11

Validation and verification

Validation and verification are important to establish that components within the water safety plan are working as expected and that the water safety plan as a whole is delivering the required results.

11.1 VALIDATION

Validation should be targeted at the assessment of the scientific and technical inputs into the water safety plan. Validation should ensure that the information supporting the plan is correct and that the elements of the water safety plan will be effective, thus enabling conformity with health-based targets (see Chapter 12) and public health policy.

> Validation involves obtaining evidence that the elements of the water safety plan are effective.

Process validation is required to show that treatment processes can operate as required. It can be undertaken during pilot stage studies, during initial implementation of a new or alternative water treatment system and is a useful tool in the optimisation of existing treatment processes. Table 11.1 details the validation of the critical limits, relating to coagulation and flocculation, for the Molendinar water purification plant, operated by Gold Coast Water (Australia), which was outlined in Figure 4.3.

Table 11.1: Validation schedule for critical limits, relating to coagulation and flocculation, at the Molendinar water purification plant

Control measure	Critical or operational limit	Validation	Comments
Coagulation, flocculation & settling – raw water inlet flow			
	Inspect daily / calibrate monthly	Refer comments	The inlet flow measuring device is important because the output from several dosing pumps is dependent upon its accuracy. Experience has shown that the instrument drifts only minimally over a one month period. However, it is easy for operators to do a visual check of the unit daily for mechanical failure and therefore, because of criticality, it is included in the daily plant check (proc. TS-01-210)
Coagulation, flocculation & settling – alum dosing			
	Treated water true colour of < 5 cpu	ADWG (1996) for True Colour	ADWG specify <15 c.p.u. however, 5 C.P.U. has been selected as a Critical limit for corrective action because colour above 5 is noticeable in larger volumes and colour above this value would be indicative of non optimal dosing that would affect other water quality parameters
Coagulation, flocculation & settling – pH control of dosed water			
	6.5 to 7.0 (low manganese conditions). 7.0 to 7.3 (permanganate dosing conditions)	AWWA "Water Quality and Treatment" 4th Edition (chapter 6) See also 'Manganese & Iron Related Problems in Aust Drinking-water Supplies" at (www.clo2.com/reading/ drinking/iron.html)	Although a range of values is shown, set points will be in force at any given time and procedures dictate that significant deviations will be investigated. The range 6.5-7.0 is close to the solubility minimum for Alum. Set points in the range 6.7 or 6.8 are common to minimise the amount of pH correction in disinfection and this is arbitrary. The reaction of permanganate with manganese will yield increased Mn2+ if an acid environment persists. This is undesirable. Refer also procedure TS-01-209 'Molendinar dosed water pH'
Coagulation, flocculation & settling – carbon dioxide dosing			

Control measure	Critical or operational limit	Validation	Comments
	Treated water alkalinity of 35 to 50 mg/l as $CaCO_3$	Experimental value	GCW is attempting to overcome the phenomenon of "pH bounce" in concrete lined pipes. This occurrence results in some consumers receiving high pH water. The higher the alkalinity the greater the resistance to pH bounce. The figure of 35 to 50 (suggested by Hunter Water) is a considerable increase over the current figure of about 20. Distribution system pH monitoring of trouble spots indicates this level of alkalinity is probably adequate. Further data is required to optimise dosing.
Coagulation, flocculation & settling – pre-filter chlorination			
	Treated Water soluble Mn levels of < 0.02 mg/l	Experimental work carried out for GCW by University of Qld. In 1986 Report entitled "Investigation into Biological Manganese Oxidation and Deposition in the Gold Coast Water Distribution System" by Dr. L. Sly	Report recommended that treated water should have less than 0.01 mg/l soluble Mn . Under normal operating conditions this is achieved. A figure of 0.02mg/L can be tolerated for short periods of time and this figure is chosen for corrective action instigation. Refer procedures TS-01-207 and 211 regarding manganese removal.

ADWG – Australian Drinking Water Guidelines
AWWA – American Water Works Association

Evidence for validation of the water safety plans can come from a variety of sources, including the scientific literature, trade associations, regulation and legislation departments, historical data, professional bodies or supplier knowledge. This can inform subsequent testing requirements, including the use of specific pathogens or indicator microorganisms. Microbial parameters, such as heterotrophic plate counts and coliform enumeration, which may be inappropriate for operational monitoring, can be used for validation purposes and the design of treatment systems as this does not form part of the routine day-to-day monitoring and management and thus the lag time in receiving the results is not a problem.

11.2 VERIFICATION

Verification may include review of monitoring control measures, microbiological and chemical testing, or review of the water safety plan overall to ensure that it is still accurate. This may be necessary, for instance, if there have been changes to processes or equipment.

> Verification is the use of methods, procedures or tests in addition to those used in monitoring to determine if the water safety plan is in compliance with the stated objectives outlined in the water quality targets and/or whether the water safety plan needs modification and revalidation.

To verify system performance, periodic checks are necessary.

11.2.1 Microbial water quality

For microbial quality, verification is likely to include some microbiological testing. In most cases it will involve the analysis of faecal indicator microorganisms (for further details see Dufour *et al*. 2003), but in some countries it may also include assessment of specific pathogen densities. Verification for microbial quality of drinking-water may be undertaken by the supplier, surveillance agencies or a combination of the two.

Approaches to verification include testing of source water, treatment end-point product and water in distribution systems or stored household water. Verification of microbial quality of drinking-water includes testing for *Escherichia coli* as an indicator of faecal pollution. *E. coli* provides conclusive evidence of recent faecal pollution and should not be detected. In practice, the detection of thermotolerant coliform bacteria can be an acceptable alternative in many circumstances. While *E. coli* is a useful indicator it has limitations. Enteric viruses and protozoa are more resistant to disinfection and consequently the absence of *E. coli* will not necessarily indicate freedom from these organisms. Under certain circumstances it may be desirable to include analysis for more resistant microorganisms such as bacteriophages and/or bacterial spores. Such circumstances could include the use of source water known to be contaminated with enteric viruses and parasites or high levels of viral and parasitic diseases in the community.

Water quality can vary rapidly and all systems are subject to occasional failure. For example, rainfall can greatly increase the levels of microbial contamination in source waters and waterborne outbreaks often occur during and shortly after storms. Results of analytical testing must be interpreted taking this into account.

11.2.2 Chemical water quality

Assessment of the adequacy of the chemical quality of drinking-water relies on comparison of the results of water quality analysis with guideline values. For additives, i.e., chemicals deriving primarily from materials and chemicals used in the production and distribution of drinking-water, emphasis is placed on the direct control of the quality of these products. In controlling drinking-water additives, testing procedures typically assess the contribution of the additive to drinking-water and take account of variations over time in deriving a value which can be compared with the guideline values.

Some hazardous chemicals that occur in drinking-water are of concern because of effects arising from single exposures or sequences of exposures over a short period. Where the concentration of the chemical of interest varies widely, even a series of analytical results may fail to fully identify and describe the public health risk. In controlling such hazards, attention must be given to both knowledge of causal factors and trends in detected concentrations, since these will indicate whether a significant problem may arise in the future. Other hazards may arise intermittently, often associated with seasonal activity or seasonal conditions. One example is the occurrence of blooms of toxic cyanobacteria in surface water.

11.3 MELBOURNE WATER CASE STUDY - VALIDATION

The validation for the primary disinfection control measure outlined in Table 7.3 is shown in Table 11.2.

Table 11.2: Validation of the primary disinfection control measure

Critical limits	Validation	Further investigation	Review schedule
No zero dosing*. Chlorine conc. is not to record zero for > 10 minutes. This allows for plant control loop time. (* no power/intensity outages for UV plants)	Upstream processes (initial kill): The set points have been calculated to achieve a minimum contact time of approximately 30 minutes with a residual >0.5 mg/l and CT≥ 15mg/l.min minimum. This will achieve at least 99% inactivation of viruses and bacteria (Ref: WHO Guidelines for Drinking-water Quality, Volume 2, 1994; Australian DrinkingWater Guidelines, National Health and Medical Research Council).	Knowledge on the significance of protozoa from protected sources and large detention times. Research programme underway. Completed research programme shows that protected catchments afford a three order magnitude reduction in parasitic protozoa and bacterial pathogens.	Annually
Chlorine residual must not be outside bandwidth for > 24 hours.	Bacterial regrowth downstream: Set points are based on achieving the retail company licence and National Health and Medical Research Council 1987. Guideline requirements for coliforms at taps and entry points, while maintaining chlorine concentrations below a level which will incur objectionable taste and odour.	Water Filter Study showed that there was no significant public health benefit measured from filtering the supply. Significance of chlorine residual to taps is being addressed by research in the water industry. Significance of total coliforms as health indicators has been assessed and has been removed as a health criteria in 2004 Australian Drinking Water Guidelines	

11.4 KAMPALA CASE STUDY – VALIDATION AND VERIFICATION

In Kampala, a risk assessment was performed on the system to assess current performance and as a means of validating whether the water safety plan would deliver water considered safe (Howard and Pedley 2003). The assessment took the form of assessment of removal of selected microbial indicators and index organisms through the treatment works (*E.coli*, *Clostridium* perfringens and coliphage) and analysis of indicator organisms (*E.coli* and faecal streptococci) in the distribution system. A quantitative risk assessment was performed, using a well-defined set of assumptions regarding the relationship between organisms analysed and pathogen groups. The process utilised the simplified methodology outlined in the WHO *Guidelines for Drinking-Water Quality, 3rd edition* (WHO 2004).

The assessment demonstrated that effective implementation of the water safety framework ensured adequate bacterial quality from the treatment works, although as the source water was of high quality this was expected. The assessment demonstrated that risks were much greater in the distribution system and therefore emphasised the need for improved safety management within the network following the water safety plan.

The assessment did indicate that the treatment works provided far less security regarding the risk from protozoan pathogens, a result again expected given that the plants were not designed with protozoa removal in mind. It was concluded that greater security could be obtained in one treatment works through better operation, but in the second investment would be required to upgrade the system. However, bearing in mind that overall rates of connection were low, alternative supplies were grossly contaminated and that poor hygiene and inadequate sanitation were likely to account for a greater proportion of pathogen transmission, it was recommended that such investment was a relatively low priority.

Verification is achieved through a number of mechanisms. At the treatment works, a regular programme of testing for *E.coli* was established (following previous practice, but with reduced frequency) and the laboratory was equipped to perform analysis of *Clostridium perfringens* as a means of testing treatment efficiency. Treatment plant audits are also undertaken on a regular basis to review operational records.

A rolling programme of testing for *E.coli* and sanitary inspection is also implemented for the distribution system. Periodic testing of faecal streptococci is also performed. These processes provide the water quality control department with data on which to ensure that the water safety plan is delivering safe drinking-water and can be incorporated into periodic risk assessments using available data.

Table 11.3 summarises the verification procedures.

Table 11.3: Validation of the primary disinfection control measure

Unit Process	Verification		
	What	When	Who
Source Water	Operational reports and audit	Monthly	WQCD
Coagulation/Flocculation	*E. Coli*	Weekly	WQCD
	Faecal streptococci	Weekly	
	Clostridium perfringens	Weekly	
	Record audit	Monthly	
Filtration	*E. Coli*	Weekly	WQCD
	Faecal streptococci	Weekly	
	Clostridium perfringens	Weekly	
Disinfection	*E. Coli*	Weekly	WQCD
	Faecal streptococci	Weekly	
	Clostridium perfringens	Weekly	
	CT values	Weekly	
Distribution System	*E. Coli*	Monthly	WQCD
	Faecal streptococci	Monthly	

WQCD – Water Quality Control Department