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Groundwater and Rural Water Supplies: Report of the Second BGS-NGO Workshop, January 2001

P J Chilton

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1. INTRODUCTION

The workshop was the second in what is likely to become a series of discussions between the staff of the British Geological Survey (BGS) and representatives of the UK-based Non-Government Organisations (NGOs) who have an interest in the water sector. The first was held in July 1999. The meeting was hosted by BGS at its Wallingford office on 31 January 2001. The workshop included a focus on two specific issues which were raised in July 1999: (a) groundwater quality and human health; and (b) the balance between the technical and non-technical aspects of water supply programmes. The specific objectives of this workshop, as set out in the letter of invitation were:

- To promote information sharing between institutions and between countries on groundwater quality concerns (both natural and anthropogenic) and how they might be addressed in water supply programmes

- To discuss how water supply activities can best integrate technical knowledge and experience with community needs and perspectives

The wider objectives of such meetings can be considered as:

- To provide an opportunity for NGOs to find out how they could use BGS skills and experience to support their groundwater-based activities

- To enable BGS staff to find out more about the scope and scale of NGO programmes in the water sector, and about the groundwater issues and problems they face.

The took the form of a series of short, problem-oriented presentations, with questions to follow. Group discussions would then allow issues raised to be explored in more detail. The programme of the meeting is given in Table 1, and the list of participants in Annex 1.

2. PRESENTATIONS

The presentations are briefly summarized here and the overheads used are collected in Annex 2. Ian Curtis, Senior Water Adviser at DFID, gave a few brief opening remarks, as he was unable to stay the whole day. He made reference to the important large dams meeting at the Institution of Civil Engineers the following day, which would review the recent ICID report on dams. He briefed the meeting on the support DFID was giving to the Global Water Partnership, and highlighted imminent DFID activities relevant to the participants. The second White Paper, addressing globalisation issues was about to be released, and the revised Water Strategy Paper would be published about four weeks from the meeting. It would not be radically different from the earlier draft, but would contain more material on "water for food", would address the balance between private and public approaches and would more explicitly target reductions in the proportion of populations remaining unserved with improved supplies.

Denis Peach, Programme Manager at BGS for Groundwater and Water Quality, gave a brief introduction to the types of work carried out within the programme in the areas of water resource management, water quality and hydrogeological processes. He highlighted the principal areas of science, and external factors which drive the programme, mentioning some of the most important gaps in knowledge which have been identified.

Table 1. BGS-NGO Workshop – Final Programme

10.15	Arrival and registration
10.30	Introduction and overview (Dr Denis Peach, Programme Manager, BGS)
11.00	*Natural groundwater quality: experience, concerns and lessons learned* (Pauline Smedley, Groundwater Geochemist, BGS) Drawing on extensive research work in Africa and Asia, the speaker will provide an overview of key groundwater quality concerns and identify steps that can be taken to help avoid problems in the future. (Note: information on groundwater pollution from anthropogenic sources - eg on-site sanitation - also available)
11.30	Open forum
11.50	*DFID's involvement in the water sector* (Mr Ian Curtis, Senior Water Resources Adviser, Infrastructure and Urban Development Division, Department for International Development)
12.00	Open forum
12.10	*Integrating technical and socio-economic imperatives on groundwater development projects* (Roger Calow, Water Resource Economist, BGS) Drawing on DFID-supported work in Africa, the speaker will discuss the broad costs and benefits of various levels of technical input on rural water supply programmes, and identify ways in which better integration of technical and community considerations can increase success and sustainability.
12.40	Open forum
13.00	Lunch
14.00	Summary of morning discussions and introduction to afternoon sessions
14.20	Group sessions to include: 1. How to address groundwater quality concerns in NGO programmes 2. How to increase success rates on water supply programmes, and how do we evaluate success anyway. 3. How to encourage pooling of important data and incremental learning on water supply projects
15.20	Plenary, summary of key issues arising and areas for potential BGS-NGO cooperation (Chair: John Chilton, BGS)
16.20	Depart

John Chilton reported briefly on a workshop of sub-Saharan professionals held at the recent Congress of the International Association of Hydrogeologists in Capetown. Forty participants, representing 10 African countries were at the workshop. While the two hours of the workshop were too short to explore issues in any detail, two key feelings of consensus were that:

- natural water quality problems are indeed a widely experienced constraint on developing groundwater for drinking water supplies,
- more and more projects are being implemented without adequate collection and archiving of even the most basic data on groundwater conditions that can be used to improve the success rate of subsequent projects.

The overheads giving these main points are included in Annex 2.

Pauline Smedley then summarised recent BGS experience related to the constraints posed by natural water quality variations on the provision of potable water supplies, citing work on iron, fluoride and arsenic in particular. Giving global distributions of the latter two, up to 260 million people may be affected worldwide. In some cases, the supply option of shallow dug wells could have been less likely to provide water of poor chemical quality. For arsenic in particular, a key issue was the choice of target for acceptable quality. Adopting the new WHO Guideline value of 10 µg/l for arsenic, as opposed to 50 µg/l, clearly would impact on the numbers of people considered to be affected. Support was needed to develop policy and criteria for the adoption of national drinking water standards, and guidance was also required on monitoring in relation to such standards. The overheads used in the presentation are included in Annex 2.

In answer to a question from Martin Sergeant (DFID) about whether arsenic concentrations were varying with time, the response was that the data so far do not indicate seasonal or longer-term trends. Variations with time are likely to be greatest at shallow depths and becoming more subdued and damped at depth. In discussion of the likely depth variations in arsenic concentrations in Bangladesh, it was explained that at the shallowest depths, groundwaters were likely to be oxygenated and lower in arsenic. Highest concentrations might be at depths of 30-70 m in reducing conditions. From 100 to 150 m, concentrations appeared lower (but there was less data) and below 150 m there might be low-arsenic groundwater, and this was a possible solution to the problem which needs further investigation.

Chris Leake, consultant to WaterAid, reminded the meeting not to forget the impact on health of water of poor microbiological quality, emphasising the importance of hygiene education as a component of water supply projects. This point was well taken; in the discussions of the Bangladesh situation, the benefits provided over the years by improved microbiological quality have tended to be forgotten.

Roger Calow then presented some thoughts on integrating approaches, and the need to balance technical with non-technical priorities. These were presented as (a) resource issues (eg from engineering and hydrogeological perspectives); (b) economics issues (cost; affordability; willingness to pay); and (c) social issues (participation; ownership; demand-responsive prioritisation). Experience suggests that one agenda tends to dominate, or is seen as being 'more important'. This can be very damaging. The speaker highlighted some examples of successful cooperation and integration, drawing on BGS work with WaterAid in Nigeria (groundwater exploration; simple mapping; training) and with various agencies in Ethiopia (drought planning; linking food and water security). 'Getting the balance right' between disciplines and approaches is difficult (problems of language; perspective; cost), but the benefits are great (added value;

change in problem definition and therefore objectives and activities; ultimately benefits to rural communities). His overheads are included in Annex 2.

3. DISCUSSION GROUPS

After lunch, the participants were divided into three groups to discuss the three issues of water quality, project success and data sharing in more detail, as shown in the programme (Table 1).

3.1 Groundwater Quality

The group felt overall that there was a need for guidelines on drinking water quality, but they should be flexible and practical and allow for country-specific variation, which is in fact the intention of the WHO Guidelines at present. It was agreed that targets or standards were required against which to evaluate water quality, otherwise it was difficult to justify using already limited resources on monitoring. However, this should be coupled with an understanding and assessment of the health risks involved. Which are the riskiest? – high, medium or low? Not all WHO Guideline values have the same safety factor built in. It was also often difficult to focus limited monitoring efforts because of the large number of parameters involved.

It was agreed that user and consumer perceptions of water quality and the various risks were also important. While there was in some cases increasing awareness of water quality issues, there was a need for improved education, raising of the awareness of the relationship between quality and health at all stages of water collection, transport, storage and use. The participants were reminded not to forget the relationship between quality and quantity; for many millions of people just getting enough water remains a major struggle.

Several of the NGO representatives asked BGS whether it could be possible to develop better geological and climatic predictors of groundwater quality problems - what are the likely problems in a country or region? It was mentioned that BGS were in the process of preparing country papers highlighting likely water quality problems, based on existing water quality data and geological knowledge for a number of countries in which WaterAid are currently working. This was linked to the broader issue of the accountability of organisations funding and implementing water supply programmes, which had been highlighted by the case of arsenic in Bangladesh. Briefing papers are available from BGS (contact Pauline Smedley). There was also some discussion of the need for pollution risk assessments for groundwater, especially to help prioritise monitoring.

3.2 Improving Success in Groundwater Supply Provision

The question of how to improve the success of water supply projects and programmes was considered to include the issue of sustainability in all its aspects – sustainability of the water resources, of the well or borehole construction, of maintenance arrangements. It means increasing affordable access to improved water for health and livelihood benefits. Success can be broken down into its component parts. The supply target needs to be defined – eg 27 litres/person within 500 m would be such a target – most programmes define such targets. Success and sustainability can also be improved by making productive use of the water for economic activities such as gardening or brick making.

There was also some discussion of the definition of success in relation to the ease or difficulty of the terrain. As coverage with and access to improved supplies becomes greater, more inaccessible communities in geologically difficult areas may remain unserved. Difficult areas may be avoided by implementers and funders tempted to "cherry-pick" to maintain success rates.

Other questions which were raised and discussed included the issue of when NGOs need to ask for technical support and help, and in which aspects of the implementation process, and who carries the risk of failure should a water point prove unsuccessful (the community; the main funder?).

3.3 Data Sharing and Dissemination

It was agreed that many programmes were not collecting even the most basic hydrogeological data from their boreholes or wells, and therefore not contributing to the overall pool of knowledge that would support future programmes. There was a need to build up the understanding amongst NGOs and national agencies of the value of such data, although many felt that it was difficult to achieve this because staff were so transient in both government and NGO sectors. Many said we can't rely on national institutions. In some respects, external organisations such as BGS represented the best chance of continuity and longevity, and should perhaps hold and promote access to data for the broader user community. Eurogeosurveys might also be a possible umbrella organisation which could help in this.

It was suggested that there might need to be minimum standards or guidelines for data collection, and there should be more financial resources put towards longer-term evaluations of project performance to really look critically at all aspects of implementation and their sustainability.

LIST OF PARTICIPANTS **Annex 1**

Mark Rowney	Action Against Hunger UK
Rhona MacDonald	British Medical Journal (BMJ)
Brian Hardcastle	Christian Engineers in Development
Ian Curtis	Department for International Development (DFID)
Bob Blakelock	DFID
Martin Sergeant	DFID
Barnaby Peacock	Intermediate Technology Development Group (ITDG)
Richard Luff	Oxfam
Larry O'Donnell	Voluntary Service Overseas (VSO)
Nick Burn	WaterAid
Jeremy Ockelford	Consultant
Chris Leake	Consultant
Denis Peach	BGS - Programme Manager
John Chilton	BGS - Hydrogeological Adviser to DFID
Dave Greenbaum	BGS – International
Dave Holmes	BGS - Environment and Hazards Directorate
Pauline Smedley	BGS – hydrogeochemistry and health
Jeff Davies	BGS – groundwater exploration, development and management
Nick Robins	BGS – groundwater development and management
Roger Calow	BGS – water policy and economics; water and livelihoods
Alan MacDonald	BGS – groundwater exploration, development and management
David Macdonald	BGS – groundwater management and modeling; water quality
Brighid Ó Dochartaigh	BGS - groundwater development and management
Jude Cobbing	BGS – groundwater development and management

Annex 2

Overheads Presented at Workshop

Groundwater Systems and Water Quality Programme

Groundwater Systems and Water Quality Work Programme

Resources and Management

National Groundwater Survey	- Knowledge synthesis and reinterpretation
Mathematical Hydrogeology	- models for the future: - 3D visualisation - Object oriented approaches - Integrated models
Quaternary Hydrogeology	- Understanding the development of K and S and influence of the Quarterly Period
Engineering Hydrogeology	- shallow groundwater as an engineering hazard

Water Quality

Diffuse pollution of Aquifers:
- Pathogen risks
- Pesticides and Pesticide Metabolites

Natural Groundwater Quality
-BASELINE

Processes

Recharge processes - Recharge through drift

Groundwater/surface water interaction:
- Upland
- River/aquifers

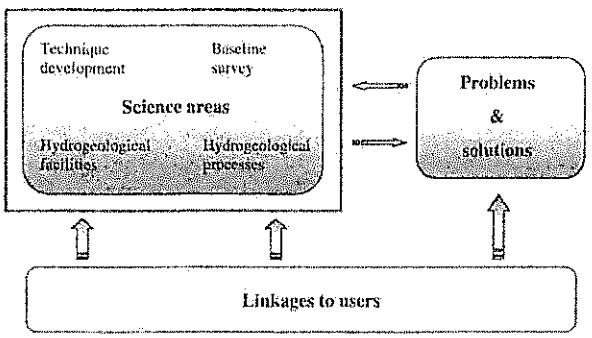
Influence of climate change on aquifer behaviour

Groundwater Systems and Water Quality Programme

Science areas

Science areas – The problems and issues identified and developed through linkgages to users are then addressed by a set of mutually supporting science programmes

- Geological controls on aquifer response, development and groundwater flow
- Aquifer characterisation, properties and processes



- Unsaturated zone processes
- Surface groundwater interactions
- Recharge of groundwater, understanding processes and quantifying
- Groundwater model development (including stochastic modelling)
- Reactive transport
- Hydrogeochemical processes
- Microbiological controls on groundwater and associated hazards
- Inputs to National Groundwater databases and DGSM

Groundwater Systems and Water Quality Programme

Science Strategy

Vision

- Multidisciplinary, integrated science across the disciplines
- Solve scaling problems. Measure at the micro, manage at the macro, but operate at the micro

Drivers

- **EU legislation** – Water framework directive
- **EA initiatives and UK legislation:**
  - groundwater regulations
  - CAMS
  - licensing review
- **Poverty elimination and sustainable livelihoods**
- **Public health** – eg, As, Fl, Crypto, Pesticides, Nitrate

Knowledge Gaps

- Uncertainty in resource calculations
- Uncertainty in environmental requirements
- Uncertainty in flow and transport processes
- Health issues (water quality knowledge deficiency)

Groundwater Systems and Water Quality Programme

Groundwater Systems and Water Quality Work Programme

Resources and Management

National Groundwater Survey - Knowledge synthesis and reinterpretation

Mathematical Hydrogeology - models for the future:
- 3D visualisation
- Object oriented approaches
- Integrated models

Quaternary Hydrogeology - Understanding the development of K and S and influence of the Quarterly Period

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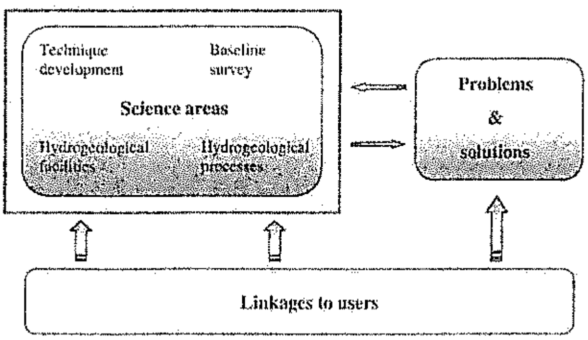

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- Health issues (water quality knowledge deficiency)

GROUNDWATER RESEARCH PRIORITIES FOR THE SADC REGION

Workshop W4
IAH Capetown Congress
Wednesday 29 November

SUGGESTED WORKSHOP FRAMEWORK

Take an investment-oriented viewpoint:

1. At the planning level

2. At the operational level

and consider key hydrogeological issues at these two stages: - noting the importance of scale

GROUNDWATER RESEARCH PRIORITIES FOR THE SADC REGION

- 40 participants, 70% from Africa, 10 Africa nations represented
- Due to time constraints, concentrated on water supply aspects from lower-yielding aquifers
- Tried to differentiate hydrogeological needs of planning from those of implementation
- Time was too short - another meeting?

EMERGING ISSUES - IMPLEMENTATION

- Doubts about the value of maps - accessible point data was widely preferred
- Satellite imagery and geomorphology are under-utilised in site selection
- Pollution risk guidance is required - ARGOSS
- Improved laboratory collaboration for QA/QC - SADC to help?
- Supply projects should be obliged to collect, collate and make data accessible:- lack of incremental learning
- Lack of feedback/connection between implementers and researchers, both North-South and in country

EMERGING ISSUES - PLANNING

- General agreement that hydrogeological maps could be a useful planning tool
- Some good experience with derivative/ interpretative maps - South Africa
- Desirable to produce innovative maps e.g. water development potential, drought susceptibility - GIS
- Natural groundwater quality problems widely experienced - uncertainty about how to predict them

WHO Guideline Values:

Chemicals of Health Significance in Water

Chemical	Symbol	Concentration ($\mu g\ L^{-1}$)
Antimony	Sb	5 (P)
Arsenic	As	10 (P)
Barium	Ba	700
Beryllium	Be	NAD
Boron	B	500 (P)
Cadmium	Cd	3
Chromium	Cr	50 (P)
Copper	Cu	2000 (P)
Cyanide	CN	70
Fluoride	F	1500
Lead	Pb	10
Manganese	Mn	500 (P)
Mercury	Hg	1
Molybdenum	Mo	70
Nickel	Ni	20
Nitrate	NO_3	50 ($mg\ L^{-1}$)
Nitrite	NO_2	3 (0.2 chronic) ($mg\ L^{-1}$)
Selenium	Se	10
Uranium	U	2 (P)

P: provisional

Groundwater acceptability problems

Iron:

(Anaerobic or acidic groundwaters)

- Metallic taste
- Discoloration

Total dissolved salts:

(Near-coastal aquifers, arid areas)

- Salty taste

Arsenic in drinking water

- WHO guideline value: 10 µg L^{-1} (provisional)

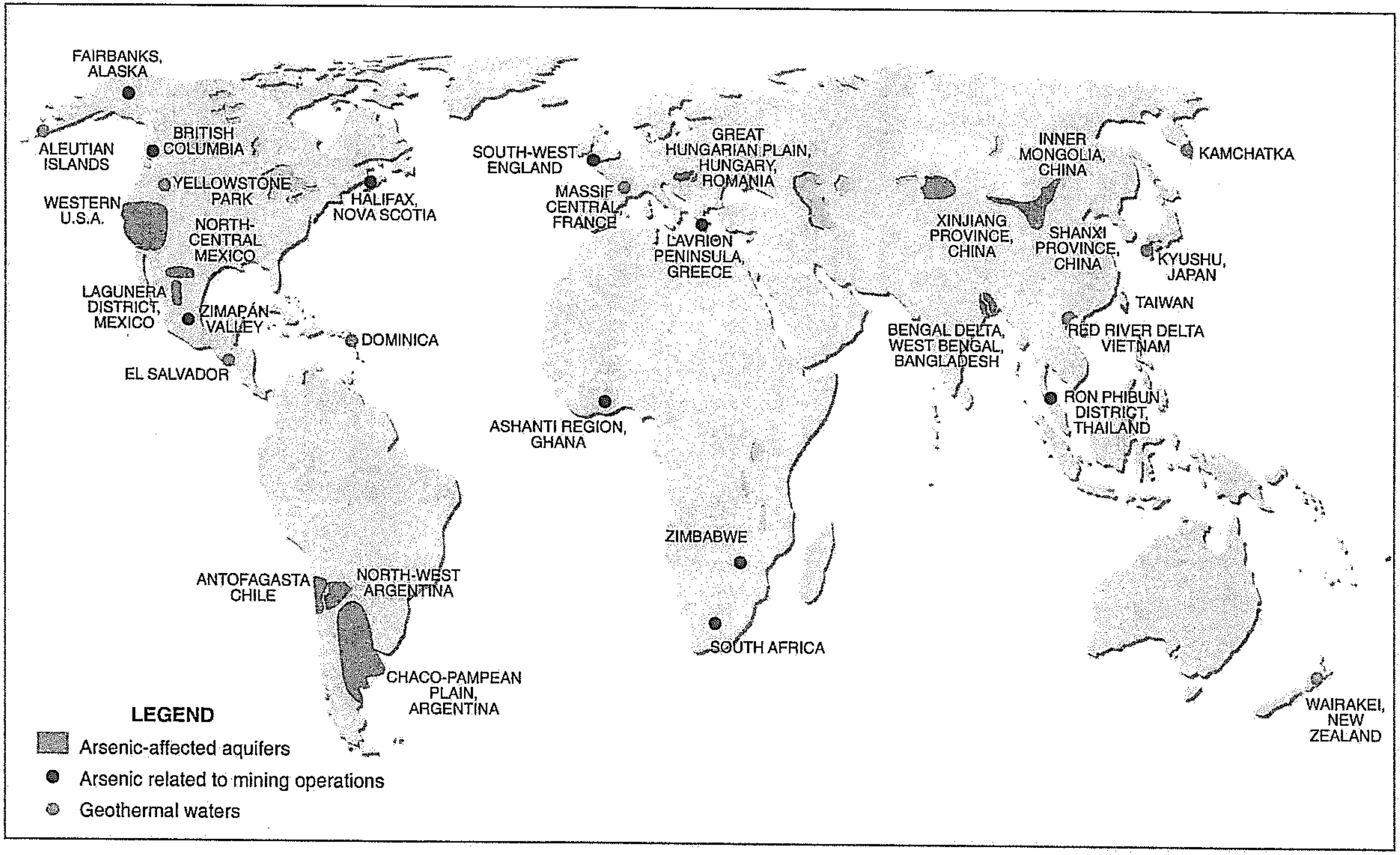
- Problem areas/aquifers:

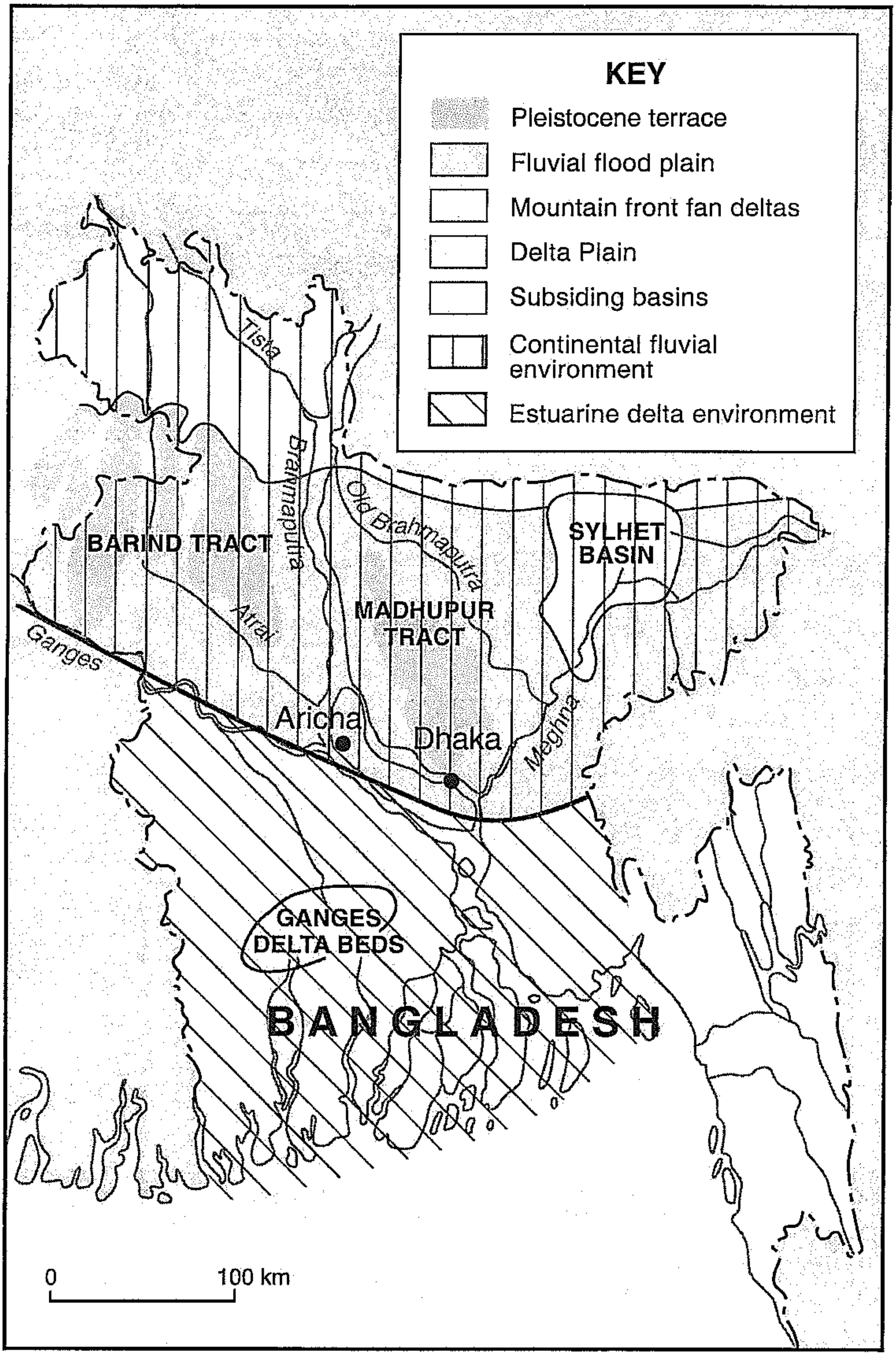
  Mining/mineralised areas

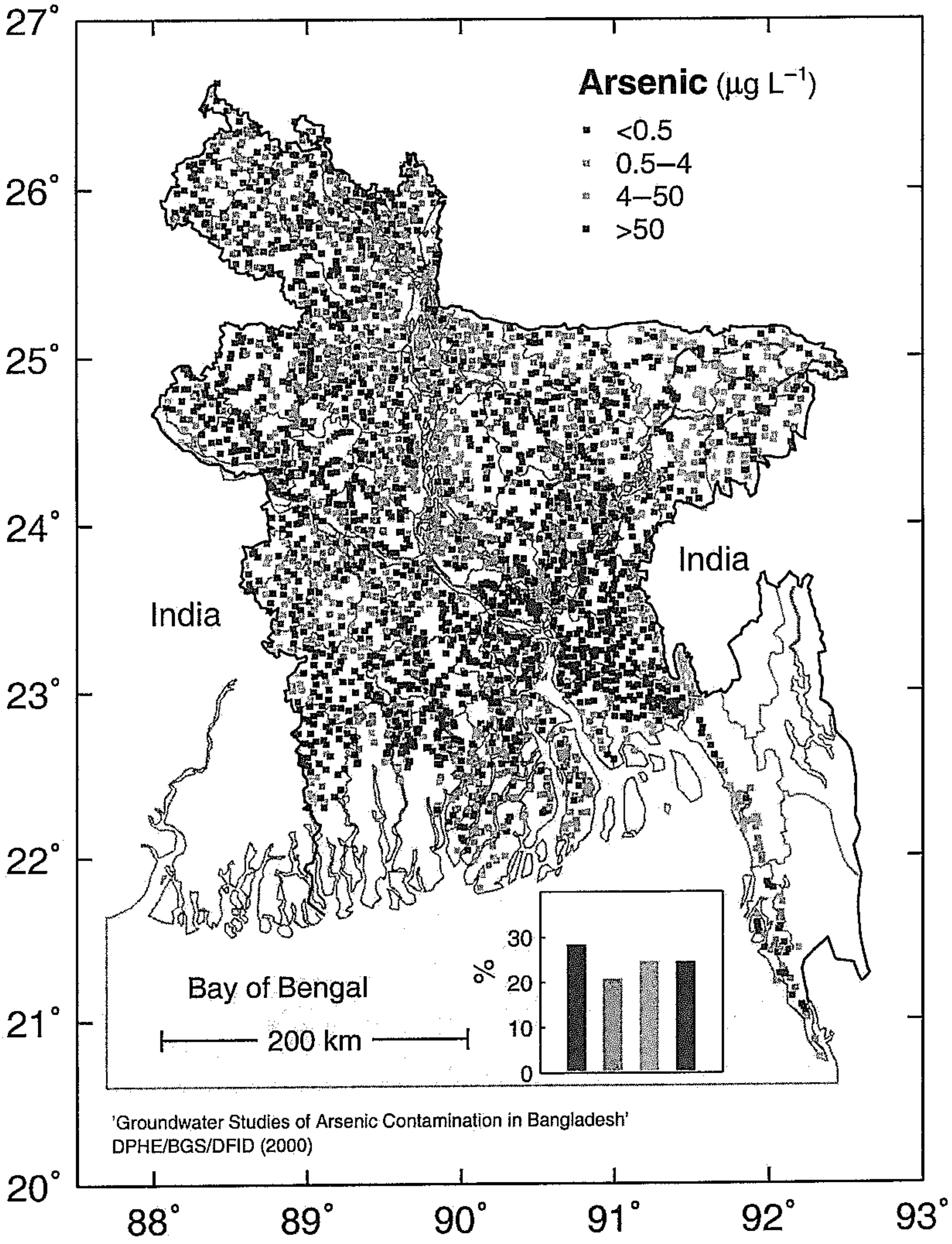
  Arid, alkaline groundwaters

  Anaerobic groundwaters

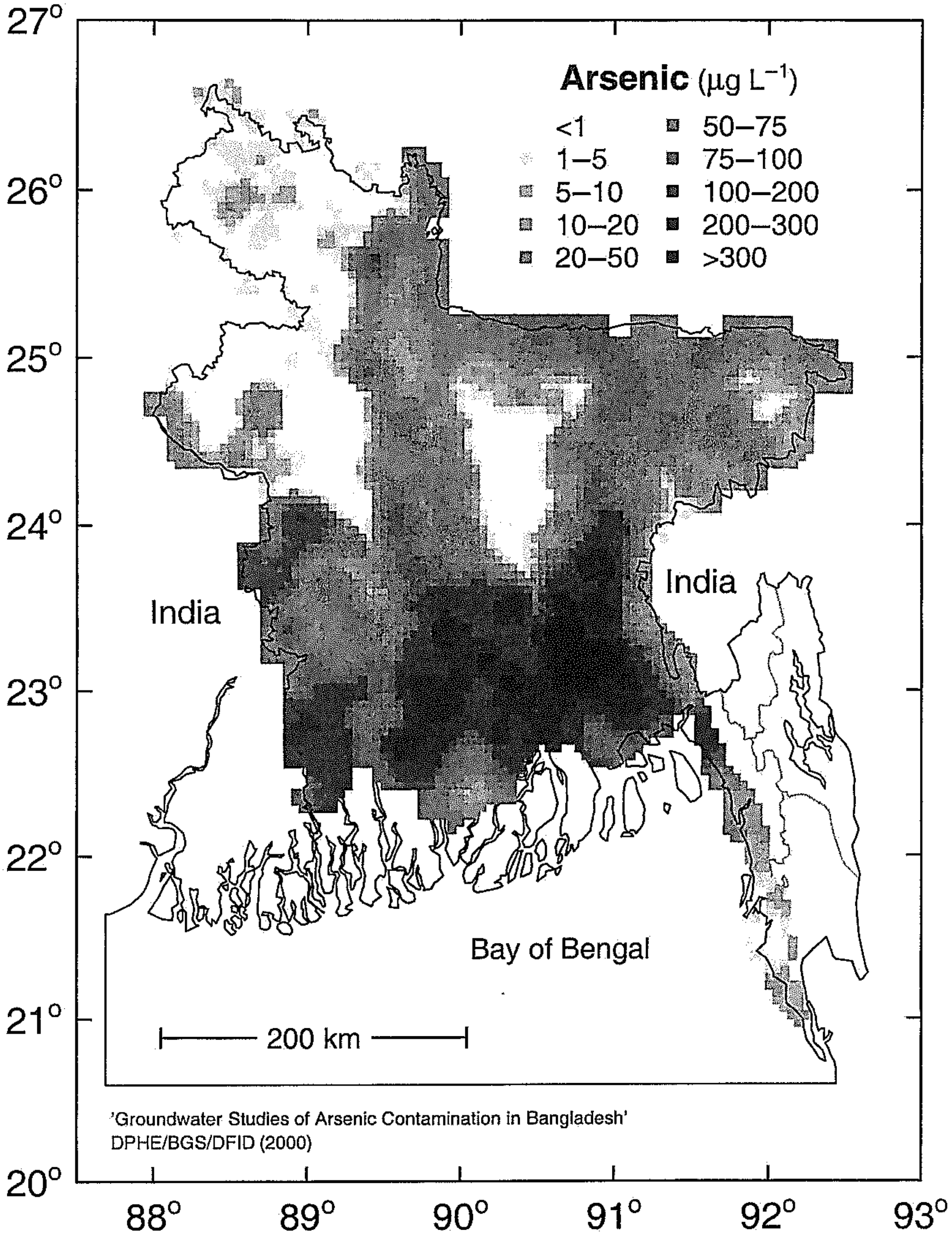
DOCUMENTED ARSENIC PROBLEMS IN GROUNDWATER AND THE ENVIRONMENT

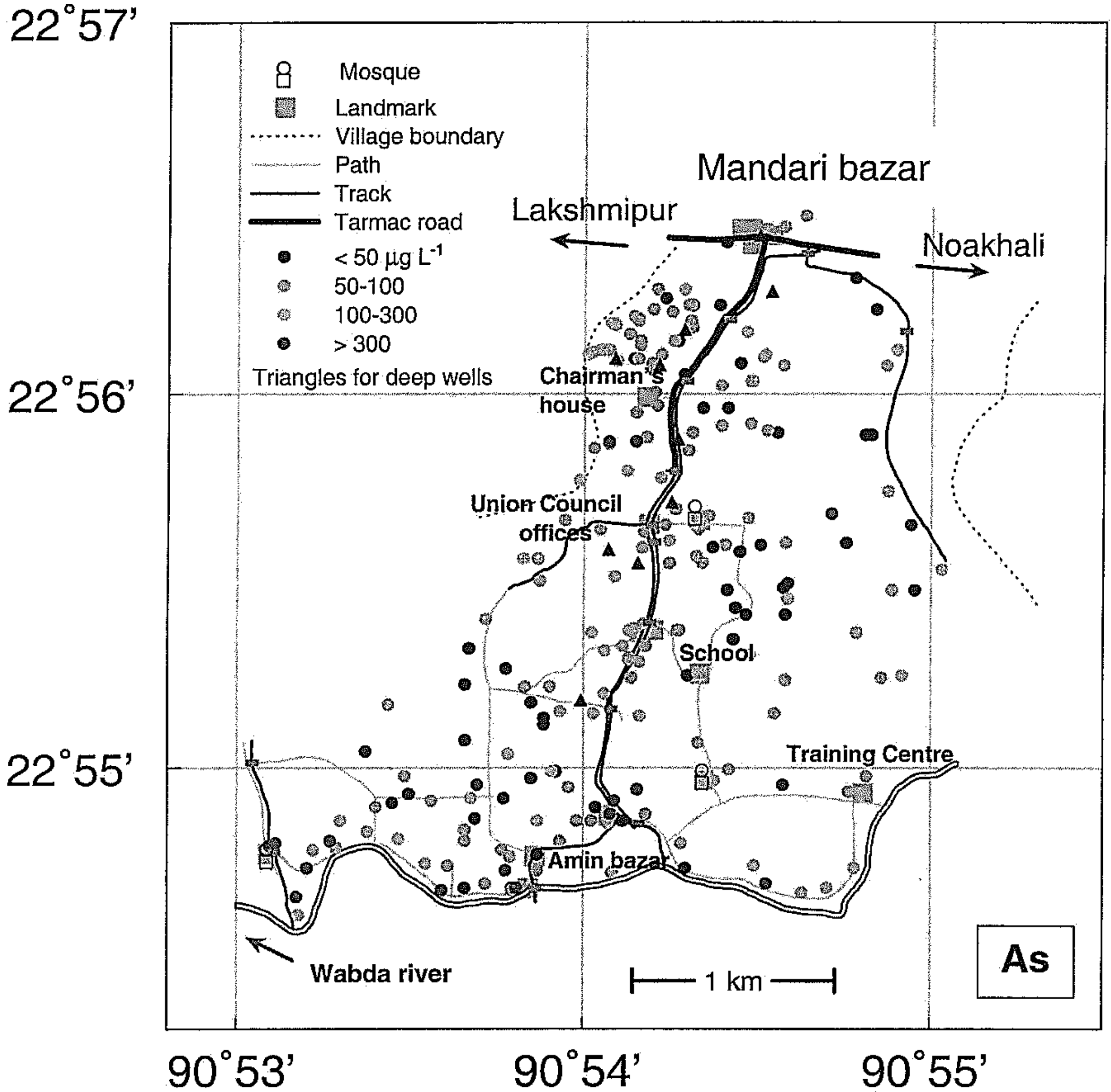



KEY
Pleistocene terrace
Fluvial flood plain
Mountain front fan deltas
Delta Plain
Subsiding basins
Continental fluvial environment
Estuarine delta environment
Tista
Brahmaputra
Old Brahmaputra
BARIND TRACT
Atrai
Ganges
SYLHET BASIN
MADHUPUR TRACT
Aricha
Dhaka
Meghna
GANGES DELTA BEDS
BANGLADESH
0
100 km

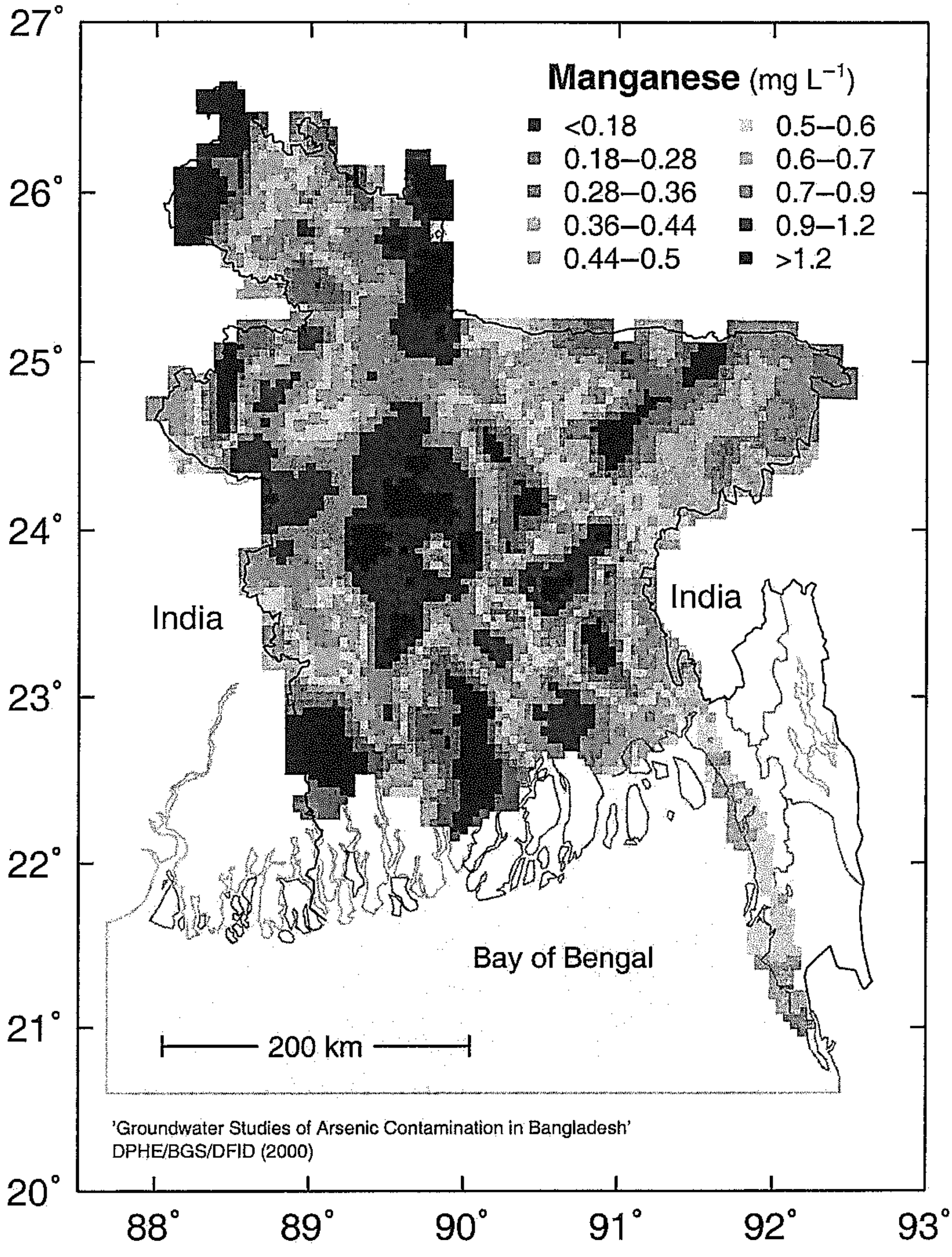


Arsenic (μg L⁻¹)
<0.5
0.5–4
4–50
>50
India
India
Bay of Bengal
200 km
%
30
20
10
0
'Groundwater Studies of Arsenic Contamination in Bangladesh'
DPHE/BGS/DFID (2000)
27°
26°
25°
24°
23°
22°
21°
20°
88°
89°
90°
91°
92°
93°


Arsenic (μg L⁻¹)
<1
1–5
5–10
10–20
20–50
50–75
75–100
100–200
200–300
>300
India
India
Bay of Bengal
200 km
'Groundwater Studies of Arsenic Contamination in Bangladesh'
DPHE/BGS/DFID (2000)
27°
26°
25°
24°
23°
22°
21°
20°
88°
89°
90°
91°
92°
93°



22°57'
22°56'
22°55'
90°53'
90°54'
90°55'
Mosque
Landmark
Village boundary
Path
Track
Tarmac road
< 50 µg L-1
50-100
100-300
> 300
Triangles for deep wells
Mandari bazar
Lakshmipur
Noakhali
Chairman's house
Union Council offices
School
Training Centre
Amin bazar
Wabda river
1 km
As


Manganese (mg L⁻¹)
<0.18
0.18–0.28
0.28–0.36
0.36–0.44
0.44–0.5
0.5–0.6
0.6–0.7
0.7–0.9
0.9–1.2
>1.2
India
India
Bay of Bengal
200 km
'Groundwater Studies of Arsenic Contamination in Bangladesh'
DPHE/BGS/DFID (2000)
27°
26°
25°
24°
23°
22°
21°
20°
88°
89°
90°
91°
92°
93°

Arsenic: 'at risk' aquifers

- Aquifers:

- Young sediments (e.g. alluvial/deltaic) ☑
- Sulphide mineral zones (mining areas) ☐
- Hydrothermal areas (e.g. New Zealand) ☐

- Groundwaters:

Aerobic:

- High pH (>8) ☐
- High alkalinity (HCO_3 > 500 mg L^{-1}) ☐
- High F, salinity ☐

Anaerobic:

- High Fe, Mn, NH_4, P ☑
- High alkalinity (HCO_3 > 500 mg L^{-1}) ☑
- Smell of H_2S ('rotten eggs') ☑

Fluoride in drinking water

- WHO guideline value: 1.5 mg L^{-1}
- Health problems:

  >1.5 mg L^{-1} – dental fluorosis

  >4 mg L^{-1} – skeletal fluorosis

  >10 mg L^{-1} – crippling fluorosis

Fluoride in drinking water

Estimated populations drinking water above acceptable concentrations:

India 60 million (UNICEF, 1997)

China 45 million (Yong and Hua, 1991)

Africa ?? (15 countries)

South America ??

Mexico 5 million (UNICEF, 2000)

Worldwide >260 million (Kloos and Haimanot, 1999)

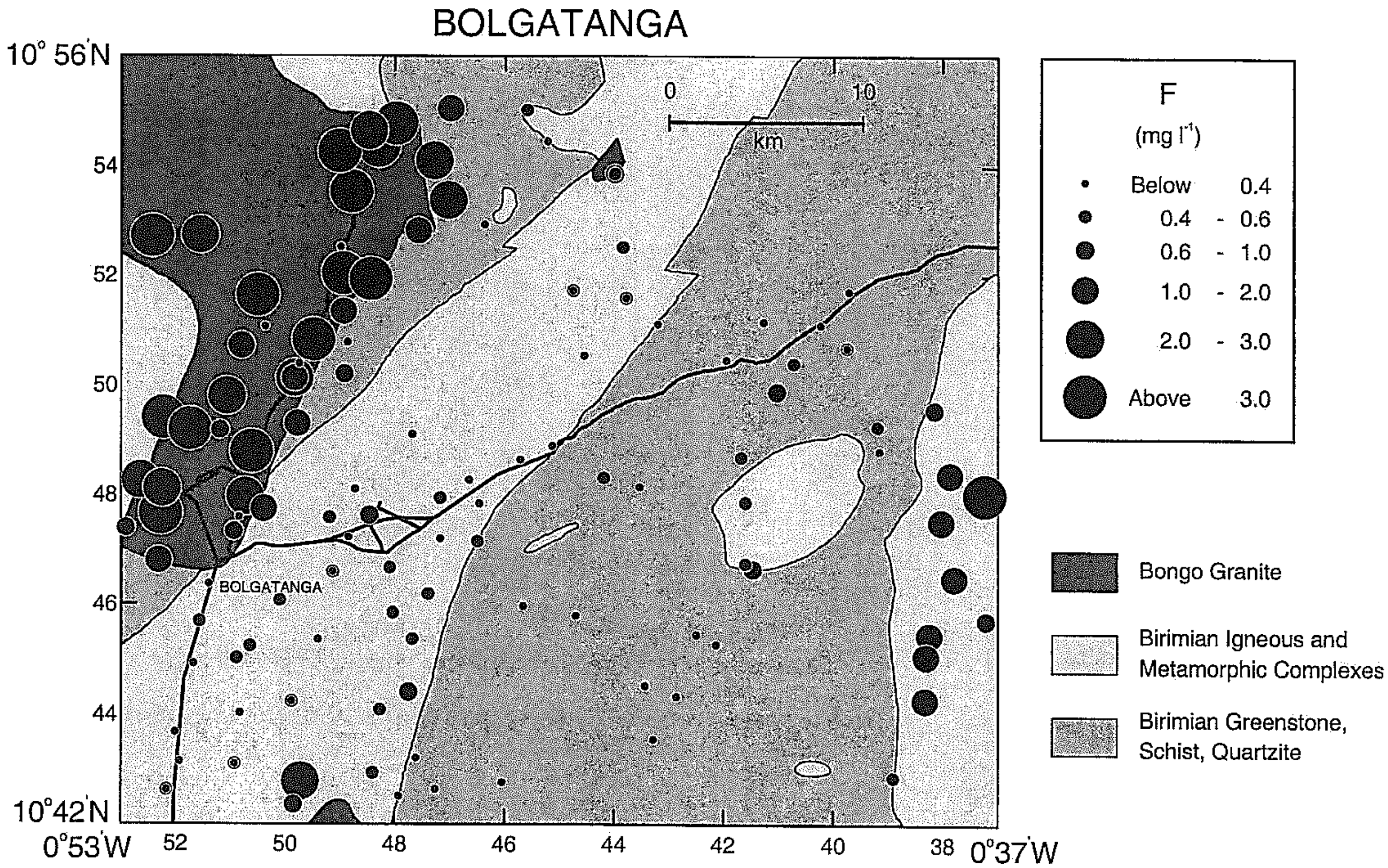
Fluoride: 'at risk' aquifers

- **Aquifers:**

- Crystalline basement (granite, volcanic rocks)
- Some sedimentary basins
- Hydrothermal areas (e.g. East African Rift)

- **Groundwaters:**

- Low Ca ($Na-HCO_3$ dominant)
- pH neutral to alkaline


BOLGATANGA
10° 56'N
54
52
50
48
46
44
10°42'N
0°53'W
52
50
48
46
44
42
40
38
0°37'W
0
10
km
BOLGATANGA
F
(mg l-1)
Below 0.4
0.4 - 0.6
0.6 - 1.0
1.0 - 2.0
2.0 - 3.0
Above 3.0
Bongo Granite
Birimian Igneous and Metamorphic Complexes
Birimian Greenstone, Schist, Quartzite

Concluding Remarks

1. Consider groundwater quality alongside quantity in water supply projects

2. Not feasible to test for every chemical everywhere:

   - Use 'intelligent' testing

   - Test for F and As as priority

   - Iterative process

3. Develop a policy on acceptable criteria for drinking-water quality

Integrating Approaches on RWS Projects

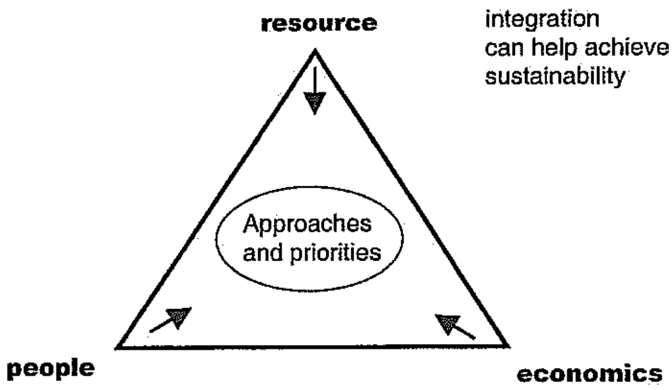
Structure of talk

- Evolution of different approaches
- Case studies - TA and KaR (Africa)
- Multidisciplinary projects; range of partners
- Experience, observations, evidence
- From perspective of 'soft' sciences

Roger Calow, BGS
Water Policy and Economics

Evolution of Different Approaches

integration
can help achieve
sustainability



Oju, Nigeria - Cooperation

- WaterAid link-up with BGS (1995 - present)
- Complementary expertise and experience
- BGS - hydrogeological investigation AND local capacity building
- Outcomes: RWS activities in neglected areas and communities - ongoing
- Costs: v high initial cost of investigation; early frictions...
- Benefits:'
  - health and broader livelihoods
  - increase success rate: communities; costs
  - wider replication
  - more appropriate choices

Oju, Nigeria - Value for money?

- Taking only one slice of benefits - drilling costs saved:
  - Costs (discounted) without invest £2.3M
  - Costs (discounted) with invest £0.8M
  - Saving (10 yrs) £1.5M
- Assumptions
  - based on comparison of success rates
  - approx 20 (success.) BHs/year across Oju
  - basic cost BH £4000 (unsubsidised) - adjusted
  - without investigation, invest (lost) continues

Amhara Region, Ethiopia - Livelihoods Perspective on Drought Planning

- ARWB, SCF, BGS, ODI; broad s'holder engagement
- Drought and food security (availability; access)
- Drought and water security (availability; access; D)
- Drought and livelihoods: drawing out food-water links

Conclusions

Difficulties of collaboration:

- language
- perspective; finding common ground (all sides)
- cost....BUT....need to focus on **value**
- 'fit' with eg sectoral institutions

Benefits of collaboration:

- added value
- change problem definition and approach
- better results
- ultimately, benefits to rural communities