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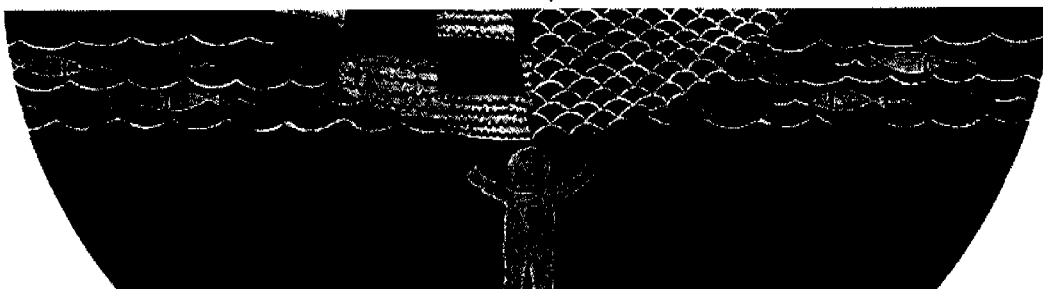
Meeting on Effective Approaches to Regulating Microbial Drinking-Water Quality

Adelaide, Australia
14-18 May 2001
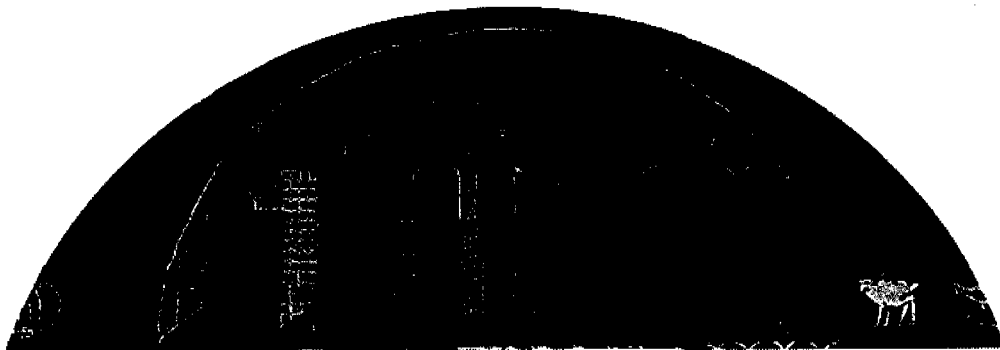
Protection of the Human Environment
Water, Sanitation and Health
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ABBREVIATIONS AND ACRONYMS

CCP	Critical Control Point
CRC WQT	Cooperative Research Centre for Water Quality and Treatment (Australia)
CDSC	Communicable Disease Surveillance Centre, Swansea, UK
DALY	Disability Adjusted Life Years
DWQC	WHO Drinking-water Quality Committee
EAWAG	Swiss Federal Institute for Science and Technology
FEA	Federal Environment Agency (Germany)
GDWQ	WHO Guidelines for Drinking-water Quality
HACCP	Hazard Analysis and Critical Control Point
KIWA	KIWA Research and Consultancy, Netherlands
MRD	Microbial Review Document
MWC	Melbourne Water Corporation (Australia)
NHMRC	National Health and Medical Research Council (Australia)
NZMoH	New Zealand Ministry of Health
QMRA	Quantitative Microbial Risk Assessment
RA	Risk Assessment
RIVM	National Institute of Public Health and the Environment (the Netherlands)
UK	United Kingdom
VKI	Now part of DHI:Water and Environment, Denmark
WEDC	Water Engineering and Development Centre, (Loughborough University, UK)
WG	Working Group
WHO	World Health Organization
WQO	Water Quality Objective
WRc	Water Research Centre, UK

MEETING ON EFFECTIVE APPROACHES TO REGULATING MICROBIAL DRINKING-WATER QUALITY

GLENELG, AUSTRALIA, 14-18 MAY 2001

1. BACKGROUND

The first WHO publication dealing specifically with drinking-water quality was published in 1958 as *International standards for drinking-water*. It was subsequently revised in 1963 and in 1971 under the same title. In 1984-85, the first edition of the *WHO Guidelines for Drinking-water Quality* was published in three volumes: Vol. 1 – *Recommendations;* Vol. 2 – *Health Criteria and other Supporting Information;* and Vol. 3 – *Surveillance and Control of Community Supplies.* The second editions of the three volumes of the Guidelines were published in 1993, 1996 and 1997, respectively. Addenda to the first and second editions were published in 1998, addressing selected chemicals only. An addendum on microbial aspects reviewing selected micro-organisms is in press.

The primary aim of the *Guidelines for Drinking-water Quality* (GDWQ) is the protection of public health. The GDWQ provide an assessment of the health risk presented by micro-organisms, chemicals and radionuclides present in drinking-water. The guideline values recommended for individual constituents of water are not mandatory limits – they are intended to be used in the development of risk management strategies, including national or regional standards developed in the context of local or national environmental, social, economic and cultural conditions. Such strategies, *if properly implemented*, will ensure the safety of drinking-water supplies through the elimination, or reduction to a minimum concentration, of constituents of water that are known to be hazardous to health.

Volume 3 of the GDWQ: *Surveillance and Control of Community Supplies* is distinct in orientation and is a document oriented towards "good practice". The present edition is principally focused upon the situation in developing countries. Other "good practice" guidance linked to GDWQ includes, for example, *Toxic Cyanobacteria in Water.*

It was recommended in 1995 that the GDWQ would be subject to a rolling revision process. Through this process, microbes and chemicals are subject to periodic review, and documentation related to aspects of "protection and control" of drinking-water quality is prepared progressively. This process was initiated at a meeting of the Coordinating Committee for the Rolling Revision of the GDWQ, at which three working groups were established. These were to address microbial aspects, chemical aspects and aspects of protection and control of drinking-water quality.

The programme of work of the Microbial Aspects Working Group (WG) was adopted directly by the 1995 Coordinating Committee meeting. For the period 1996-98, it comprised preparation of selected Microbial Review Documents (MRDs). In its first phase of work, review documents on a number of specific microbes were prepared. A future strategy for major revision of the microbial aspects of the WHO water-related guidelines, including the GDWQ, was also developed.

Since the 1995 Coordinating Committee meeting, a series of chemical review documents has been prepared, adopted and published through addenda to the GDWQ as output of the work of the Chemical Aspects WG.

The WG on aspects of Protection and Control met in 1996 (Bad Elster, Germany) and in 1998 (Medmenham, UK). The Terms of Reference of the WG have been established, and five institutions assist in the co-ordination of the principal thematic areas of work: resource and source protection (Federal Environmental Agency, Berlin); materials and chemicals used in the production and distribution of drinking-water (NSF-International); water treatment (WRc, UK); and monitoring and assessment (Robens Centre, UK; VKI, Denmark). All of these institutions are WHO Collaborating Centres concerned with water. A plan of work has been pursued, based initially upon the recommendations of the Co-ordinating Committee, which has included development of a series of documents principally concerning aspects of "good practice" in achieving the safe conditions described in the GDWQ *per se* and organization of meetings.

The Berlin 2000 Coordinating Committee meeting adopted a plan of work for the development of the 3rd Edition of the GDWQ and their subsequent rolling revision; a plan of work for the development of supportive materials on implementation of the GDWQ and a Procedures Manual for the conduct of the preparation of the third edition of the GDWQ and their subsequent rolling revision.

At an expert consultation in Stockholm in 1999, a harmonized framework for assessment and management of risk relating to microbial hazards associated with water which linked health targets, risk management, public health status, assessment of risk and guideline derivation was developed.

In Berlin, this framework was further developed and adapted for drinking-water into a proposed scheme for microbial aspects for the 3rd Edition of GDWQ. Essential building blocks to support the development of the 3rd Edition of GDWQ were identified in the Medmenham (1998) meeting as critical review documents on major issue areas, as follows:
- Resource protection;
- Treatment (major issue with fluctuations of efficiency);
- Distribution (maintaining safety);
- Household Management;
- Indicators and Testing;
- Hazard Characterisation and Risk Assessment (selected pathogens).

2. OPENING

2.1 Welcome from the Hosts

Don Bursill from the Australian Cooperative Research Centre for Water Quality and Treatment (CRC WQT) introduced the South Australian Premier, The Hon. John Olsen MP and invited Mr Olsen to welcome the meeting delegates.

The Premier welcomed the international and Australian representatives and discussed the role of water in all societies as a precious and finite resource. The Hon. Mr Olsen discussed the role of CRC for Water Quality and Treatment in initiating and supporting drinking-water quality research in Australia and the collaborative role of the CRC WQT with international organizations concerned with water.

2.2   Welcome from WHO

Jamie Bartram responded to the welcome by the Premier and welcomed participants on behalf of WHO. He thanked the relevant Australian groups for hosting and sponsoring the meeting (the National Health and Medical Research Council and the CRC for Water Quality and Treatment). Dr Bartram discussed the need for continued improvement in drinking-water quality management in both developing and developed countries, and the role of risk-based water-quality management.

2.3   Scope and objectives of the meeting

The meeting comprised a joint meeting of the Microbial Aspects WG and the WG on Aspects of Protection and Control. The overall purpose of the meeting was to review progress with the development of the Microbial Aspects of the third edition of the GDWQ, and to plan and orient the finalization of the 3rd Edition and of supportive documentation.

The specific objectives of the meeting were:
- to review the draft outline text and make specific recommendations regarding its structure, detailed content and development;
- to review the background materials required to support and substantiate the development and derivation of the Guidelines; and to make specific recommendations regarding their further development and the process for this in the context of the 'GDWQ Procedures Manual';
- to review the various items of documentation in development to support implementation of the Guidelines and to make specific recommendations regarding their further development and the process for this in the context of the 'GDWQ Procedures Manual'; and
- to adopt a realistic plan of work to lead towards publication of the third edition of the GDWQ in 2003 and to lead towards a subsequent process of 'rolling revision'.

Don Bursill acted as Chair for the meeting. Phil Callan and Melita Stevens acted as Rapporteurs for the draft text document and meeting report, respectively. Meeting participants are listed in Annex 1 and the agenda as adopted in Annex 2.

3.   GENERAL RECOMMENDATIONS (THIRD EDITION OF GDWQ)

3.1   Framework Approach for microbial aspects of the GDWQ

Stockholm Framework
An expert meeting, called in 1999 by WHO, sought to provide a harmonized basis for risk assessment/risk management for water-related infectious disease (drinking-water, wastewater and recreational waters) including shellfish production. The output of this meeting in Stockholm took the form of a "harmonized framework" and a book discussing its principal elements. The framework should provide the overall approach taken in all WHO guidelines including the GDWQ for infectious water-related health hazards.

The Stockholm meeting emphasized that microbial hazards are different from chemical hazards. For example, there are many microbial hazards with common sources; short-term exposures can be significant; risk assessment and risk management are especially closely inter-linked, (for example, an absence of a safeguard can be hazardous as well as the presence

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of a pathogenic microbe). For these reasons, hygiene, multiple barriers from catchment to consumer, risk assessment and good practice in management including Hazard Analysis and Critical Control Point (HACCP) form important components of approaches to health protection. In applying this to drinking-water, meeting participants recommended that assessments should be considered for those in the 'normal population' that are more vulnerable (such as children or adults who might be at higher risk of serious illness but not the effects of immune system impairing illnesses such as HIV/AIDS.

Australian Approach To Drinking-Water Quality Management
The approach in Australia towards the development of drinking-water quality guidelines involves elements of risk assessment, Total Quality Management and (HACCP). A framework for drinking-water quality management has been developed by the National Health and Medical Research Council (NHMRC) which is responsible for drinking-water guideline development in Australia. The framework was developed to reduce reliance on end-point testing and incorporates HACCP principles.

The NHMRC "Framework for Management of Drinking Water Quality" incorporates preventative management guidance already present in the 1996 *Australian Drinking Water Guidelines*. Elements of other management systems including ISO9001, ISO14001, HACCP and the AS/NZS Standard for Risk Management were incorporated into the Australian framework to ensure compatibility. The framework was developed through a consultative process, involving the water industry, catchment managers and health regulators. Desktop trials and targeted industry consultation showed the framework to be a realistic risk management approach to drinking-water quality. The framework was available for public comment from 5 May–6 July 2001 and was to be incorporated into the *Australian Drinking-Water Guidelines* in late 2001.

Meeting participants supported the direction taken by the NHMRC towards water quality management and recognized similarities between the Australian approach and the proposed direction of the revision of the 3rd Edition GDWQ and endorsed this an appropriate risk management approach.

Risk-Based Framework
Meeting participants endorsed the overall approach proposed previously, linking risk assessment and risk management with both components clearly evidence-based.

The risk assessment component would need to take account of the occurrence and consequence of hazards and to include elements of hazard characterization and lead to the development of water quality targets based upon public health information and risk.

Meeting participants recommended that the risk management component be based upon two fundamental elements:
- System Assessment – an assessment of the system's ability to meet the defined water quality targets
- System Management – to ensure water quality targets are met
  - supporting programmes (good practice)
  - water quality production control (HACCP)

The risk assessment and risk management components would be supported by (routine and incident) management plans, corresponding documentation and by independent surveillance.

The purpose of system assessment would be to determine whether a supply system, of any type, from catchment to consumer could reach adopted water quality targets. The purpose of "system management" would be to ensure that adopted water quality targets were met in practice. It was noted that "management" in this context extended beyond the remit of any single agency and that inter-agency cooperation to ensure safe drinking-water supply was essential. HACCP was viewed as the principal tool to support good practice in management for safety.

An evidence-based, quantitative system assessment would provide a rational basis for selection of effective control measures or barriers which could be designated critical control points (CCPs) for the HACCP component and ensure that the collective impact of good practice through attention to CCPs would ensure safety.

The GDWQ WG planning meetings in Medmenham (1998) and Berlin (2000) advocated that an approach analogous to HACCP be applied to risk management in the 3rd Edition of the GDWQ. While this does not imply direct transferability, there are many lessons to be learned from the extensive experience obtained in the food sector. HACCP was developed as a management system for the operational side of food production. Risk assessment and recognition of the reality of non-zero risk create challenges to the application of HACCP to water supply that imply the need to address risk directly.

The participants agreed that the principles of HACCP were appropriate in the management of drinking-water safety. HACCP could be applied to various scales and supply types. Significant issues were raised regarding the adoption of (Codex Alimentarius) HACCP terminology for drinking-water from catchment to consumer, which was considered possible including the use of terminology already existing in the water industry to maximise understanding and acceptance.

HACCP is a component of a comprehensive drinking-water risk assessment/risk management framework. Participants recommended that in adapting HACCP to water supply, appropriate resource and source protection measures be control points to be individually addressed.

Access to control points in the catchment was seen as a major issue. One approach to achieving this is the establishment of multi-agency management approaches involving multiple stakeholders. Another difference to HACCP in many food applications is the typical need for a greater number of CCPs, potentially one for each barrier of a multiple barrier system. It was further recognized that giving examples of HACCP approaches and CCPs involves the potential pitfall of neglecting the specifics of each situation, and the discussions showed very clearly that all individual steps in the process of providing drinking-water are not CCPs. Rather, one-and-the-same step may be used as a CCP in one setting but not in another, depending on criteria such as criticality or accessibility. Meeting participants recommended desk top trialling of the risk management approach as a component of its development.

HACCP is viewed as one very helpful tool in the wider context of good practice and drinking-water hygiene. As such, it will be an important element of the revised GDWQ.

Water Quality targets
Meeting participants agreed that reliance on current parametric measures (e.g. *E. coli* counts) to ensure safe drinking-water was not adequate to manage water safety. It was recommended

that the GDWQ provide guidance on the selection of appropriate site-specific pathogens for the derivation of water quality targets. It was noted that such water quality targets would not be measured or assessed directly but would rather provide a basis for determining the adequacy of control measures (i.e. system assessment). Water quality targets would not be required for all pathogens, but for selected pathogens that represented the greatest overall challenge. These pathogens would vary from system to system according to for example, the principal sources of pollution. It was suggested that typically one or more from each of the major groups of pathogens of concern (protozoal cysts, viruses, bacteria) would be required. Priorities should be based on the health risk arising from occurrence of the hazard, not the characteristics of individual pathogens.

The concept of using individual pathogens to represent major groups of micro-organisms that contribute to the disease burden from drinking-water was discussed at length. Such pathogens should present greatest overall challenge to prevention of waterborne disease burden taking into account:
- prevention of disease burden (likelihood and severity);
- environmental occurrence;
- contribution of water to overall disease burden (potential impact of interventions); and
- availability of direct information or reasonable proxies.

The underlying assumptions relating to the use of such example pathogens include that if an example pathogen were controlled then at least equal level of health protection would be secured against other pathogens in group.

Hygiene Codes
Meeting participants endorsed the need for customised hygiene codes for many water supply systems as well as generic examples to support implementation, especially in smaller systems and developing countries. These should be reflected in both the GDWQ *per se* and in supporting texts, especially those on implementation, monitoring and surveillance, including GDWQ Volume 3. The Guidelines themselves should include one to three examples of worked out hygiene codes (see also section 4.20).

Indicators
The use of indicators within a risk management framework is an essential element for both monitoring the effectiveness of individual barriers and verification of the safety of the final products. Analyses for traditional bacterial indicators in consumer tap water is not an operational tool. Reliance on the absence of microbial indicators (particularly *E coli* and other coliforms) as a mangement tool has limited value and is minimized using a risk management, multiple barrier approach to water quality. Meeting participants endorsed the need to differentiate between indicators used for monitoring of processes to manage barriers and indicators used to verify end-product quality; and that different information was required from these different classes of indicators (this is also addressed in sections 4.17, 7.1 and 7.2 and Annex 15.

3.2   Reference level of Risk and Derivation of Health-based Water Quality Targets

Meeting participants recommended that the issue of reference levels of risk be discussed in further meetings concerning development of the GDWQ and that this be explicitly addressed in the third edition of the GDWQ. The draft text on this was discussed by participants (see

Annex 9). It was noted that coordination between the WGs on microbial aspects and on chemical aspects would be required to account for relative risk in guideline derivation.

Meeting participants agreed that a consistent approach to GDWQ development for chemical and microbiological aspects was preferable, based on a risk-based decision making. Meeting participants agreed that the proposed structure of the 3rd Edition of GDWQ be reviewed in light of the approach adopted for microbial aspects and in particular to move towards best-estimates of risk and risk-based decision making (reference level of risk) and also preferably towards common management approaches.

The need for a review document on the derivation of health-based water quality objectives was not foreseen at the Berlin 2000 DWQC meeting. However, the importance of using a common metric such as Disability Adjusted Life Years (DALYs) was noted both at the Berlin and Stockholm meetings. A draft paper on this issue had been prepared and was reviewed and discussed at the meeting.

The approach of using a common metric such as DALYs with a sound health basis was strongly endorsed. Participants noted that adopting such an approach would result in significant impacts on disease and drinking-water intervention priorities. Comments and discussion are summarized in Annex 9.

The overall recommendation was that the text be updated to take account of the reviewers' comments (see Annex 9). The text would then be presented for discussion at the forthcoming GDWQ/Manila meeting with the recommendation that it be considered by the final task force meeting (2002) as the basis for future guideline derivation for both microbial and chemical hazards.

The need for a substantive effort to ensure comprehension of the DALY concept as a "reasonable" and "rational" means to analyse diverse and complex health risks suggest a major commitment to communication issues.

The document had been prepared by Johan Melse and Arie Havelaar (RIVM, Netherlands). Reviewers nominated were: Douglas Crawford-Brown (University of North Carolina, USA), Pat Murphy (USEPA) and David Casemore (retired, UK) or Rachel Chalmers (CDSC, UK). Each hazard also requires a specialist reviewer Bill Reilly (Scottish Centre for Infection and Environmental Health) for *E. coli* O157, Chuck Gerba (University of Arizona, USA) for viruses, Dennis Juranek (CDC, USA) for *Cryptosporidium* and John Lee (PHLS, UK) for *Legionella*. Further reviewers with an environmental/public health perspective and familiar with the DALY concept should be included (possibilities proposed included WHO staff: Alan Lopez, Chris Murray, Annette Pruess, Carlos Corvalan; Professor K. Smith (University of California, USA) and Guus de Hollander (RIVM, Netherlands).

3.3 Quality of Evidence

Meeting participants endorsed the need to address the issue of quality of evidence in causality, in population dose-response and in the effectiveness of water-related public health interventions; and for a ranking scheme as proposed in the Stockholm meeting report. It was proposed that this be targeted for the rolling revision following publication of the 3rd Edition of the GDWQ.

3.4 Uncertainty in Microbial Risk Estimates

Meeting participants endorsed the use of best-estimates of health risk in order to better inform decision-making, and especially the move towards increased cost-benefit analysis in policy making. The importance of undertaking uncertainty analysis on risk calculations was emphasized and it was noted that having confidence in making "cost estimates" where there is significant uncertainty is more difficult than having confidence that estimates have been biased to over-estimate risk. This reflects a "trade off" between seeking more realistic risk estimates and how much confidence we can have in the estimates. In the case of pathogens we may be able to have much greater confidence in low-level risks than we can have with cancer risks where "one hit" risks are typically more than 10 to 15 orders of magnitude below the measurable effect levels. Meeting participants recommended that this recommendation, and its implications, be brought for the attention of the forthcoming GDWQ meeting in Manila and subsequently to the next DWQC meeting

3.5 Public Education/Awareness/Participation

Meeting participants agreed that perception of risk by the public did not necessarily equate to safety for drinking-water and that GDWQ should emphasize the importance of public participation and of specific measure to support dissemination of information.

3.6 Revision of Volume 1 of GDWQ

A preliminary draft of the major elements of the revised text of Chapter 2 (Microbial Aspects) of the 3rd Edition of the GDWQ was presented to the meeting and extensively discussed. The draft text was adopted as a working document and was revised during the meeting during a series of WG sessions. A modified draft was produced and recommendations were made as to its further development.

4. SPECIFIC RECOMMENDATIONS (DOCUMENTS IN DEVELOPMENT)

4.1 Hazard Characterization Document

Harmonizing approaches to hazard characterization for food safety and for water, sanitation and health as a WHO HQ component of risk assessment – risk management, is important and is being addressed in cooperation with RIVM (Netherlands) through development of a guidance document on the process of hazard characterization This document had not been discussed by the GDWQ WGs previously. The draft guidance document was discussed and comments are contained in Annex 3. General recommendations arising from discussion were that the document should be updated to take account for comments made and then subjected to further peer-review. Meeting participants recommended that efforts be made to ensure the document be applicable to both food and water; and that the document be applicable to pre-formed toxins with acute health affects with cross-reference to other documents dealing, for example, with toxic cyanobacteria.

Proposed peer-reviewers were: Desmond Till (Consultant, New Zealand), Peter Teunis (RIVM, Netherlands), Joe Eisenberg (University of Berkley, California, USA), Ursula Blumenthal (LSHTM, UK), (TDR at WHO). Already proposed as peer-reviewers are Joan

Rose, Chuck Gerba (University of Arizona, USA), Mark Sobsey (University of North Carolina, USA), Nick Ashbolt (University of New South Wales, Australia).

4.2 Pathogen Groups and Example Pathogens

Review documents on selected pathogens would be required in guidelines derivation and to support locally-specific risk assessment.

The meeting participants agreed on the relevance of *Cryptosporidium parvum* as a example pathogen for protozoan parasites but suggested the need to confirm equivalent protection against *Entamoeba histolytica*. Discussion focused on the relevance of bacterial and viral example pathogens, primarily around the importance of the natural history of *Vibrio cholerae*, the potential use of Enteroviruses as group representing viruses (alternatively hepatitis A or E or Coxsackie B virus) and the need to address both *E. coli* O157 and *Shigella dysenteriae* in order to account for pathogens with both human and animal sources. It was agreed that further review was required on the significance of sources of *Vibrio cholerae* to inform GDWQ development. *Legionella pneumophila* was discussed as a special case.

The 2000 meeting of the DWQC noted that risk assessments to support the derivation of GDWQ would be needed for selected pathogens only and adopted a template for the preparation of these documents. Meeting participants endorsed the need for a risk assessment document for each of the pathogens identified above. Annex 4 contains the recommended modified template for these risk assessments. It was noted that a number of common elements existed among the risk assessments for individual pathogens and it was recommended that a general introductory text be prepared containing these as outlined in Annex 5.

4.3 Cryptosporidium Risk Assessment

A draft risk assessment for *Cyptosporidium* was reviewed at the 2000 meeting of the DWQC. It was recognized as the type of information required to support guideline derivation. Specific comment on the draft was provided to the authors during the 2000 Berlin meeting and the document had been revised since that time.

Discussions concluded that there was substantive comment that needed to be taken into account prior to peer-review. Comments are contained in Annex 6.

The draft risk assessment had been prepared by Peter Teunis (RIVM, Netherlands), Gertjan Medema (KIWA, Netherlands) and Daniel Deere (Sydney Catchment Authority, Australia) Reviewers recommended: M. Sobsey (University of North Carolina, USA), N. Ashbolt (University of New South Wales, Australia) in addition to those proposed at the 2000 meeting of the DWQC who were Dennis Juranek (Centres for Disease Control, USA); Kim Fox (USEPA, Cincinnati), Rachel Chalmers (Communicable Diseases Surveillance Centre, UK) and/or David Casemore (retired, UK) and Paul Hunter (University of East Anglia, UK).

4.4 Enteric Viruses Risk Assessment

The preparation of a risk assessment for enteric viruses was recommended by the 2000 meeting of the DWQC and in subsequent discussion with meeting participants. The draft document had been prepared and was discussed by meeting participants.

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The adequacy of existing information on the sources, prevalence and significance of water-borne viruses were discussed in light of the use of reference pathogens. It was determined that significant inadequacies in the amount and quality of data was of concern when attempting to derive best-estimates for viral occurrence and concentration in developing and developed countries world-wide. It was noted that Professor Charles Gerba has completed a risk assessment for Coxsackie B viruses. Comments and recommendations regarding the draft text are included in Annex 7.

The need for text concerning selection of viruses to be included in the document was noted and the author of the document was asked to prepare a proposal to the Microbial Aspects WG as a first step towards its further development.

It was recommended that a more detailed review of available viral data be undertaken particularly for the potential example pathogens and that the format of the document conform to the general format agreed (Annex 4).

The draft document had been prepared by Willie Grabow (University of Pretoria, South Africa). Peer-reviewers proposed include Martha Sinclair (CRCWQT, Australia), Mark Sobsey (University of North Carolina, USA), Gertjan Medema (KIWA, Netherlands), Nicholas Ashbolt (University of New South Wales, Australia). Reviewers previously identified were Christine Moe (University of North Carolina, USA) and Pierre Payment (Canada).

4.5   *E coli* O157/*Shigella* Risk Assessment

The preparation of a risk assessment for *E coli* O157 and/or *Shigella* was recommended by the 2000 meeting of the DWQC and in subsequent discussion with meeting participants. Paul Gale (WRc, UK) was approached to develop the document. No progress has been made with its preparation.

Meeting participants endorsed the ongoing need for risk assessments on these key pathogens and recommended confirmation that this could be produced with the available time. The risk assessment(s) should be prepared according to the recommended template contained in Annex 4, noting the importance of difference in sources.

Will Robertson (Health Canada) offered to participate in the drafting of the RA.

4.6   *Legionella* Risk Assessment

The preparation of a risk assessment for *Legionella* was recommended by the 2000 meeting of the DWQC and in subsequent discussion with meeting participants. John Lee (UK) was approached to develop the document. The document was not tabled for detailed discussion at the meeting. Discussion and recommendations regarding *Legionella* risk assessment information and methodology are contained in Annex 8.

4.7   Further Risk Assessments
There was a further recommendation that risk assessments be produced for *Vibrio cholerae*, *Shigella dysenteriae* and *Campylobacter*. These may need to be based more extensively on

epidemology and there is a need to involve relevant specialists. The issues surrounding pathogen risk assessments were recommended to be raised at the final task-force meeting in 2002.

Potential reviewers were Patrick Grimont (Institut Pasteur, France) and Bill Reilly (Scottish Centre for Infection and Environmental Health).

4.8   Information on individual pathogens in GDWQ

Readers of GDWQ may expect information on specific pathogens and such information is not readily available else-where. The 2000 Berlin meeting recommended that WHO and IWA explore the potential for collaboration in this area. Meeting participant recommended that a collection of fact sheets would be best compiled in monograph format, as well as posted on a web-site to enable ease of update.

4.9   Groundwater Protection text

The 1996 meeting of the Protection and Control and Microbial Aspects WG in Bad Elster, Germany, recommended preparation of a text on the control of health hazards in drinking-water from various sources including groundwater. The 1998 (Medmenham) meeting further noted the need for guidance on spring protection and bank-side filtration. The development of a text on pathogen and indicator attenuation in ground-waters and the effectiveness of source protection measures was agreed at the joint meeting of the Microbiology and Protection and Control WGs (Medmenham, 1998) and an outline proposed.

This initiative was discussed at the Berlin (2000) DWQC meeting, at which discussion focused on its importance for the development of the third edition of the GDWQ and the need to merge this text with the need for broader guidance on resource protection, in preparation by the Protection and Control WG (including guidance on spring protection and bankside filtration). The three principal areas in which guidance was required were noted as: attenuation of pathogens and indicators in the sub-surface; the importance of well-head protection (sanitary completion) and the broader issues of groundwater quality management. Plans for this document, including substantial draft text, structure and scope of the monograph were reviewed at a dedicated planning meeting in February 2001.

Discussion outcomes and recommendations are contained in Annex 10. Meeting participants recommended that the document be completed as outlined taking into account the comments contained in Annex 10.

The document was being prepared by Oliver Schmoll (FEA, Germany), Guy Howard (WEDC, UK), Mike Barrett (Robens Centre, UK), John Chilton (BGS, UK) and Ingrid Chorus (FEA, Germany) Reviewers nominated were: Steven Foster (BGS, UK), Mr. Xu (Department of Water Affairs and Forestry, South Africa), Bukari Ali (University of Science and Technology, Kumasi, Ghana), Matin Ahmed (Bangladesh), Al Dufour (USEPA), Michael Taylor (New Zealand Ministry of Health), Peter Dillon (CSIRO, Australia), Richard Evans (Sinclair Knight Merz, Australia), Jack Schijven (RIVM, Netherlands) and Alec Percival (Australia).

4.10 Surface-water sources

At the Berlin 2000 DWQC meeting the need for information concerning surface-water quality and especially regarding the occurrence of pathogens (including those to be used in Guidelines derivation, noted in section 4.2) was noted and the development of a corresponding text, was recommended. Specific recommendations were made regarding coverage and orientation.

The protection of surface waters is important in regions where these are used as a source for drinking-water supply. Preparation of a monograph on surface-water protection to complement the outlined monograph on groundwater protection (section 4.10) was considered essential. Surface water protection is the first step in the management of a multiple-barrier approach for the protection of drinking-water. Moreover, source water quality determines the extent of treatment required.

This text should be clearly centred on health aspects and highlight the importance of avoiding upstream pollution for both pathogens and chemicals. It is suggested that the structure follows the principal sections as outlined for the groundwater monograph: (i) provision of scientific background information, (ii) information needed for both the characterization of the natural conditions and human and animal activities in the catchment, (iii) options for managing the catchment in order to avoid upstream pollution, and (iv) identification of critical control points and their verification.

Oliver Schmoll offered to prepare a detailed outline of the document by the Manila meeting in 2001, including suggested authors. A first draft of this text is planned to be available in Autumn 2002.

4.11 Drinking-water treatment

At the GDWQ meeting in Medmenham in 1998, the need for an expert review of the state of knowledge and available information on treatment efficiency and pathogen removal was identified. It was recommended that the review address disinfection and other treatment processes and that it emphasize quantitative aspects, to the extent possible. It was further noted that the review could become a free-standing publication as well as act as a source of information required for the development of the third edition of the GDWQ. A draft of the text was developed by Mark LeChevallier and reviewed at the Berlin 2000 DWQC meeting. It was felt to be of high quality and to have taken this guidance substantially forward; and specific proposals for improvement were made.

The revised text was reviewed and discussed by meeting participants. The results and recommendations of discussions are detailed in Annex 11.

It was agreed that the issue of toxic cyanobacteria, including both bacterial cells and toxins should be referred to in the text but not included in detail. Reference to the text *Toxic Cyanobacteria in Water* should be included.

The meeting participants endorsed the need to maintain a consistent approach with the use of HACCP terminology, mainly the designation of CCPs. Guy Howard (WEDC, UK) will liase with Mark LeChevallier (AWWSC, USA) to update CCPs in line with the approach recommended at the meeting.

The previous recommendation regarding the need to include case studies of global applicability was repeated and endorsed.

It was recommended that the text in its current form be submitted for peer-review and that comments from the meeting be incorporated as part of the peer-review process.

The text had been prepared by Mark LeChevallier (AWWSC) and Kwok-Keung Au, (AWWSC). Reviewers proposed to date are: CINARA, Colombia; VITUKI, Hungary; Professor Ohgaki (University of Tokyo) with AIT; NEERI, India; Peter Huck (University of Waterloo, Canada), Chuck Haas (Drexel University, USA); Malay Chauduri (Indian Institute of Technology, Kanpur, India); Dr Endo (NIID, Japan), Dan Smith (University of Alberta, Canada). Mary Drikas (AWQC, Australia) and Tom Hall (WRc, UK) were added to the review list. Michael Taylor offered to contribute to review also.

4.12 Fluctuation in treatment efficiency

The need for a review document on fluctuation in efficiency of treatment was not foreseen at the Berlin 2000 DWQC meeting, although its importance for the above-mentioned treatment text was noted in discussion. The importance of the issue was also noted at the Stockholm meeting. In attempting to prepare the first draft of the revised GDWQ, the need for such a review had become evident.

The concept of using mathematical models to determine the impact of nominal and failure modes of treatment performance was introduced by Peter Teunis (RIVM). The benefit of multiple barriers for incremental risk reduction can be quantified using a simple mathematical model, supporting established views on its significance. The use of a fixed binomial model showed that a low percentage of treatment failure can significantly impact the theoretical infection risk for consumers. Challenges to modelling real world drinking-water systems arise from the need to include identified failure modes within process control, survival analysis and the incorporation of time-series data. It was noted in the presentation that the concept of HACCP being able to minimize fluctuations needs to be further investigated.

Discussion summary is contained in Annex 12.

It was recommended that the concept of barriers which are themselves influenced by the action of other barriers need to be included using real world data. Meeting participants recommended that the text be a stand-alone document and include variations in source water-quality. A small team was invited by the meeting to determine if information from the modelling document should be included into the Treatment Text document or be considered as a separate monograph to be referred to in the GDWQ and report back and prepare a concrete proposal **and that preparation of a draft should be targetted for the end of 2001.**

Chuck Haas (Drexel University, USA) had been approached to be substantively involved in this area of work and had indicated his interest in this. The proposed team comprised Daniel Deere (Sydney Catchment Authority, Australia), Al Dufour (USEPA) and Peter Teunis (RIVM, Netherlands) who would also consider the involvement of Dr Haas in drafting. Informal offers of support have been received from Eureau and Vivendi. Michael Taylor expressed interest in contributing to eventual review.

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4.13 Water-quality changes in piped distribution sytems

At the GDWQ WG meeting in Medmenham, 1998, it was recommended that a text be developed concerning water-quality changes in piped distribution and storage. Relevant issues identified included leakage, low pressure, discontinuous pressure and discontinuous supply in relation to recontamination of water in the distribution system; good hygiene practice during repair and installation; and re-growth.

At the Berlin 2000 DWQC meeting it was noted that public health oriented monitoring of microbial water-quality should be based on that consumed (i.e. collected from the tap) and not simply water in supply. Problems of maintaining water-quality within storage tanks and containers in the home were highlighted, as were data that highlighted health impacts and contamination through cross-connections and back-siphonage, in addition to ingress. Critical aspects were identified as opportunities for, and development of, sanitary inspection for piped systems; identification of CCPs and approaches to verification of quality.

The full first draft document was reviewed and discussed at the meeting with summary and comments contained in Annex 13.

Meeting participants noted the need to re-balance the document to better emphasise health concerns and in particular the importance of barriers to ingress of pathogens and less on regrowth issues; and also endorsed the need to include consideration of risk management principles throughout the document. Melita Stevens (Melbourne Water Corporation, Australia) offered to liase with chapter authors on the adoption of a risk management approach.

It was recommended that information from the outstanding Chapter 6 relating to prevention of back-siphonage be incorporated into Chapter 3, underpinned by information supplied by the Water Services Association of Australia (WSAA). The development of Chapter 6, was not considered necessary in light of the preparation of a dedicated text on this theme.

It was agreed that the document should include discussion on small systems as a new chapter. Guy Howard offered to assist in the development of the sanitary inspection and small system components of this document.

Preparation of the document has been led by IWA through Richard Ainsworth. Potential reviewers included: Ray Morris (IWA); Guy Howard (WEDC, UK); Mike Smith (WEDC, UK); Mark LeChevallier (AWWSC, USA); Dick van der Kooij (KIWA, Netherlands); Ed Geldreich (retired, USA); Anne Camper (Montana State University, USA); Stig Regli (USEPA); Jean-Claude Bloch (University CNRS, Vandoeuvre, France); Ken Robert (USEPA); and Don Reasoner (USEPA).

4.14 Water-quality changes in non-piped distribution and household management

The need for guidance in this area for developing countries in particular was agreed at the Berlin 2000 meeting. A draft report was tabled at the meeting with extensive review and discussion, with a summary and outcomes contained in Annex 14.

Meeting participants agreed that the document should be amended to include epidemiological evidence. Tables of inactivation rates of micro-organisms were considered very useful.

Participants agreed that care should be taken to ensure that advocacy of household treatment should not be interpreted as a justification to downgrade community water supplies.

It was concluded that some text about household water treatment should be included in the main text of the GDWQ, including a statement regarding what evidence is available on efficacy, inactivation and intervention to support GDWQ development.

Meeting participants recommended that the comments and recommendations be addressed in improving the document which should then be submitted for peer-review.

The document had been prepared by Mark Sobsey (University of North Carolina, USA). Offers of support had been received from Eric Mintz (CDC, USA) and Han Heijnen (WHO staff), the latter in relation to rainwater catchment. Potential reviewers proposed previously were: Robert Quick (CDC, USA); Felipe Solsona (WHO/PAHO CEPIS); Caroline Chang (WHO/PAHO, Ecuador); and Steve Gundry (University of Edinburgh, Scotland). Reviewers added during the meeting were: Gerhard Offringa (WRC, South Africa); Willie Grabow (University of Pretoria, South Africa); Teechat Boonyakarnkul (Ministry of Health, Thailand); Guy Howard (WEDC, UK; and Martin Wegelin (SANDEC, Switzerland).

4.15   Indicators text

At the meeting in Medmenham in 1998, meeting participants noted the absence of an authoritative review of microbiological indicators in relation to health concerns in drinking-water quality; and also noted the material present in the Volume 2 of the 2nd edition of the GDWQ. Participants at that meeting recommended that a review be prepared and considered its publication as a free-standing product appropriate. The document was being prepared in collaboration with the OECD. OECD interest in the theme derived from a series of conferences, most recently at Interlaken in 1998. Drafts were reviewed at a meeting in Basingstoke, UK in July 2000 at a UK/DWI-organized seminar and at a technical finalization meeting in November 2000, in Kuesnacht, Switzerland supported by ICD and hosted and organised by EAWAG.

Concern was raised that the content of the text did not meet the proposed objectives. It was noted that there was a lack of direction and objectivity within the text and some use of outdated information including some incorrect interpretation of the significance of indictors for drinking-water quality. It was considered that significant effort would be required to improve the structure of the text and to improve its content before the document would be suitable for peer-review.

It was noted by reviewers that the text contained valuable general information, but that the present text was not adequate to support GDWQ derivation. Comments and recommendations are contained in Annex 15.

Reviewers proposed previously were: Ray Morris (IWA) and Paul Berger (USEPA). Additional reviewers identified at the meeting were: Mark Sobsey (University of North Carolina, USA); Chuck Gerba (University of Arizona, USA); and Joan Rose (University of South Florida, USA).

4.16 "Loop closing" - public health surveillance

The "Stockholm framework" (see Fewtrell and Bartram 2001) advocated that risk assessment–risk management be seen as a cyclical process with embedded feedback. This should be reflected in the GDWQ, but is weak in the second edition.

A presentation on the role of public health surveillance was made, outlining the advantages and disadvantages of current methods used to identify waterborne illness within communities. Discussion centred around the usefulness of epidemiological studies in developing and developed countries and the discrepancy between measured disease outcomes using health surveillance and risk estimates calculated using quantitative microbial risk assessment.

It was recommended that the Guidelines per se include a section on public health surveillance. Michael Taylor offered to participate in the further development of this aspect.

4.17 Drinking-water supply surveillance

A presentation of the role of public health oversight of drinking-water supplies was made by Desmond Till (Consultant, New Zealand) on behalf of Michael Taylor, (Ministry of Health, New Zealand). This outlined the role of systematic review by public health authorities to ensure that water-quality management strategies developed by the water supplier are appropriate, and are being reliably implemented. Discussions centred on the need for such assessment to focus on assessing the effectiveness of barriers, control points and associated management measures throughout the entire water supply chain.

It was agreed that a short section on drinking-water supply surveillance should be prepared for inclusion in the GDWG which should explicitly address this aspect.

4.18 Hygiene codes

The need for an overview document describing the application of safety management approaches including HACCP to water supply was not foreseen at the Berlin 2000 DWQC meeting, although the importance of this for the GDWQ was noted in discussion. The importance of the issue was also noted at the 'Stockholm' meeting. In attempting to prepare the first draft of the revised GDWQ, the need for such an overview had become evident. Guy Howard (WEDC, UK) had prepared the overview, which has entailed liaison with those leading preparation of most of the above-mentioned texts.

Meeting participants agreed that the text discussed should be further developed, including structuring to more closely reflect the HACCP-type approach.

Preparation of hygiene codes should be concluded before the GDWQ final Task Force meeting and will require coordination with other sustantiation documents. Work after the final Task Force meeting should focus on integration of these into guidance documents (including guidance on surveillance and control in rural and urban community water supplies) and on dissemination of these guidance resources. Efforts should be made to ensure materials are widely available, for example through the watermark internet site and an interim document.

Guy Howard (WEDC, UK) agreed to continue to liase with those developing individual documents to ensure consistency in this area; and to work with Melita Stevens (Melbourne Water Corporation, Australia) and/or Dan Deere (Sydney Catchment Authority, Australia) to draft a text on the applicability of HACCP principles to water supplies, for inclusion in the two monitoring volumes and associated background material in preparation. This would illustrate how control points can be arrived at from an understanding of hazards and entry points into the water supply and provide examples of how the different hygiene codes would fit together into a catchment to consumer chain with multiple barriers in different scenarios. Alan Godfree (North West Water, UK), Samantha Rizak (CRCWQT, Australia), and Gertjan Medema (KIWA, Netherlands) were recommended as reviewers.

4.19 Toxic cyanobacteria

Where appropriate, guidance on toxic cyanobacteria will be integrated into Volume 1 of the GDWQ, particularly in chapter 2.

The WHO monograph "Toxic Cyanobacteria in Water" has been seen as an authoritative and comprehensive work and has gained acceptance within both the water management and public health fields in many countries. It filled a need for a document which incorporated advice on health significance (hazard and risk assessment), water quality management and treatment. The document focused on the incidence and significance of the toxin microcystin, due to the strong knowledge base on this toxin, and availability of toxicological information to enable guideline derivation. This continues to be important. However there is now evidence that other toxins are also important in some countries, e.g. cylindrospermopsin associated with *Cylindrospermopsis raciborskii*. Since the publication of the first edition of this monograph, both the recognition and management of toxic cyanobacteria has received greater attention in many regions.

The need for a second, updated edition of 'Toxic Cyanobacteria in Water' was acknowledged at the meeting in Berlin 2000 (see report). New developments and issues now evident for the second edition are listed in Annex 16. Ingrid Chorus offered to discuss initiation of updating of this text, with relevant experts using the 5th International Conference on Toxic Cyanobacteria in July 2001 as a forum for compilation of the scientific evidence needed. A draft is envisaged by early 2003. As documented in the Berlin meeting report, guideline value suggestions for further cyanotoxins will go through the informal procedure.

4.20 Legionella management

Meeting participants noted the need to address Legionella in the GDWQ and endorsed pursuit of a document encompassing both risk assessment and risk management aspects and following the wider approach being developed for microbial hazards in the GDWQ.

4.21 Water-quality for travellers

Following the recommendations of the GDWQ meeting in Berlin, a document on this theme had been put together by NSF-International for the Protection and Control WG and was presently under for peer-review. The approach taken in the document is not fully consistent with the approach taken by the Microbial Aspects WG in GDWQ revision, with regard to performance targets. The meeting supported the need to have the document revised to take account of this and then to be reviewed by the Microbial Aspects WG.

5. MICROBIAL ASPECTS WORKING GROUP

The meeting endorsed the nomination of the following individuals as members of the Microbial Aspects WG, with the objective of ensuring longer-term perspective and quality control and oversight of working group products:

- Theechat Boonyakarnkul, Ministry of Public Health, Thailand
- Willie Grabow, University of Pretoria, South Africa
- David Cunliffe, South Australian Department of Human Services, Australia
- Mark Sobsey, University of North Carolina, USA
- Arie Havelaar, RIVM, the Netherlands

6. PLAN OF WORK

6.1 Timetable

The plan of work addresses both the development of individual documents to substantiate and to support the implementation of the Guidelines; and the development of the text of the Guidelines *per se*. The overall objective agreed as realistic was to work towards the implementation of the Final Task Group meeting for the third edition in December 2002.

For the various texts which substantiate or support the implementation of the Guidelines, it was agreed that as far as possible, these should be available at the time of the Final Task Group meeting for the third edition and that these should be in the most advanced state achievable (i.e. in some cases published and, in most cases, ready to publish). The timeline for individual documents is summarized in the Table below.

WHO Guidelines for Drinking-Water Quality - 3rd Edition – WORKPLAN

	2001								2002												2003				
	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
Main Text							M				IWA										GDWQ FINAL TASK FORCE MEETING				
Cryptosporidium RA								WG																	
DALYs							M																		
E. coli O157 RA								WG																	
Enteric Viruses RA								WG(1)																	
Groundwater							M																		
Hazard Characterization																									
Household																									
Hygiene Codes(2)																									
Legionella RA + Management								WG																	
Other RA (x3)																									
Peak Events																									
Piped Distrbution								WG																	
Surface Water							M																		
Testing/Indicators	Pending discussion with authors and OECD																								
Treatment																									
Generic Risk Assessment																									
Drafting																									
Peer-review																									
Public domain																									
Manila meeting	M																								
Working Group Review	WG																								
IWA Conference	IWA																								

1 initial review by working group and authors of Cryptosporidium risk assessment

2 drafting of hygiene codes as such until August 2002; thereafter an integration of codes into guidance documentation including GDWQ volume 3

6.2   Developing understanding of and support for the new approach

Since the overall approach to microbial aspects in the Guidelines *per se* represents a significant development taken compared with the existing edition, it was agreed that it was important to disseminate information on this and seek further feedback upon it. For this purpose, a short (e.g. four-page) briefing note should be prepared. This should be translated and disseminated among all WHO regions, inviting comment. Opportunity should be taken to present and seek feedback upon the approach at suitable international meetings. Potential events included the AWWA/EUREAU/WSSA meeting in Bonn, in October 2001 and the IWA Congress in Melbourne in April 2002. WHO Regional Offices should be encouraged to act similarly at suitable regional events, also, including those scheduled by WPRO during 2001. The interest of PAHO/CEPIS in the GDWQ was noted in this regard. Information on the updating of the GDWQ should be disseminated through the WHO internet site, including the briefing note on the process and a list-server should ideally be established for this purpose.

7.   OTHER BUSINESS

7.1   H₂S test

WHO receives many requests for information and comment on this microbiological test. It is a potentially important issue particularly for developing countries. Some trials have been undertaken in India, and these data have been made available for WHO to comment on. The Microbial Aspects WG supported the view that a critical review of the significance and applicability of the H₂S test should be added to the work programme of the WG. Within the WG, Mark Sobsey will be the leader of this investigation. Individuals identified as potential reviewers were: Roger Fujioka (University of Hawaii, Hawaii, USA), Mark LeChevallier (AWWSC, USA) and Guy Tarantos (University of Puerto Rico). The work of Wesley Pipes, which founded presence/absence tests, was recalled and its importance and relevance noted.

7.2   Heterotrophic Plate Count Bacteria (HPC)

Regulation of Heterotrophic Plate Count (HPC) bacteria is an emerging issue for drinking-water systems, particularly plumbed-in household appliances. An offer has been made to WHO from NSF-International, a WHO Collaborating Centre, to support an international meeting on this issue, following which a small group would draft a position on HPC for consideration within the GDWQ process. Nicholas Ashbolt (University of New South Wales, Australia) was recommended as an appropriate participant.

7.3   Items on Microbial Aspects WG Programme of work not placed on the agenda of the meeting

* Information on specific pathogens

7.4   Items on P&C WG Programme of work not placed on the agenda of the meeting

* Nitrate and nitrite (to be on the agenda of the meeting in Manila in November 2001).
* Materials and chemicals used in production and distribution of drinking-water (to be on the agenda of the meeting in Manila in November 2001).
* Packaged water.

- Management of *Legionella*.
- Household plumbing (to be on the agenda of the meeting in Manila in November 2001)
- Arsenic in drinking-water.
- Disinfection practice.
- Desalination.
- Indirect re-use.
- Monitoring and assessment – urban.
- Monitoring and assessment – rural.
- Trans-boundary waters.
- Chemical spills and exceedences.
- Water-quality in emergencies.
- Laboratory quality.
- Chemical monitoring protocol.
- Information for the public.
- Fluoride in drinking-water.

7.5   Research issues

During the course of the meeting a number of research issues of high priority for the further development of guidelines as follows:

- Risk assessment of regrowth microorganisms
- Validation of risk assessment for *Cryptosporidium* Genotype 1 against epidemiological evidence
- Sources of viruses (human/non-human), for instance adenoviruses
- Occurrence concentrations for pathogens in different source waters and removal during treatment processes
- Case fatality rates for *Cryptosporidium parvum*
- Relationship between travel times and die-off for pathogens in groundwater
- Wider application of QMRA

8.   ADOPTION OF REPORT

The draft meeting report was adopted by meeting participants and after editing was endorsed by the proposed members of the microbial aspects working group.

9.   CLOSE

WHO thanked the meeting organizers, participants and observers for their contributions. The National Health and Medical Research Council (NHMRC), the CRC for Water-Quality and Treatment were thanked for their sponsorship and hosting of the meeting. The Water Services Association of Australia (WSAA) was thanked for their support of the previous weeks meeting.

Annex 1

MEETING ON EFFECTIVE APPROACHES TO REGULATING MICROBIOLOGICAL WATER-QUALITY

Adelaide, Australia 14-18 May 2001

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* Invited, but unable to attend.

Annex 2

MEETING ON EFFECTIVE APPROACHES
TO REGULATING MICROBIOLOGICAL WATER-QUALITY,

Adelaide, Australia, 14-18 May 2001

Monday, 14 May
1. Welcome from hosts
2. Welcome from WHO
3. Scope and objectives of meeting
4. Nomination of Chair and Rapporteurs
5. Adoption of agenda
6. Introduction of participants
7. "Stockholm framework"
8. HACCP in the food industry
9. Australian Approach to Drinking-Water Quality Guidelines
10. Introduction to draft Guidelines text
11. Discussion of items 5 – 8

Tuesday, 15 May
12. Hazard Characterization document
13. Pathogen Risk Assessments
14. *Cryptosporidium* Risk Assessment
15. Enteric viruses Risk Assessment
16. *E coli* O157/*Shigella* Risk Assessment
17. *Legionella* Risk Assessment
18. DALYs paper
19. Discussion on risk assessment in GDWQ based on presentations 10 – 16

Wednesday, 16 May
20. Treatment text
21. Fluctuation in treatment efficiency
22. Surface Water Sources
23. Groundwater text
24. Water-Quality Changes in Piped distribution systems
25. Water-Quality Changes in non-piped distribution, and household management

Thursday, 17 May
26. HACCP overview paper and discussion of control points in agenda items 18 – 22
27. 'Indicators' document, and discussion of 'verifications' in agenda items 18 – 22
28. 'Loop closing' – Public Health Surveillance
29. Working Group Session

Friday, 18 May
30. Working Group Session
31. Plan of work
32. Any other Business
33. Adoption of Report
34. Close

Annex 3

HAZARD CHARACTERIZATION TEXT

General

The draft document was considered confusing and rather incomplete and needed further development and peer review. Some parts were very detailed, where others were cursory in content. It could, however, provide a practical and structured approach for the characterization of microbial hazards, when modified.

The document requires considerable modification to emphasize the differing roles of food and water as it is heavily biased towards food. While it is accepted that food and water are both consumed, there are inherent differences in the two with regard to hazard characterization, that the document does not address. A few simple examples are: food as a substrate is likely to contain greater nutrient factors for microbial growth than water; the pH can be quite variable for food, either restricting or enhancing microbial growth, whereas water is usually in a favourable range for the survival of micro-organisms; many foods customarily are subject to heat treatment prior to consumption which is not always the same for water and also with some food micro-organisms there is potential for toxin production, which appears not to be addressed.

Examples are required relating to water on hazard identification, and hazard characterization, leading to risk characterization or estimates for a given population.

- The document in its present form is very large and could be even larger with the additional detail required. The detail required is complex, particularly regarding dose response modelling.
- The GDWQ could contain references for water to the appropriate sections of the WHO-FAO guidelines on hazard characterization for details when the document is completed, incorporating the previous suggestions.
- Whilst much information was brought together the hierarchy remained unclear.
- Guidance for a tiered approach should be more specific.
- The document is not well structured at present: revised section numbering may improve this.
- The level of guidance provided is unbalanced, especially with respect to dose response models, which are treated in great detail as opposed to other empirical methods, which would be needed to analyse some of the proposed data sources.
- Tighter integration between data categories and (specified) analysis methods is needed as is specific guidance relating data categories to models to models/statistical methods.

Purpose/Scope

It is conspicuous that on page 6 "Scope": only bacteria and viruses are noted and not protozoa (or other metazoan parasites). Their coverage is essential if the document is to be applicable for water.

Data collection/evaluation

- Excellent part on discussion of data and their significance/use.
- Important detail missing in the sections on human data (except feeding studies): asymptomatic cases. These are important for public health (as these subjects still may shed pathogens) and are usually not studied.

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- Various data sources: distinguish the inclusion of heterogeneity from specifying heterogeneity. The latter would be most informative for modelling purposes but may not often appear possible.
- Formulate research priorities for data collection: what would help most to advance hazard characterization further.

Analysis
- Provide more explicit guidance for tiered approach, with respect to dose response modelling in particular.
- The tables on pages 20-22 (Tables 1, 2, and 3) might need a reference to the ILSI framework for QMRA.
- Stronger integration with data would be useful.
- Slightly unbalanced parts on model selection: the discussion of the single hit/independent action issues is treated in extensive detail, other important issues (identifiability, segregation between pathogen/host factors and quantal data, etc.) are treated only very briefly.
- A little more elaboration on end-points past infection/acute illness: population measures, common metrics like the DALY, disutility.
- Formulate research priorities for model development: what would help most to advance hazard characterization further.
- Discussion of the feasibility/usefulness of population transmission models (secondary transmission, dynamic aspects); e.g. see corresponding chapter of the ILSI book, which gives a brief overview.
- The distinction between random distributions and non-random distributions as discussed on page 25 is incorrect: for instance, the negative binomial distribution is just as much a random distribution as the Poisson distribution.

Additions/Appendix/References
- Provide an appendix introducing/discussing important basic technical issues (concepts of probability, likelihood, uncertainty).
- Provide annotated list of references: which references are available for which problems/issues?

Conclusion
The document is not complete, needs to give more guidance, particularly practical guidance on how to integrate data sources, models, and statistical methods. In its complete format it should stand alone as a reference monograph for both food and water. The GDWQ should contain reference to appropriate parts of the monograph and in its modified form would provide the detail needed for the use of the guidelines.

Additional Comments from Group Discussion
- Emphasize the importance of occurrence of micro-organisms in clumps.
- The importance of the issue of viability of environmentally occurring pathogens: freshly released pathogens may be more infectious than those that have been in the environment for a long period (ageing - decreased infectivity). We need to consider the (physiological) state of the organisms: are they injured or not, what about the infectivity of viable but non-culturable pathogens?
- Survival of the various barriers to infection should be differentiated with respect to the delivery matrix (adaptations to low pH conditions, for instance).

- Would it be possible to find a dose response relation for severity as an outcome?
- Dynamic approach may be necessary to include development of immunity, age-related susceptibility.
- Data acquisition: look at pre-exposed populations to consider immune/defence responses.
- When is there sufficient information to separate variation from uncertainty?
- Bias neutral approach should be explained more prominently: not worst case choices, propagation of uncertainty (Monte Carlo methods).
- Intoxications related to pathogenic micro-organisms are missing. Pre-formed toxins should be treated (or at least referred to). Toxins may cause acute effects, but also long-term effects, even after a single exposure. Should long-term effects (delayed sequelae) be included? Some discussion on this subject, proposal to only include long-term effect resulting from short-term (single event) exposure, and leave effects resulting from chronic exposure to toxicologic arena (c.f. cyanotoxins).
- Other aspects not covered: inhalation/dermal exposure (staphylococci, clostridia), other ingested metazoan parasites (helminths). Inhalation and helminths are important issues in developing countries.
- It was noted that exposure to pre-formed toxins/chronic exposure do not fit comfortably alongside the hazard characterization document in its present state.
- It was agreed that guidance to research priorities would be an important and cost-effective spin-off.

Annex 4

PROPOSED GENERIC RISK ASSESSMENT TEMPLATE

Purpose of document

To provide information and guidance to risk managers on how to apply the risk assessment framework for:

- Prevention/control of epidemic and /or endemic transmission;
- Determine/demonstrate/verify the level of protection of the population served by a specific water supply;
- Determine management options for adequate control of risk of disease transmission through drinking water.

Target audience

Persons responsible for setting standards for drinking-water, evaluating adequacy of drinking-water quality or water treatment, and /or controlling infectious disease and persons in water utilities responsible for system design, implementation and supervision. The information should be targeted at application in both high and low-tech applications.

Publication format

Each document should be of 30 to 50 pages and should ideally be published separately on the internet and in a printed version that can be organized and easily updated, for instance in a loose-leaf binder. An introductory chapter on microbial risk assessment approaches and application of the information from the documents in risk management will precede the pathogen-specific text. The approaches to assess health risk that will be described are microbial risk assessment (either qualitative or quantitative) and epidemiological studies. The *Cryptosporidium* text provide a detailed example of stochastic analyses in quantitative microbial risk assessment; others are expected to be more concise.

Suggested content

Describe the risk assessment approaches that can be used for the pathogen. The approaches described can be the microbial risk assessment or epidemiological studies, or both.

In the epidemiological approach, the health effect and burden in the exposed population is measured and an attributable risk to water or the risk reduction by an intervention (e.g. treatment barrier) is estimated by simple statistical methods.

In the microbial risk assessment approach, the exposure of the population to the pathogen is assessed and the health risk is estimated using dose-response data. Describe the available information on health effects and health burden of the pathogen, the available dose-response information and how to assess exposure to the pathogen through drinking-water. Describe how to combine this information to assess health risk.

Provide two or three worked-out typical examples of a risk assessment in different water supply situations where the pathogen poses a potential risk in drinking-water. Show the estimate of risk based on the evaluation of exposure and effect assessment, and discuss potential effectiveness of feasible risk management options.

It is possible but not required to use a stochastic approach to the risk assessment (the approach used in the *Cryptosporidium* text); however, when providing a point estimate of risk, it is important to discuss variability and to provide, to the extent that information on the distribution of a key variable exists, a quantitative estimate. In addition, it would be useful to provide some kind of a sensitivity analysis to illustrate which uncertain or variable factors are most important in determining the level of risk and what the effect of variation of their values in a reasonable range would be. The level of detail in the analysis will depend to a large extent on how well different factors are understood. If no adequate data is available, reasonable default values should be suggested.

1. Rationale for pathogen selection

1.1   Introduction to the pathogen. Discuss whether it could be used as surrogate/index for other pathogens.

1.2   Table of pathogen characteristics

Pathogen characteristics	Rating/comment
Epidemiological evidence of waterborne transmission	[high, medium, low]
Health burden, DALY	[high, medium, low]
More difficult to remove at system barriers	[high, medium, low]
Sufficient high quality data available for risk assessment	[high, medium, low]
Ability to proliferate in water	[high, medium, low]
Epidemiological evidence of waterborne transmission	[high, medium, low]

1.3   Taxonomic position

1.4   Life cycle - numbers excreted from major hosts (may be tabulated)

1.5   Epidemiology – disease (focus on estimating burden of disease (mortality rates, severity, incidence, duration), immunity, prevalence, routes of transmission (range of hosts), lessons from waterborne outbreaks (may tabulate deficiencies and situations).

1.6   Features that make it difficult to remove at treatment barriers (persistence, disinfection resistance). Discuss biological features important to environmental persistence.

1.7   Table of CT/IT for disinfection.

2. Problem formulation

2.1   Risk management requirements for prevention of the pathogen
(description of the range of sources [catchment-to-consumer] and identification of those that may be controllable. Hence, description of the system boundaries important for the pathogen for both conventional distribution and non-piped systems.

2.2   General description of various types of hazardous scenarios that make systems vulnerable to the pathogen (and its surrogates). [Specific examples in Case Studies]. Provide the likelihood of hazard occurrence and their significance clustered into risk scenarios. Such scenarios should include a baseline ("normal" condition) as well as events that are likely to result in peaks of pathogens. In addition to the normal scenario, two or three "event" scenarios could then be selected as additional examples for risk assessment.

2.3   Identification of manageable control points for the reference pathogen within the two generic types of system structures.

3.   Exposure assessment
MRA
3.1   Description of the information necessary to assess consumers' exposure via drinking-water. For individual examples discuss the approach to estimating variability of pathogen occurrence, e.g., peak occurrence events, associated frequency and how, and to which extent, different factors contribute to variability of pathogen exposure.

3.2   Methods of direct analysis and their limitations when applied to water through the supply system. Discussion of physical presence-type assays versus measures of 'viable' and 'infective' pathogen numbers. Indication of the error in assays and appropriate quality control strategies, including assessment of method performance (pathogen recovery from water and reproducibility of assays).

3.3   In estimating the health effects associated with a given exposure, while data are primarily presented for healthy adults, more detailed assessments should be considered for those in the 'normal' population that are more vulnerable (e.g. children or adults who might be at higher risk of serious illness). The effects of immune system impairing illnesses such as HIV/AIDS should be noted to support separate development of appropriate advice.

3.4   Description of surrogates to measure at barriers to better ascertain decimal reductions, necessitated due to the likelihood of low pathogen numbers through treatment.

3.5   Discuss data on stochastic approaches available for exposure assessment.

3.6   Summary tables:

Table   Example concentration of pathogen in source and drinking-waters

Country	Nature of catchment	Source #/L	Finish #/L	Treatment train	Ref.

Table Reduction of pathogen by well-designed and operated treatment processes

Type of process	Removal by barrier ($\log_{10}$-units)	Most important efficiency-determining parameters
Raw water storage		
< month		
> year		e.g. Short-circuiting
Groundwater		
Suficial systems		
Deep aquifers		
Disinfection processes		
Chlorine		e.g. dose, turbidity, disinfectant demand etc

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Chloramines	
Chlorine dioxide	
Ozone	
UV	
Filtration processes	
Coagulation/filtration	
Rapid sand filtration	
Slow sand filtration	
Diatomaceous earth	
Membrane filtration	e.g. Membrane pore size, water flux
Other	
Soil passage	
Distribution	
With residual disinfectant	
Without disinfectant	

Epidemiological studies
3.7   Describe the use of proxies for epidemiological studies (e.g. faecal indicators, monitoring data describing efficiency of intervention in intervention study)

4.   Health effect assessment

MRA
4.1   Description of human feeding trials and quality of data (actual pathogen numbers ingested, status of pathogen fed and numbers and types of humans exposed).

4.2   Apply dose response model(s), if available, or reasonable assumptions to estimate population risk of relevant health effects. Summary of single-hit model results recommended for use for the reference pathogen. Brief discussion on stochastic approach in a box. The analysis should consider risk in a previously unexposed population and, to the extent that exposure is known to confer some level of immunity, the analysis could also consider a previously-exposed population. If secondary transmission is known to be a major factor in the spread of disease, an approach to estimating its effect could also be discussed.

Epidemiological studies
4.3 Describe the application of epidemiological studies (intervention studies) to collect health effect data and conduct its analysis.

5.   Risk characterization

MRA
5.1   Summary to pull together exposure assessment and dose-response to present results as infections per year and DALYs.

5.2   Highlight uncertainties and their effects on the risk characterization. List assumptions of disease end-point(s) used in DALY estimation.

Epidemiological studies

5.3   Summary of health effects assessment using epidemiological studies, typical reduction in disease burden by an intervention or by means of a different drinking-water supply.

5.4   Highlight uncertainties and their effects on the risk characterization.

6.   Risk management options

Evaluation and discussion of generally available risk management strategies.

7.   Research priorities

7.1   Prioritise data needs in order of what MRA model is most sensitive to and where greatest uncertainly lies with existing data.

7.2   Focus on needs for a risk management as well as the science of risk assessment.

8.   Case studies

8.1   Conventional distribution system with pathogen data

8.2   Non-piped system

8.3   How to undertake MRA when no actual pathogen data is available.

Annex 5

PATHOGEN RISK ASSESSMENT FRAMEWORK- GENERIC MRA APPROACH

Proposed Contents

Preface

Introduction

Approaches to assess microbial risk

Epidemiologic-based assessment
Qualitative assessment
QMRA Process
Problem formulation
Exposure assessment
Dose-response models: His theory model for infection
Risk characterization

Summary and advice for risk management

References

Annex 6

COMMENTS ON THE DRAFT *CRYPTOSPORIDIUM* RISK ASSESSMENT TEXT

- Define its purpose and target audience and how and for what purposes it will be used by them. The document is less applicable or useful for small water supplies, less knowledgeable persons in water community, developing countries and non-piped supplies.
- The document is a comprehensive risk assessment directed primarily at developed countries and piped supplies.
- The document can be condensed, more and consistent use of boxes for much of the detail.
- Case studies focus on risk management approach, not just QMRA, but it was questioned if all seven were necessary?

Introduction
It is unclear from the title versus preface (MRA+RM) that this Chapter deals with data needs and method to undertake WHO's Risk Management framework for *Cryptosporidium*.

Problem formulation
Integrate with HACCP and 'Risk Management' actions. Terminology: use of "tolerable risk" "acceptable risk"; alternative is "**equivalent disease burden** (to cancer 10^{-5})" as end-point descriptor.

Hazard identification
- This is not the first step, it follows problem formulation. There is confusion over the terms "narrow" and "broad" hazard identification. Comprehensive and supported by references
- Extreme resistance to chlorine and other chemical disinfectants is highlighted.
- Other factors leading to risk are highlighted but need to be put in a clearer perspective, as *Cryptosporidium* is a good index for the presence of environmentally robust enteric pathogens from mammals, but indicate its weaknesses (e.g. for viruses).
- There is apparent inconsistency: e.g. that genotypes appear host specific, human outbreaks with type-2; and human infectivity with type-1 and type-2 equivalent (as said in 3.1.10).
- Disinfection resistance/persistence needs updating from Korich work (1990) in light of newer methods – also critique of these methods. A summary table of CT values was suggested. There is a need to spell out persistence of oocysts vs 'viability' – given we only look for intact oocysts, and that is what is important today (to control counts) say this at top page 18 as well.
- The purpose of the section on HACCP at this point is unclear and incomplete. Dan Deere (Sydney Catchment Authority, Australia) has additional text and schemes that may aid this section. This section could be moved to chapter 2 or outside of the risk assessment document.

Exposure assessment
- This describes methods of *Cryptosporidium* detection in water and their limitations or drawbacks, but the overall impacts of these limitations on variability and uncertainty of quantitative microbial risk assessment (QMRA) are not made clear or emphasized enough. Emphasis on statistically describing variability takes away from the more important limitation (uncertainty) of not measuring infectivity. Discuss the various types of distributions and changes that may occur from source to customer.

- What if no pathogen data (4.1): rather than focus on indicator bacteria, focus on sanitary surveys for sources-locations (types/numbers of mammals, septic systems, infiltration/cross-contamination etc) supplemented with indicator bacteria data is suggested.
- The section on direct monitoring could include Australian data in Table 4.1 (also DWI data, if it is possible to use this for England) and should include footnote on range of recoveries for such data (e.g. 1-60%) and units (#/L). Make sure not to encourage routine final water testing – but of sources and barrier performance (p 23 versus p22).
- The methods to detect viability and what they actually determine should be described clearly. Cost should be described and accessibility in developing countries is not mentioned.

Source water quality
Presents quality categories of watersheds as an approach when no monitoring data are available. Six categories based on land use, faecal sources (human and animal), faecal contamination levels (based on *E. coli*) and location of intake (this last is not consistently described for all categories).
- pp23-24: replace the word "present" with "detected". Provide information on the variability with the SD.

Treatment efficiency
This section is comprehensive except:
- Lacks consideration of solar (UV-thermal) treatment for non-piped (household) supplies.
- Does not include softening and effects of alkaline conditions (high pH).
- Does not clearly emphasize the distinctions between total, viable and infectious oocysts.
- Introduces SSRC as a treatment surrogate but does not address it relative value for physical removal processes versus inactivation (disinfection) processes.
- The use of phages as surrogates for removal in some granular media is questionable.

Consumption
Identifies the importance of distinguishing heated and unheated water consumption, but does not clearly address water use in preparation of unheated foods. Discussion of water consumption by persons with HIV-AIDS or other immuno-deficiencies may not belong here.

Effect assessment
Epidemiological studies as sources of information on effects assessment (Calderon, Frost and colleagues) should be mentioned. It is a detailed mathematical treatment of human volunteer dose-response data, which may not be understandable for the typical reader. Inclusion of a simpler presentation or treatment of dose response would be useful. Inconsistency: "viability" of oocysts used in studies quoted, e.g.>80% by excystation, but no value for neonatal mice.

Hypergeometric versus beta-Poisson versus single hit and logistic single hit – perhaps list features in general table. Hence Table 5.1 is not needed, just Table 5.2, Fig 5.1 and Fig 5.2. Clarify that for DALY calculation, duration and severity data necessary for each end-point.

Risk management options
This can be condensed to the key points and focus on what management is possible and what information is needed to support these decisions. Use this to identify the important research needs.

The discussion on tiered approach to risk management gets mixed with risk characterization issues. The discussion of certainty of risk estimate also does not belong here; probably belongs in risk characterization. Risk Management Actions section would benefit from a conceptual model or diagram.

Better, clearer guidance on HACCP would improve the usefulness of the information here.

Case studies
- These are informative examples of QMRA. They are site-specific. It is unclear how this relates to HACCP and its application to water supply management. Inclusion of a HACCP analysis in case 1 example is confusing. Who is the target audience and what is the illustrative purpose for the case studies?
- A "how to" framework (perhaps a decision tree approach) for the cases would be useful.
- Where does the user/reader begin if they want to do a case study of their own system?

Annex 7

ENTERIC VIRUS RISK ASSESSMENT TEXT

The document should be adjusted to conform to the proposed format outlined in Annex 4.

First Reviewer Comments
- Most review comments focused on restructuring the document.
- Illustration needs to be made on where the sources of the viruses are. Maybe need two case studies dealing with diffuse and point sources.
- The document needs to be aligned with the other risk assessment texts to avoid unnecessary duplication with each MEHC removed, i.e. just give data on enteric viruses and start with the Water-Borne Viruses section.
- Next cover the risk of public health impact and management options (focus on human excreta) i.e. problem formulation.
- Include HACCP within the document but focus on virus-related issues only.
- Use Table 1 to illustrate what is currently done.
- Then introduce the hazards & problems of analysis
  - Use viral group sub-headings
  - Add astroviruses along with rotaviruses
  - Discuss 'new' or newly identified viruses here, such as enterovirus 71 and hand foot and mouth disease
  - Method performances – stochastic approach
- Case studies: illustrating if QMRA is possible or necessary?
  - Survival (various media), transport, temp, etc.
  - Use of models (phage) needs to be identified where appropriate
  - Some studies support, some do not for phages
- Is there a need to suggest monitoring – and if so, which, what and why?

Second Reviewer Comments
Comments on the structure of document:
- Needs a more consistent and comprehensive description of each virus or group
  - Hepatitis viruses described in detail
  - Enteroviruses described in detail
  - Adenoviruses described in detail
  - Caliciviruses - very little detail which needs to be expanded
  - Rotaviruses - very little detail which needs to be expanded
  - Others that can be potentially included are astroviruses, reovirusess picobirnaviruses
  - Include specific, uniform contents/topics in description
- Introduces the work carried out at US EPA CCL, but this should be referred to earlier
- Water Treatment and Disinfection Technology Section:
  - This section is very brief and needs more detail.
  - Include tables or refer to tables elsewhere
    - CT values for chemical disinfectants
    - IT (dose) values for UV (now among worst case waterborne pathogens)
  - Heat (thermal) inactivation
- A section is needed that addresses virus survival and persistence in the environment including the following issues:
  - survival in waters of different quality;

- survival in soil material and subsurface media;
- survival in treatment media and residuals (backwash water);
- transport in water, soils, and other related environmental media;
- effects of temperature, pH, sunlight, particle-association, etc; and
- differences and variability among viruses in survival and transport.
- The report is too dismissive of the potential value of viral indicators in certain situations and applications such as:
  - reductions by treatment;
  - survival and persistence;
  - detecting faecal contamination by viruses in water and other media; and
  - it is necessary to acknowledge that comparative studies may or may not show comparable responses
- The text stresses the importance of viral monitoring. This importance is questioned as follows:
  - Do we really want to promote viral monitoring?
  - Why?
  - In what context?
  - What is the purpose?
  - How will the data be used?
  - How would you do it? Sampling details
  - Which methods, viruses, etc?
- Critical of use of specifications in WHO, USEPA etc for viruses in drinking-water
- Discussion needed on HACCP relating to viruses. May need to be in separate document for guidance for all pathogens. Endorses HACCP for water as a proof of concept.

Specific questions to be addressed
- Effect of age on mortality due to HAV (CDC data)
- The suitability of other viral models such as that developed by Joe Eisenberg i.e. an approach which describes the transition of members of the population through different states of disease needs further consideration.

Discussion
- Keep HAV as "reference" pathogen for viruses due to available data. But problem is that Coxsackie are more resistant.

- Need to be able to define health outcomes. HAV is well defined for water. Information about Coxsackie B virus with different health outcomes appears weaker.
- Need viral data for source water occurrence, so use of enteroviruses is possible because data is available.
- Using the "reference" pathogens is not about monitoring. Use of HAV is due to severity of health outcomes.
- Medical researchers have information on viral outcomes, including sequalae. Gaunt, Univ. of Texas at San Antonio has compiled health effects data of enteroviruses and prepared a report for US EPA. He also did a QRA for Coxsackie viruses which may assist.
- For Coxsackie B there is information available on animal and human infection studies.
- Using a group of viruses (e.g. enteric viruses) and having a qualitative approach will not permit a quantified health outcome.
- Quantity of water consumed for risk assessment should be standardised -- there is not specific data then use a default value of 1.0 L/day.
- Efficiency of recovery of viruses from drinking-water needs to be addressed.
- Advantages of working with groups of viruses-- work with larger numbers but spectrum of species or types.
- The Draft document contains information on problem formulation, HACCP etc. One Case Study -- Risk Assessment on Coxsackie B virus (includes information on HI etc.). Some uncertainty analysis and sensitivity analyses are undertaken.
- Shortcomings of data available -- only qualitative (presence/absence), quantitative data is restricted. Data on infectious doses. Clumping excluded.
- Calculated risk of infection = 100 per 10,000 consumers per year. Once subject to sensitivity and uncertainty analysis.
- **RESEARCH NEED** -- where are the viruses coming from esp. adenoviruses coming from animals or people?

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Annex 8

LEGIONELLA DISCUSSION

A small group of participants was identified to consider the relevance of draft texts and discussions held during the meeting, to development of guidelines for *Legionella* including from a risk assessment and risk management perspective.

It was noted that drinking-water supplies may be a source of low numbers of *Legionella*, reflecting the natural occurrence of the organism in environmental water sources. The presence of the organism within the distribution system in low numbers generally does not pose a public health risk. However when delivered to warm-water containing devices that support growth (temperatures in the range 20°C - 45°C favour growth), *Legionella* numbers may increase significantly. Temperature may also influence virulence of the organism, with *Legionella* bacteria held at 37°C having greater virulence than the same bacteria kept at below 25°C.[1]

Human legionellosis cases occur, often in the form of point-source outbreaks, when there is exposure through inhalation of respirable water droplets (aerosols) or droplet nuclei containing these bacteria. Older people and those with underlying disease or immuno-suppression are at higher risk of developing clinical disease following exposure. The high case-fatality rate and serious complications of this disease cause it to have a high public health impact.

Devices associated with legionellosis have included warm/hot water systems, cooling towers, and spa pools, in diverse settings including hospitals, hotels, factories and other establishments. There are established mechanisms for minimising survival and growth of *Legionella* in these situations. Maintenance of cleanliness within water systems and devices is vital to minimize the development of biofilms and deposits, as these can foster the growth of *Legionella* as well as protect the organism from concentrations of biocide that would otherwise kill or inhibit growth if the organism were suspended in water. Control can be achieved by a requirement for all hot water storages to be maintained at temperatures of 60°C or higher. In addition, the use of a disinfection process (e.g. UV, or regular hot water flushing) is suggested in the case of warm/hot systems. In cooling towers automatic biocide dosing can be used while in spa pools disinfection together with filtration can provide a high degree of protection. Risks may also be reduced by minimising public exposure to water droplets and aerosols (e.g. by siting cooling towers away from public thoroughfares).

Risks of *Legionella* are amenable to control through application of a HACCP-type approach. Maintenance of temperature, biocide dosing and biocide concentrations and control of materials could be Control Points.

Meeting participants noted that such control points generally lie outside the usually accepted boundary of the system for which water supply authorities are responsible. Hence the management of the hazard of *Legionella* by water suppliers alone may have little impact on public health outcomes. Nevertheless, in keeping with the WHO principle that drinking-water

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[1] Health & Safety Commission (2000). Legionnaires disease: The control of *Legionella* bacteria in water systems. Her Majesty's Stationery Office, Norwich.

should be suitable for all normal domestic purposes, approaches to effective control of the health risk from *Legionella* should be addressed.

The group agreed that *Legionella* should be included in the guidelines and that a small section was also warranted dealing in general terms with re-growth organisms in general. Although quantitative risk assessment appears feasible for this organism in principle, members were not aware of any attempts to do so and felt there are likely to be important information gaps. For example, data enabling dose-response modelling may not readily take into account organism numbers when there is clumping together of bacterial particles in droplet nuclei and protozoa. It is likely that there are substantial variations in strain virulence and human susceptibility to infection. There is also a lack of information about the level of risk (if any) from household exposures to cold water.

Annex 9

DERIVATION OF REFERENCE LEVELS OF RISK

The text on derivation of reference levels of risk when concluded, would ideally illustrate the linkage from infection to population health effects and employ an integrated and universal metric: DALYs.

The text, although intended for only specialist readership, should include a short summary that would be comprehensible to non-specialists. This is evident when the reader encounters Table 1 and has an inadequate sense of what DALYs comprise to allow a reader to comprehend the numbers pre-stated.

An introduction to the concept is needed. This would include, for example, (i) that historically health-sector input to water management has been driven principally by outbreak prevention; new approaches are needed to provide for objective health-sector input in relating water management to health protection; and (ii) that such objective input is only one component of the complex regulation process requiring multi-stakeholder participation in national/regional/local standard-setting. Cross-reference to the developing text of the GDWQ is necessary.

The need for a "reference level of risk" (RLR) for international guideline setting was endorsed. Noting the inherent weaknesses in the 10^{-5} lifetime excess risk of cancer, it was recommended that the RLR be presented as 'central stage' both here and in Chapter 1 of the GDWQ and 10^{-5} lifetime excess risk of cancer being one application of this. The RLR and ten-fold greater/lesser risk should be illustrated alongside other more everyday risks. Presentation of a risk range is critical to move thinking away from seeing any RLR as being a sharp line where everything below the RLR is acceptable, but it is totally unacceptable above the RLR.

Whilst noted in the text, it was recommended that the importance of best-estimate/bias neutral approach support informed decision-making be further emphasized in both summary and text. The merits of avoiding compound conservatism must be tempered with a caution against too literal an interpretation of the "best estimate". While judgements to bridge gaps in our knowledge might be confidently made as being abundantly cautious in any aspects of high uncertainty, such confidence in a best estimate is much more difficult.

Some/limited sensitivity analysis should be included to provide an indication of the overall robustness of the conclusions. The robustness of DALYs seems to be an inherent strength that should be highlighted in presenting the merits of DALYs to a sceptical audience. A number of areas of merit were noted as being contentious but anchored outside to the text itself. These included age weighting, discounting and severity weights. The text should note and explain, but not attempt to justify these aspects, relying rather on referring to other sources of information.

A frank recognition that the use of DALYs will assist in relating the primarily scientific judgements of risk assessment to the more societal value-laden judgements of risk management. The process of deriving DALYs can be primarily considered in the domain of risk assessment. However, greater transparency and opportunity for evaluating different values of severity weightings based on culture-specific issues is needed.

Annex 10

GROUNDWATER TEXT

This document relates to protecting groundwater quality from a public health perspective and therefore does not deal with quantitative aspects of groundwater management, except where this directly affects a quality issue of health concern. The target audience is public health practitioners, groundwater specialists and environment managers.

The role of source and resource protection as the first of a series of multiple barriers to protect water safety is emphasized.

The document falls into four major sections:

- Background science.
- Situation assessment – characterisation of the information needs.
- Management measures.
- Control points and verification.

Comments

Discussion of the contribution of groundwater to waterborne disease needs to identify the vulnerability of groundwater.

The target audience should be carefully considered as trying to reach too broad an audience may reduce the level of technical discussion. The structure of the document was endorsed as it is focused on the management of groundwater resources from a public health perspective and covers both microbiological and chemical aspects. It is important that this focus is retained as there are many other available texts dealing with groundwater resource management.

The structure of the document is logical and works through situation assessment/information needs, management actions and finally monitoring and control points. This is done for all pollutants rather than separating chemical and microbial contaminants, providing a coherent approach. However, there is an obvious need to ensure that duplication is minimized between different sections. The document also highlights the importance of institutional, regulatory and socio-economic aspects of groundwater pollution and protection.

The first section provides the basic science – health, microbiological and hydro-geological. Chapter 1 remains pending and will be completed once the remaining sections have been prepared. This will give a health overlay to the document. It is suggested that this include description of some recorded outbreaks linked to groundwater.

The other three chapters in Section 1 provide some scientific detail but retain a management orientation – therefore, not all the detailed science need be included. Chapters 3 and 4 should ensure that the discussion focuses on movement, transport, survival and attenuation in groundwater and not a general discussion. The authors of these chapters should collaborate with the authors of Chapter 2 – hydrological processes. Chapter 3 must ensure that the science-management balance is maintained and should refer to more detailed texts and papers on groundwater microbiology.

A major issue of concern is to ensure that the terminology is consistent with the guidelines. At present the groundwater text identifies specific control points in pollutant sources (e.g. lining of a landfill), whereas these were upstreamed to IWRM (or prerequisites) in some meeting background documents, with the CCP being identified as a protection zone encompassing all the specific pollutant issues. It will be necessary to ensure a consistent approach is adopted, which should take into account institutional/management implications of the terms used. It was discussed to what extent a CCP approach can be realistically applied to some aspects of groundwater quality management, particularly those that relate to the catchment. In particular there are concerns whether some measures that are suggested as CCPs can be continuously monitored.

It was recommended that:

1. The monograph should be a stand-alone background document that supports the GDWQ.
2. Short text (few pages) should be included in the GDWQ and cover the following:
   - Statement of principle regarding the importance of source protection in controlling the quality of drinking-water derived from groundwater sources.
   - The necessity to ensure proper sanitary completion/wellhead protection is in place and maintained (include basic criteria).
   - That land-use controls are based on travel time/dilution/attenuation concepts to be meaningful as opposed to application of uniform set-back distances without consideration of site specific physical characteristics.
   - To provide brief information on the movement, survival and attenuation of contaminants in groundwater.
   - To recognize that the risks from some pathogens (e.g. viruses) or some hydro-geological environments (e.g. karstic) water quality may be difficult to control without treatment.
   - Provide examples of groundwater protection zones, groundwater risk categories and refer to hygiene codes.

Annex 11

TREATMENT TEXT

General comments
- The three reviewers agreed that this document contains very valuable information, is well-written and easy to read. The information is not drowned in a comprehensive overview literature, but relevant information is provided.
- The document provides quantitative information as much as possible.
- The document provides information on:
  - efficiency of unit processes;
  - factors affecting performance; and
  - parameters/factors to be used for monitoring performance (control point monitoring):
- There is a need to indicate which treatment process were specifically developed for microbes (disinfection) and which not (physical-chemical removal processes)

One treatment process, ultraviolet (UV), was selected to be looked at from the viewpoint of someone responsible for design and/or operation of a water treatment system, to determine whether the document provided the information needed for design of a system and for monitoring the performance of the system during operation (control point-monitoring).

Design of UV system
The document provides information on:
- background on mechanism of inactivation;
- UV dose required for inactivation of bacteria, viruses and protozoa (laboratory-studies);
- factors affecting performance:
  - photo-reactivation (qualitative); and
  - information was missed on the effect of reactor design, lamps, lamp ageing and fouling, turbidity to scatter UV, masking by particles. For other processes in the document, this kind of information was provided.

Information was missed on:
- UV dose modelling; and
- UV disinfection kinetics.

Operation of UV system
The document provides information on the use of parameters to assess the performance of the system:
- "dose" monitoring (flow+sensor)
- UV transmittance monitoring

It also provides information on how to verify performance by monitoring indicators. The use of these parameters in a HACCP-type framework to monitor the performance of this control point is not explicitly stated. Operational factors such as lamp ageing, lamp fouling were missed, the application of bio-dosimetry to verify performance was also missed.

Specific comments

- p.32-45: disinfection by-products are not dealt with consistently (no discussion of THM's, bromate etc.).

- p.45 Secondary disinfection requires discussion on the use of disinfection residuals to indicate ingress in the distribution system.

- p. 41: a reference for the ClO_2 inactivation rates determined with cell culture is needed. Limitations of the excystation method should be discussed or the reference of Ransome et al. (1993) should be removed.

- Table 3. Self purification processes (p.8): add "sunlight" under Physical Processes (data are available to show microbial inactivation. Add "natural coagulation-flocculation" under Chemical Processes. Note *Cryptosporidium* agglomeration with other particles on page 9.

- Coagulation-flocculation-sedimentation (p12): cite three reviews on viruses and Rx: Sproul, Leong and Payment and Armon. Add HAV data from Rao et al. And Sobsey et al.

- Filtration (p17+): add helminths to Figure 5. Pore size of filter and size of microbes *Schistosome* cercariae; helminth ova.

- p18: granular high-rate: add section on chemically-modified filter media (alum, polymer, etc.?). Add section on filter-adsorber systems SSF (p23+): comment on possible inactivation of protozoan infectivity by SSF or point out information needs here?

- Precoat filtration (p24): add data on virus adsorption by DE filters.

- Microfiltration (p27): add data or note removal of particle-associated viruses by microfilters.

- UF and NF (p30): clarify/quantify/omit phrase "MF systems should not be regarded as absolute barriers to pathogens".

- p31: consider adding sections on "Adsorption" and "Filter-adsorption"?

- p31+: PreRx Oxidation: note that oxidation for iron and manganese removal may promote physical removal by adsorption or coagulation or precipitation of pathogens.

- Comments about creation of disinfectant demand and protective effects on microbes by preoxidation need modification to reflect possible beneficial rather than adverse effects.

- p33 Primary disinfection: 2nd para.: Add info on membrane-associated. viruses and data on chlorine inactivation of cell-associated HAV (Sobsey et al.).

- p34, 2nd para: Add info on oxidative effects of chlorine on viruses.p36 Tables 11-13: Add CT = CT_{99}

- p36: Add info on monochloramine reactions. With bacteria from Stewart and Olson.

- Clarify that free chlorine is such a strong oxidant that it reacts with many microbial targets.

- Add Venczel and Sobsey data on HAV and MS2 inactivation kinetics by monochloramine (persistent fraction)?

- p41: add data on HAV inactivation by O_3

- p43: discuss and explain more clearly mercury lamps for UV irradiation: low (monochromatic) and medium (polychromatic) pressure lamps and their features.

- Relationship to action spectrum for nucleic acids and microbial inactivation.

- p43+: add data (Table 18 and text) on UV inactivation of adenoviruses (Meng and Gerba, others); now the "worst case" virus of the "worst case" waterborne pathogen group for UV.

- Add most recent data and highlight inactivation of Cryptosporidium and Giardia by low doses of UV!

- p52+: Disinfection Models: indicate other models that have been developed and can be used: Venczel et al.
- Treatment variability section: Better quantitative treatment of variability in terms of operations and management is suggested for this section. It should be more clearly linked to HACCP, CCPs and CLs and to response actions and activities when CLs not met.
- Suggestion: put this section after "Critical Control Strategies" section.
- Very good presentation of control points for processes and water system treatment train.
- Introduces Failure Mode and Effects Analysis (FMEA).
- Identify the best control points per unit process or step and reiterate the need for real time measurement.

Conclusions: the text on the single most important factors for removal processes and disinfection processes needs clarification and more specific recommendations.

Group discussion
- Message that getting good quality input water is a good start could be more explicitly stated.
- It is hard to rank protective measures, liked that it started with bank filtration. Not good on giving guidance on how to prioritise the treatment processes which are most appropriate. Quantitative issue with ranking table, no guidance on how to use the table.

Need a paragraph up front on toxic cyanobacteria – and then include referencing in this and GDWQ on where to get information, i.e. from Toxic Cyanobacteria in Water.

Case studies need to be included in the Treatment Text, including case studies for pathogens.

Annex 12

FLUCTUATIONS IN TREATMENT EFFICIENCY TEXT

Initial presentation led to questions related to process management
- Can HACCP be effective in preventing (short-term) treatment failure?
- Probably, but achieving a high log reduction and preventing short-term failure are two different things.

- Are there CCPs for reliability, and if so, are these different from CCPs for average (nominal) performance?
- Is there such a thing as an ``inherently stable" treatment process?
- The more ``critical" a control point, the more carefully it needs to be controlled in order to achieve stability.

General Discussion
- Linked barriers: correlated operation of multiple barriers.
- Failure as a distinct issue, separate from process performance.
- Tendency to less barriers - larger failures.
- Fluctuation minimisation may also improve nominal performance.
- *Cryptosporidium* in Sydney catchment - 3 decades variation!

General comments
- Presentation was appreciated and considered relevant. The concept proposed may have value in predicting the efficacy of multiple barriers and would be valuable in estimating cost-benefit trade-offs of multiple barriers.

Specific comments
- Neither the fluctuations and how they are measured nor any adverse effects associated with the fluctuations were defined.
- The frequencies of the fluctuations were not defined. Are we talking about rare fluctuations, e.g. once or twice per year, or more frequent fluctuations, e.g. twice a week?
- What is the relationship between fluctuation and treatment efficiency and can the fluctuations be related to some type of health effect?

Group discussion
- General scope of this paper needs clarification: why are we doing this?, what is stability? How is stability measured?
- Some discussion on the availability of data on occurrence of (short-term) failure.
- Control of barriers (feed-forward) decreases the influence of failure of one barrier.
- Spin-off of this kind of approach - use for limit setting on control charts.
- Early warning systems (Bayesian forecasting) improved when additional use of process parameters.

The addition of other scenarios would be valuable, specifically:
- linked performance reductions, i.e., where one barrier failure affects another. To what extent will this reduce the benefits predicted for multiple barriers;
- continuous distributions with extreme values may be more realistic and useful than using the arbitrary concept of failure. However, we may have to use a failure distribution as well as a fluctuation distribution or a combination of many distributions;
- non-treatment barriers should also be considered. Not exhaustively but enough to test the applicability of the concepts apply outside of treatment; and
- to make it more like real water supply situations. This would probably involve fewer barriers, with each barrier having performance reductions that are more extreme in magnitude and less frequent.

Other points raised in discussion
- We should obtain real data to encourage more realistic scenario testing and could obtain support perhaps from AWWARF or others. In the interim, agencies could get together for pilot work, which would enable a much better proposal to be produced.
- We could enhance the recommendations on multiple barriers and, in particular, ensuring that one barrier can respond with greater removal efficiency in the event of failure of the previous barrier. However, such recommendations should be based on science.
- Could try using neural networks.
- Chuck Haas had indicated that he would be able to assist by the end of the year to provide more data and help analyse it.

Communication
- Document uses simple language and does "state the obvious" in public health terms, which is useful and this should be continued if the work is taken any further as most people will want to know what the maths shows but won't be able to draw conclusions themselves from the maths.

Points for discussion by the group
- The paper showed that, for the examples, fluctuation was more important in relation to total disease burden than nominal performance.
- This leads us to focus on peak event minimisation rather than nominal performance enhancements. Is this dangerous? On the one hand, cross-benefits of fluctuation minimisation measures are likely to also improve nominal performance. In contrast, if large fluctuations are very rare, perhaps we should focus on nominal performance instead.
- In relation to the above two points, are there generalisations that apply across many/most/almost all systems? if not, can we provide guidance for others to apply to their systems to work out whether they should focus on fluctuations or nominal performance or a combination of both.

Recommendations
Peter Teunis (RIVM, Netherlands), Dan Deere (Sydney Catchment Authority, Australia) and Al Dufour (USEPA) were asked to look at the design of the paper and to consider the advisability of putting this in the treatment text or maintaining it apart in light of, for instance, short-term events in source water.

Annex 13

WATER QUALITY CHANGES IN PIPED DISTRIBUTION SYSTEMS TEXT

Review Comments - General
(a) adequacy to support Guidelines derivation - detailed and comprehensive for supporting rationale of Guidelines derivation; and
(b) usefulness as part of GDWQ and associated documentation - very informative and valuable as a very accessible resource for explaining the key issues with regard to distributions - effectively presents, orients and emphasizes key issues (nice, direct statements on key issues).

Consistency of language and care with precise meaning required improvement, for example:
♦ "acceptable risk"
♦ "admissible level"??
♦ "...(HACCP) is an approach that gained the approval of the food industry for controlling food quality."
♦ "indigenous pathogens"??
♦ "distribution system is the last barrier before drinking-water reaches the consumer"??
♦ "there must be no doubt whatsoever about (disinfection's) reliability

The text should be more explicit and specific on the evidence for *E. coli* re-growth outside warm-blooded animals. The text should be written in a style which is accessible to a wide target audience, including professionals of varying backgrounds (small/large systems, developing countries etc.). It should be reviewed by a cross-section of the target audience to ensure it is useful and easy to use.

A very good synopsis of the place of the distribution system within the overall framework of water-quality. It is essentially a practical document and, although the HACCP approach of critical control points is there in essence, they are not actually identified as such. This could be overcome by a bit more descriptive text about HACCP within the text of the document.

In the context of HACCP the quality of the water entering the distribution system is the first control point. So it needs to be clearly identified whether the responsibility rests with the supplier or the distributor where these are distinct.

There needs to be a chapter on conducting a sanitary survey of the distribution system. It also needs something on critical control points and management for small community services.

Comments by Author

Chapter 1
▪ Some parts of the chapter act as a general introduction to other chapters and more cross-referencing is required.
▪ Traditional microbiological monitoring practices and regulations are known to have very limited usefulness but readers may feel there is insufficient detail concerning alternatives or if any exist.
▪ The chlorine residual/no chlorine residual dilemma could be discussed further.

- No discussion of the health implications of animals commonly found in water mains (e.g. *Asellus aquaticus*, nematodes).

Chapter 2
- More information and emphasis required for the effects of water composition on corrosion and scale formation.
- More information and emphasis concerning control of coagulant residuals (dissolved and particulate) leaving the treatment works.

Chapter 3
- Some complex engineering recommendations might be best presented by giving real examples with diagrams.

Chapter 4
- Need more detail and/or examples concerning criteria for identifying when cleaning is required and is suitable.
- Need to distinguish between these criteria for identifying where non-abrasive cleaning procedures are suitable in comparison with other renovation methods (*structural and non-structural relining*) and the process for selecting the most appropriate individual cleaning method.

Chapter 5
- Based entirely on US and UK practice and research. Requires a broader base of references and practices.
- Hot climate input is absent.
- Are there any recent innovative approaches or disinfectants?

Chapter 6
- Should cover minimum requirements for materials in terms of leaching organics and supporting microbiological growth with examples of schemes.
- Should include a review of common design and construction problems that may cause microbiological deterioration such as cross connections, backflow and typical schemes to prevent this.

Chapter-by-chapter Review

Public Health and Microbiological Standards
This chapter provides an introduction to the subject of distribution systems but the title and some of the text reads like an introduction to a broader topic rather than just distribution systems, e.g. guidelines/standards, chemicals/micro risks, indicators, source protection/treatment micro considerations etc. Suggest this be reviewed in the context of the whole guidelines documents

There is not really a clear focus or a logical flow to this chapter. e.g. looks at introduction of micro-organisms at different stages of catchment to tap, then regulations, then monitoring programs and finally problems in households and large buildings.

Suggest that this chapter should be structured with a focus on a preventive approach to managing drinking-water quality in distribution systems. Thus sequence would include

system assessment (hazards etc), preventive strategies, operations and control, verification, incident and emergency response, training, community involvement etc.

The key preventive strategies need to be specified:
- fully enclosed distribution system and storage cross connection and back-flow prevention;
- achieving required disinfection 100% (target) of the time;
- backup systems (power supplies etc.);
- regular maintenance; and
- maintaining adequate system pressure.

Composition of Treated Waters to Minimize Potential for Microbiological Changes
This document focuses on microbiological and chemical changes within the distribution system. Any details on microbial aspects which need to be retained from the revised first chapter could be included here.

Design and Operation of Distribution Networks
Planned Maintenance of Distribution Systems
Precautions During Construction and Repairs

Sound chapters which draw on established industry practice (AWWA, Water UK etc)
Provide the detail at the asset level (reservoirs, tanks, pipes, pumps, valves etc) and would effectively underpin a revised first document .

Other Comments during discussion

- There is mention of the introduction of pathogens through polluted source water, through ingress etc
- All systems have biofilms and these can provide a sink for pathogens.
- There needs to be information on how pathogens survive and the extent to which they are attenuated in the distribution system (? Adequately addressed).
- What indicators are used to measure quality and ingress? *Clostridium* spores as an alternative indicator to *E. coli* have been suggested by some, but EU reviewed and considered too conservative *E. coli* for health impact of water? This needs further discussion and review; HPC for general water quality.
- Concern was expressed about small distribution systems, especially those that do not have treatment and disinfection; they should be covered.
- System hygiene and flushing. Is there anything in the document that gives guidance on distribution system sanitary surveys? The document seems to be weak on sanitary survey information.
- Noted that there is a lot about quality, but not necessarily stressing safety. The chapters should focus on maintaining safety. The chapters have not been written in the context of risk management. There needs to be a focus on preventive strategies in an overall preventive approach to managing water quality in distribution systems.
- It may be necessary to restructure in light of the risk management approach" .
- The group agreed not to proceed with Chapter 6. Information on backflow should be included in Chapter 3.

Annex 14

WATER QUALITY CHANGES IN NON-PIPED DISTRIBUTION, AND HOUSEHOLD MANAGEMENT

The contents of the draft document comprises:

- the need for water treatment and safe storage of non-piped supplies;
- the microbiological improvement and health benefits of on-site treatment and safe storage of non-piped supplies;
- a review and analysis of candidate storage methods (e.g., containers) to protect household water during use;
- a review and analysis of treatment methods (physical and chemical) to improve the microbiological quality and reduce the contribution to infectious disease of non-piped water supplies;
- consideration of costs and related economic aspects of household water treatment and safe storage systems;
- the importance of and role for education, training, behaviour modification and social marketing to achieve acceptance and sustainability of household treatment and storage systems for non-piped supplies; and
- recommendations on which household storage and treatment methods appear to be the best choices because scientific evidence shows that they improve microbiological quality and reduce water-related infectious diseases.

The proposed next steps include revision of the current draft document, inclusion of guidance on household or point of use treatment and storage.

Review comments:

- Overall view on document – covers area that WHO has needed to cover for some time. The information is much needed. Finalize as quickly as possible.
- This is a good paper. It is a comprehensive review of the literature, which contains good information on the evidence that good quality water is important for good health.
- Suggest condensing and combining some sections e.g. combine Introduction and Purpose sections. Add justification and objectives.
- Structure – move physical inactivation processes adjacent to the chemical inactivation processes; place more emphasis on inactivation processes as these will be more used than filtration; place them side-by-side.
- Put quantitative epidemiological evidence in the document. Include a table of recorded epidemiological evidence that quantifies the reductions in waterborne disease due to the treatment intervention.
- Efforts are needed especially in developing countries to use epidemiological intervention studies to assess and demonstrate the benefits of household water treatment and safe storage.
- Stress the importance of the epidemiological evidence that was reviewed as evidence of the benefits of household treatment and storage systems. Include the specific evidence that safe drinking-water reduces illness. This data should be included.
- Put in tables of microbial inactivation rates as hard evidence for effectiveness of disinfection processes (SODIS and chlorine); very useful for practitioners.
- Reference was made to bacteriostatic properties of silver and questions raised whether it really works. Evidence suggests that silver tolerant bacteria are selected for and will still

grow. This leads to lack of bacteriostatic effect. Provide more information on what silver does and does not do.

- Provide more details in tables. Instead of "high, medium or low", put in percentage reductions by treatment processes, for example.
- GDWQ should include a short piece of text about feasibility of household water treatment and tables of recorded health impact and inactivation rates or reductions of microbes in water.
- GDWQ should include a statement of principles for use of household water treatment and storage systems as an incremental improvement in health.
- Provide visual or schematic presentations of household treatment and storage methods.
- Number the headings and topics to make them easier to follow.
- Separate costs from comments in Tables.

Recommendations for further activities:

- have a harmonization workshop/meeting to identify and get consensus on appropriate household treatment and storage systems;
- include household treatment and safe storage in the GDWQ; and
- produce a technical manual about household treatment and storage systems for users.

Caution was expressed about chlorination interventions/treatments: related to acceptability if dose is too high such that the water tastes unacceptably of chlorine.
- Stress need for guidance on how to properly dose.
- Need for the development of kits for users to check chlorine residual.
- Information was also needed on technology evaluation i.e. from testing under "real world" conditions; for instance continuous run flow or continuous operation as opposed to single batch challenge.
- It was suggested that the health education side needed more work. Current thinking suggests that hygiene education and sanitation deliver the greatest proportion of available gains in health. It should be emphasized that water interventions or improvements in quality by treatment will result in decreased illness and significant improvements in health.
- Long-term sustainability issues relating to cost will need to be addressed and in particular it should be emphasized that just because improve health outcomes from low-cost household systems are possible should not mean that governments need not pursue reliable, safe water supply as a long term goal.

Group Discussion
- Scope. It is intended to be relevant for households in both developed and developing countries.
- There is a need for a plain language statement of what a treatment method will do and what it will not do. Also a clear way of indicating when a treatment is not working properly.

Annex 15

INDICATOR TEXT

General Comments

- The document needs an executive summary. It is a very comprehensive document, but not easily accessible. The document clearly misses an overall discussion to give an overview and generally analyse what the state-of-the-art is and what the priority research needs are.

- The chapter on treatment efficiency has a large amount of overlap with the document on Treatment Efficiency by Mark LeChevallier (see Annex 11). The information that is required here is how to use indicators to assess treatment efficiency, both using microbial and non-microbial indicators. This is essential information for HACCP and not available elsewhere.

- It is difficult to determine the line and logic in this document. There is a lot of good information, especially on catchment, but difficult to use.

- The document should provide good guidance on on-line monitoring, especially for treatment.

- The statement on occurrence of endemic transmission in developed countries may trigger disproportionate reactions, so evidence should be formulated carefully and included.

- Overall the document is very descriptive and relatively weak in analytical approach. Lots of the information on processes and management principles could be deleted. Missing is a critical analysis of the pro's and con's of different indicators and monitoring approaches for different purposes, with the body of evidence. It needs to provide a critical assessment of when to use indicators and what indicators to use.

- The text needs to give more guidance on design of monitoring programmes, e.g how to characterize a source, how to monitor a treatment step, how to monitor the distribution system. At some places it seems to endorse certain practices without critically analysing it (e.g. UK *Cryptosporidium* monitoring). Opinions are given, not the supporting evidence.

- There is a big gap between lots of detail and cutting edge listing of indicators in chapter 3, and very conventional discussion of possible indicators in the chapters on parts of the chain.

- Massive amount of valuable textbook information.

- Some parts, notably the introduction, are a major improvement on the Zürich Draft, and congratulations are due to the authors. However, there is substantial room for further improvement and some corrections and improvements of fundamental importance submitted at the Zürich Meeting have not yet been incorporated.

- The document is in need of polishing with regard to editorial style, English grammar, typing errors, etc.

- Terms such as "indicator", "model", "surrogate", "index", "index organism" and "reference organism" should be clearly defined and consistently used throughout the document according to definition.

- Statements, at least those of fundamental importance, should be supported by reference to appropriate peer review literature.

- References to the literature should be updated and in many cases more appropriate references should be included.

- Some issues may be considered for review in terms of opinion or the interpretation of results. These are open to discussion or debate. However, there are statements, which are technically not correct, or based on outdated information or incorrect interpretation of results. These errors should be corrected.

- With regard to the overall message of the document, some parts fail to reflect objectively on the value and importance of testing for pathogens and some indicators, notably phages.
- A negative perception is reflected by arguments which are technically not correct or based on outdated information, or on debatable interpretation of results and information in the literature.
- This is enhanced by detailed listing of the disadvantages of tests for pathogens and some indicators, with little if any reference to the advantages and benefits of these tests.
- There are inconsistencies and contradictions. The information and messages of the chapters should be harmonized, and duplications should be eliminated.
- The authors are advised to consult at least the following references, each of which contain long lists of references to other relevant literature, when rewriting fundamentally critical parts of the document: Grabow (1996, 2001), Grabow et al (2001), Reynolds et al (1996).

Detailed Comments

THE USE OF INDICATOR ORGANISMS IN HEALTH RISK MANAGEMENT
THE NATURE OF THE PROBLEM

This section is a major improvement on the Zürich Draft. References should be updated and appropriate references to supporting information in the literature should be added.

Page 2: *The disease burden is high*
- Reference should perhaps be made to the socio-economic impact of waterborne diseases, including the financial impact on consumers who contract waterborne diseases, as well as legal and financial implications for the water supply utilities concerned.
- The Walkerton case with *E coli* O157:H7 could be referred to as an example, pointing out that *E coli* is one of the easiest organisms to inactivate in water.

Page 9: **New challenges: viruses and protozoa**
- Suggest write first time used "bacteriophages (phages)" and thereafter use only the term "phages".
- Paragraph 1, last sentence, should read something like: "These phages were suggested as indicators for the potential presence of viruses, and for the survival and behaviour of viruses in the environment including soil passage, as well as the removal and inactivation of viruses by water treatment and disinfection processes" (References, Grabow, 2001).

Page 10: **End-product testing: too late**
- Obviously commonly used tests for indicator organisms and pathogens are too slow to immediately detect breakthroughs, etc.
- The detection of such events relies on other tests such as continuous monitoring for chlorine levels, turbidity, organic compounds, etc.
- The "too late" tends to be over-emphasized.
- The value of results on the efficiency of treatment processes, even if available only after days or weeks, should be recognized. For instance, if we know that a treatment process failed certain expectations a week ago and nothing has been changed to the treatment process since then, we have every reason to believe that the treatment process will also fail these expectations today and next week.
- This would imply that the treatment process has to be improved to meet the expectation, after which it is tested again and a week later we would know whether or not the expected improvement has been accomplished.

- Likewise monitoring results, even if outdated by a week, provide essential information on the ongoing efficiency of treatment processes and the emergence of deficiencies due to any of a variety of reasons.
- Every deficiency in treatment does not result in disease and death.
- The purpose of microbiological monitoring is, therefore, not to monitor waterborne diseases but the efficiency of treatment and disinfection processes, and the risk of waterborne diseases.

Page 10: **Back to the drawing board ...**

- The potential health implications of disinfection by-products appear to be over-emphasized here and elsewhere. Unfounded scares about these products cause major damage and confusion. Message should be strongly founded on the recent WHO EHC.
- All available evidence clearly confirms that the benefits of disinfection for controlling real risks of infectious diseases outweigh potential health risks of disinfection by-products to the extent that concerns about disinfection by-products are negligible (Craun et al, 1994; Proceedings of the ILSI Conference on Disinfection Byproducts, Miami, November 1999) and recent WHO EHC.
- It would be important to address this issue at an appropriate place in the document.
- Wherever this issue is being referred to, the term "toxic by-products" should be replaced by rather "potentially hazardous by-products" because according to definition the theoretical concern referred to implies potentially carcinogenic activity and not toxic activity.
- However, the bullet concerned should perhaps be deleted here and rather replaced by something more important and relevant like:
  - New approaches to water quality guidelines based on principles such as risk assessment, acceptable risks and risk management.
  - New strategies for monitoring the efficiency of water treatment and disinfection processes based on principles such as HACCP.

Page 10: *Direct pathogen testing*
Appropriate references should be included, for instance, Payment epidemiology studies on drinking-water supplies; replace Grabow 2001 by Grabow et al, 2001; etc.

Page 12: *Balancing of microbial and chemical risks*

- This section should be rewritten to reflect realistic perspective as indicated in comments on the same issue referred to on Page 10.
- The description of the potentially adverse health risks associated with disinfection by-products in the words used here cause much confusion and misinterpretation, particularly in developing countries.

Page 15: *New methodologies: molecular technologies*

- Paragraph 3: Replace "... are now being developed to overcome ..." with "... are now available to overcome ...".
- Last sentence: After "... such as the cell culture PCR method for *Cryptosporidium*" add "... and viruses."
- Add appropriate references such as Slifko et al; Sobsey et al; Reynolds et al, 1996; Gantzer et al, 1999; Grabow et al, 1999, 2001.

ASSESSMENT OF MICROBIAL WATER-QUALITY

Minor improvement such as typing errors, and grammatical and editorial polishing, are required.

Page 12: Window: The reference to bottled water should perhaps be deleted because bottled water is due to be addressed separately elsewhere.

Page 12: Substantial parts on phages should be rewritten.
- A number of statements and conclusions seem to be debatable, and are in need of confirmation by reference to supporting literature.
- There is virtually no reference to the literature for the entire section on phages.
- The general perception of the section on phages is that it conveys a negative image of the value of phage indicators by focusing on shortcomings and speculating about limitation with little if any information on the benefits of phages as indicators.

Bacteriophages
- Suggest write "bacteriophages (phages)" first time used and thereafter only "phages".
- Paragraph 1, last sentence: "All groups have significant limitations in these roles." Suggest rewrite to read something like: "Various groups of phages have valuable indicator features for specific purposes. This is largely because in several respects they resemble human viruses much closer than any bacteria commonly used to indicate faecal pollution. Despite certain shortcomings and limitations, awareness of the indicator value of phages is gaining ground world-wide."

Page 13: 1. Somatic coliphages.
- Host specificity of somatic coliphages should be clarified; i.e. what "number of other bacterial species, including species which may occur naturally in the aqueous environment" are infected by somatic coliphages?
- What evidence is there with regard to the statement "It is possible for somatic coliphages to occur unrelated to faecal pollution"?
- The following sentence which reads "Their usefulness as an index of faecal pollution and enteric viruses is therefore limited" seems basically correct. However, depending on what "index" is supposed to mean, phages are not intended to be used for any of these two purposes.
- The indicator value of phages is addressed in the last sentence, and "nevertheless" should be deleted.
- Unless there is sound evidence for the presence of viruses in raw waters in the absence of phages, the part of the last sentence which reads "... when present in raw waters ..." should be deleted.
- The last sentence could, therefore, read something like "Evidence has been presented that somatic coliphages serve a valuable role as indicators for the behaviour of viruses in the environment, and for the removal and inactivation of viruses in water treatment and disinfection processes (Grabow, 2001 and other references such as Havelaar, Sobsey etc)."
- Most of the rest of the section could be deleted and rather be replaced by relevant information such as hosts used for detection, indicator features of somatic coliphages, and evidence on shortcomings of coliphage indicators.

Page 13: 2. F-specific RNA bacteriophages.
- The speculation that F-RNA coliphages may replicate in water environments has not yet been confirmed.

- Unless there is acceptable evidence for the statement "replication after excretion" the following conclusion should be deleted: "They are therefore not a reliable index of faecal pollution or as a surrogate for enteric viruses."
- The following statement should be deleted for the same reason: "They have been used primarily as an index of sewage contamination ..."
- Most of this section should be replaced rather by information on basic features of the phages, their potential benefits as indicators, basic information on their detection, and data on their value as indicators/surrogates/models for viruses.
- The widely accepted nomenclature for F-RNA phages should be used.
- Reference should be made to typing of F-RNA phages and its value.
- The sentence following after the F-RNA section should be deleted or corrected.
- The statement that "Attempts to show correlation between coliphage numbers and enteric virus numbers or disease outbreaks have failed ..." is correct. However, such a correlation has never been expected and phages are not intended to be used for this purpose. The subsequent conclusion that "... the rationale for monitoring coliphages remains largely hypothetical" is, therefore, not correct because the rationale for monitoring coliphages is based on other features of the phages.

Page 13: b. *Bacteroides phages*
- As in the case of coliphages this section is in need of substantial correction and improvement.
- This includes technical details.
- For instance, the statement that methods have not been standardised is not correct.
- Likewise, the statement "may correlate with enteric virus numbers" is presented in the wrong context.

Following on the above, much of what appears in the window on Page 13 is in need of improvement and correction.

- The purpose of the sentence above the window regarding "health risk for laboratory workers" is not clear and debatable. For instance, the health risk for laboratory workers is addressed for some organisms but not for others such as *E coli*. Tests for *E coli* may include a variety of pathogenic strains; why are these not considered a health risk to laboratory workers?
- In the case of *B fragilis* phages there is a statement which says "some of the host bacterial strains may be opportunistic pathogens." Which of the host strains used are opportunistic pathogens? What information is there on their pathogenicity and risk to laboratory workers? What literature support is there for this concern?

How does the health risk constituted by the *B fragilis* hosts compare with that of *E coli* O157:H7 and other pathogenic strains of *E coli*?

Page 14: **Sulphite-reducing clostridia and *Clostridium perfringens***
- Window: The last sentence refers: "They are not recommended for the routine monitoring of distribution systems as they tend to survive and accumulate and may be detected long after pollution has occurred."
- This statement should perhaps be deleted or revised because it is debatable since properly treated drinking-water is generally expected to be free of *C perfringens*.

- It may, in fact, be argued that *C perfringens* actually has very attractive features for monitoring distribution systems.
- In this window it should perhaps be pointed out that one of the attractive indicator features of *C perfringens* is that they fail to multiply in water environments. This implies that they are specific indicators of faecal pollution, and more closely resemble the behaviour of many pathogens than indicators such as coliform bacteria.

Page 14: *Pseudomonas aeruginosa and Aeromonas spp.*
Paragraph 2: The reference to bottled water should perhaps be deleted because bottled water is addressed separately elsewhere.

Page 15:
- Window, paragraph 1: This paragraph should be deleted or corrected because most of it is not correct, or based on debatable interpretations and opinions. The second sentence is an example of unfortunate and debatable opinion seemingly aimed at reflecting negatively on tests for pathogens. No reference is given, but it would appear that the statement refers to the paper by Allen et al (2000) "Pathogen monitoring - old baggage from the last millennium." The paper basically refers to the incident where the detection of *Cryptosporidium* in the Sydney drinking-water supply caused an outcry with substantial financial implications. It was only determined much later that the oocysts detected were not viable and constituted no health risk. It is argued that if no effort had been made to monitor the drinking-water supply for *Cryptosporidium* the whole incident with ripples world-wide would not have taken place and much confusion with enormous financial implications would have been saved. However, the other-side-of-the-coin interpretation is that valuable lessons have been learned. Among these lessons is evidence that the treatment processes concerned failed to remove oocysts and the indicators used for routine monitoring of the water failed to indicate the presence of oocysts, despite claims that treatment and quality monitoring were carried out according to widely accepted specifications. In addition, the incident can be interpreted as strong reason for the development of better methods to detect pathogens. The reason is that if appropriate methods were available it would be possible to immediately confirm that the *Cryptosporium* oocysts detected were non-viable and constituted no health risk. Furthermore, the findings alerted to strong reason for carefully inspecting the drinking-water supply from raw water source to treatment and disinfection processes because drinking-water is not expected to contain *Cryptosporidium* oocysts, dead or alive.

- Window, paragraph 2: First sentence: Suggest delete "should only be considered ..." Instead, the importance of pathogen testing for purposes such as assessment of the efficiency of water treatment and disinfection processes, and for determining the numbers of pathogens in raw water sources, should be emphasized. Without this information it is not possible to formulate guidelines and specifications for the efficiency of treatment and disinfection processes (CCPs), and for assessment of the extent to which CCPs meet requirements. Without these data it would not be possible to introduce a HACCP system and to assess the efficiency of a HACCP system.
- The second sentence should be deleted because tests for commonly used indicators have similar limits which likewise need to be fully understood.
- The last sentence is basically correct but should also be deleted because tests for pathogens are not intended to be used either as "index of water quality changes" or as "index of recent faecal contamination." These features should, therefore, not be presented as a

disadvantage of tests for pathogens. In addition, the sentence contradicts a statement in this regard under *Protozoan parasites*.

Page 16: *Enteric viruses*
- This section is in need of substantial revision with regard to technical correctness, interpretation of results and substantiated opinion.
- The section does not contain a single literature reference to substantiate any of the statements.
- For instance:
  - **paragraph 1**: The list of viruses for which waterborne transmission has been confirmed is incomplete. Waterborne transmission has also been confirmed for astro- and adenoviruses, enteroviruses (at least coxsackieviruses), and for caliciviruses other than Norwalk virus.
  - In the second last sentence the "if not all" should be deleted because it is incorrect.
  - The last sentence should be deleted because it is incorrect, which could be substantiated by a list of references.
  - In fact, the failure of conventional indicators and specifications for water treatment to ensure virological safety of drinking-water supplies should be emphasized in this section, with due reference to literature.

  - **paragraph 2**: The first sentence should be deleted because it contradicts the second sentence, which is more correct.
  - The second sentence should be corrected to read something like "Human enteric viruses are always associated human faecal pollution as far as is known."
  - The following sentence should be rewritten to read something like "The absence of enteric viruses does not indicate the absence of faecal pollution because their occurrence in faeces is highly variable. They are, therefore, not intended to be used as indicators of faecal pollution. However, when they are detected in water, their presence is more reliable evidence of human faecal pollution than that of any commonly used indicators of faecal pollution, including *Escherichia coli*."

  - **paragraph 4:** The statement "They are all pathogenic (to human or animals) ..." is not correct because:
    (a) Reoviruses are not known to be pathogenic, and some human enteric viruses such as echoviruses are rarely associated with clinical manifestations; and
    (b) there is no meaningful evidence of human enteric viruses being pathogenic to animals by normal routes of exposure.

The above features of enteric viruses are important and should be emphasized in this section.

Page 16: *Protozoan parasites*
This section requires rewriting for reasons similar to those outlined for *Enteric viruses*.

Page 17
- The list of references is grossly incomplete and outdated.
- In addition, the reference to Allen et al (2000) should be deleted unless explained and interpreted in objective perspective as outlined in comments on Page 15.

The Tables on Pages 19 to 22 are in need of revision; for instance:

First Table:

- The abbreviation VG is not defined, and NSD is defined only in the second table.
- Why is the column "association with faecal material" blacked out for Microbial (pathogens)?
- Why is the column "Risk to analyst" blacked out for "Microbial (non-pathogenic)"? What about pathogenic *E coli* strains any many other pathogenic strains which may be isolated by these methods? There could at least be an indication of "L" because the risk to the analyst is certainly not lower than in the case of tests for phages.
- The purpose and value of the inclusion of the column "Risk to analyst" is debatable.
- In the text there could be a paragraph briefly explaining the risk of microbiological tests to the analyst, together with advice on precautionary safety procedures.
- In the column "Survival in the environment" there is an "NSD" for *Bacteroides* phages: compared to other phages this could at least be an "L" or possibly even an "A".

Second Table:

- The purpose of the column "Health risk" is not clear because it is blacked out for everything except "Turgidity" which has an "NSD".
- The column "Outbreak investigation" is blank for *Pseudomonas, Aeromonas*.
- The columns "Treatment efficiency (removal)" and "Treatment efficiency (disinfection)" indicate "NR" for "Microbial (pathogens)". This is debatable. NR may be correct for routine monitoring, but the tests are indeed necessary for assessment of the efficiency of these treatment systems. Therefore, the indication could at least be "RA".

CHAPTER 3: ANALYTICAL METHODS FOR MICROBIOLOGICAL WATER QUALITY TESTING

Revision and correction is required.

- *Virus adsorption-elution methods*
The reference to Vilagines et al (1997) is not appropriate because this paper is on recovery by glass wool and not glass powder.

- Table 3.1: Delete "Enteric viruses" from this Table which is for bacterial pathogens.

- Table 3.4:
  - **Sulfite reducing clostridia spores**: clarify: Is pasturisation intended to enhance the germination of spores or to select for spores, or for both?
  - **Somatic coliphages**: Unless meaningful details and confirmation can be submitted, the statement that "multiplication of somatic coliphages is possible in waste-waters" should perhaps be deleted, or revised to read something like "... possible but seems to rarely take place to meaningful extent."
  - **Enteroviruses**: The single statement is not correct, and the entry is incomplete and in need of major revision.

There are no details for a number of target organisms.

- *Cultivation of phages:* Replace Grabow (1996) by Grabow (2001).

Box 2: "Limitations of phages"

- The text right above the Box refers to "deficiencies in the application of phages, however, which are summarised in Box ..."However, no indication is given as to what "deficiencies" reference is made to. From the Box it appears that "deficiencies" refer to the use of phages for purposes they are not intended to be used for. The use of the word"deficiencies" is, therefore, debatable.
- The statement that "some somatic coliphages may replicate in water environments" should perhaps be revised as suggested for Table 3.4.
- The statement "phages cannot be regarded as absolute indicators, models or surrogates for enteric viruses in water environments" is debatable. For instance, what is meant by "absolute"? Is there any "absolute" indicator, model or surrogate? The statement could possibly read something like: "Phages have valuable features as indicators, models or surrogates for enteric viruses in water environments, but there are certain shortcomings." In view of these and other considerations the last sentence of the paragraph should be deleted.
- Under "models for differing situations (see also Table 3.3)" the following corrections are recommended: "*B fragilis* phages" should read "*B fragilis* HSP40 phages ..." because the statement does not apply to all *B fragilis* phages.
- Replace Grabow et al (1998) by Grabow (2001).
- Under techniques for viruses it should be pointed out that highly sensitive techniques for a wide spectrum of viruses are available today.
- The perception the reader gets from Box 3 is that molecular techniques are described for the detection of bacteria with occasional reference to the possibility of using similar techniques for viruses and protozoa. The box should perhaps be presented in balanced fashion outlining basic principles of molecular techniques which apply for the detection of all micro-organisms, followed by an indication of how these techniques are applied for viruses, protozoa and bacteria.
- In the context of the document, molecular techniques are actually predominantly used for the detection of viruses and protozoa and not for bacteria, the great majority of which are readily detectably by cultivation procedures.

3.3.7. Faecal biomarkers

- Reference to more recent data on the use of phages to distinguish between faecal pollution of human and animal origin should be included, notably molecular typing of serogroups of F-RNA phages (see Grabow, 2001).
- Quantitative assessment of the origin of faecal pollution would appear to be difficult. It is correct that quantitative assessment of the origin of faecal pollution can not be carried out to meaningful extent by means of phages. However, this can also not be carried out by means of faecal sterols or any other method currently available, as far as is known. In the case of phages it can at least be confirmed that any particular phage detected is of human or animal origin.
- Nicholas Ashbolt may have more recent information on using faecal sterols to distinguish between faecal pollution of human and animal origin.

3.4.1. Laser scanning analysis
The Reference Standridge et al (1992) does not appear in the List of References.

3.4.2. DNA - chip array
- It would not appear relevant or necessary to explain at what laboratories these methods were developed, ie Stanford University, Affymetrix Inc, etc.

- Last paragraph: The current average of conventional tests for faecal indicators is not 48 hours but 24 hours.

3.4.3. Biosensors

The "pathogens" referred to should be clearly defined. It would appear that the text refers predominantly to bacteria. What are "microbes"? What about viruses and protozoan parasites?

3.4.4. Solid state Biochips

What are "microbial cells"? Are these bacteria, protozoan parasites or viruses?

3.5.2. Statistical issues

The statement in the last sentence "... occasional P/A-testing is of no value at all" is not correct.

Table 3.5. Methods for the detection of microbial contamination in drinking-water

This table is in need of major revision, correction, updating and completion, including basic grammar and editing.

For instance: Section for bacteriophages:

- Many more advantages should be listed, including advantages which are much more important than the low cost and ease of performance.
- The statement "phages cannot be regarded as absolute indicators, models or surrogates for enteric viruses in water environments" has been referred to earlier; questions include:
  - What is an "absolute indicator"?
  - Is there any "absolute indicator"?
  - What is "indicator" supposed to mean in this context, i.e., indicator of what? Phages are not considered reliable indicators of the numbers of viruses present, but valuable indicators/models/surrogates of the survival and behaviour of viruses in water environments.
- The ISO method for somatic coliphages has been published.
- ISO has no standard method for the cultivation of animal/human viruses.
- Reference to the "Cultivation of animal/human viruses" appears inappropriate because animal viruses are irrelevant in this regard.
- What is the bullet "biosafety issues" under viruses and protozoa supposed to mean?
- Under "Cultivation of protozoa" the purpose of the bullet "does not provide information on infectivity for man" is not clear. Similar references to "infectivity" are made elsewhere. Which of any of the methods for the detection of micro-organisms concerned, including *Escherichia coli*, provide information on "infectivity"? Why is it addressed for some organisms and not for others?
- Statements on "infectivity assay" and extremely poor cell culture propagation of protozoa are outdated.
- The sections for PCR and RT-PCR should clearly address techniques for viruses, protozoa and bacteria.
- The Table should point out that procedures based on cell culture amplification in combination with molecular detection are now available for the sensitive and specific detection of a wide spectrum of viruses with confirmation of viability and infectivity (see Grabow et al, 2001).

- Failure to distinguish between viable and non-viable organisms is listed as a disadvantage for many tests but not for Flow cytometry.
- Failure to indicate "infectivity" is listed as a disadvantage for many tests but not for others such as ribotyping, DNA chip array, Biosensors, etc.
- Details on "Faecal sterol biomarkers" are incomplete.
- For most tests the failure to distinguish between viable and non-viable organisms is listed under "Disadvantages" but in the case of "Biosensors" it is listed under "Application".

REFERENCES

Craun G F, Bull R J, Clark R M, Doull J, Grabow W, Marsh G M, Okun D A, Regli S, Sobsey M D and Symons J M (1994) Balancing chemical and microbial risks of drinking-water disinfection, Part I. Benefits and potential risks. Aqua 43, 192-199.

Grabow W O K (2001) Bacteriophages: Update on application as models for viruses in water. Water SA 27/2 (April 2001) (in press).

Grabow W O K, Taylor M B, de Villiers J C (2001) New methods for the detection of viruses: call for review of drinking-water quality guidelines. Water Science and Technology.

Annex 16

UPDATE OF 'TOXIC CYANOBACTERIA IN WATER' IN ORDER TO PROVIDE EVDIENCE INPUT TO GDWQ

Items suggested for change and further development:

- Guidelines have been released in several countries, e.g. Canada, Australia, Brazil. Requires assessment of institutional acceptance and application.
- Management plans have been developed and evaluated in many countries.
- Increasing number of studies recording toxic cyanobacteria in the scientific literature
- Increased recording and prevalence of toxigenic *Cylindrospermopsis raciborskii* in temperate geographic areas Europe, North America, Australia.
- Evidence of cyanotoxins in reticulated water supply in some countries
- Increased emergence and recognition of toxic cyanobacteria in wider spread of geographic regions and countries: Europe (particularly France, Portugal), Asia-Pacific-China (more provinces), South Korea; Australia, New Zealand.
- Increasing evidence of significance of cyanotoxins for impact as a contaminant in fish and shellfish in freshwater. This represents an important additional exposure route and pathway requiring assessment for the provision of advice on public health significance.
- Major advances in water treatment technology for cyanotoxin removal – significant need to consolidate the new information into an authoritative document.
- Significant advances in analytical methods – new research developments are underway.
- Major research advances in genetic characterisation of toxigenic cyanobacteria.
- Movement toward appreciation of toxic cyanobacteria and blooms as evidence of eutrophication in countries which are developing water resource assessment policies and initiatives in tandem with economic development.
- More case examples of cyanobacteria and cyanotoxic event management in relation to water supply and recreation → better developed guidance for situation assessment and planning.
- New epidemiological work, if it becomes available.
- Advances in ecological understanding.