2017

Effects of Water Sampling Methods

DISCUSSION ON DIFFERENT METHODS OF IN-FIELD WATER TESTING USED FOR DETERMINING METAL LEVELS IN DRINKING WATER

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Table of Contents

Preamble

This paper is for discussion purposes only, and focusses specifically on the measuring on the in-field testing methods for determining levels of metals in drinking water, with a focus on lead levels.

Currently a situation exists in Australia where some water testing being done in the field, is creating public concern about elevated levels of lead in drinking water. The methods used for this in-field water testing vary dramatically, and it is possible that some of these testing techniques may/or may not be adequate in generating accurate data on metal levels in water. This has the potential to impact opinion regarding the possible effects on public health, and/or the suitability and safety standards of plumbing products. Therefore, further consideration is required to determine if recent public concerns about lead levels are justified.

Besides looking at different testing methods used in the field, it is also useful to look at the testing required to be performed by manufacturers of plumbing products used in contact with drinking water. These tests are mandatory for products to be certified with the WaterMark.

The purpose of this paper is to generate debate amongst authorities on the subject matter including standards bodies, government health and building authorities, and industry groups, about developing a standardised method of water sampling and testing with regards to extraction of metals in the field, across all states and territories in Australia. The objective of these sampling protocols would be to monitor for typical exposure to lead to determine if there are concerns related to effects on human health. The testing method should be appropriate for the type of building and should reflect typical usage patterns of the inhabitants. This method could be captured in an existing standard such as AS/NZS 5667.5:1998 – Water quality—Sampling – Guidance on sampling of drinking water and water used for food and beverage processing (AS/NZS 5667).

Please note: the author is not an authority on the subject, just a party interested in the topic due to its relevance to the health and safety of the community, and his long involvement in the plumbing industry. It has been written as a discussion tool for industry groups the author is a member of, and specifically for the AHSCA (WA), MPA (WA) and the PPI Group. Prior permission is needed for reproduction purposes.

Executive Summary

Many factors contribute to the variability of lead concentration results from drinking water testing. These factors include the type of materials used in the plumbing system, the age & complexity of the plumbing system itself, usage patterns, flow rates, stagnation areas, chemicals introduced into the water supply, and fluctuations in water quality (pH and alkalinity).

Lead level results may also vary depending on the sampling and testing methodology used, specifically: (a) The flushing and/or stagnation periods prescribed in the tests; (b) The volume of water extracts tested.

The difference in testing protocols can be noted in two recent high-profile Australian examples, where the methods varied considerably:

- Perth Children's Hospital – initial testing used a combination of first draw extracts of 100mL and 2-minute flush extracts of 100mL; whereas 2nd round testing used a total extract of 250mL (two x 125mL extracts averaged), taken after 30-minute stagnation periods.

- NSW Study by Macquarie University – the phase 1 testing used first draw extracts of 1L after a 9-hour stagnation period and a smaller number of 2-minute flush 1L extracts. The phase 2 case studies used 150mL water extracts.

These in-field methods differ significantly to the end-of-line testing prescribed in the Australian Standard AS/NZS 4020:2005 – Testing of products for use in contact with drinking water (AS/NZS 4020). This appears to approximate how much lead an adult would consume in a day. It uses a total volume of 2L taken from eight water extracts of 250mL. One extract is after a 16-hour stagnation time and the other seven are after 30-minute stagnation times.

Health Canada also appears to have recognised the effect sampling protocol has on results of water testing performed in measuring the typical exposure to lead in drinking water for their population. Further, they recognise the size and complexity of the building being tested affects results, and set out different testing approaches to cater for this.

They also believe that the objective of water sampling and testing is to monitor for typical community exposure to lead. This determines if there are concerns with regards to the effects on human health.

For residential dwellings, Health Canada recommends using either: (a) Random Daytime Testing (RDT) - 1L extracts without prior flushing or a prescribed stagnation period; or (b) 30MS Sampling – flush then 30-minute stagnation period and 2L collected (two x 1L extracts averaged).

For schools, multi-dwelling residences and large buildings, Health Canada recommends RDT sampling – total extract of 250mL (two x 125mL extracts averaged), without any prescribed stagnation or flushing.

The USA homeowners tap sample collection procedures published by the EPA, prescribes the collection of extracts of 1L after a stagnation periods of at least 6-hours.

Australia could also benefit from having a more detailed and standardised approach to the in-field sampling and measuring of metals levels in drinking water. It is believed this standard methodology would generate more consistency and reliability in lead level results. This approach may need to vary depending on the type of building being assessed, and it should reflect typical usage patterns of the inhabitants.

Concentrations of metals in water will vary depending on the contact time of the water with other materials, therefore any methodology needs to stipulate flushing and/or stagnation periods. This will depend on the typical usage of water in that style of building. Typically testing with long stagnation times is used for specific purposes (eg. identifying sources of lead signals or accessing the impact of a treatment regime), not in determining average daily intakes of lead. The sources referenced in this appear to favour RDT or 30MS testing methods for residential applications (though RDT may be preferred in terms of costs and practicality), and RDT testing for commercial applications.

Also, the measured levels of metals may be more concentrated or diluted depending on the volume of the water sample extract, therefore this volume should also be specified. To ensure the testing is robust in indicating if excessive daily doses of lead are consumed, the volume decided on needs to consider the consumption of typical users. From the sources referenced, extract volumes tend to favour 1L extracts for residential applications, and at least 250mL (an average glass of water) for commercial applications. Smaller volumes than these are more useful for specific testing purposes, not for typical lead exposure testing.

These new methods could be built on the practices in place internationally, and from the detailed methodology set out in AS/NZS 4020 which is already used in Australia by manufacturers of plumbing products for potable water.

Finally, it is proposed any changes could be incorporated into an existing Australian Standard such as AS/NZS 5667.5, and that federal and state governments and industry groups enforce this new testing regime.

Testing Methods

1. AS/NZS 5667.5:1998 – Water quality—Sampling – Guidance on sampling of drinking water and water used for food and beverage processing

AS/NZS 5667 provides useful information with regards to water testing, however, as further detailed below, it leaves a lot of variables up to the individual testing facility, which leaves room for different results to be generated from the same site.

For example, when looking at testing of a distribution system, clause 4.1.4 recommends that samples should be collected at distinct locations in the system, and from the ends of distribution systems. Samples should be collected after a flushing time of 2 to 3 minutes, but sometimes as long as 30 minutes.

When looking specifically at consumer's taps, clause 4.1.5 states that *'the flushing time depends on the sampling purpose; if the effects of material on water quality are being investigated then the initial draw-off should be sampled. For most other purposes, a flushing time of 2 min to 3 min is sufficient to establish equilibrium conditions'.*

Whilst this is useful, it does not specify how long the stagnation period should be before an initial draw-off sample is taken. Also, the actual volume of water to be collected is not specified. Clause 7.1 just states that *'The volume of the sample to be collected depends on the number and types of analyses to be performed'*.

As concentrations of metals in water will vary depending on contact time of the water with other materials, and as the measured levels may be more concentrated or diluted depending on the water sample extract volume, results on the same source may vary significantly depending on who is performing the testing.

2. AS/NZS 4020:2005 – Testing of products for use in contact with drinking water

As a prerequisite of gaining certification to the WaterMark, manufacturers of plumbing products used in contact with drinking water in Australia, need to have their products tested to AS/NZS 4020. This prerequisite exists for many WaterMarks, and includes, but is not limited to:

- AS 3688:2016 – Water and gas systems—Metallic fittings and end connectors
- AS/NZS 4032.1 – Water supply—Valves for the control of heated water supply temperatures—Part 1: Thermostatic mixing valves—Materials design and performance requirements
- AS/NZS 3718:2005 – Water supply—Tap ware

AS/NZS 4020 specifies requirements for the suitability of products for use in contact with drinking water, with regards to their effect on the quality of water. The testing protocols are comprehensive and prescriptive – these test methods are summarised in Table 1 of clause 6.1.

The standard covers plumbing products in general such as in-line products and end-of-line fittings, although this paper is more focussed at end-of-line fittings such as tapware. Whilst the standard discusses two methods of testing, being in-the-product exposure and immersion exposure, in-the-product exposure is to be used wherever possible for extraction testing, so we will also concentrate on this method.

End-of-line fittings which are defined in clause 3.6 as being *'Any product, or part of a product, installed within 250mL draw-off of a drinking water delivery point. Note: Products typically include taps, tap* *components, fittings, flexible hoses, drink dispensers, boiling water dispensers, drinking fountains, water treatment appliances, hose-connection vacuum breakers, ball valves and flow-control valves'*.

Scaling factors are defined in clause 3.14 as *'the ratio of end-use surface area to volume ratio to the test surface area-to-volume ratio'*. Clause 5 provides details when scaling is used, but does state that *'a scaling factor is generally not applicable for in-the-product testing'.*

If a range of products is produced, clause 4.2 states *'Where a manufacturer produces a complete range of product sizes of the same material composition, tests on the greatest surface area-to-volume product shall qualify the remainder of the range, provided that the same manufacturing conditions and processes are used for the complete range of products'.*

Extraction of metals is covered under clause 6.7, with limits of maximum allowable concentration of metals detailed in Table 2 – these limits are taken from the Australian Drinking Water Guidelines (ADWG). The maximum level for lead (Pb) is shown as 0.01mg/L.

Under clause 6.7.1 products in general are tested for metal extraction in accordance with Appendices H to J. In this clause, it states that *'the amounts of the specified metals in the first and/or seventh extracts shall not exceed the limits given in Table 2'.* An additional Appendix I is referenced in clause 6.7.2 for end-of-line fittings, which covers all the different extraction procedures for end-of-line fittings, including metal extraction testing.

For general products, such as in-line fittings, in brief, Appendix H details that:

- after a cleaning protocol, duplicate product samples are filled with test water and held for 24 hours of contact time, then the first water extract from each product sample is removed and tested.
- Blank tests are also performed to determine the level of metals from other sources such as the container or external sources.
- If the results do not exceed the specified limits, no further testing is required.
- If either result does exceed the specified limits, this process is repeated six more times (including one contact period of 72 hours), with the seventh water extract being tested.
- If the limit for any metal is exceeded, testing is done on the seventh extracts using a further three samples.

For end-of-line fittings, Appendix I states that *'in-the-product exposure is used wherever possible for test extractions'* so we will again focus on this method. In brief I6.3 details that:

- testing is performed using duplicate product samples which undergo a cleaning and flushing protocol
- using test water, the first water extract of 250mL is taken after 16 hours of contact time, then the product sample is flushed.
- The second water extract of 250mL is taken after 30 minutes contact time, the product sample is flushed, and this is repeated another six times.
- In total, eight water extracts of 250mL are taken.
- The eight water extracts of 250mL are mixed together to create the composite water extract of 2L.
- Blank tests are also performed to determine the level of metals from other sources such as the container or external sources.
- If the composite extracts do not exceed specified limits, no further testing is required.
- If either composite extract does exceed the specified limits, the test extractions are repeated using a further three fresh samples.

This method would seem to approximate how much lead an adult who drinks 2L of water a day would consume via eight separate intakes of 250mL (ie. a glass of water) - one long stagnation period and seven shorter stagnation periods.

3. Testing used in the report - 'Report on Perth Children's Hospital Potable Water – Chief Health Officer Review - July 2017' (PCH Report)

In May 2016, lead was identified in the drinking water supply of the new Perth Children's Hospital, at levels above those specified in the Australian Drinking Water Guidelines (ADWG) 2011, Version 3.3 (Updated November 2016). Testing was done on 25th June 2017 using a site-specific method which was approved by the Chief Health Officer (CHO). This methodology appears in part based on the Health Canada method called 30MS Sampling (30MS). Results showed an overall 74% compliance rate with the ADWG value for lead - well under the 95% compliance rate required by the ADWG.

The main conclusion from the PCH Report were:

1. The source of the lead in the water is from brass fittings that have undergone a process of dezincification.
2. Many of these brass fittings are located within approximately 1,200 Thermostatic Mixing Valve (TMV) Assembly Boxes, that are located within a metre or two of drinking outlets.
3. Phosphate treatment has been partially but not sufficiently effective in reducing lead levels.

The process of dezincification seems to have arisen from the nature of the brass itself, water stagnation, inconsistent flushing and a series of hyperchlorination events (there have been as many as 5 events). There is limited information provided about these hyperchlorination events and it is not clear if they were in accordance with plumbing guidelines or manufacturer's instructions.

The CHO is recommending that the TMV Assembly Boxes be removed and replaced with the best replacement option. Whether this recommendation will be accepted, and if so, when it will be implemented, are still unknown.

As stated above, the Stage 2 water sampling (S2S) testing used in the PCH Report is called the 30MS Sampling (30MS) method. Whilst site-specific, it appears based on methods detailed in the document 'Lead in Drinking Water' published by Health Canada, and other supporting studies.

The PCH method seems to be a mixture of the methods Health Canada recommend for residential purposes (RDT or 30MS with 1L extracts), and the method recommended for commercial purposes (RDT with a 250mL total extract).

Briefly, the method used averages the results from 2 x 125mL water samples (ie. a total of 250mL) taken after stagnation periods of 30 minutes.

Some notes on the testing used:

Guideline Value of Total Lead in Drinking Water:

The report refers to the ADWG which states that based on health considerations, the concentration of lead in drinking water should not exceed 0.01mg/L. This maximum allowable lead level is based on a World Health Organisation assessment and was determined by the need to protect the groups most at risk - young children, infants and pregnant women. The PCH Report explains the calculation in detail as follows:

Extract from PCH Report - Appendix 4: PCH Stage Two Sampling Program Analytical Methodology (p34)

> *The value was determined as follows:*
>
> $$0.01\text{mg/L} = \frac{0.0035 \text{ mg/kg body weight per day} \times 13\text{kg} \times 0.2}{1 \text{ L/day}}$$
>
> *where:*
>
> - *0.0035 mg/kg body weight per day is the lead intake which, based on metabolic studies with infants, does not result in an increase in lead retention (Ziegler et al. 1978. Ryu et al. 1983).*
> - *13 kg is the average weight of a child at 2 years of age.*
> - *0.2 is the proportion of total lead intake attributable to water consumption. Sufficient data are available to indicate that 80% of intake is from food, dirt and dust.*
> - *1L/day is the average amount of water consumed by a young child."*

Testing Methodology Used to Determine Value of Total Lead in Drinking Water:
Whilst several testing methodologies were used at PCH such as the:

- Australian Standard (AS) method:
  - First Flush: 100mL water sample analysed; to determine if the tap and/or associated fittings near the tap are contributing;
  - Eight Litre Flush: 100mL water sample analysed; to determine if the piping and/or fittings further upstream are contributing.
- Canadian 30MS method:
  - Flush - 30 Minutes Stagnation – First Flush: Two x 125mL water samples (total of 250mL) averaged & analysed – to determine if the tap and/or associated fitting, and piping and/or fittings further upstream are contributing.
- BTP Sampling method:
  - 24 Hours Stagnation - First Flush: 50mL cold, 50mL hot & 50mL mixed - all analysed to determine possible lead sources.

The decision matrix shown below in the extract from Appendix 5, highlights why 30MS was used for the Stage 2 Sampling (S2S).

Evidently the method was selected over others, such as the AS method, as it was believed 30MS produces a suitable measure of variability of water quality across the site under simulated typical usage patterns (PCH Report, p74). With regards to the testing used for the BTPs, it does mention in the PCH Report that the 24 hours stagnation experiments performed are not representative of typical usage patterns when the hospital is occupied and operational (p137), and that the small water samples (50mL) are to determine possible lead sources not drinking water quality (p121).

The 30MS method is explained in more detail in Appendix 5 below, but basically water samples are collected and tested as follows:

- Water is stagnated in the system for 24 hours
- Outlets are flushed with cold taps fully open for 5 minutes
- Taps are then closed for a stagnation period of 30 minutes
- After the 30 minutes stagnation period, the first two x 125mL slugs of water from the cold tap outlet are collected for analysis using a low flow technique
- The water samples are acidified (2% nitric acid) and held for 16 hours prior to analysis

- The water samples are then thoroughly mixed, and the lead concentration is determined by averaging the results for the two samples (ie. total of 250mL)

Extract from PCH Report - Appendix 5: PCH S2S Program Sampling Methodology (p 36/37)

3.2 Method – Random 30MS Sample

Samples are to be taken by collecting a sample from drinking water fountains or at cold water taps where water may be used for drinking or food preparation.

The method is based on the 30 Minute Stagnation (30MS) sampling technique.

Sample (30MS) – The tap should be flushed for 5 minutes, allowed to stand for a 30 minute stagnation period before a sample is taken.

Sample Technique - Two 125 mL samples should be collected, preferably in wide-mouth sample bottles, at a medium to high flow rate, without removing the aerator.

The samples need to be held for a minimum of 16 hours after they are acidified using a 2% nitric acid solution and prior to analysis. Each sample should be thoroughly mixed prior to being analysed using an appropriate method. The lead concentration is determined by averaging the results from the two samples.

Sample bottles are to be sealed immediately after a sample is collected and are subject to standard chain of custody certification to the laboratory.

Table 1 - Perth Children's Hospital Stage 2 Water Sampling – Decision Matrix

	Australian Standard		Canadian Approach			
Consideration	1st Flush	After 2/3min (8L)	30MS (large volume)	RDT (Domestic) (large volume)	RDT (Large Building) (low volume)	30MS (low volume) (Large Building)
Contamination from tap & associated hardware	Yes	No	No	Yes	Yes	Yes
Contamination from pipe line/steady state	No	Yes	Yes	No	No	Yes
Sample Practicality (volume/weight)	Yes (100mL)	Yes (100mL)	No (1L)	No (1L)	Yes (2x125mL)	Yes (2x125mL)
Simulate occupied building	No	No	Yes	No	No	Yes
Indicator of water quality to consumer	Good	Poor	Poor	Good	Good	Good

*1st Flush: A sample taken from a drinking water tap without any prior flushing.
**RDT: Random Daytime Testing is the collection of a sample from a drinking water tap without any prior flushing.

4. Testing used in the study 'Widespread copper and lead contamination of household drinking water, New South Wales – August 2016' (Macquarie Report)

In August 2016, Macquarie University conducted testing on water extracts from 212 homes across NSW and made the following findings:

- 8% of water samples contained lead which exceeded the maximum level specified in the Australian Drinking Water Guidelines (ADWG).
- Analysis showed that household plumbing fittings (taps and connecting pipework) are a significant source of drinking water contamination, and specifically that kitchen tap fittings are a primary source of drinking water contamination.
- The study demonstrated plumbing products that contain detectable lead up to 2.84% are contributing to contamination of drinking water.

Note, the study does recognise that the results may be affected by other contributors such as lead paint on the roof, lead flashing, uPVC piping, supply network infrastructure, supply source, etc.

The method used in this study is outlined briefly below:

- A citizen science approach was adopted whereby members of the community submitted water extract samples for analysis.
- The sampling method was based on the Australian Standard AS/NZS 5667.5:1998 Water quality – Sampling—Guidance on sampling of drinking water and water used for food and beverage processing
- In Phase 1 of the study:
    - Sample size of 212 - First draw samples were taken after a <u>stagnation period of 9 hours</u> in <u>1L bottles</u> (to simulate filling a kettle first thing in the morning)
    - Sample size of 10 – Samples taken <u>after a 2-minute flush period</u> in <u>1L bottles</u>
- In Phase 2 of the study:
    - A case study was done on 4 homes with using samples collected in <u>150mL bottles</u> (to capture the water present in the tap fittings themselves)

5. Testing methods discussed in the document 'Lead in Drinking Water – Document for Public Consultation; Consultation period ends March 15, 2017' (Health Canada Report)

In Canada, the maximum acceptable concentration (MAC) of lead in drinking water is currently set at 0.01mg/L, and is based on a provisional tolerable weekly intake of lead established by the World Health Organisation (WHO). This paper proposes that a new MAC of 0.005mg/L be set for lead in drinking water based on a sample of water taken at the tap and using the appropriate protocol for the type of building being sampled.

P8 of the Health Canada report states *'Lead is present in tap water principally as a result of dissolution (corrosion) from components of distribution and household plumbing systems that contain lead, such as pipes, fittings, solder or service connections to homes. Corrosion can be caused by several factors, including the type of materials used, the age of the piping and fittings, the stagnation time of the water in the pipes and the water quality (eg. pH and alkalinity) in the system'.* P9 adds to this complexity, by stating *'The relative contribution of lead in dissolved lead and particulate forms is not clearly understood and likely varies with water chemistry, plumbing configuration, stagnation time, flow regime, age of the plumbing materials containing the lead and use patterns'.*

The report states on p9 & 10 that exposure to lead can only be properly assessed by monitoring lead levels at the tap, but that the concentrations of lead can vary significantly both across a system and within an individual site, making the assessment of lead exposure from drinking water challenging.

Larger buildings, such as schools, are identified on p14 & 15 as being more difficult to measure due to the complexity of use patterns, variations in the age and configurations of plumbing and maintaining stagnation. The variability of lead concentrations is also affected by the water quality and the sampling method used. One 2016 Canadian study found *'lead levels were highly variable (lead concentrations varied by a factor of 10 - 2,000 between taps) within large buildings and system-wide'.*

P12 & 13 of the report looks at several studies comparing the three main water sampling protocols:

- **RDT Protocol (Random Day Time**) – collection of a random 1L sample from a drinking water tap without any prior flushing and no specified stagnation time.

- **FF Protocol (Fully Flushed)** – flushing for 5 minutes then collecting a 1L sample.

- **30MS Protocol (30 minutes)** – tap is flushed for 5 minutes; water is allowed to stand for a 30-minute stagnation period; Two x 1L samples are taken; Results are averaged.

The European studies referenced in the report indicate that RDT sampling is representative of usage patterns, enabled the detection of a substantial proportion of sites with lead issues, is relatively inexpensive, is practical to implement and is acceptable to consumers. It was also determined RDT had a stagnation time close to or higher than the actual average inter-use stagnation time, and therefore RDT may over estimate lead exposure.

The studies also show 30MS to be representative of usage and enables lead detection nearly as well as RDT, but that 30MS is more reproducible than RDT. However, 30MS is relatively expensive, less practical to implement and less convenient to consumers. FF sampling was not found to be representative and did not enable detection at sufficient problem sites.

Based on this the report suggests both RDT and 30MS can be appropriate for compliance monitoring, and that the selected protocol should be appropriate to meet the desired objective. If the objective is public health, p12 states the sampling protocol should represent the *'average of typical exposure to lead drinking water in the population. It is important to note that a sampling protocol that assesses the average intake of lead will not capture the highest concentrations of lead or the full contribution of lead from the service line'*. That is, sampling protocols using long stagnation times to capture the highest levels of lead are best used for treatment purposes (eg. investigating the efficacy of corrosion control treatments).

With regards to sampling protocols, the report recommends different protocols as follows:

Monitoring in residential buildings:

- Recommends testing once per year at 20 residences in a water supply zone
- Typically, sampling is done on the cold water tap in the kitchen or another suitable location used for drinking or food preparation
- Can use either protocol:
  - RDT Sampling – to better reflect consumer use there is no prior flushing and no prescribed stagnation period; A 1L sample is collected.
  - 30MS Sampling – the tap is flushed for 5 minutes and allowed to stand for a 30-minute stagnation period; Two x 1L samples are collected; Results are averaged.

Monitoring for schools, multi-dwelling residences and large buildings:

- Recommends testing once per year
- Typically, sampling at each drinking water fountain and at a proportion of taps used for drinking or food preparation
- Suggest use only RDT protocol as it captures typical exposures:
    - RDT Sampling – without a stagnation period and without prior flushing; Two x 125mL samples are collected (total of 250mL); Results are averaged.

6. Testing used in United States Environmental Protection Agency WSG197 – 'Clarification of Recommended Tap Sampling Procedures for the Purposes of the Lead and Copper Rule' – Signed February 29, 2016

In the USA, the Lead and Copper Rule, 40 C.F.R. Sections 141.80 to 141.91 requires monitoring at consumer taps to identify levels of lead in drinking water that may result from corrosion of lead-bearing components in a public water system distribution system or in household plumbing.

Homeowners required to collect samples from a tap that has not been used for 6 hours, and to collect the samples in a 1L sample bottle.

7. Other examples

The Department of Health in Western Australia guidance article called 'Standard drinking water test' offers little detail and basically refers consumers to a list of NATA approved laboratories for more information. These laboratories are then meant to advise consumers on the correct sampling procedures, volumes of water samples to take, sample bottles, temperatures, etc. However, our enquiries with some of the laboratories confirmed very different regimes depending on which laboratory was contacted.

Recent field testing we have witnessed by some local government bodies utilised bottles ranging from 60mL to 100mL, and used a variety of testing methods such as overnight first-draw samples, 2-minute flush samples, and 30-minute stagnation samples.

Conclusion

Recent events and incidents around Australia have raised questions about the levels of lead in our drinking water. A review of these incidents has highlighted apparent inconsistency and a lack of standardisation in the on-site sampling methods undertaken as the basis for testing.

In preparing this paper the author has identified what he believes is an opportunity for standards bodies, government health and building authorities, and industry groups, to consider implementing a standardised method of water sampling and testing with regards to extraction of metals in the field, across all states and territories in Australia.

References:

AS/NZS 5667.5:1998 – Water quality—Sampling – Guidance on sampling of drinking water and water used for food and beverage processing; *Standards Australia/Standards New Zealand*

AS/NZS 4020:2005 – Testing of products for use in contact with drinking water; *Standards Australia/Standards New Zealand*

AS/NZS 3718:2005 – Water supply—Tap ware; *Standards Australia/Standards New Zealand*

Report on Perth Children's Hospital Potable Water – Chief Health Officer Review; July 2017; *Department of Health - Government of Western Australia*

Standard drinking water test; *19th April 2017; Department of Health - Government of Western Australia*

Widespread copper and lead contamination of household drinking water, New South Wales, Australia; *August 2016; Macquarie University*

Lead in Drinking Water – Document for Public Consultation; *Consultation period ends March 15, 2017; Federal Provincial Territorial Committee on Drinking Water – Health Canada*

WSG197 – Clarification of Recommended Tap Sampling Procedures for the Purposes of the Lead and Copper Rule; Signed February 29, 2016; *United States Environmental Protection Agency*