Both terrorism and armed conflict can be threats to water security, either directly or indirectly. Both forms of violence have used disruption or poisoning of water supplies as a weapon, and both may cause collateral damage to water supplies. The distinction between war and terrorism can be arguable. Special Operations forces may use some tactics similar to terrorists, with similar repercussions for water systems, but the main practical distinction is between formal military actions and more informal, smaller scale guerrilla-style activities that may be directed more at civilian personnel and designed to engender fear and panic as much as specific damage.

1. Armed conflict

1.1. RISK ASSESSMENT

It is generally difficult to assess risk on anything but a short-term basis. But it is clearly possible to undertake some preventative measures. These will be similar in the main to those for terrorism, although heavy bombing and shelling disrupt water distribution and sanitation systems more and are likely to leave a more long-lasting “war footprint”, specially in the environment, e.g. in pollution from explosives or materials released from the plant under attack. Examples might be depleted uranium from shells or PCBs from electricity stations, e.g. in Bosnia. Mining or bombing of dams, distribution pipelines and treatment plants, the disablement of management systems, whether human organisational or computer control systems, and general environmental pollution are the main risks.

1.2. EMERGENCY RESPONSE

This is the key area for action and improvement. The present situation seems rather inadequate and amateur, especially in leaving a large part of the work to NGOs like the Red Cross and Red Crescent. We recommend the following:
1. Creating special sections of the military or under military control that are more specialised in water and sanitation provision and restoration than the current military engineers, in order to take the strain off the NGOs and to enter the arena before it is safe for the NGOs. NGOs have a multitude of other interests and are funded on a non-professional basis, mainly by donations.

2. A pre-existing emergency plan should be developed wherever possible with community leaders organising the initial response.

3. The military should take overall control of restoration as soon as possible.

4. Finally, perhaps in the long-term the UN might develop a formal and specific set of rules for responsibilities concerning protection and restoration of water supply and sanitation in armed conflicts.

1.3. PRIORITIES FOR EMERGENCY SERVICES

The overall aim must be two-fold: (i) to provide adequate volumes of water for drinking and, most importantly, sanitation, and (ii) to prevent the outbreak of epidemics of disease and poisoning, e.g. from chemical, bacteriological, viral toxins or petroleum products in the water. We recommend the following order of priority:

1. **Provision of any water is the first priority** — quantity is more important than quality especially for use in sanitation rather than for drinking, as the most immediate danger is from disease caused by inadequate sanitation facilities.

2. **Continuity of supplies of both water and power is the second** most essential element. Restoring and securing electricity supplies is essential for pumps and control systems.

3. Provisions should be **extended to the whole of the population that has been affected**, whether by restoring public water supply networks or by mobile supplies.

4. **Attend to water quality** if the emergency supply was unsafe. This may involve importing freshwater in bottles or containers and provision of portable water treatment systems. But part of the community plan should be:

   (a) **Education of the people** in what to do in an emergency. Advise should be provided prior to or as early as possible in a conflict. This should comprise advise on (i) storage of water, including refrigeration where possible, (ii) purifying and disinfecting their own water by boiling (10 min at 100°C kills most biological vectors; pasteurisation at 60°C for 10 min removes living bacteria but not spores), other measures like exposure to ultraviolet light in sunlight or use of chlorine
or dilute bleach to kill pathogens, filtering for helminths and other parasites, and also for sediments as bacteria and viruses tend to adhere to surfaces in multiple layers that make some inaccessible to UV irradiation, and (iii) the dangers of specific diseases. The EU standard for safe water is 100 bacteria/ml, but safe levels for viruses vary: one virus may be enough if it spreads or invades bacteria which then spread their transformed cells. Water temperatures of 10–30°C are typical optimum temperatures for proliferation. The worst sources for emergency water supplies, especially in warm climates, are surface and shallow groundwater because of the danger of faecal pollution. Typical shallow groundwater in Africa, from a metre or two in depth is likely to be warm enough for bacterial proliferation, whereas in central Europe it is likely to be cooler than 10°C, especially in winter, so that E. coli (a good indicator species) cannot multiply. Somewhat deeper groundwater will be cooler and will have been filtered more effectively during a longer period of percolation.

(b) The availability of cheap, basic equipment with which to do this. Filtering is best done with a sub-2 μm membrane rather than simple filter paper. This will also remove many pathogens.

1.4. ENVIRONMENTAL REHABILITATION

This must generally await cessation of hostilities. It will begin with the long-term reconstruction of permanent storage, distribution and sewage networks and treatment plants. Even longer-term activities will involve cleanup, likely to be mainly chemical, of the remaining products of war in soils and water bodies. Again, we recommend that this should be made part of the formal responsibilities of combatants.

1.5. SUMMARY STATEMENT ON DEALING WITH IMPACTS OF ARMED CONFLICT

1. Protection and reconstruction of water supply systems is a priority and community plans should be in place prior to hostilities wherever possible. The military should have responsibility for securing water supplies before it is safe for aid agencies. Consideration should be given to establishing clear UN rules on responsibilities for the protection and reconstruction of supplies.
2. Instruct public in treatment methods and distribute emergency equipment at the earliest opportunity.
2. Terrorism

2.1. RISK ASSESSMENT

A terrorist attack can occur anywhere, any time, perpetrated by a small cell without any links to foreign commands or international financial transfers. Many attempts have been made to poison water resources, not just since 9/11. The main result of such an event is not just the cases of mortality or morbidity, but the panic caused. An extreme case of panic could cause mass infection by people evading quarantine spreading the infection nationally or even globally (cp. SARS and Avian flu).

There are three broad types of risk:

1. Disruption of the public water supply system – a quantity issue
2. Poisoning of the PWS – a quality issue
3. Disruption of sewage systems – not so effective and of lesser significance

Terrorists generally have less powerful mechanisms available to them than national armies. Fear and panic tend to be a major aim of terrorist actions; widespread death and illness are generally of secondary importance and often beyond their capability.

2.2. METHODS OF ATTACK DISCUSSED

These included:

1. Chemical, biological, radiological and physical. The first three fall broadly under the heading of poisoning. The last involves disruption and destruction of water supply and sewage networks, including computer control systems.
2. Many simple methods are available, but anthrax, smallpox or radioactive materials like polonium and caesium 137 are not so easily obtained.
3. Mixtures of agents will be more difficult to eliminate than single agents.

Chemical agents are the easiest to get and use. Biological agents like myco-toxins are harder to get and more expensive, and the effects may be delayed for weeks.

2.3. EMERGENCY RESPONSE

Devising effective counter-measures is complicated by the fact that the impacts may be long, medium or short term. However, chemical, biological and radiological events are generally similar to other sources of water pollution, so that many counter-measures will serve as protection for both normal risks and terrorist attacks. It is impossible to continually monitor every part of the system. There is especial danger from “backwater” introduction of...
agents. A small pump fitted to a domestic water tap can counteract the mains water pressure and allow agents to flow backwards into the system. Irish and Scottish terrorists threatened backwater introduction via street fire hydrants Jones (this volume) in 1999 and 2007, respectively.

2.4. RECOMMENDATIONS

1. Priority must be given to **intelligence information**, especially that derived from intercepting electronic traffic, and to **continuous online monitoring**. Further development of online monitoring systems is needed to increase effectiveness and the number of parameters covered, including DNA analysis, luminescence and live animals, and to reduce the currently very high costs ($100,000 per instrument). This has an important feedback to WG3 (this volume) in terms of the possible willingness or ability of private water companies to afford the equipment – who should control security measures?

2. Remove sensitive information on water systems from the public domain, e.g. from websites.

3. Training of medical community in identifying signs of an attack, e.g. increases in diseases and disorders (cp. American College of Preventative Medicine online guide, sponsored by the EPA and American Water Works Association).

4. Education of the public, raising their awareness of the risks, and their potential role at all stages from early warning to safe response. This is an area where Nato Science could play a unique role in an educational campaign. One suggestion might be to promote local or home storage of freshwater for emergency purposes in areas at risk.

5. Improving cyber security and vetting of employees – disablement of computer control systems by hackers is an increasing threat to automated systems.

6. Wider adoption of national agencies responsible for coordinating anti-terrorist activities, as in the USA and UK. The EPA works with other federal agencies, like the Centers for Disease Control and Prevention, the FBI, and Department of Defense, and with the water sector organizations, like the Water Environment Research Foundation, to develop water security technologies and protocols for detection, treatment and response, and to disseminate information to stakeholders. The EPA’s Drinking Water Laboratory Response Preparedness Project aims to develop regional incident response plans. Israel also continues to make serious efforts to protect water supplies.
7. Improved physical protection of facilities – fencing, security cameras, etc.
8. Tightening of global money flow controls.
9. Developing improved and cheaper domestic-scale in-house safeguarding systems, like UV irradiation and carbon filters with pre-programmed automatic responses when overloaded or used up.

Online protection should include remote control for double dose chlorination, and diagnoses of swimming patterns of fish, especially *Gnatonemus Petersi* (Elephant fish), and *Daphnia*. Fluorescein can aid observation of bacteria and *Daphnia*. Expansion of real time DNA-series identification for early warning of biological agents is recommended, as funded by Nato and the US Homeland Security Office.

Poisoning by drinking polonium-200 or caesium-137 seems to be much less effective in large water systems because of the large dilution effect. But water contaminated with radioactive elements could be sprayed from a truck and cause panic as well as many casualties. Water soluble caesium chloride, obtainable in powder from hospital supplies, is very dangerous and there is currently very little awareness of the problem. There is a danger of inadvertently giving terrorists ideas.

Although it is not easily obtained, anthrax could cause widespread deaths and persist for ages. On the other hand, *Botulinum* bacteria can be found naturally and botulism is a powerful, short-term infection that could kill thousands.

2.5. SUMMARY STATEMENT ON TERRORISM

1. Awareness is the key to prevention of attacks, including prior intelligence and engendering awareness amongst the general population.
2. Avoiding panic, preparing the people for possible events and careful restriction of information to the public. Aim to avoid “waking sleeping dogs” by giving information to the enemy that may help them execute the attack.
3. Install systems for continuous monitoring of water quality.
4. Long term aim should be removing the causes of terrorism.