The role of science in solving wicked water problems – examples from groundwater management in emergency contexts

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New tools for wicked water problems may supplement and enhance fundamental science that provides the basic framework for solving such problems, but cannot replace it. The more troublesome a problem becomes, the more expansive is the search for a solution. While this is applicable generally, it is particularly relevant in emergency contexts where a rapid response is required. This paper investigates the need for new tools in the context of groundwater exploration, development and management, drawing on experiences in Chad, Sri Lanka and Sierra Leone.

Where problems of water supply are already felt and significant population numbers are involved, the speed with which the problem must be addressed often leads to a paralysis of effective analysis. This may lead to the adoption of tools that are poorly suited to the problem. Examples of this situation are typically (but not exclusively) observed in emergency responses to disaster situations where, in an instant, the lives of thousands of people depend on the ability of a small number of aid workers to provide a safe and adequate water source.

Public health is the main driver behind emergency response and water supply is one of the critical components of public health programmes. A major contribution to this is developing confidence in adequate groundwater resources to meet the immediate, and potential long-term, requirements of a disaster. Competent groundwater professionals are not always appropriately represented in the emergency response workforce and effective co-ordination is lacking (Lipscombe, 2007; Lytton, 2008; Villholth *et al.*, 2008).

There are many situations where the quality and quantity of surface water is unable to provide a reliable resource, and groundwater is a viable alternative. However, groundwater is both more resilient and more vulnerable and it is essential to plan properly (Villholth *et al.*, 2008). There are numerous broad-scale guides for investigating groundwater, including in emergency contexts (e.g. UNESCO, 2006; Carter, 2007), but the analysis of very local conditions, and the resulting application of appropriate methods, is essential. The planning logic and techniques required are specific to the situation but comprise fundamental steps (Table 1).

Table 1 Wicked problem: obtaining adequate groundwater supply for recipient population.

Planning step	Tools required
Analysis of the supply/demand situation, including timing and duration	Location and aquifer yield analysis from existing local wells and boreholes/Statistics of population numbers, water use and growth
Physical conceptualisation of the groundwater system	Geology map, topographic map, air photos, location and aquifer data from local wells and boreholes
Identification of targets and construction method	Geophysical methods, remote sensing and refinement of hydrogeological analysis. Modelling methods (simple and complex)
Installation of water point	Hand auger/drilling rig/spring enhancement
Assessment and long-term planning	Frequent and regular monitoring of rainfall volume, groundwater levels, extraction yields, groundwater quality. Integrated analysis of the monitoring data

All of the above tools are generally available. However, data from existing wells and boreholes is often inaccessible or compromised in some way (inaccurate location, lacking a date tag, or measurement unit not specified). Notwithstanding these limitations, the authors have adopted the above approach in a variety of situations: in eastern Chad, water sources for large numbers of refugees were identified in fractured rock and sedimentary aquifers in wadis (Lytton *et al*., 2007); in Sri Lanka an appropriate understanding was gained of the post-tsunami problem (Lytton, 2008; Villholth *et al*., 2008); in eastern Sierra Leone, local NGO staff were trained in the use of the above tools to appropriately target well locations for small village water supplies.

Data acquisition and management is a significant issue, including in the most developed countries. Even where primary data are not available, once groundwater sources are established, their sustainability is dependent on the collection, storage and analysis of appropriate data. Agencies of the UN, INGOs and participating governments have a major role to play in this.

The tools to address the problems described are old-fashioned ones involving good input data, appropriate data analysis and a robust monitoring programme to support the initial approach taken and guide the direction of future work. The lesson learnt from the authors' experience in emergency contexts is that a modest amount of appropriate planning, design, measurement and analysis will provide answers even for the most wicked water problems.

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