

SERVICES & FACILITIES ANNUAL REPORT - FY April 2014 to March 2015

SERVICE Isotope Community Support Facility	FUNDING Block	AGREEMENT F14/G6/11/01	ESTABLISHED as S&F 1991	TERM 2014-?
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TYPE OF SERVICE PROVIDED:

Isotope Community Support Facility (ICSF) meets the need in the NERC Community for stable isotopic analyses (O, H, S, C, N) and training in support of research related to all NERC Science Priority Areas, but especially **Earth System Science, Sustainable Use of Natural Resources** and **Natural Hazards**. We provide in-depth training to postgraduate students in the principles and practice of stable isotope geochemistry (this year amounting to ~90% of our effort), and support grant-funded and direct-access PI's. ICSF offers PI's access to the Scottish Universities Environmental Research Centre's (SUERC) world-class, comprehensive suite of stable isotope systems for analyses of minerals, fluids and organic compounds, in a unique environment (SRG score $\alpha 5$) with the highest level of service (SRG score $\alpha 5$), as reflected in our most recent user survey (100% users think overall service is excellent; 92% consider student training excellent, 8% judging it good).

Analyses are produced for successful projects directly, or through intensive, one-to-one postgraduate supervision. Output is primarily measured by (i) peer-reviewed publication (19 in 14/15), and (ii) the production of motivated young scientists, trained to fulfil the strategic needs of the NERC and the UK. The NERC Strategy notes "*Postgraduate training sustains the flow of top talent and skills for UK science, business and government*"; ICSF facilitates this flow particularly through our student-centred project portfolio, >50% of which receive direct external stakeholder funding, with ~25% holding NERC CASE awards, and 30% industry funded. In the last ten years, 100% of research students trained by ICSF have gone on to full time employment, with ~60% in the exploration/environmental industries and the rest in government/survey and academia. In this way, ICSF promotes the government's priority for the long-term health of the science base. Our focus on industry-centred Natural Resource Geoscience, broader Earth System Science and Natural Hazards (90% of our portfolio this year) closely reflects the evolving NERC Strategy: Business of the Environment.

This year 19 approved and 3 pilot projects were supported from 13 UK Institutions (4 new PI's). 19 PhD students underwent training, making use of 8 isotope ratio mass spectrometers and 7 conventional and laser preparation systems.

HOST INSTITUTION, FACILITY MANAGEMENT AND PARTNERSHIPS

ICSF is headed by Prof. Adrian Boyce with technician Mrs Alison McDonald. ICSF is hosted by SUERC, and benefits significantly from its complementary in-house technical support and academic expertise. Our PI's also derive added value from our partnership with our sister NERC Facilities (NIGL, AIF, LSMSF, RCF-EK). Facility access and quality is governed by biannual NIGFSC peer-review of formal written applications.

ANNUAL TARGETS AND PROGRESS TOWARDS THEM

Against a backdrop of on-going NERC/BGS budget cuts to the Facility, and an overall climate of uncertainty regarding the future structure of NERC, the governance of Facilities and the status of BGS, ICSF has managed a slight increase in the numbers of successfully approved projects this year, and has continued to evolve our portfolio in response to continued demand from the Community. We have seen 4 new PI's successfully apply for Facility funding, and whilst maintaining our core activities in Natural Resources and Earth System Sciences, we have successfully expanded further into Climate Systems studies, supporting two NERC Programmes in the process (UKOA and RAGNARoCC). Our peer-reviewed publications have been maintained at a high tempo (19 papers), with the breadth of our impact reflected in 13 international co-authors, and 4 industry co-authors. Furthermore, a record number (7) of PhD (and one masters) theses were published this year.

A major move last summer/autumn of some of our key equipment to a new building (funded exclusively by SUERC) saw a great effort from Facility and SUERC staff to minimise disruption to our users. ICSF was also successful in obtaining grants and other funding that co-funds staff and system developments which, along with SUERC-funding makes up the deficit from Facility funding cuts. At the current levels of budget and usage, development time could not be sustained without such co-funding.

SCORES AT LAST REVIEW (each out of 5)				Date of Last Review:	2009
Need $\alpha 5$	Uniqueness $\alpha 5$	Quality of Service $\alpha 5$	Quality of Science & Training $\alpha 4.5$		Average $\alpha 4.88$

CAPACITY of HOST ENTITY FUNDED by S&F	Staff & Status	Next Review (March)	Contract Ends (31 March)
100%	1 Head – Prof. Adrian Boyce (100%) 1 Technician – Mrs Alison McDonald (Grade E)	tba	tba

FINANCIAL DETAILS: CURRENT FY						
Total Resource Allocation £k	Unit Cost £k			Capital Expend £k	Income £k	Full Cash Cost £k
	Half day of full Facility time	Unit 2	Unit 3			
174	0.638			0	0	271,730

FINANCIAL COMMITMENT (by year until end of current agreement) £k					
2014-15	174	2015-16	169		

STEERING COMMITTEE	Independent Members	Meetings per annum	Other S&F Overseen
NIGFSC	8	2	AIF, NIGL, CIAF

APPLICATIONS: DISTRIBUTION OF GRADES (current FY — 2014/15)

	10	9	8	7	6	5	4	3	2	1	0	R*	Pilot
NERC Grant projects*		1	3										
Other academic													1
Students			1									2	
TOTAL		1	4									2	1

APPLICATIONS: DISTRIBUTION OF GRADES (per annum average previous 3 financial years —2011/2012, 2012/2013 & 2013/2014)

	10	9	8	7	6	5	4	3	2	1	0	R*	Pilot
NERC Grant projects*			1										
Other academic													
Students				4	2							1	1
TOTAL			1	4	2							1	1

PROJECTS COMPLETED (current FY – 2014/15)

	10 (α5)	9	8 (α4)	7	6 (α3)	5 (α2)	4	3 (α1)	2	1 (β)	0 (Reject)	Pilot
NERC Grant projects*				1								
Other Academic												
Students			1	2								

Project Funding Type (current FY – 2014/15) (select one category for each project)

Grand Total	Infrastructure						PAYG					
	Supplement to NERC Grant *		PhD Students		NERC Centre	Other	NERC Grant*	PhD Students		NERC Centre	Other	
	NERC	Other	NERC	Other			NERC	Other	NERC	Other		
22	6		7	6			3					

Project Funding Type (per annum average previous 3 financial years - 2011/2012, 2012/2013 & 2013/2014)

Grand Total	Infrastructure						PAYG					
	Supplement to NERC Grant *		PhD Students		NERC Centre	Other	NERC Grant*	PhD Student		NERC Centre	Other	
	NERC	Other	NERC	Other			NERC	Other	NERC	Other		
28	4		13	9			2					

User type (current FY – 2014/15) (include each person named on application form)

Academic	NERC Centre	NERC Fellows	PhD Students	Commercial
22			19	

User type (per annum average previous 3 financial years - 2011/2012, 2012/2013 & 2013/2014)

Academic	NERC Centre	NERC Fellows	PhD Students	Commercial
20	1		15	

OUTPUT & PERFORMANCE MEASURES (current year)

Publications (by science area & type) (calendar year 2014)											
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses	
	27			1		1	29	19	3	7	

Distribution of Projects (by science areas) (FY 2014/15)

Grand Total	SBA	ES	MS	AS	TFS	EO	Polar
22		17	2.4	.3	1.2	0.5	0.6

OUTPUT & PERFORMANCE MEASURES (per annum average previous 3 years)

Publications (by science area & type) (Calendar years 2011, 2012 & 2013)											
SBA	ES	MS	AS	TFS	EO	Polar	Grand Total	Refereed	Non-Ref/ Conf Proc	PhD Theses	
	20						20	12	5	3	

Distribution of Projects (by science areas) (FY 2011/2012, 2012/2013 & 2013/2014)

Grand Total	SBA	ES	MS	AS	TFS	EO	Polar
28		24.3	1.2	0.3	1.5	0.3	0.4

Distribution of Projects by NERC strategic priority (current FY 2014/15)

Grand Total	Climate System	Biodiversity	Earth System Science	Sustainable Use of Natural Resources	Natural Hazards	Environment, Pollution & Human Health	Technologies
22	0.6	0.6	6	11.9	2.1	0.6	0.2

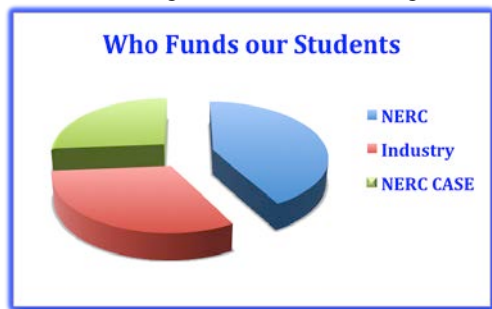
*Either Discovery Science (Responsive Mode) or Strategic Science (Directed Programme) grants

NOTE: All metrics should be presented as whole or part of whole number NOT as a %

OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2014/15):

TRAINING – A CORE EFFORT

NERC's recent large investment in PhD research studentships through DTP reflects its commitment to delivering the next generation of Earth and Environmental scientists. ICSF is committed to contributing to this aim. In the past year ICSF has supported 19 students who received training in the principles and practice of stable isotope (C, H, S and O) geochemistry. The majority of these projects relate to **Earth System Science, Sustainable Use of Natural Resources** and **Natural Hazards**. 13 of these students received NERC awards, including 5 CASE students (Figure); Industry stakeholders directly funded 6.



9 students presented data to national conferences (e.g. *EGU*; *Goldschmidt*; *AGU*; *MDSG* – at latter of which two Facility students scooped the Anglo American best poster, and the Rio Tinto best talk awards), and 8 had papers published in peer-reviewed journals (e.g. *Chemical Geology*; *EPSL*; *Economic Geology*). Training starts with project development, through formulation of the application in close consultation with Prof. Boyce. On-site training and data acquisition then forms the central part of ICSF support, which ends with thesis completion and peer-reviewed publication. Through NERC CASE and external stakeholder-linked studentships there is a strong interaction with industry: ~60% of ICSF students received direct industry support.

PROJECT THROUGHPUT

19 approved and 3 pilot projects, involving 18 PI's (including 4 PI's new to ICSF and 1 new institution), were supported by ICSF this year. The bulk of effort went into four areas, (1) data accumulation and training for recently approved projects; (2) paper redaction; (3) development of new projects with academic partners; (4) personal research and technical development. Prof. Boyce takes a hands-on role in helping PI's develop their projects, contributing as early as possible to new projects once approached by PI's.

RESULTS – PAPERS

Since last year, 19 peer-reviewed papers were published in international-level publications (Annex 6), incorporating an extensive database acquired from ICSF. These included 4 papers in a major Geol Soc. Special Volume "Ore Deposits in an Evolving Earth", published in 2015. All the published papers are collaborative, reflecting the collaborative nature of the Facility. Citations have doubled in five years, including a 25% increase in one year, 2013 (400 in 2014). The applied and international nature of the project work has resulted in 17 of these papers have international co-authors, and 11 have industrial co-authors (3 of whom were PhD students during research phase). These efforts highlight the commitment of the Facility to produce and foster high quality, international-level science, and tangible measures of impact for the NERC portfolio.

PERSONAL RESEARCH – ADDING VALUE

Whilst NIGFSC-approved projects remain central to ICSF's mission, Prof. Boyce is keen to be involved in projects and processes that bring added value to the Facility. Thus, in concert with the new NERC Strategy of fostering International Partnerships, he develops international collaboration in areas that are of direct relevance to PI's (e.g. developing partnerships in mineral deposit studies with Kyushu University in direct compliment to ICSF research avenues). He is also a Co-I on a successful multi-national EU Coal and Steel Fund grant examining the use of abandoned mine waters as a geothermal resource, evolving from previous Facility collaborations. I am also on NERC's £13M *SoS Minerals* Programme Executive Board, and on the Science Advisory Group of NERC's *Resource Recovery from Waste* Programme.

PROJECT DEVELOPMENT

This year has brought 8 new projects to ICSF (an average of 8 new projects are approved each year). This has been achieved whilst diversifying our portfolio, and increasing our user base, with 4 new users this year. This sustained tempo is set against the service cuts from NERC/BGS, and it is largely development that has been affected as we maintain our commitment to the NERC Community.

SYSTEM DEVELOPMENTS

The past year has seen the arrival of the Isoprime VisION mass spectrometer with an Elementar PyroCube elemental analyser. We are currently finalising its commissioning, and anticipate that, when fully operational, it will free up hands in the lab, replace a near obsolete workhorse mass spectrometer, at a time when there is significant pressure, and it is shared across 2 NERC Facilities – ICSF and LSMSF-EK. This is an established and successful cooperative arrangement, which ensures maximum value for NERC.

This year, SUERC's Stable Isotope Lab expanded into a new purpose-built building, resulting from an SUERC investment of around £300k. This is housing new lines that have been built in-house, with ICSF contributing to this effort by redesigning and building a mercury-free hydrogen extraction line following a successful small Capital Bid, which will eventually replace our existing systems.

NEW NERC FUNDING

2 new Facility Projects, funded by NERC, came on stream this year costed through Grant funding: Achterberg RAGNARoCC Programme award (NE/K002546/1) and Polya's "Predicting secular changes in Arsenic Hazard in Circum-Himalayan Groundwaters" (NE/J023833/1). We anticipate another costed grant to begin analytical work in the coming year: Teagle's "A journey through an Active Fault Plate Boundary" (NE/J022128/1). In addition, we anticipate a further 3 costed grants to come on stream next year from the *SoS Minerals* Programme.

SCIENCE HIGHLIGHTS. *To focus on economic and societal impacts and benefits where possible:*

IMPACTING ON A MAJOR GLOBAL ENVIRONMENTAL CATASTROPHE

Lawson, M., Polya, D., Boyce, A.J., Bryant, C. and Ballentine, C.J. (Submitted) Dating and tracing organic matter associated with arsenic release in shallow Cambodian groundwaters. Submitted to GEOCHIMICA COSMOCHIMICA ACTA
The extensive contamination of groundwaters by geogenic arsenic (As) utilized by millions of people as a primary source of drinking water in South and South East Asia has long been recognised as a public health catastrophe. In this paper we present the most extensive interrogation to date of the isotopic and chemical signature of ground and surface waters at a known As hotspot in Cambodia that is minimally impacted by groundwater pumping practices. We show that extensive surface-groundwater interaction occurs in natural settings in the absence of groundwater abstraction, and over very short timescales. Further to this, we show that recharge close to the ponds can and does transport modern organic carbon into the aquifer system, although groundwater organic carbon is more commonly shown to be a mixture of both surface and sedimentary derived organic matter. We show that the age of the organic matter has a direct impact on rates of increase in groundwater arsenic concentrations. **This finding suggests that anthropogenic activity can change the relative contributions of these different organic matter sources to groundwater.** We hypothesize that this has the potential to ultimately influence both the spatial distribution and the temporal evolution in dissolved groundwater arsenic concentrations in groundwater, the major source of drinking water in this region.

HOW MUCH DOES HUMAN ACTIVITY IMPACT ON THE THERMAL STRUCTURE OF GROUNDWATER?

Westaway, R., Scotney, P., Younger, P. and Boyce A.J. (2015) Subsurface absorption of anthropogenic warming of the land surface: the case of the world's largest brickworks (Stewartby, Bedfordshire, UK). SCIENCE OF THE TOTAL ENVIRONMENT, 508, 585-603.



**Stewartby Brickworks,
Bedfordshire, England**

**Viewed here from the air on
30 September 1947, this was
for many years the world's
largest brickworks.**

**Its subsurface heating effect
throughout more than a
century of operation is
estimated as ~200 TJ; in
2014, even though many
years have elapsed since
closure, a subsurface thermal
anomaly of ~7 °C persists at
~20-30 m depth beneath one
of the former brick kilns.**

Anthropogenic perturbation to the thermal state of the shallow subsurface beneath urban areas, results in the creation of subsurface Urban Heat Islands (UHI). Investigations into UHI's concentrate on changes to land use and perturbations to groundwater flow as causal mechanisms, rather than considering the more challenging topic of direct conductive effects caused by thermal loads from buildings or specific industrial practices. Whilst previous workers have been in no doubt that these subsurface UHIs, have been caused by human activity, it has nonetheless proved difficult to establish specific causes of these instances of 'heat pollution', whereby the natural thermal state of the subsurface has been significantly perturbed. This study leaves us in no doubt of the impact of human activity on shallow groundwater.

Stewartby works (Figure), for a time the world's largest brickworks, began operation around the start of the twentieth century and closed in 2008. Subsurface temperature measurements are available in its vicinity, obtained as part of monitoring of an adjacent landfill in one of the former quarries for the Oxford Clay, which was the raw material for brick manufacture. A striking subsurface temperature anomaly, an increment of ~12°C, was first measured in 2004, and has subsequently decayed over time. The anomaly is centred beneath one of the former brick kilns, which operated between 1935 and 1991. Our detailed modeling shows that, after kiln shutdown, this subsurface thermal anomaly began to dissipate by upward heat conduction and release of heat into the atmosphere; at present about half of the peak energy stored remains, decreasing at ~1% per year. The major conclusion of the paper is that **this indicates that warming of the atmosphere will be sustained in the future by dissipation of the large amount of energy stored in pre-existing subsurface thermal anomalies on a global scale**, an issue of major societal implications that demands more detailed investigation.

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

Laboratory: We will bring on stream the new Isoprime VisION mass spectrometer for routine S isotope work to support our many mineral deposit related projects. This will allow us to diminish the impact of cuts on our users. We propose to build a new *in situ* laser-based fluorination line as a preparation line for development of SF₆ analyses, which will allow us to become one of the first labs in the world to offer routine *in situ* Mass Independent S isotope analyses.

Science: We anticipate proposals to emerge from the 3 of the 4 successful major grants from NERC's £10M *SoS Minerals* Programme which have been fully-costed in the development stage. This would provide £111k over 3 years, subject to final sign-off of the grants. More importantly, it will place ICSF central to the success of this exciting Programme, in which all successful grants have delivered, as a *sine qua non*, major industrial support to the main grants, and a cohort of around 15 students, several of whom will be involved in isotopic research with ICSF through the Programme.

Training: ICSF will continue to make training a top priority. Following the first steps of the NERC DTP Training Schools, we are working with our sister Facilities to develop an isotopic workshop to the breadth of NERC PhD students, training approved project students, and we anticipate, stimulating further demand from the NERC Community for our Facilities. One of ICSF's foci will be on applied stable isotope geochemistry.

NERC Demand Management: SUERC has been penalised by NERC Demand Management review, as a result of which there will be a quota operated in SUERC. Future PI and co-I activity from Prof. Boyce will thus be constrained, with implications for future progress of the Facility in a world of pressurised Facility budgets.