areas of a country can be sampled relatively rapidly and lessons have been learnt regarding the staffing of field teams and use of external services such as commercial analytical laboratories. It has provided valuable training to staff and as a result we have more experienced team leaders than we would have had if G-BASE had continued with its restricted sampling. Indeed, although the G-BASE sampling rate has declined we are in a much better position to accelerate sampling than we were five years ago. We now have sufficient experienced team leaders to run two teams for up to 12 weeks (i.e. 24 sampling weeks a year). Procedures are now well documented and kept up to date (sampling – Johnson, 2005; field database – Lister et al, 2005; data conditioning - Lister and Johnson, 2005). The laboratory has no analytical backlog and results are generally received in the same financial year that they were collected. The Information Management Programme now has a geochemistry data management project and this has led to a far better corporate adherence to coding data. Externally the project has produced a comprehensive information brochure (Johnson and Breward, 2004) and several peer-reviewed publications about the project (Fordyce et al, 2005 and Johnson et al, 2005).

This strategy document is the most recent to have been produced by the G-BASE project manager for planning purposes in recent years. For information, previous ones are given in the appendices of this report and include: "A history of the G-BASE project (Revised March 2006 - Appendix 1); "The demise of G-BASE" (January 2002 - Appendix 2);"Completing G-BASE" (July 2003 - Appendix 3); and "Geochemical Baseline Surveying 2005-10" (March, 2004 - Appendix 4). These are useful reference documents and also contain previous estimates for the cost of completing G-BASE. In 2003 the cost of completing G-BASE was estimated to be £7.5M (including planning, sampling analysis and data QA/QC). The five year plan for 2005-10 to complete SE England was costed at £5M; SW England would cost approximately the same giving an estimated total cost £10M including urban areas. In 2000 it was calculated that it cost £20 to sample each site, increasing to £27 by 2003, and £35 by 2005. These estimated sampling costs are now annually produced in the field campaign reports (e.g. Scheib and Brown, 2005). The escalating costs can be related to working in the most expensive part of Britain plus increasing expenditure on staff costs through overtime. In 2006 the cost per site was estimated at £30 (Scheib et al, 2006) but this included two weeks of urban sampling which is generally cheaper to sample per site on account of the higher sampling density. Recent field reports are used as a guide to estimating the sampling costs. For this report the 2003 "Completing G-BASE" estimates are updated taking into account the areas sampled 2004-6.

The project has a high output of reports and publications (Appendix 5). It is a source of frustration to many G-BASE staff who are persistently diverted to CR work that no time is left in the year to write up some of the really good science that can come out of the G-BASE data.

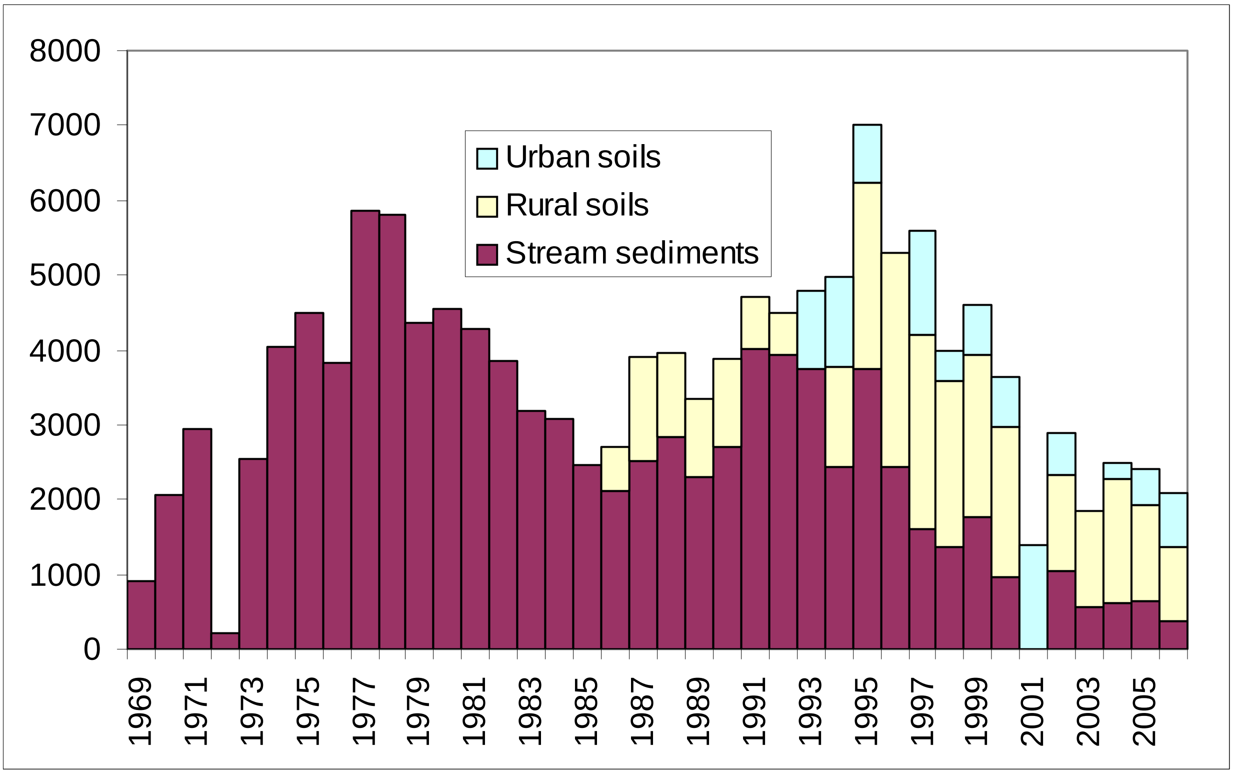


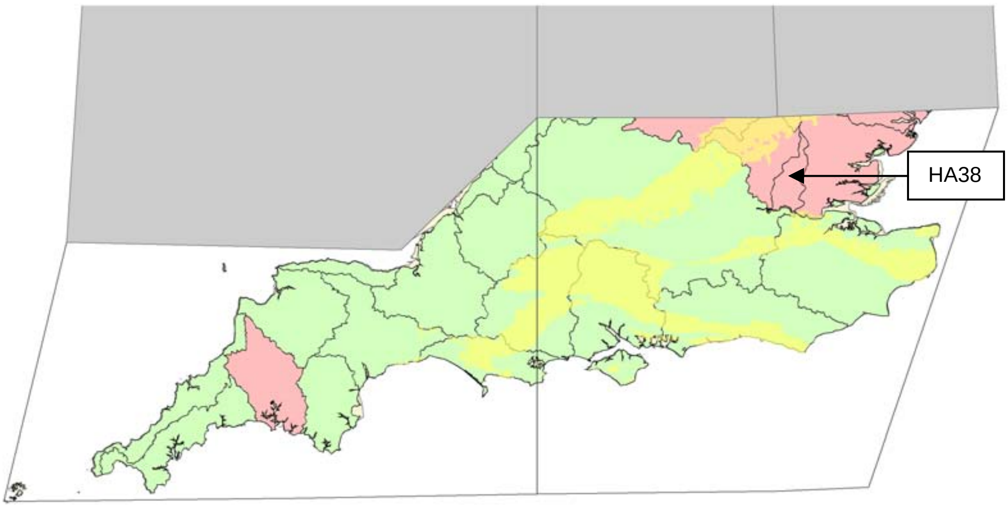
Figure 1: Figure showing the G-BASE sampling rate since 1970

2 What is left to do?

By 2004 it was estimated that some 185,000 km^2 of Great Britain had been sampled leaving 42,000 km^2 of regional sampling to do in the south of England. This latter figure took into account the large urban areas (notably London), the already sampled part of the Tamar catchment and areas not usually sampled such as lakes, coastal margins, mountain peaks etc.. In 2005-6 a regional area of 4,600 km^2 was sampled (Scheib and Brown, 2005 and Scheib et al, 2006). Updating the 2004 calculation this leaves an area of approximately 37,400 km^2 left to sample from 2007 onwards. The total area of Great Britain (England, Wales and Scotland)[1] is 230,000 km^2. **The geochemical drainage sample baseline is therefore 84% complete**.

It is worth noting that the Tellus project area of N Ireland is approx. 14,200 km^2. **Therefore, the area of England left to sample is more than 2½ times that sampled intensively over the past three years by the Tellus Project.**

Of the remaining area to be sampled approximately 20% is underlain by Chalk so the drainage system will be poorly developed in these areas, a clear deficiency already seen in the only existing regional geochemical baseline information produced by Webb et al (1978). There may be some gain by sampling winter-flowing seasonal streams in spring rather than high summer.



Grey area represents completed atlas areas, grey outlines in south represent SW and SE England atlas boundaries. Remaining area to be sampled has been divided into hydrometric areas, the green areas are to be sampled whereas the red areas have been sampled (though parts of the Tamar Catchment and Lee Catchment (HA38) still need to be completed. The main areas of Chalk are shown in yellow.

Figure 2: Figure showing the area of southern England still to be sampled (c. 37,400 km^2)

[1] http://worldatlas.com

G-BASE's principal objective is to produce a geochemical baseline for Great Britain based on a high resolution drainage sampling programme collecting stream sediment samples at a density of one sample every 1.5 ~ 2 km^2. Over the last 10 years the baseline data has been supplemented to great benefit by the inclusion of regional soil sampling at a density of one sample per two km^2. This period of time has also seen much more comprehensive range of analyte determinations than was possible in the early phases of the project. Some 22 urban areas have also been sampled by collecting soils at a density of 4 samples every km^2 in selected urban areas. The soil and water data has been a very valuable asset to BGS particularly with legislatively driven demand for the data. With so much of the stream sediment baseline completed it makes sense that, if national coverage is to be achieved as soon as possible, we must focus on the completion of the national geochemical baseline using drainage sediments. The use of stream sediments is the best method for defining regional geochemical baselines, a fact shown by the widespread use of this as the media of choice by so many national surveys in their national mapping programs.

There is approximately 7,400 km^2 of land area underlain by the Chalk (Figure 2) where the drainage sampling density will be poor and 30,000 km^2 where normal drainage sampling can be done. Whilst some drainage samples can be collected over the Chalk, soil sampling will also need to be done to create a complete geochemical baseline. On this basis, using a sampling density of 1 drainage site per 1.7 km^2, this will be c.17,600 drainage sites and for the non-Chalk areas and an estimated 2,200 drainage sites for the Chalk areas. With a duplicate sample collected at one in every hundred sites this represents about 20,000 sites to be sampled. Using a soil sampling density of 1 sample per 2 km^2, the remaining 37,400 km^2 of land area to be sampled should give 18,700 soil sites though only 3,700 of these will be in the Chalk area (an additional c.200 soil duplicate samples will be collected). The number of samples estimated still to be collected is summarised in Table 2.

Area to be Sampled (km^2)	Drainage Sites (@ 1 per 1.7 km^2	Drainage Samples			Soil Sites
		sediment	water	pans	
Non-chalk – 30,000	17,600	17,600	17,000	17,500	15,150*
Chalk – 7,400	2,200	2,200	800	1,500	3,750*
All – 37,400	20,000*	20,000*	18,000*	19,000	18,900*

Table 2: Table summarising the estimated samples remaining to be collected (asterisk are totals that include field duplicate samples)

Table 2 shows that **using the current sampling strategy we have approximately 20,000 drainage sites and 18,900 soil sites left to sample**.

3 Getting the work finished quickly

Options need to be investigated as to how to get the work finished as quickly as possibly. Firstly, as previously mentioned the work will need to be run like a CR project and thus be assigned a correspondingly high priority status. Secondly, we need to look at the sampling methodology so see if we can collect samples more efficiently and faster.Thirdly, we need to look at the strategy by which we define the national geochemical baseline - do we need to be collecting both soils and sediments to achieve this and can we change the sampling density?

3.1 G-BASE WORK TO BE ASSIGNED HIGH PRIORITY

BGS must assign staff resources to the project that will not be withdrawn in the event of other commissioned work requiring the same staff. If staff are going to be spending long periods in the field then a long-term schedule of staff allocation should be drawn up to ensure fieldworkers can plan their year (both personally and professionally).

3.2 IMPROVEMENTS TO SAMPLING METHODS

The use of teams of undergraduate student samplers is the most cost-effective way of sampling. The G-BASE project is constantly reviewing its methodology and will change procedures if necessary to improve efficiency, but not at the cost of degrading the resulting data quality. A recent example of updating procedures has been the change to using GPS to locate sample sites and much greater use of ArcGIS in the planning process. Valuable lessons will have been learnt from the Tellus work that will need to be considered and assessed (e.g. use of vehicles by sampling pairs when sampling outside the main summer field season). However, **the basic methodology of G-BASE has been refined over a period of more than 35 years and there is little that can be done to improve on it**. History shows that inexperienced newcomers to the project who have tried to "tweak" procedures have usually done so with great detriment to the overall efficiency of the project. Every step in the procedure has been established for a good reason. For example, panned heavy mineral concentrates are collected at all drainage sites, a procedure that takes about 20 minutes. As the pans are not routinely analysed it is often suggested we could save 20 minutes at each site by not collecting them. An in-depth understanding of the methodology would show this is not viable - a very important step in the sampling process is leaving the fine sediment to settle out from water in the sediment pan. Making the samplers collect a panned concentrate ensures there is sufficient settling time.

3.3 CHANGING THE SAMPLING STRATEGY

Our aim is to produce baseline geochemical maps for Great Britain and this target was set in motion many years ago by the collection of stream sediments. If we were about to embark on such a project today we would still opt to use stream sediments as the best media for doing this. **We should focus on completing the geochemical baseline using drainage sediments.** The sampling density is usually a parameter that can be changed to accommodate a fixed budget and time schedule. However, as the G-BASE project is a high resolution geochemical mapping exercise it would greatly degrade the final data set to reduce the sampling density, particularly as 20% of the population live in the remaining 16% of Great Britain still to be sampled. Existing data can be used to demonstrate important geochemical features would have been missed if the sampling had been at a lower density. **It is therefore strongly recommended not to alter the sampling density at this late stage of the geochemical mapping of Great Britain.**

In order to speed up sampling, the systematic collection of soil samples could cease, collecting soils only where the drainage network is poorly developed (i.e. over Chalk). This would mean 15,150 less sites to be visited (see Table 2) and therefore a significant saving in sampling and analytical costs.

There are no real cost savings or time efficiencies to be gained by collecting only sediments at drainage sites. One of the great advantages of drainage sampling is the variety of media that can be collected from the same site (sediment, water, and panned heavy minerals). The laboratory costs for water samples plus the time-consuming field-office methods (pH, conductivity, and alkalinity) make the stream water samples an expensive additional cost. **Whilst the water chemistry results add great value to the stream sediment baseline, it must be debated as to whether the water analyses could be sacrificed in order to complete the national baseline maps more cheaply.** Not analysing water samples will not get the work finished more quickly but it would substantially reduce analytical costs. However, there is growing interest in G-BASE water data from several potential clients (e.g. SEPA in Scotland) and not continuing with this survey would be a serious loss to BGS. Stream water samples have a finite storage time so it would not be desirable to collect water samples to be stored until budget was available for analysis.

If soil samples are dropped from the G-BASE survey it should be possible (subject to resolving IPR and analytical issues) to obtain soil samples from Rothamsted Research. These are soil samples from the National Soil Inventory and couldbe analysed at the BGS laboratories by XRF (see Appendix 6). **It is estimated that 5691 NSI soils from across England and Wales on a 5 km grid would cost £260,455 to reanalyse in the BGS XRFS laboratory** (a cost that does not include any staff time for collating samples and data conditioning). The provision of data at this lower resolution of 1 sample per 25 square kilometers would provide commercially valuable data with respect to the Contaminated Land Regulations for England and Wales. It will then be possible to integrate the low resolution soil data and high-resolution stream sediment to provide accurate estimates of the probability of exceeding soil guideline values due to naturally occurring harmful elements. However, without samples from Scotland this would still not give a national geochemical baseline for soils.

4 How long will it take?

Table 3 shows a sampling rate calculator based on sampling teams consisting of four sampling pairs, collecting 8.5 sites per day for 5.5 days per week. It is estimated that under the current sampling strategy one team sampling for 21 weeks each year (equivalent to 2 teams for 10.5 weeks) would take 10 years to complete the sampling. If soils are dropped then it would take 6 years (one team sampling for 21 weeks per year). These times will be halved if the number of sampling teams was doubled. It would not be practical to sample between November – February so the maximum number of sampling months per year would be 8 months (34 weeks).

It must be remembered that G-BASE effectively works 7 days a week so 21 weeks would be 147 days of staff time and not 105 days.

Sampling Teams	Weeks									
	21	42	63	84	105	126	147	168	189	210
1	3927	7854	11781	15708	19635	23562	27489	31416	35343	39270
2	7854	15708	23562	31416	39270	47124	54978	62832	70686	78540
3	11781	23562	35343	47124	58905	70686	82467	94248	106029	117810
4	15708	31416	47124	62832	78540	94248	109956	125664	141372	157080

Table 3: Estimated sampling rates based on a team of 4 sampling pairs collecting 8.5 sites per day, 5.5 days per week. Yellow highlighted boxes show the approximate sample numbers for a sediment only sampling programme whereas the pink boxes show the target if soil samples are collected as well.

5 What will it cost?

Year	Cost per site £
2003	30.40
2004	30.87
2005	34.51
2006	30.32

Table 4: Estimated sampling costs per site from field campaign reports (costs include staff time, overtime (from 2005), accommodation, staff and student T&S, consumables and transport)

5.1 SAMPLING COSTS

Recent field campaign reports document estimated sampling costs per site (Table 4). These costs include staff time, overtime, accommodation, staff and student T&S, consumables and transport costs. Costs per site have increased as teams have moved southwards reflecting the greater expense (accommodation) of working in the south of England. In 2003 costing estimates were based on pre-field season (i.e. pre-2003) cost of £27 per site (see Appendix 3), by 2005 this had risen to £35. The 2006 figure of £30 per site is possibly misleading because G-BASE has run down all its stocks of consumables (sample bags etc.) as there was insufficient OR budget this year to replenish stocks. Estimates for completing the work will be based on a cost of £35 per site and the sample number figures from Table 2:

All drainage sites – 20,000 x £35 = £700,000
Soil sites (Chalk) – 3,750 x £35 = £131,250
Soil sites (non-Chalk) – 15,150 x £35 = £530,250

The relative proportions of these costs attributed to staff time, OR and internal services (transport) has varied each year but can be estimated at 30% staff time, 5% internal services and 65% OR.

5.2 ANALYTICAL COSTS

Current (i.e. 2006) analytical costs per sample charged by the BGS laboratories are shown in Table 5. Estimates based on these costs are given in Table 6. The laboratory costs represent the single biggest expense to completing G-BASE. **It will be a strategic decision as to whether senior management feel the project must continue to use the BGS laboratories and at what cost**. The Tellus project has demonstrated the problems to be encountered using external laboratories and it is difficult to find anywhere in the world that will offer the range, quality and volume of XRFS analyses that the BGS laboratories currently produce for G-BASE.

Sample Preparation	**per**	**Notes**
surface soils (A)	8.10	full preparation
deep soils (S)	4.00	drying sieving and storing
stream sediments (C)	7.50	full preparation
pan concs (P)	3.25	drying and storing
Analysis		
XRFS	39.50	full programme of elements
pH soils	4.50	only done on c. 50% of soils
Loss-on-ignition soils	5.50	only done on c. 50% of soils
ICP-MS (waters)	30.00	
ICP-AES (waters)	18.50	
Ion chrom. (waters)	21.60	
NPOC (waters)	9.00	
Combined costs		
surface soils	47.60	prep+ XRFS
stream sediments	47.00	prep+ XRFS
stream waters	79.10	four analytical methods

Table 5: Current (2006) G-BASE analytical costs per sample

Sample Media	**Number of samples**		**Laboratory Costs (£)**
	Collected (inc. duplicates)	**Submitted for analysis**	
Stream sediments	20,000	20,800	977,600
Stream waters	18,000	18,720	1,480,752
panned concentrates	19,000		61,750
surface soils (chalk only)	3,750	3,900	205,140
deep soils (chalk only)	3,500		14,000
surface soils (all area)	18,900	19,656	1,033,906
deep soils (all area)	18,500		74,000

Total costs (sediment + water + all area soils) = £3,628,008

Total costs (sediment + water + chalk soils only) = £2,739,242

Table 6: Estimated laboratory costs to complete G-BASE

5.3 OTHER COSTS

5.3.1 Staff Costs

If the G-BASE project is simply going to become a sampling and laboratory analysis project then the staff costs that will be needed, in addition to those that already form part of the sampling costs, will be for project management, campaign planning, farms/landowner access, monitoring and checking laboratory progress, data validation, and general administration (ordering equipment, T&S processing etc.). Obviously these costs will depend on the length of time taken to complete the project. An attempt to estimate these costs is given in Table 7.

Band	daily cost
4	£294.99
5	£217.43
6	£174.11
7	£138.56
8	£104.39
9	£83.46

Item	Band	Days	Cost (£)
Project Management	4	600	176,994
Project Management	5	300	65,229
Planning	6	150	26,117
Planning	7	150	20,784
Planning	8	150	15,659
Farms Access	8	250	26,098
Administration	8	250	26,098
Data validation	8	250	26,098
Data Conditioning	6	250	43,528
		TOTAL	**383,075**

Item	Band	Days	Cost
Project Management	4	360	106,196
Project Management	5	180	39,137
Planning	6	90	15,670
Planning	7	90	12,470
Planning	8	90	9,395
Farms Access	8	150	15,659
Administration	8	150	15,659
Data validation	8	150	15,659
Data Conditioning	6	150	26,117
		TOTAL	**255,961**

Table 7: Estimate of "other" staff costs (based on 2006-7 rates). Top table is for continuation as sediment and soil survey (Plan A), bottom table for drainage sampling only (Plan B)

The data conditioning, particularly the process of levelling the data with other areas is a cost that should be borne by the Information Management Programme. The East Anglia atlas area with some 8000 sample sites (drainage and soil) took ten weeks of staff time to complete the data conditioning. To complete the project under the current sampling strategy (drainage and soil sites) with approximately five times as much data would proportionately take and estimated 50 weeks or 30 weeks if drainage samples only are collected.

5.3.2 Equipment and Consumables

The G-BASE equipment store has become very run down in recent years due to very low levels of OR budget. Any acceleration in sampling would need an injection of funds into refurbishing/replacing equipment, particularly if more sampling teams are to be deployed at any one time. A rough estimate of costs is £5k, the biggest expense being the wooden sieve sets and pans. Consumables (such as sample bags) are to a large extent included in the cost of sampling each site but materials that are purchased less frequently (e.g. nylon sieve mesh) would not be costed into the site sampling costs.

A further expense that has to be considered are the reference materials that the project needs to insert as controls during the laboratory analyses. The primary (or certified) reference materials cost between £500-2000 per kg. The secondary reference materials are collected by BGS staff and would probably require 6 samplers collecting drainage sediment for 2 weeks. Budget for reference materials should be around £4k of OR.

5.3.3 Total costs

From the preceding sections estimates of costs can be made which are summarised in Table 1. Plan A (continuing present strategy, drainage and soil sampling) will cost an estimated £5.3m whereas Plan B (drainage samples only with soils from chalk areas) £3.7m. This compares with the Tellus geochemical project which is estimated to have cost £2.4m (pers. comm. M Young, email 20/12/06) to complete an area 38% the size of the area remaining for G-BASE to map. The Tellus programme has included some urban sampling, a more extensive range of analytes and interpretation of the data.

6 Staff Resources

BGS currently has the resources to field a team for 24 weeks per year or 2 teams for 12 weeks (i.e. summer season) per year. Staff recruitment policy has been to employ graduates with the intention of spending nor more than 2 – 3 months on fieldwork each year, with the rest of the annual staff time being spent on interpretative work or working on other BGS projects. It has always been a very positive point of the G-BASE project that its field geochemists are very employable and most are generally fully funded on BGS projects all year, generally with less than 50% of time allocated to G-BASE. Futhermore, there was a policy pre-2002 of recruiting post-graduates to lead G-BASE teams for 4 – 6 weeks a year but whose considerable skills were needed outside G-BASE fieldwork (e.g. Barry Rawlins and Louise Ander). Any plan to accelerate G-BASE sampling must be aware of staffing issues that would arise from the requirement to send staff to be out into the field outside the normally accepted summer field season. This is particularly so at a time when many staff deferred publishing G-BASE work that would have greatly enhanced their career prospects in order to help BGS in its commitment to get the Tellus geochemical sampling finished, during almost continuous field seasons. It would be iniquitous to expect staff to further undermine their career prospects in this way, especially when scientific output is such an important performance indicator in BGS/NERC.

Any accelerated sampling would initially need to start slowly in order to get new staff trained up to lead field teams over at least a three-month period. Within BGS there are recent recruits that have G-BASE experience and could be potential become field team leaders. Staff commitments to G-BASE over the coming years will need to consider what requirements there will be for international geochemical mapping. This has drained G-BASE of key members of staff over the past ten years.

7 Other Issues

There are a number of issues that need to be addressed if the G-BASE project becomes focused on a programme of accelerated sampling

1. Availability of students outside the summer vacation
2. Urban sampling programme – this has provided local authorities useful information in the context of legislatively driven initiatives. G-BASE has sampled much of north and east London, the work needs to be completed and written up.
3. The East Midlands and East Anglia data for soils, sediments and waters is now available for interpretation. Resources need to be set aside to write up this work and interpret the results. There are potentially some very interesting peer-reviewed papers that will come from this data
4. This report is concerned with the current sampling role of G-BASE. The project is currently involved in many other areas (co-funded projects, university collaboration using the geochemical data, publication writing, etc.) and these roles need to be supported from within a BGS programme.

8 Recommendations

1. It is recommended that the G-BASE fieldwork be accelerated to achieve a national geochemical baseline as soon as possible
2. G-BASE can complete the baseline more quickly be refocusing on the drainage sediment baseline and collecting soils only where the drainage is poorly developed (i.e. chalk-lands). This would enable two teams sampling for 10.5 weeks each year to complete the sampling in six years
3. Current staffing resources could complete the work in six years. Sampling at a faster rate would need to deploy more staff and a plan for recruiting staff and training over a period of at least 3 months
4. Staffing issues that may involve staff working for much longer periods in the field need to be anticipated and addressed so that the career development of staff is not curtailed by being perceived as simply geochemical samplers
5. G-BASE should be conducted more in the manner of a commissioned project so staff are not continuously lost to “higher priority” work
6. The sampling season should be extended to be as long a feasible using lessons learnt during the Tellus geochemical sampling
7. Analytical costs represent the single-most biggest expense. Within the laboratories there will be cost efficiencies to be derived from an accelerated, planned and stable sampling programme. Hopefully, a reduction in analytical costs could be negotiated. Costs could also be reduced by dropping the water sample analyses which should be the subject of discussion but is not a favoured option.
8. The feasibility and usefulness of creating a soil baseline for Great Britain from soil samples already collected by other organisations should be further investigated particularly regarding IPR issues, the density of sampling and analytical methodologies
9. If resources are redirected into sampling, other current areas of G-BASE work should not be neglected. These included co-funded projects, urban sampling and data interpretation, university collaboration, interpreting and reporting the East Midlands and East Anglia geochemical data and peer-reviewed publications
10. The data quality control, data levelling, databasing and preparation of national geochemical baseline maps should be funded from the Information Programme.
11. Planning for the national maps should start now by determining what product the customer wants and making sure that the existing data is ready for incorporation into national maps. The dilemma to be faced is that many of the staff that would be earmarked to lead the accelerated sampling are also the most appropriate staff to be doing the data conditioning which does require the skills of a geochemist.

Appendix 1 : History of the G-BASE Project

G-BASE

Internet Information

History of the G-BASE project

Version 1.1

31st March 2006

history.pdf

History of G-BASE

In 1968 the Institute of Geological Sciences (IGS) (now the British Geological Survey, BGS) began a regional geochemical sampling programme in the northern Highlands of Scotland. This work was aimed at producing maps to show the distribution of trace elements in stream sediments. Prior to this, earlier geochemical studies were mainly involved with uranium reconnaissance work, a programme supported by the UK Atomic Energy Authority (1967 –1972).

The establishment of a Geochemistry Division on 1st August 1967 must be seen as a step that initiated the regional geochemical mapping programme. Funded by the Department for Trade and Industry the project in the early 1970's was known as the Regional Geochemical Reconnaissance Programme and was closely associated with the work of the DTI Mineral Reconnaissance Programme. The project was then based in the Radioactive and Metalliferous Minerals Unit.

The earliest samples are from the Sutherland atlas area and collected in the summer of 1968 as part of the uranium reconnaissance work. The first systematic sampling for the regional geochemistry started in Orkney and Shetland in the summer of 1970. The work has progressed southwards from northern Scotland ever since. The first geochemical data from the regional survey of northern Scotland was placed on open file in 1972 for the Caithness ¼" Geological map sheet area.

A further reorganisation of the IGS saw the creation of a Special Surveys Division in 1977 and the Regional Geochemical Reconnaissance Programme became a major project within the Metalliferous Minerals and Applied Geochemistry Unit. Work on the Orkney and Shetland geochemical atlases commenced in 1974 and the Shetland atlas was the first to be published in 1978. Between 1975 and 1990 the work was funded by the UK Department for Trade and Industry (DTI). After 1990 funding for the work came from the Department of Education and Science and subsequently, the Office of Science and Technology. The project was renamed the Geochemical Survey Programme (GSP) in 1988 and again in 1994 to the Geochemical Baselines Survey of the Environment Project (G-BASE).

The activity of regional geochemical surveys, as described in the IGS Annual Report of 1978, has been maintained until the present but with a far greater emphasis on environmental rather than minerals related issues:

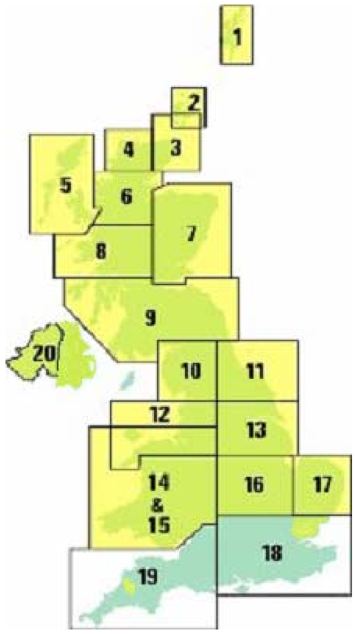
"While the principal application of the data is to the determination of variations in bedrock composition, the mapping is of direct value to organisations engaged in mineral investigations, including IGS in the Mineral Reconnaissance Programme, also funded by the DTI. The data also have potential applications, being increasingly realised, to a range of other disciplines and activities, particularly agriculture, medical geology, land-use planning and regional geological studies"

During the lifetime of this long project analytical, statistical and data processing techniques have evolved substantially. Initially stream sediments were analysed for 16 elements using optical emission spectroscopy, atomic absorption spectrophotometry and delayed neutron activation (U). A direct-reading emission spectrometer was used to determine some 25 elements for the Hebrides and subsequent atlas areas. The current analytical method is XRF, which commenced on the Welsh stream sediments and now determines 48 elements (Ag, Al, As, Ba, Bi, Br, Ca, Cd, Ce, Co, Cr, Cs, Cu, Fe, Ga, Ge, Hf, I, K, La, Mg, Mn, Mo, Na, Nb, Nd, Ni, P, Pb, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Ta, Te, Th, Ti, Tl, U, V, W, Y, Zn and Zr). Major changes in the analytical methodology have meant there has been a need to standardise results produced by different analytical methods over a long period of time. The strict analytical controls and use of standard, duplicate and replicate samples initiated at the start of the work has enabled a high quality seamless geochemical database to be created and maintained.

Improved analytical techniques for water analyses by ICP-OES and MS has enabled the project to complete a greater range of determinants on the water samples which were originally just collected for pH, conductivity, F and U analyses. The collection of soil samples has also increased as a consequence of moving into lowland areas dominated by intensive agriculture and more mature drainage systems. In particular, the demand for geochemical baseline data in urban areas has been significant enough to justify higher resolution baseline determinations using soils in major urban centres.

The geochemical mapping initially set out to produce maps corresponding to the quarter inch geological map sheets. These evolved into the atlas areas shown in the figure, and the geochemical atlas is the principal product of the survey work. Digital distribution of the data is increasingly important and the geochemistry is integrated into GIS with other layers of geoscience information.

G-BASE continues to be one of the BGS's principal science budget-funded projects. Its aim and objective fit well within the aims of the BGS and the mission of the NERC. Few BGS projects have produced such a wealth of external peer reviewed publications, a fact that has established BGS regional geochemistry mapping in high esteem around the world. Geochemists who have worked on this project have established reputations in the field of geochemistry and have become key figures in the development of international geochemical projects and working groups. Many geological organisations around the world have adapted the G-BASE methodology for their own national geochemical surveys.



Progress of the G-BASE project till 2005. Sampled areas are in yellow, numbers refer to geochemical atlas index (see atlas summary document). Northern Ireland sampling has been completed by the Tellus Project.

Appendix 2 : Demise of the G-BASE project

A note on the demise of G-BASE resources since April 2000
C C Johnson
10th January 2002

Geochemical Baseline Survey of the Environment (G-BASE) is a long running core science survey project within BGS scheduled for completion in 2012. By 2012 we should have produced a geochemical baseline for the UK mainland. A description of the project is attached in Annex A. The difficulty in allocating resources to deliver the 2002-2003 planned deliverables has prompted me to look at the level of funding for the project in recent years. This has indicated a significant decline in funding of the project since 2000 as shown by Figure 1 (staff cost and OR allocations since 1995) and Figure 2 (GBASE man days allocation since 1995). The data for these figures is attached as Annex B.

Since April 2000, the overall cut in Science Budget allocation for G-BASE (based on staff costs and OR) has been £159.5k, i.e. a 38% cut on the 1999-2000 allocation. Expressed in terms of man-days, the project has had a cut of 33% since 2000.

In 2000-2001 the project became critically depleted in staff through resignations, retirement, redeployment to other projects (made easier through the matrix system), and transfers to other BGS offices. The postponement of fieldwork in central East Anglia through foot and mouth enabled us to avoid a crisis in staffing teams for fieldwork.

The decline in funding has also caused a significant drop in the number of internal and external publications being produced by the project. The year 2000 saw the lowest number of G-BASE publications since 1981 (see Figure 3). Publications for 2001 have not yet been included though there is a similar low level of output. This illustrates the danger of the project just becoming a sampling exercise without ever having the resources to write things up.

G-BASE is a science budget programme from which many valuable contracts have arisen (for example, the Southern Sumatra Geochemistry Project part of £2.2m project, and Morocco regional geochemistry, a contract worth £573k). Geochemistry staff (from the former Geochemistry Group) have been greatly over allocated in the last few years indicating the continued demand for this type of work.

Maintaining a BGS capability in the field of geochemical mapping is essential in order to win large international contracts and fulfil its strategic science obligation to complete the geochemical baseline of the mainland UK by 2012.

Two new blood staff were assigned to G-BASE at the end of 2001 and I took over active project management of G-BASE in October 2001.

I have identified three areas that urgently need strengthening next year. We need:

1. more geochemists with experience of collecting drainage samples and leading field teams.
2. geochemists with experience in data QC/QA procedures.
3. more scientific publications from the G-BASE team

It is difficult on the reduced budget allocation for G-BASE in 2002-2003 to resource:

a) the training of new staff in G-BASE methodology in both the office and field

b) delivering a regional sampling programme that will catch up with what was lost to foot and mouth in 2001 and maintaining a rate of sample collection that will enable project completion in 2012

c) allocating staff time to write up and publish G-BASE results.

The continued reduction in G-BASE budget will mean a decline in the number and quality of deliverables, a continued decline in our geochemical mapping capabilities, and a marked reduction in our scientific output. There are insufficient resources available to develop new G-BASE digital products.

The strategy for 2002-2003 must be to reduce planned sampling by 20% and to focus on fewer deliverables. Senior management must be made aware of the impact this will have on the long-term deliverables of the G-BASE project.

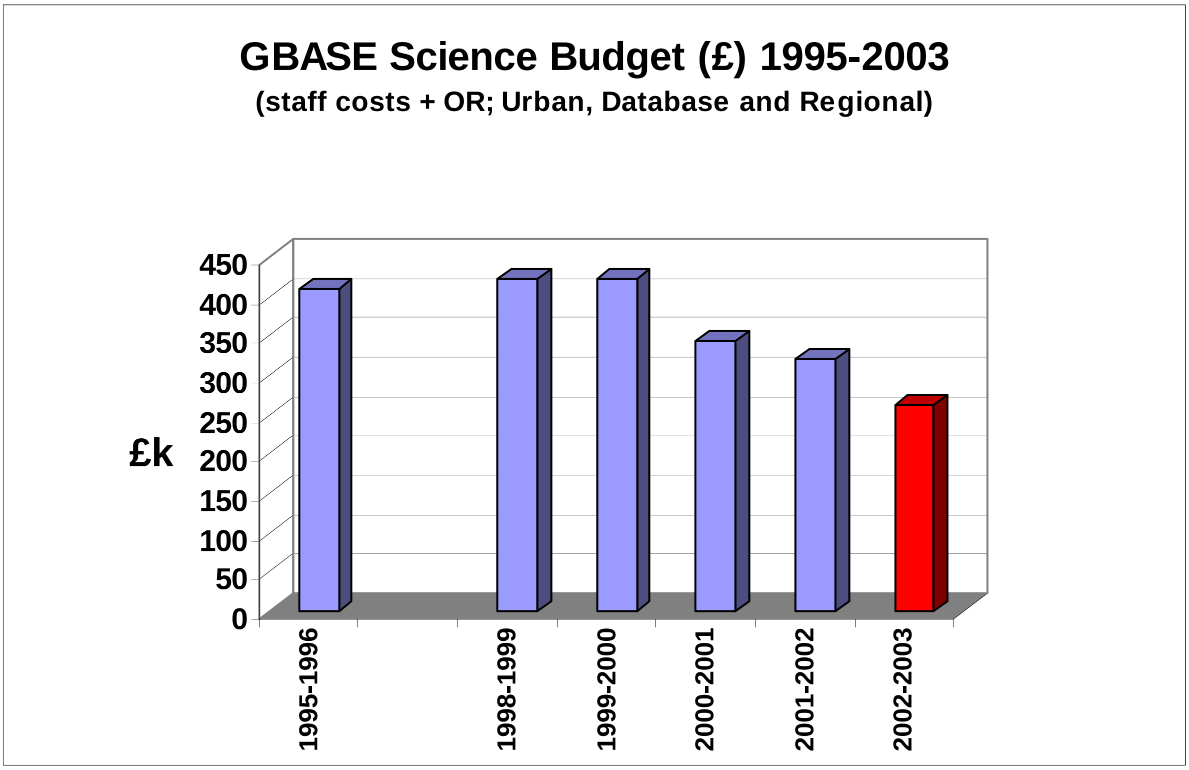


Figure 1: G-BASE science budget allocation 1995-2003

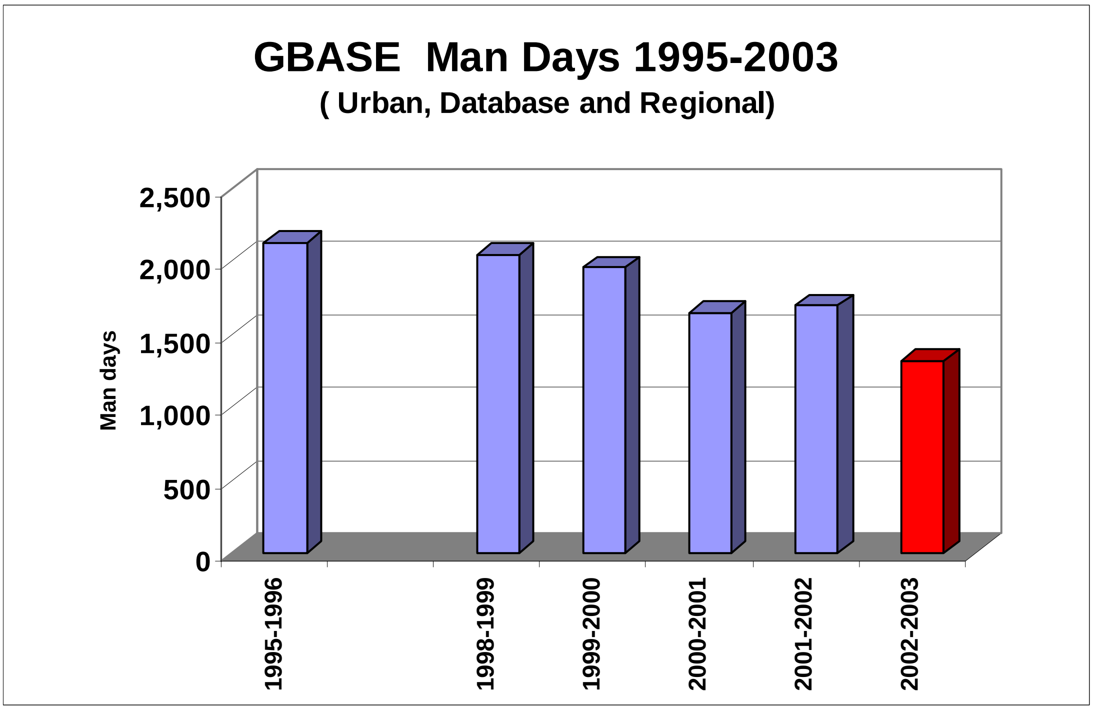


Figure 2: G-BASE man days 1995-2003

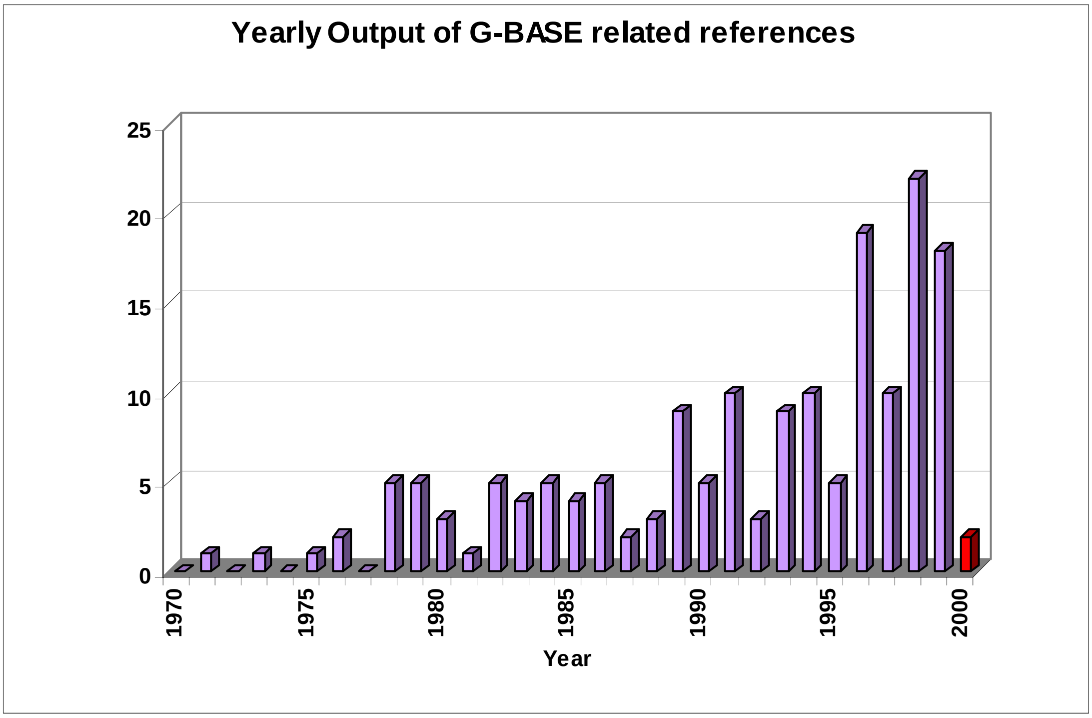


Figure 3: G-BASE publications (internal and external) 1970-2000 (taken from the G-BASE Endnote bibliography)

ANNEX A: G-BASE Project Description and case for Project[1]

Project Description

G-BASE is a systematic survey to establish a geochemical baseline across the UK. The overall objective is to support UK environmental sustainability and development as defined under Agenda 21 at the UN "Earth Summit" in Rio in 1992 [see end of this section]. The strategy is to provide the user community with an accessible, well documented, and quality controlled geochemical database of the UK surface environment. This is achieved by the collection of data at a high spatial resolution (approx. 1 sample per 1.5 sq. km) using a variety of sample media (soil, water, panned concentrates and stream sediment).

The work is concerned with regional trends rather than site specific investigations and in urban areas, where there is demand for data of higher resolution, soil samples are collected at 4 samples per sq. km. Chemical data are principally inorganic elements and physiochemical parameters that may effect an element's distribution (e.g. pH).

The project supports R&D that demonstrates the use of G-BASE data (e.g. identifying sources of Pb isotopes in G-BASE samples) and is involved in national and international committees concerned with the standardisation of geochemical mapping procedures. Data collected by G-BASE are used in a wide range of both internal and external projects that have, for example, assisted in geological mapping and mineral exploration, and in environmental geoscience within urban, coastal and estuarine areas.

The principal product of the work has been the Regional Geochemical Atlas series, one of BGS's "flagship" publications. Output is now increasingly being redirected to digital products as layers in GIS or on CD-ROM.

Although the G-BASE project is managed principally under the Lands and Resources Directorate, there are essential aspects of the project carried out "seamlessly" across other Directorates. The G-BASE urban geochemistry is administered under the Hazards & Environment Directorate, and the handling and quality assurance of geochemical data and geochemical databases is administered under the Information Services and Management Directorate.

Case for Project

G-BASE is of direct benefit to the nation at a local, regional and national level and is highly supportive of the BGS mission. It is relevant to corporate, legislative, economic and educational interests. The project builds up institutional capabilities that are in demand for CR projects both in the Hazards & Environment Directorate (e.g. Crich Rolls Royce Project) and in BGS International (e.g. Morocco and Mauritania).

Within the context of Agenda 21, G-BASE provides a geochemical baseline with which to systematically plan mineral resource development; identify and prioritise the investigation, development and remediation of contaminated land; identify and preserve geochemical factors that influence the sustainability of bio-diversity and habitats, and improve the epidemological links between the environment and potential influences on health. The project is a primary

[1] Taken from 2002-2003 PSS

source of environmental data which can be used to underpin legislation such as the Environment Protection Act (1990), Part IIA and the European Water Framework Directive[2].

G-BASE is a long-running strategic project which has systematically sampled 75% of the British mainland from north to south and is currently in East Anglia.

The project is pertinent to many other BGS programmes both in a multi-disciplinary and regional sense. The provided geochemical data is used to support refined geological mapping, thematic and geotechnical surveys, hazard assessment, and mineral exploration and metallogenic modelling.

Agenda 21 - Sustainable Development

Agenda 21 was drawn up at the UN "Earth Summit" in Rio in 1992, at a gathering of 179 heads of state and government.. It is an action plan for sustainable development for the world in the 21st century. Agenda 21 is one of five documents agreed during the United Nations Conference on Environment and Development (UNCED), in Rio de Janeiro in June 1992. It is a blueprint for sustainable development in the 21st century, aimed at providing a high quality environment and healthy economy for all the peoples of the world. Sustainable development can be defined as *"meeting the needs of the present without compromising the ability of future generations to meet their needs"*.

The agreement is seen as a guide for individuals, businesses and governments in making choices for less environmentally destructive developments, and ultimately a challenge to translate understanding into action in developing sustainable lifestyles. Agenda 21 sees sustainable development as a way to reverse both poverty and environmental degradation. A major theme is to eradicate poverty by giving poor people more access to resources such as skills and information that are needed to live sustainable lives. It calls upon governments working in participation with international organisations, business, regional and local governments and non-governmental organisations (NGOs) and citizens groups to develop national strategies for sustainable development.

[2] An example of a strategy document arising from the Environment Protection Act is that of the Lewes District Council which can be downloaded from their web site at www.lewes.gov.uk

Annex B

Summary of yearly allocations (taken from project files)

Period	Regional GBASE				Urban GBASE				Databasing				Totals	
	Staff (£)	*OR (£)*	*Staff + OR*	*Man days*	*Staff (£)*	*OR (£)*	*Staff + OR*	*Man days*	*Staff (£)*	*OR (£)*	*Staff + OR*	*Man days*	*SB (£)*	*Man days*
1995-1996	230,571	178,000	408,571	2,126									408,571	2,126
1998-1999	259,500	162,000	421,500	2,043									421,500	2,043
1999-2000	260,000	162,000	422,000	1,957									422,000	1,957
2000-2001	128,800	91,300	220,100	1,029	36,100	29,000	65,100	301	39,800	18,900	58,700	317	343,900	1,647
2001-2002	132,700	73,000	205,700	1,034	42,000	24,000	66,000	320	39,900	7,800	47,700	339	319,400	1,693
2002-2003	113,000	57,000	170,000	840	34,000	20,000	54,000	240	33,000	5,500	38,500	237	262,500	1,317

(note: Urban and databasing funding for 2002-3 based on 20% cut of 2001-2 budget)

Appendix 3 : Completing G-BASE

Chris Johnson, 21st July 2003

1 *Introduction*

This note outlines what will be required to complete the geochemical mapping of Great Britain. It puts forward the facts of what remains to be done as a basis for developing a strategy for G-BASE beyond 2004. Estimates are based on extrapolations of our current work practices. Issues such as the continued collection of panned concentrates, alternative analytical schemes, cofunding, expanding the fieldwork to other times of the year, and use of students as samplers will needed to be discussed in order to better formulate future plans.

The aim is to complete the geochemical mapping of Great Britain (a definition which excludes Northern Ireland). Drainage sediments remain the most appropriate method for producing high resolution baseline geochemical maps and, with 80% of GB completed, a change from this strategy would need to be for very compelling reasons. However, the need to finish the survey just because we have done so much already cannot be used alone to dictate a future strategy. We must demonstrate to BGS, customers, academia and the public the usefulness of a completed geochemical baseline.

The value of soils and surface waters to environmental issues has been demonstrated over the past five years and a full range of sample media are now collected as part of the G-BASE project. The increased cost of collecting a full range of samples as opposed to just a single medium is not an issue. It is the chemical analysis and interpretation of the increased range of samples that has significantly increased the resources required by the G-BASE project.

2 *What has been done?*

A summary of the areas sampled and the number of samples collected is given in Table 1. The basic sampling areas have been geochemical atlas areas which initially started out as being based on the ¼" geological map sheets. These are shown in Figure 1.

1. Shetland	11. NE England
2. Orkney	12. NW England and
3. South Orkney	13. Humber-Trent
4. Sutherland	14. Wales & W Midlands
5. Hebrides	15. Wales & W Midlands
6. Great Glen	16. East Midlands
7. East Grampian	17. East Anglia
8. Argyll	18. SE England
9. Southern Scotland	19. SW England
10. Lake District	20. Northern Ireland

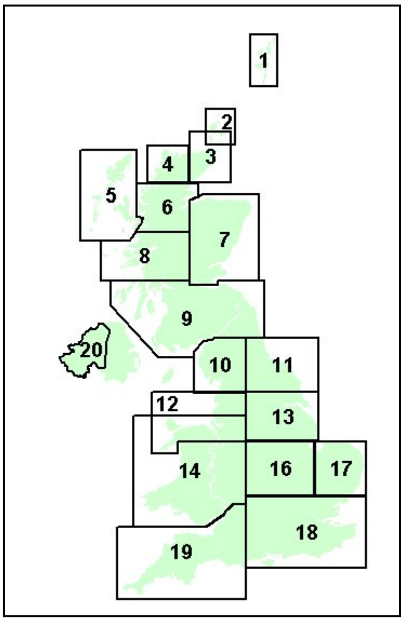


Figure 1: Figure showing outlines of atlas areas

Atlas	Sampling Completed	Area (km^2)	Stream Sediments	Soils	Stream Waters
Argyll	1977	12477	9560	0	8680
East Anglia	~2004	11000	*In Progress* *1258*	*In Progress* *2849*	*In Progress* *1082*
East Grampians	1980	17779	9920	0	4230
East Midlands	2000	17603	5047	7330	4385
Great Glen	1974	10672	7270	0	6933
Hebrides	1975	4704	3370	0	3370
Humber-Trent	1997	14722	4296	6763	3101
Lake District	1980	10027	6200	0	2585
North-east England	1988	9610	4306	502	2153
NW England & N Wales	1990	11178	5203	2064	3000
Orkney	1970	960	437	0	672
Shetlands	1970 1990	1406	1254 1240	0	1254 1240
South Orkney & Caithness	1969	3232	1287	0	1287
S Scotland & N England	1986	27707	19000	0	4230
Sutherland	1972	4668	2460	0	2622
Tamar Catchment	2002	920	494	468	492
Wales and West Midlands	1994	34024	18927	3800	13444
		192,689	**101,529**	**23,776**	**64,760**

Table 1: Summary information for areas sampled till Summer 2004
(compiled by Louise Ander and Chris Johnson)

G-BASE work can be divided into three categories:

1. Regional Mapping
2. Urban sampling
3. Ad hoc co-funded work

It is estimated that 80% of Great Britain will have been sampled by 2004. Approx. 185,500 km^2 will have been sampled (allowing for a 7,200 km^2 overlap in atlas areas) and 45,700 km^2 (see Section 3) remain to be sampled after 2004.

For the regional mapping atlas areas 18 and 19 remain to be sampled (see Figure 1 - SE, SW and Southern England). The southern part of area 17 (East Anglia) is currently in progress and can be completed in the Summer of 2004. By end of 2004 it is proposed that we abandon sampling on the basis of "atlas" areas and collect samples by drainage catchments.

The Humber-Trent Atlas is being prepared for publication in early 2004 and the East Midlands data set is almost complete and awaits error checking and normalisation. There is overlap between the NW England and N Wales atlas and the Wales and W Midlands. The latter area was also reported as two separate atlases for surface waters, and stream sediments and soils.

Urban areas sampled until the end of 2002 are shown in Table 2. Urban sampling is no longer considered part of the G-BASE project and a rather artificial division was created when the matrix was introduced. The former urban part of G-BASE is now a different project (GSUE). This effectively doubled project management cost and destroyed flexibility to operate between urban and rural areas as required by the sampling plan for a particular year. Further discussion on urban geochemical sampling is not pursued here though any future strategy should consider merging the GSUE and G-BASE projects.

Cardiff	Leicester	Scunthorpe
Corby	Lincoln	Sheffield
Coventry	Manchester	Swansea
Derby	Mansfield	Stoke-on-Trent
Doncaster	Northampton	Telford
Glasgow	Nottingham	Wolverhampton
Kinston-upon-Hull	Peterborough	York

Table 2: List of urban centres sampled till end of 2002

The ad hoc co-funded work includes the Shetland follow-up survey, Northern Ireland, Tamar catchment and Glasgow drainage survey.

3 *What's left to do?*

Summer field campaigns for 2003 and 2004 are planned to complete the sampling of the East Anglia atlas area. The area of England below the line of Northing 235000 will remain to be sampled (with the exception of part of the Tamar hydrometric area which was sampled in 2002). This area would be designated as atlas sheets SE and SW England. However, the preference is to complete sampling using drainage catchments (or "hydrometric areas") as defined by the Environment Agency (EA) and used by the Centre for Ecology & Hydrology (CEH). This breaks the task down into more manageable areas to report results rapidly and is a logical data sub-set given that we collect drainage samples.

These hydrometric areas are shown in Figure 2, digitised from raster graphic files[1] and available as polygons in Arc View. The areas of the drainage catchments have been tabulated in Table 3. From this it is estimated that 42,000 km^2 remain to be sampled. The following factors need to be considered when arriving at this estimate:

- this area does not include Northern Ireland. This region could be sampled as part of the separate RESI project.
- catchment boundaries overlap areas already sampled in the East Midlands and a correction is made for such areas.
- 920 km^2 of the Tamar catchment have already been sampled so this area has been subtracted from the estimated total.
- major urban centres, principally London at 1400 km^2, have been excluded from the sampling areas.
- 5% has been deducted from the total area to allow for areas not usually sampled (transport corridors, coastal fringe, lakes etc.)

[1] available from http://www.nwl.ac.uk/ih/nrfa/station_summaries/map.html

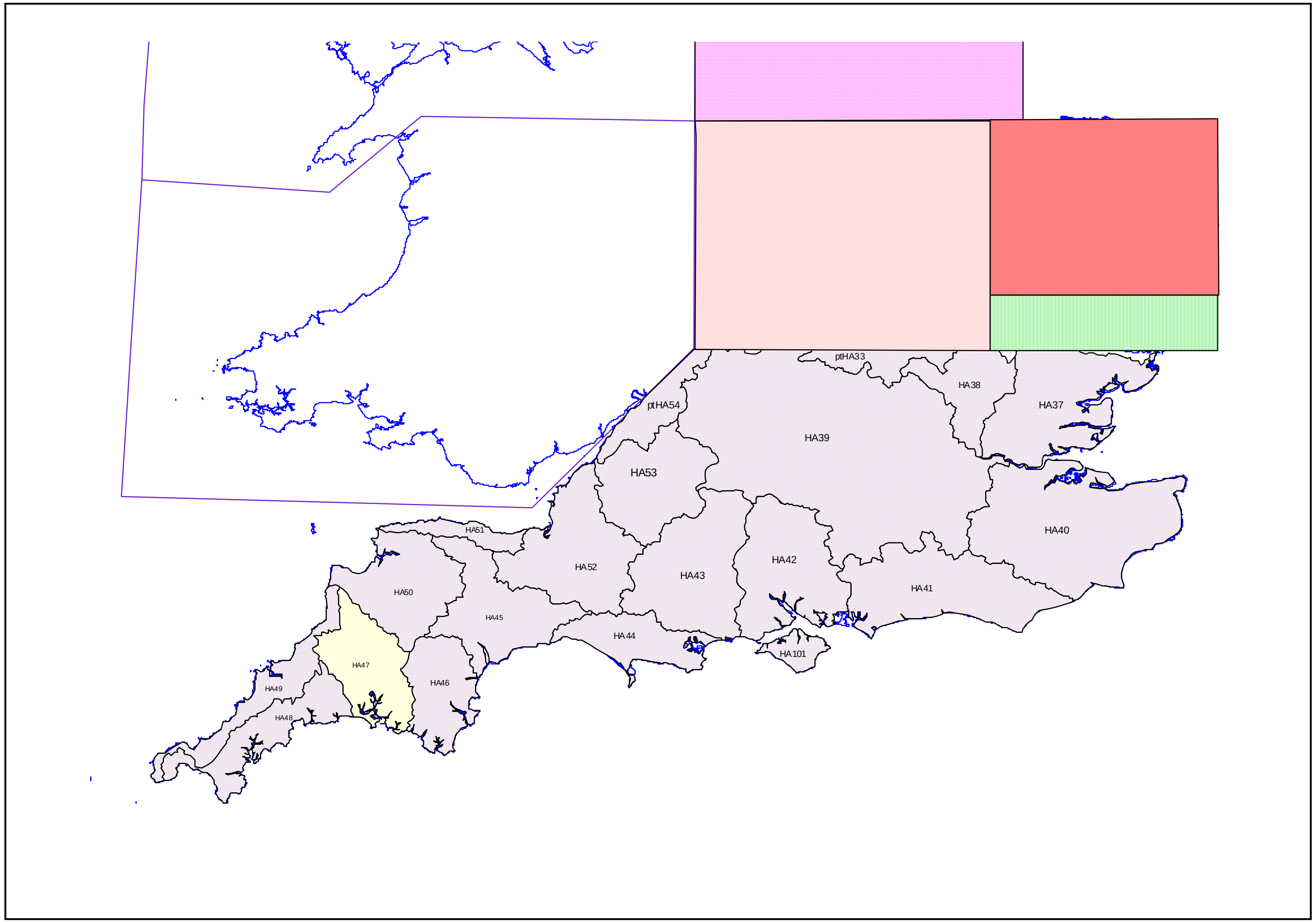


Figure 2: Area remaining to be sampled subdivided into hydrometric areas

Notes: The East Anglia region (green) is to be sampled in by 2004. The Tamar drainage catchment (part of which was sampled in 2002) is highlighted in yellow.

Hydrometric area	Catchment Name	Total area (A) (km^2)	A - 5% (km^2)	Notes
HA49	Camel	1,235	1,173	
HA48	Fowey	1,555	1,477	
HA47	Tamar	1,813	1,722	920 km^2 sampled in 2002 in 35 days. Plymouth urban area covers 44 km^2
HA50	Taw	2,163	2,055	
HA51	Washford	514	488	
HA46	Teign	1,498	1,423	
HA45	Exe	2,239	2,127	
HA44	Frome	1,287	1,223	Bristol urban area covers 121 km^2
HA52	Yeo	2,773	2,634	
HA43	Avon	3,000	2,850	
HA53	Frome	2,200	2,090	
ptHA54	Little Avon	910	865	
HA38	Lee	1,412	1,341	
HA39	Thames	10,947	10,400	432 km^2 overlap onto East Midlands atlas. London urban area covers 1400 km^2
ptHA33	Upper Ouse	657	624	
HA42	Test	2,711	2,575	Southampton and Portsmouth urban area covers 100 km^2
HA101	Isle of Wight	376	357	
HA41	Arun	3,098	2,943	
HA40	Medway	4,700	4,465	
HA37	Chelmer	3,096	2,941	
		48,184	45,775	
			42,000	km^2 estimate allowing for items above

Table 3: Southern England drainage catchment areas

4 How long will it take?

Between 1970-2004 some 185,500 km^2 of Great Britain will have been sampled. This represents an average sampling rate of about 5300 km^2 per year. However, the sampling rate has dropped significantly since 2000 because of reduction in funding and the loss from the project (through resignation and transfers) of many experienced geochemists. No samples were collected in 2001 due to foot and mouth disease restrictions, and the current input to fieldwork is one team (BGS team leader, assistant and 9 student samplers) sampling for 9 weeks. The average rate of sampling is now at about 2,750 km^2 per year. At this rate, the remaining 42,000 km^2 would take a further 15.3 years beyond 2004, i.e. completion in 2020. This represents a sampling rate of 306 km^2 per week and 137 weeks to complete the survey.

Table 4 models the result of increasing the number of sampling teams and length spent in the field each year.

Teams	Number of weeks each team in the field per year						
	8	**9**	**10**	**11**	**12**	**13**	**14**
1	2022	2020	2018	2017	2016	2015	2014
2	2013	2012	2011	2011	2010	2010	2009
3	2010	2010	2009	2009	2008	2008	2008
4	2009	2008	2008	2008	2007	2007	2007

Table 4: A table modelling the effects of increasing the number of sampling teams and number of weeks per year spent doing fieldwork

The current position is highlighted in yellow predicting a finish in 2020. Note that time taken to complete the work is rounded to complete years.

If two teams were operating in the field, as has been done for most of G-BASE's history until recent years, project completion would be in 2012 as predicted in recent G-BASE project plans. Four teams operating for 3 months a year would finish the work by the end of 2007. We currently do not have enough equipment or staff of the appropriate grade or experience to run more than two field teams each year.

5 How much will it cost?

A calculation of the cost to finish the work is given in Table 5. This is based on an area of 42,000 km^2 remaining to be sampled and sampling densities of 0.5 and 0.57 km^2 for soils and drainage sediments respectively.

Area left to be sampled	42,000	km2	
sample density soils	0.50	per km2	
sample density sediments	0.57	per km2	
Number of samples left to collect:			
soil sites =	21,000		
drainage sites =	24,000		
Sampling costs			
estimated cost per site	£27		(based on Staff and OR costs for 9 weeks field work, summer 2003)
Total cost =		**£1,215,000**	(with no inflator figure included)
Preparation and analysis costs			
	No. of san	**Cost**	
Surface soil	21,000	£1,039,500	(calculated with only 50% of soils being determined for LOI and pH)
Deep soil	21,000	£63,000	(drying and storing only costs as samples not routinely analysed)
water	24,000	£1,895,280	
stream sediment	24,000	£1,080,000	
			(no costs for panned concs which are just stored)
	Total	**£4,077,780**	
Estimated cost to complete geochemical mapping of GB			
		£5,292,780	
			This figure is for sample collection and analysis only It does not include costs for project management or data QA/QC

Table 5: Summary of estimation of costs to finish sampling and analysis

The estimated sampling cost of £27 per site is based on the proposed budget for the 2003 field season (see Annex). This figure is used without any inflation factor and it includes OR and staff time. It has risen sharply over the past three years (in 2000 it was calculated at less then £20 per site). Factors responsible for the recent increase include:

- better H&S controls (e.g. use of hired minibuses instead of BGS Landrovers)
- higher rates for accommodation as we move southwards and coastwards
- changes to T&S payment to actuals
- higher staff grades being used to lead teams in the absence of suitably trained more junior grades

Ways of making sampling more efficient should be considered (e.g. drop the collection of panned concentrates from mature agricultural catchments) but saving through improvement in efficiency will be offset by increasing accommodation and subsistence costs as we move southwards.

The figure of £5.3M to complete the sampling excludes large urban areas, principally the 1400 km^2 of the London urban area. This figure covers sample collection and analysis. It does not include project management, data checking and normalisation, or reporting and interpreting the results. These tasks would add an estimated £2.2M to costs. The task allocations in G-BASE for 2003 are shown in Figure 3 as relative proportions of the total staff days allocated (incorporating some tasks from the data management project).

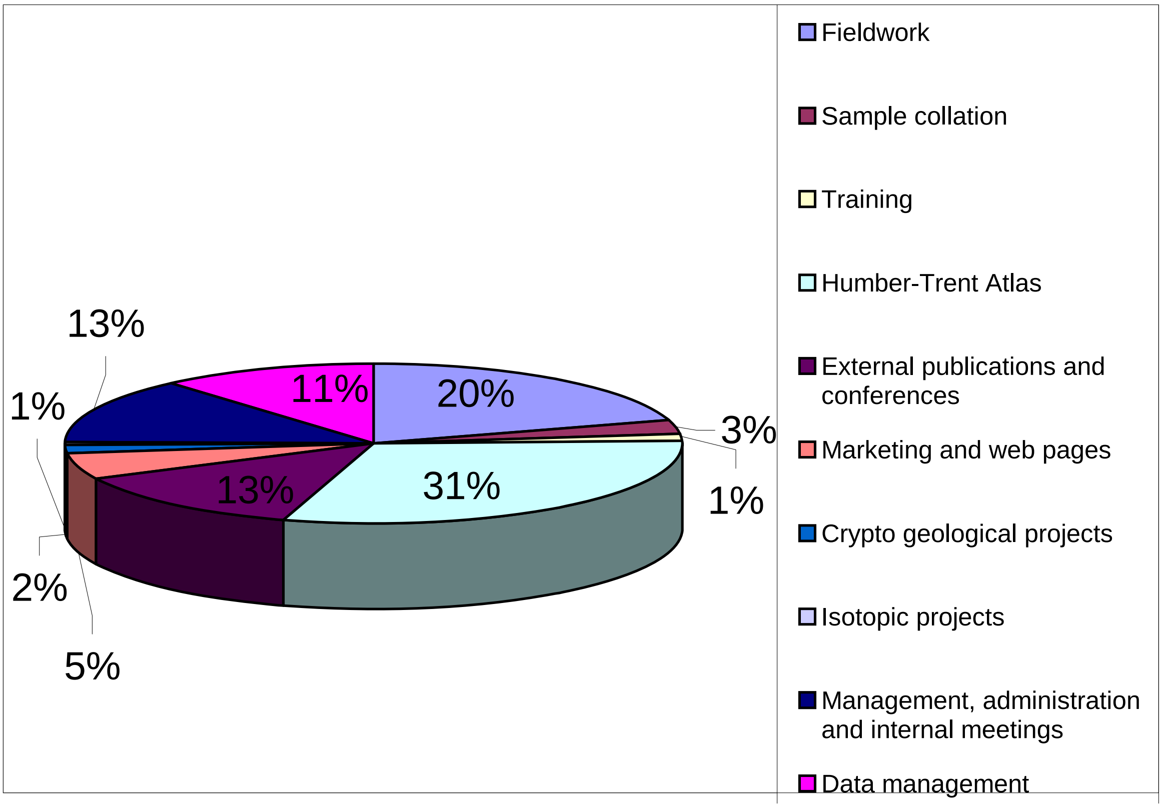


Figure 3: A pie chart showing the relative proportion of G-BASE task allocations (staff days) in 2003-4

Less resources are available to do fieldwork in 2003-4 because of the shortfall in the data management project budget, the effort required to finish the Humber-Trent atlas, and the high profile the project wishes to have at the International Symposium on Environmental Geochemistry (ISEG) in Edinburgh, September 2003. Tasks directly related to field work account for approximately one quarter of the project's staff time resources. From Table 6 it can be seen that the annual G-BASE analytical budget currently stands at £225.7k based on samples to be collected by one sampling team for 9 weeks.

	G-BASE (E1286S74) £k	GSUE (E1327S83) £k	"Blue" Data Management (E1350S91) £k
Staff Costs	110.0	40.7	20.7
OR	55.0	11.0	1.5
Analytical Budget	225.7	21.0	-

Table 6: 2003-2004 budget allocations for components of the geochemical survey projects *(Note - Both the G-BASE and GSUE budgets contain an element for co-funded projects, namely Tamar Catchment and Glasgow drainage survey)*

The sampling density to complete the mapping will be more variable than that given in Table 5, particularly over the areas of chalk and limestone still to be sampled (see Figure 4). However, the figures used for sampling density represent an average value for the remaining area.

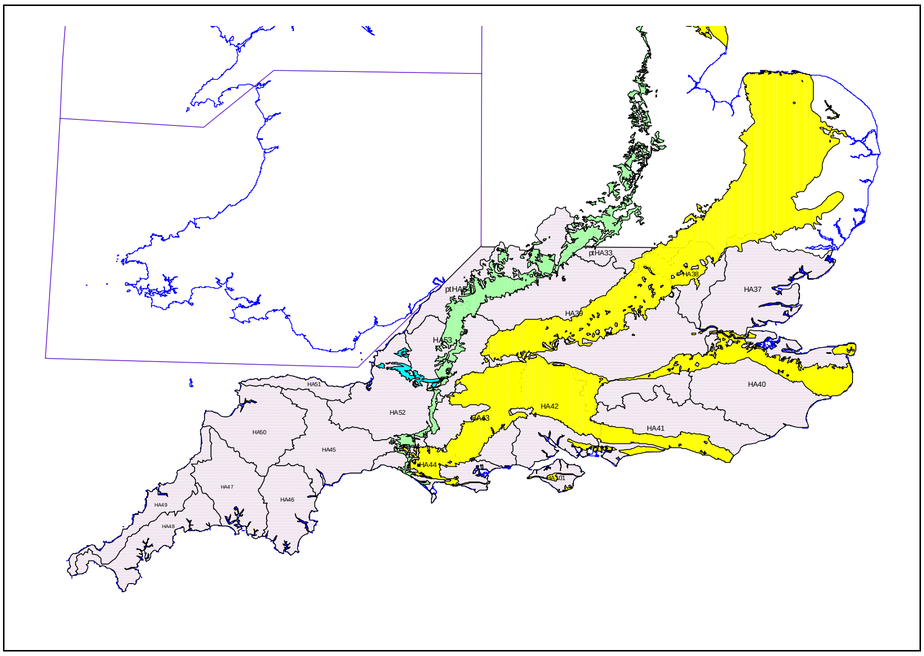


Figure 4: A map showing areas of chalk and limestone where the drainage sampling density will be greatly reduced. (Yellow - Cretaceous Chalk; Blue - Carboniferous Limestone; Green - Jurassic Oolitic Limestone)

6 Summary

- at the current rate of sampling the geochemical baseline map of Great Britain (GB) will be completed by 2020

- doubling the current field effort to two teams sampling each summer would result in completion by 2012

- by the end of 2004 baseline data will be available for 80% of the GB land area

- fieldwork and analytical costs to complete the survey are estimated to be £5.3M, the analytical costs representing nearly 80% of this total

- with project management, data checking and normalisation, and basic reporting a total project budget to finish the work of £7.5M is suggested.

ANNEX: Example of field campaign budget calculation

Estrimated fieldwork costs for Summer 2003							
					SSO @ £171 per day		2394
Project Duration	9	weeks from 12/7			HSO @ £137 per day		8083
BGS team Leader	9	weeks from 12/7			SO @ £113 per day		6328
BGS assistant team leader	9	weeks from 12/7			ASO @ £86		1204
Super VW	9	weeks from 12/7				*total staff*	18009
VWs	9	weeks from 12/7					
						Total	£51,620
Number of VWs	8						
(costs calculated on a 7 day week)						sites =	1907
COSTINGS	£					cost per site	£27.07
Accommodation							
	7103						
T&S							
BGS Team Leader	1323						
BGS Assistant Team Lead	1323						
Super VW	3254						
VWs	12600						
Staff Overtime	2700						
Transport							
minibus hire	1956						
Landrover costs	1368	(includes fuel costs)					
VW transport costs	880	(no of VWs x 2 for changeover)					
minibus fuel	474						
Incidentals (£50 per week)	450						
Mobile phones	180						
Total	33611						
Estimated Number of samples							
stream sediments	632						
panned concentrates	632						
waters	632						
top soils	1275						
profile soils	1275						

Appendix 4 :Geochemical Baseline Surveying 2005-10

GEOCHEMICAL BASELINE SURVEYING 2005-2010

C C Johnson. 23RD March 2004

The Need

1. Legislatively driven demand for information about the behaviour of chemical elements in the surface environment is underpinned by basic geochemical baseline data
2. Systematic surveying is central to the stated mission of the BGS and the project objectives concerning science for a sustainable future are well aligned with NERC's strategic and scientific priorities
3. Baseline geochemistry will be a component of all cross-cutting themes relating to soils, pollution and contamination, climate change, health and sustainable minerals development
4. The project has demonstrably delivered world-class science and has the potential to continue to play a leading role in international geochemistry
5. The project gives BGS staff the training and expertise in regional geochemical mapping activities, an area of work that requires skilled staff to compete for international contracts. The project gives valuable practical experience to environmental and earth science graduates through its summer sampling programme, training not offered by universities themselves
6. Geochemical surveying continues to be the activity that sustains the capabilities of the BGS chemical laboratories.

The Plan

ACCELERATE THE BASELINE MAPPING OF SOUTHERN ENGLAND

The twenty percent of Great Britain that remains unmapped represents the region where a third of the population live. This greatly devalues the worth of the corporate Geochemistry Database. Two regional sampling teams will operate each summer to accelerate the mapping with an additional team targeting urban areas. The geochemical baseline surveying, sample analyses and reporting the results is the primary objective of the project.

Task 1 - Regional Geochemical Mapping of Southeast England

Sample 26 000 km^2 of southern and southeast England defined by hydrometric areas HA37 - HA42 (see attached figure) collecting drainage and soil samples as per standard regional sampling procedures. This will represent some 12.000 soil sites and 12 000 drainage sites taking an estimated 94 weeks for a standard geochemical sampling team of four pairs. This can be achieved over a five year period using two teams for 9-10 weeks each summer.

Task 2 - Urban Baseline Mapping in Southeast England

Urban baseline mapping should be targeted to requirements of the data users and future sampling should only follow consultations with local authorities. The planned development areas detailed by the ODPM in "Sustainable communities building for the future" (including the Thames Gateway, lie within the proposed area for Task 1. The urban and regional baseline mapping should be integrated where possible to make sampling more cost efficient. Data can be integrated into groundwater and urban projects such as the Thames Gateway. Estimated urban area in the southeast (principally Greater London) is 1500 km^2. The target should be to collect from **6000 sites over the five year period**. This will take a standard geochemical sampling team 20 weeks (4 weeks each year).

Task 3 - Annual Reporting of Geochemical Results by River Basin Drainage areas

It is important that a more rapid reporting of results and deposition to the Geochemistry Database is achieved. It is proposed that **each summer's field campaign is written up as a drainage catchment report** along the lines of the one produced for the Tamar catchment area. This will require more rapid throughput in the chemistry laboratories with sampling, analysis and reporting to be completed within each financial year.

PRODUCE VALUE ADDED GEOCHEMICAL PRODUCTS

Adding value to the geochemical data and maintaining BGS's high international profile in the field of geochemical mapping is a secondary objective.

Task 4 - Scientific publications and conference contributions

Produce a minimum of two peer-reviewed publications and one conference presentation each year

PROVIDE A GEOCHEMICAL RESOURCE AND SERVICE TO BGS THROUGHOUT GREAT BRITAIN AND NORTHERN IRELAND

Baseline geochemical surveying provides data and samples used in many projects throughout BGS. It is a secondary objective to provide geochemical data, samples and skills to such projects

Task 5 - Contribute geochemical input to BGS projects

- using geochemistry to assist geologists to solve geological problems (e.g. characterising parent materials using factor analysis)
- to service the geochemical requirements of other parts of GB as required (e.g. RESI in N Ireland, soils in Scotland, contaminated land in urban regions)
- provide the advice, skills, methodologies, and training necessary for BGS International to bid for International projects with a geochemical component
- provide the samples and data necessary to assist in isotopic characterisation projects
- contribute a geochemical input to matters relating to health and the environment

The Resources

The resources need to be based on the current combined G-BASE and GSUE resources with additional budget to cover the OR and staff costs for sending out an additional sampling team for 10 weeks. The internal services budget will need to double to account for doubling the current sampling rate.

Annual requirement: Staff £300k; OR £200k; and analytical internal services £500k

Five year requirement: Staff £1500k; OR 1000K; and analytical internal services £2500k

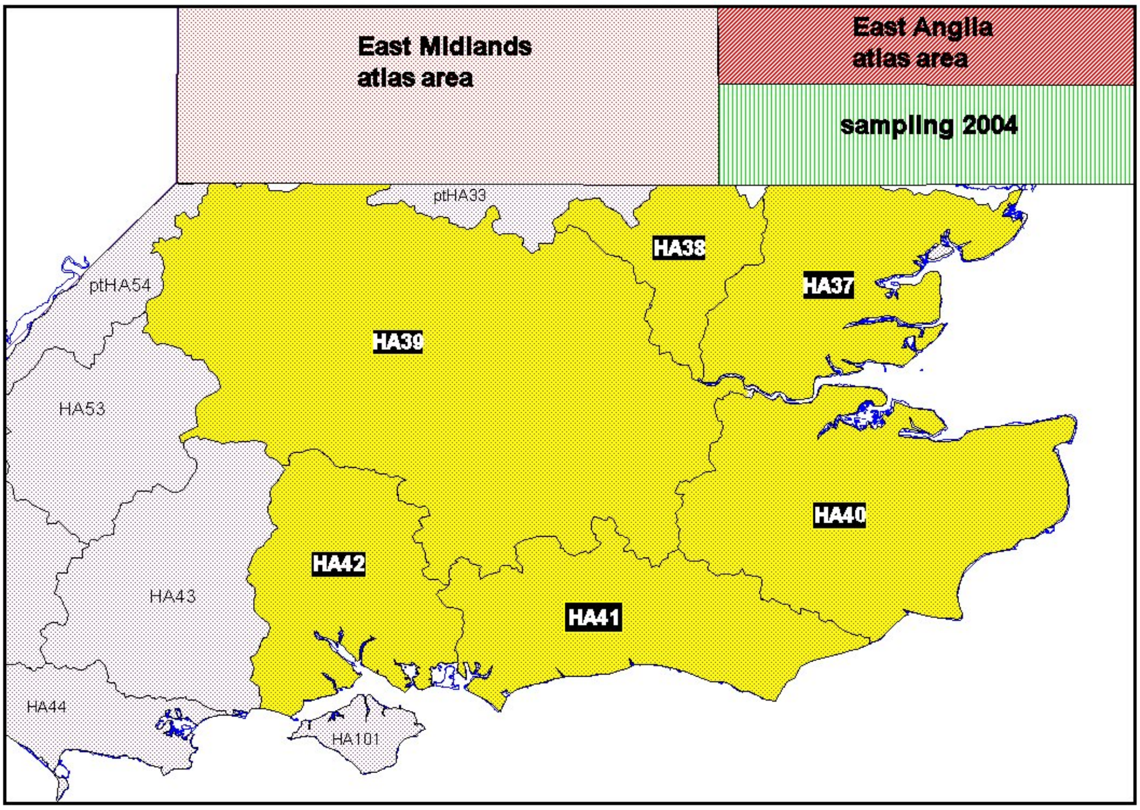


Figure showing the hydrometric areas of SE England to be targeted (highlighted yellow) during 2005-2010 for baseline geochemical surveying

Appendix 5 :G-BASE publications since 2000

The following lists publications that have been produced using G-BASE data, samples or staff time.

Internal Publications

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Fordyce, F M, Dochartaigh, B É Ó, Lister, T L, Cooper, R, Kim, A W, Harrison, I, Vane, C H, and Brown, S E. 2004. Clyde Tributaries: Report of Urban Stream Sediment and Surface Water Geochemistry for Glasgow. *British Geological Survey, Keyworth, UK*, Commissioned Report No. CR/04/037.

Fordyce, F M, Ferguson, A J, Rawlins, B G, Lister, T R, and Breward, N. 2001. Urban Geochemistry - the Geochemical Baseline Survey of the Environment (G-BASE) programme. in *Superficial Deposits Characterisation in the Urban Environment; A Best Practice Guide to Mapping and Research.* McMillan, A A, Ellison, R A, and al, e (editors). *Internal Report Series,* IR/01/68. (Keyworth, Nottingham: British Geological Survey.)

Freestone, S E, O'Donnell, K E, and Brown, S E. 2004. Geochemical baseline data for the urban area of Mansfield. *British Geological Survey, Keyworth, UK*, Internal Report No. IR/02/082.

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Appendix 6 :Estimates for Analysing NSI soils for England and Wales

Email from Barry Rawlins to Chris Johnson (04/12/06)

Assuming IPR issues can be sorted with respect to data ownership, further to G-BASE meeting, you wanted costs for analysing the 5691 soils across England and Wales (5km grid) for the G-BASE suite of major and trace elements based on XRF pellets:

Grinding 5691 samples and making pellet (unit cost £5.00)=£28455
Analysing all by XRF for full suite of G-BASE and CRM's (5800 x £40 unit cost XRF analysis) = £232000

Grand total= £260455

This assumes they can make pellets from about 12-20 g of ground material, which I recall after talking to Mark Ingham, he is pretty sure they can. There may be a further small component of extra XRF staff time to calibrate for small diameter pellets and this may push price towards £300k.

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