MASSEY UNIVERSITY
COLLEGE OF HEALTH
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Technical commentary and opinion relating to the nature, health significance and persistence of trace of methamphetamine on indoor surfaces.

Report 1: nature and health significance.

13 June 2016

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1. Background

1.1 Nature of the engagement

Housing New Zealand have indicated that they would value some background technical commentary and opinion on the following:

1. The nature of the recommended clean-up guideline (0.5 µg/100 cm^2) for methamphetamine residues from surfaces.
2. Any information about surface methamphetamine loadings that might be linked to potential for adverse health effects.
3. Expected natural rates of loss of methamphetamine residues on surfaces over time.

Statement relating to free provision and non-exclusivity of the information

I am happy to provide this information to Housing New Zealand and other agencies or private individuals as part of my public service function as a University academic, and am also preparing a series of shorter briefing notes relating to aspects of the same issue.

Statement confirming absence of personal financial interest

To compensate for time taken in preparing these comments Housing New Zealand has kindly offered to pay Massey University up to $8,100 by way of a short-form contract, with the exact sum depending on hours spent. This will be invoiced at a future date. None of this money will be paid to me personally. After deduction of overheads by the University for contract administration, the balance of any funds received will be used in support of Massey University postgraduate research projects within the School of Public Health, within the College of Health. This is my standard practice for external contracts through Massey University; they are a means of obtaining research funding for postgraduate students that I am supervising or co-supervising. Within the tertiary education sector it is usually necessary to seek such additional funding for postgraduate research students by way of research grants, scholarships or contracts. Supplementary funds of this type typically help to cover costs of laboratory consumables, external analytical tests, and other advanced forms of computational analysis, to allow masters and PhD students to complete their thesis work to a suitable academic standard.

1.2 Overview of expertise

This document contains expert opinion relating to traces of methamphetamine residues on surfaces. It is appropriate for me to first outline my areas of expertise to establish the basis upon which I feel qualified to offer technical commentary in this area. In later sections I will identify significant technical documents and outline the reasoning upon which my opinions are based. I have prepared an outline of my background and areas of expertise in 'brief of evidence' format, as **Appendix 1**.

In overview form, my core area of professional expertise is the technical appraisal, risk assessment and management of chemical contamination issues.

My academic qualifications are a BSc(Hons)(First Class) in Chemistry (1987) and a PhD in Environmental Analytical Chemistry (1990). My post-qualification experience includes one year in postdoctoral research, 11 years as a chemistry lecturer at the University of Waikato, and 10 years with the Waikato Regional Council in regional government, and 4.5 years as a senior lecturer at Massey University in Wellington. My role with the Waikato Regional Council was as a technical specialist in chemical contamination issues across the board (air, land, water, *etc*.), including contaminated sites. My responsibilities ranged from provision of scientific advice through to coordination of specific research programmes.

My academic teaching and research have covered two main areas: (a) environmental chemistry and risk assessment, particularly in relation to chemical contamination issues, and (b) analytical chemistry method development, including new methods in forensic science. I am currently the 'major leader' for the Massey University's Environmental Health teaching programme, and teach in chemistry and toxicology.

At national level I have contributed to New Zealand policy and legislation development in the areas of contaminated land, hazardous substances, and air quality, gained experience with hazardous emergency management, and served as an expert witness in legal proceedings, and as an independent hearings commissioner.

In relation to this evidence it is relevant that I provided technical input into and peer review of the *Guidelines for the Remediation of Clandestine Methamphetamine Laboratory Sites* [**1**]. This document was published by the Ministry of Health in 2010 and (in the absence of further guidance) has been used since then (2010-2016) as the New Zealand standard reference document by practitioners involved in investigating methamphetamine contamination and remediating contaminated properties.

In addition I was a member of Ministry for the Environment technical advisory groups that oversaw development of technical documents that support the '*Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011*' [**2**] which are also referred to as the NESCS regulations. The two documents of most relevance here are: '*Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health*' [**3**] and *Toxicological Intake Values for Priority Contaminants in Soil*.' [**4**]. The 'Methodology' document sets out a New Zealand exposure-risk model for determination of numeric guidelines for contaminants from toxicological reference values, and is incorporated into the NESCS regulations by reference. Although the context of the methodology document is soil contamination, the adopted exposure-pathway risk methodology provides a general guide to the New Zealand approach to determining risk-based guideline values.

1.3 Documents referred to in this assessment

As part of this assessment I will refer to a number of documents by name and/or number in the text, at points where they inform my commentary or opinions. The identities of these are provided in a single reference list in **Section 4** of this report. The first and most frequently referenced of these (reference [**1**]) is:

- Ministry of Health (2010). *Guidelines for the Remediation of Clandestine Methamphetamine Laboratory Sites*. Wellington: Ministry of Health.

For simplicity, this document will be referred to as the *NZ Methamphetamine Guidelines*.

2.0 Nature of current clean-up target for surface methamphetamine

2.1 Identity, regulatory status and intended context

The current remediation guideline for methamphetamine residues from surfaces, as recommended by the Ministry of Health in the NZ Methamphetamine Guidelines [**1**] is 0.5 µg/100 cm^2:

> "The Ministry of Health currently recommends that surface wipes for methamphetamine not exceed a concentration of 0.5 µg/100 cm^2 as the acceptable post-remediation re-occupancy level for a dwelling that has been used as a clan meth lab."

In words, this figure is ***half a millionth of a gram*** of methamphetamine for each ***100 cm^2 area*** of wall. An example of 100 cm^2 is a square patch of dimensions 10 cm wide by 10 cm high.

This figure is not a mandatory clean-up target, or a standard that has (yet) been adopted in any New Zealand statute, regulation or New Zealand Standard. As such it carries no intrinsic weight but instead exists as a 'recommended-practice' reference point, which gains regulatory solidity only when adopted operationally by public agencies (such as territorial authorities) who have a say in re-habitation of a residence after a meth lab clean-up. The numeric remediation guideline is also presented as being open to future modification, through use of the word 'currently' in the excerpt cited above. To emphasize the non-mandatory status of the remediation guideline it is worth noting the first sentence of the disclaimer in its parent document, the NZ Methamphetamine Guidelines [**1**], which reads:

> "These guidelines have no statutory effect and are of an advisory nature only."

The first excerpt above is the only written statement in the NZ Methamphetamine Guidelines [**1**] which explicitly links the Ministry of Health to the recommended remediation guideline 0.5 µg/100 cm^2. With this in mind it is worth noting that the same statement also specifies that the intended context of its use was for "a dwelling that has been used as a clan meth lab." This specific phrasing reflects that fact that during the development of the NZ Methamphetamine Guidelines [**1**] it was not anticipated that the recommended remediation guideline for methamphetamine may also be applied to a multitude of cases where methamphetamine had merely been smoked within the walls of a dwelling. The front page title of the NZ Methamphetamine Guidelines [**1**] also make it clear that their intended context was the remediation of methamphetamine laboratories.

The majority of potential health risks associated with buildings used as meth labs are linked to inhalation risks of the higher-volume and toxic chemicals that are used in the

manufacturing process, in particular, various solvents. It is possible that the authors of the NZ Methamphetamine Guidelines [**1**] may have opted for a higher remediation target (a) had the potential relevance of smoking been foreseen, and/or (b) if representative data had been available describing the ordinary prevalence and concentrations of traces of methamphetamine on the interior walls of ordinary residential properties and hotel/motel units.

The Australian guidelines [**5**] (published in 2011) do explicitly accommodate both options (manufacture and smoking) in the same remediation target for methamphetamine on surfaces; however with experience and ordinary prevalence data (see **Section 2.3.2** of this report) it is possible that the Australian guidance may be open to future modification.

2.2 What the guideline is and what that means

2.2.1 Overview

The numeric remediation guideline for methamphetamine can be referred to in two ways:

- In New Zealand it qualifies as a 'risk-based guideline value' adopted from an overseas jurisdiction, as defined in reference [**6**] (Ministry for the Environment (2003, revised 2011).
- In some overseas jurisdictions, it would be regarded as a 'technology-based' clean-up target, as the term is used by Hammon and Griffin (2007) [**7**].

Although it may be referred to as 'risk-based', the remediation guideline does not denote the onset of either a quantifiable health risk, or a sharp transition from 'benign' to 'harmful.' As will be outlined below, the term 'risk-based' refers to the nature of the process that was followed when a guideline is developed, and not the consequences of one being exceeded. For reasons that will be outlined below, the existence of either minor or significant health risks can not be inferred from a simple exceedance of the 0.5 µg/100 cm^2 remediation guideline.

2.2.2 How risk-based guidelines are developed and what they represent

Risk-based guidelines are numeric limits have been developed to define tolerable concentrations or loadings of toxic substances in various media, including water, food, air, soil, and for some contaminants such as methamphetamine, surfaces.

The first step in developing any risk-based guideline is to determine and agree a toxicological **reference dose** (RfD) which can also be referred to as a tolerable daily intake (TDI). In general a reference dose is:

> "an estimate of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of harmful effects during a lifetime." [**7**]

In most cases the reference dose is based on the lowest dose at (or just above) which the very beginning of a potential health effect occurs,[1] which is then divided by uncertainty factors to create a substantially lower number still.

The combined uncertainty factor can range from 10 to 1000 but is commonly 100. A factor of 100 is designed to allow for differences in sensitivity between species (*e.g.* extrapolating from rats to humans) and between individuals (*i.e.* variation in sensitivity within a human population). Use of the uncertainty factor provides some assurance that the onset of any effect is unlikely to occur in even the most sensitive individuals of the most sensitive subgroups of the population (*e.g.* children), even if exposed over the long term.

Once a toxicological reference dose has been established, risk-based guidelines applicable to various media (soil, food, water, a surface) can be derived from it.

The toxicological reference dose (RfD) which sits well behind the NZ [**1**] methamphetamine remediation guideline is 0.0003 mg/kg body weight, and was initially derived by the

[1] These 'minimum onset thresholds' go by various titles depending on what exactly is being tracked:
- **NOEL = no observable effects level** (the highest dose at which no effect of any type is observed);
- **NOAEL = no observable adverse effects level** (the highest dose at which no adverse effect is observed);
- **LOEL = lowest observable effects level** (the lowest dose at which an effect of any type is observed);
- **LOAEL = lowest observable adverse effects level** (the lowest dose at which an adverse effect is observed);
- **BMDL = benchmark dose level**;
- **BMD_{10} = benchmark dose level associated with a 10% effect**.

Experimentally these thresholds can sometimes be hard to tell apart.

California EPA OEHAA based on a review of human data. Rationale for and derivation of this figure is provided in Salocks (2009) [**8**]. Briefly, an estimated LOAEL (Lowest Observable Adverse Effects Level) of 0.08 mg/kg body weight was divided by a combined uncertainty factor of 300.[2]

After a toxicological reference dose (RfD) has been established, the guideline development process itself requires identification and quantification of possible exposure pathways, or ways that the contaminant can make its way from the source to become absorbed (or available for absorption) by an individual. One of three dominant entry routes are considered as the final step in an exposure pathway: these are ingestion, inhalation, and absorption through the skin. Exposure pathways are context-specific and vary widely. In the case of methamphetamine on surfaces for example, one pathway is transfer of methamphetamine to a child's hands which are then transferred to their mouth, leading to ingestion as the entry route. Another route is potential absorption through the skin.

Assumptions made in quantifying exposures that could occur through the various pathways tend to be realistic when good information is available, and conservative (precautionary) where data is limited. On the whole, the inclusion of precautionary assumptions around a number of exposure factors means that this process probably tends to estimate exposures as being higher than they are likely to be in most cases, but this approach is regarded as being appropriate in the face of uncertainty.

After exposure pathways are identified and numerically characterised, then a risk-based guideline value can be back-calculated by working our what level of exposure (from all pathways working together) would be sufficient to meet the toxicological reference dose (RfD).

In recent New Zealand history this sequential process has been illustrated in some detail as part of published background work that went into developing Soil Contaminant Standards (SCS values) for use in the *Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011*

[2] The factor of 300 itself includes:

- Division of the LOAEL of 0.08 mg/kg by 10 for extrapolation from a LOAEL to a NOEL (No Observed Effect Level);
- A further division by 10 for inter-individual variation in population response; and
- A further division by 3 to allow for incompleteness in the database.

No additional factor was found to be necessary to allow for differences between short and long-term exposure, due to the nature of the toxicological response (end-point).

(also known as the NESCS) [**2**]. Reference doses for priority contaminants in soils were first developed as documented in 'Toxicological Intake Values for Priority Contaminants in Soil' [**4**]; and an exposure-pathway methodology was then refined and applied through which concentration limits in soil were developed by being indexed against the reference doses, as documented in 'Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health' [**3**] (with both documents being published by the Ministry for the Environment in 2011). The 'Methodology' document [**3**] is now incorporated by reference into the national environmental standard (NESCS) [**2**]. Through incorporation into regulations by reference, the risk-based guidelines developed through this process made a transition to becoming standards, and are referred to as Soil Contaminant Standards (SCS values).

A key point about risk-based guideline values (or standards) is that the name 'risk-based' refers to the process that was followed in their development. Specifically the phrase 'risk-based' means that through consideration of exposure pathways, the guideline is one that was quantitatively indexed to an agreed toxicological reference value (RfD or equivalent). The toxicological reference value itself is set at a very conservative level to effectively guarantee lack of an effect, and variability in some of the exposure assumptions can often produce guidelines that may vary by factors of 2, 3, 4 or 5 times (see section below). Generally the various estimates will produce guidelines of a similar magnitudes, and defining a safe order-of-magnitude is really how most guidelines of this type should be viewed, from a risk perspective.

For these reasons, exceeding a 'risk-based' guideline value by a marginal amount can not (and should not) be taken to imply the onset of any genuine or measureable health risk. Such guidelines do not have that level of precision, and are also buffered by an aggregate of uncertainty factors that in combination tend to make them highly precautionary.

Guidelines or standards developed through less rigorous methods are usually referred to by another name, as 'threshold' values. The distinction between 'risk-based' guidelines and 'threshold' values is emphasized in Ministry for the Environment (2003, revised 2011) [**2**]:

> "Environmental guideline values can be risk-based or threshold values. Risk-based values are derived from a given exposure scenario (protection of human health) or the protection of a nominal proportion of species in an ecosystem. Threshold values may be derived from toxicological data where insufficient data is available to calculate risk-based values. Guideline values may also be classified as threshold values where insufficient information on their derivation is provided."

2.2.3 Origin of New Zealand's recommended guideline

Ministry for the Environment (2003, revised 2011) [**2**] sets out principles and a preferred hierarchy for selection of numeric guidelines/standards in New Zealand, as recognized by the authors of the NZ Methamphetamine Guidelines [**1**]. The hierarchy, in order from most to least preferred, is:

1. New Zealand derived risk-based guideline values;
2. Rest of the world derived risk-based guideline values, with preference given to those that employ risk assessment methodologies and exposure parameters consistent with that already used in New Zealand;
3. New Zealand derived threshold values;
4. Rest of the world derived threshold values.

The first preference in this guideline hierarchy is not available now, and was not available when the NZ Methamphetamine Guidelines [**1**] were written. This is because New Zealand has not yet developed its own risk-based guideline for methamphetamine residues on surfaces.

At the time that the NZ Methamphetamine Guidelines [**1**] were being written however, two other 'risk-based' guidelines had been developed or drafted in overseas jurisdictions. In keeping with requirements of the second category of the guideline hierarchy, both of these employed risk assessment methodologies and exposure parameters consistent with those already used in New Zealand. Either of these overseas guidelines could potentially be adopted under step 2 of the guideline hierarchy:

1. In California, a clean-up standard of **1.5 µg/100 cm^2** had been formally adopted through amended legislation. The NZ Methamphetamine Guidelines [**1**] discuss this and other numbers, and explain its background and rationale as follows:

   > "In California, the Office of Environmental Health Hazard Assessment (OEHHA) and Department of Toxic Substances Control (DTSC) have developed a risk-based target remediation standard/guideline (clean-up standard) for methamphetamine in residences used to illegally manufacture methamphetamine. On 1 January 2010 the statute was amended to less than or equal to 1.5 µg/100 cm^2 when legislation was passed by AB 14898 (Health and Safety Code section 25400.16) replacing the standard 0.1 µg/100 cm^2 on the grounds that extensive research found the standard (0.1 µg/100 cm^2) to be overly conservative and that a standard of 1.5 µg/100 cm^2 would be sufficiently protective to make properties safe for human occupancy."

2. Meanwhile in Australia, an 'Investigation Level' (IL) of **0.5 µg/100 cm^2** for methamphetamine on surfaces had been prepared by the consulting firm *Environmental Risk Sciences Pty Ltd* under contract to the Australian Crime Commission. This report [**9**]

had (and has[3]) only been released in draft form; however the technical author followed an appropriate risk-based methodology of a type that could qualify under category 2 of the New Zealand guideline hierarchy. It is unclear whether this value was ever formally peer-reviewed, but it was subsequently adopted as part of Australia's *'Clandestine Drug Laboratory Remediation Guidelines'* (published in 2011) [**5**].

Both of these figures could be seen as risk-based, but for reasons that may remain unclear, the Australian 'Investigation Level' (0.5 µg/100 cm^2) was chosen for recommendation in the New Zealand methamphetamine guidelines (see [**1**], Table 3: Summary of remediation guidelines for New Zealand residential properties).[4] Given that the California EPA OEHAA/DTSC guideline was based on the same toxicological reference dose and most sensitive receptor [**8**] and made use of a more sophisticated exposure model [**9**], and had been adopted by statute by an overseas jurisdiction at time that the NZ Methamphetamine Guidelines [**1**] were written, it could be argued that the Californian figure of 1.5 µg/100 cm^2 may have been a more justifiable first choice as a New Zealand remediation guideline. (Having noted this, there is one 'external' reason for recommendation of the lower of the two numbers in the context of a methamphetamine laboratory cleanup, which relates to potential risks from chemical residues other than methamphetamine. This reason is outlined below in **Section 2.2.4**.)

Variations in assumptions made in risk modelling can change the outcome significantly. Environmental Risk Sciences (2009) [**9**] acknowledge and discuss reasons for the factor of three difference between their derived figure of 0.5 µg/100 cm^2 now used in Australia and California's OEHHA/DTSC guideline of 1.5 µg/100 cm^2. Both derivations started with the same toxicological reference dose (RfD), and derivation of both was based on potential effects on the most sensitive residential receptor: young children aged 6 months to 2 years

[3] Environmental Risk Sciences (2009). Derivation of Risk-Based Investigation Levels, Clandestine Drug Laboratory, Site Investigation Guidelines. Prepared for the Australian Crime Commission, Ref: ACC/09/R001, 6 October 2009. Available from: http://www.enrisks.com.au/wp-content/uploads/2012/12/Derivation-of-Risk-Based-Guidelines-for-Website.pdf

[4] Note that a cursory reading of the summary provided in **Section 5.5** of the NZ Methamphetamine Guidelines [**1**] may potentially mislead by giving the opposite impression, that the adopted guideline came from a US jurisdiction. This summary reads: "In an effort to determine a level of methamphetamine at or below which the site remediation process could be considered adequate for the protection of people who would subsequently reoccupy a dwelling, the Ministry of Health has evaluated the current remediation guidelines used overseas, in particular in the United States. The Ministry of Health currently recommends that surface wipes for methamphetamine not exceed a concentration of 0.5 µg/100 cm^2 as the acceptable post-remediation re-occupancy level for a dwelling that has been used as a clan meth lab."

[**8, 9**]. In discussing reasons for differences in the resulting guideline, Environmental Risk Sciences (2009) (Appendix C) [**9**] describe their own approach in the following terms:

> "...a point value, simplistic application of a more complex exposure model (which considers exposure distributions and microactivity patterns based on diary entries), SHEDS (USEPA, 2007). The conservative nature of the approach adopted can be illustrated by comparison of the IL derived for methamphetamine with that derived by OEHAA (2009) using the more complex SHEDS model…"

With these factors in mind it may be worth noting the disclaimer in the NZ Methamphetamine Guidelines [**1**], to accommodate the possibility of an alternative view being taken on the most appropriate source of a remediation target that meets the conditions outlined in category 2 of the guideline hierarchy:

> "These guidelines have no statutory effect and are of an advisory nature only. The information should not be relied upon as a substitute for the wording of the relevant legislation or for detailed advice in specific cases, or, where relevant, as formal legal advice. If advice concerning specific situations or other expert assistance is required, the services of a competent professional advisor should be sought."

Some comments about the possibility of New Zealand developing its own guideline are provided in **Section 2.3** of this report.

2.2.4 A secondary rationale for use of a low number

As indicated above, the majority of potential health risks associated with buildings used as clandestine laboratories are linked to inhalation risks of the higher-volume and toxic chemicals that are used in the manufacturing process, in particular, various solvents; but also other potential by-products of the methamphetamine manufacturing process that may exist on walls and other surfaces. For this reason the methamphetamine remediation target in the NZ Methamphetamine Guidelines [**1**] is only one of several numeric remediation guidelines.

In the context of a lab clean-up, methamphetamine residues can be used as a marker for potential presence of other unknown chemical by-products of manufacturing. In this context a very low clean-up target for methamphetamine can be very useful, because cleaning down to a very low remediation target for a known residue will ensure that other unmeasured, unidentified or unquantifiable chemical residues on interior surfaces would also be reduced to extremely low concentrations.

Reasoning here is that if the readily measurable target substance methamphetamine can be reduced to vanishingly small quantities, then any other potentially problematic precursors or by-products from the manufacturing process that might be present on surfaces would *also* be reduced to very low concentrations, whether or not they were identified and measured. In this way, methamphetamine residues can be used as a convenient **marker** for the likely removal of all other possible chemical residues produced in a clandestine lab during manufacturing, some of which may be more toxic. (This reasoning does not apply to the home smoking scenario.)

The authors of the NZ Methamphetamine Guidelines [**1**] understood this and explain that these considerations as being part of their reasoning in recommending conservative remediation guidelines for known contaminants. They note:

> "The Ministry of Health's rationale for the remediation guidelines assumes that if decontamination activities are sufficient to remove methamphetamine and VOCs (also iodine, lead and mercury if the amalgam/P2P method is used) to acceptable levels, other chemicals for which a remediation guideline value has not been given will have been sufficiently removed as well." [**1**; page 23].

2.2.5 How the New Zealand guideline might be viewed in other contexts

In California, where a risk-based figure of 1.5 µg/100 cm^2 is in use, the Australian IL being used in New Zealand and all lower values might be regarded as 'technology based' clean-up targets [**7**]. This phrase reflects that fact that a driver of remediation can be our modern ability to detect ultra-trace levels of various organic compounds down to vanishingly small (ultra-trace or 'forensic level') concentrations.

The authors of the NZ Methamphetamine Guidelines [**1**] noted that although over 20 states in the US have/had established their own clean-up targets for methamphetamine residues from surfaces, these other values were/are not 'risk-based.' Rather they are based on levels that (a) can be that could be measured down to using modern analytical instruments, and (b) are so low that they are "believed to be set at sufficiently conservative levels to still be health-protective."

Modern instrumental methods for chemical analysis used in commercial laboratories can commonly reach over ten times lower than the Australian IL (to ~0.05 µg/100 cm^2) but every method will eventually reach an instrumental detection limit. When that detection limit is reached, the result is simply reported as being 'less than' (<) the detection limit, or a 'non-

detect.' In relation to these considerations and for some purposes it can be useful to appreciate the following points:

- 'Non-detected' results do not mean that the residues are no longer present. Non-detected results simply mean that if residues are still present they are below the detection limit of the available methodology and technology; we have reached the point where an analytical instrument or method can no longer detect them.

- Though risk-based, a constraint on the numeric value of any clean-up standard is that it must be set at a level that a range of capable instrumental methods used in commercial laboratories can comfortably reach. If the New Zealand standard had been set 20-30 years earlier, the limit would have necessarily been set at a much higher value. This is because we would have been relying on an earlier generation of analytical instruments possessing higher detection limits.[5]

2.3 Possibility of a New Zealand risk-based guideline

2.3.1 Existence of the option

New Zealand could at any point take the approach of developing its own risk-based guideline value for methamphetamine residues on surfaces. Such a value would sit at the top tier of the guideline hierarchy [**2**] and supersede the need to resort to guidelines developed in other jurisdictions operating under similar but slightly different contexts. In keeping with contaminated land guideline development, the Ministries of Health and Environment would be appropriate sponsoring agencies.

2.3.2 Potential relevance of external constraints

Potential significance of background prevalence

Constraints imposed by external realities occasionally insert themselves into the guideline setting process, resulting in guidelines that are higher than they would be in a world determined by idealized assumptions expressed in toxicological equations.

The Maximum Acceptable Value (MAV) for arsenic in drinking water (10 µg/L) is a good example of this. Long-term excess cancer risk from at this concentration is likely to be

[5] For modern testing of organic compounds to trace level the industry standard is now based on chromatographic separation with detection by mass spectrometry (with abbreviations including GC-MS, HPLC-MS, and HPLC-MS-MS). Before mass spectrometric interfaces were developed detection relied on the previous generation of chromatographic techniques (e.g. GC-FID and HPLC).

substantially higher [**10**, **11**] than the excess cancer risk of 1 in 100,000 normally tolerated in New Zealand, and used in setting other guidelines for non-threshold contaminants of this type [**3**]. In this case the external reality is that arsenic occurs naturally at reasonably elevated concentrations in some source-waters, and this would make it difficult for some drinking water supplies to realistically meet the MAV after treatment if the MAV were set at a substantially lower concentration. For example, the natural long-term average concentration of arsenic in water leaving Lake Taupo at the start of the Waikato River is already 10 µg/L, before any anthropogenic influence of the Wairakei geothermal power station is felt [**12**].

The tolerable intake for cadmium in food is a second example, where there is essentially no safety factor between modern dietary intakes, and the lowest concentrations that might correspond to adverse health effects in some people; or in the words of Järup and Åkesson [**13**]: "...no margin of safety between the point of departure and the exposure levels in the general population." This reality is imposed by the combined effect of natural and anthropogenic cadmium in modern foods and diets [**14**], a significant proportion of which is attributable to the long-term use of phosphate fertilizers on farmland [**15**, **16**].

Similarly, soil standards for arsenic and cadmium were set with reference to survey data defining the background ranges of these two elements in New Zealand soils [**3**]. Further examples can be found in the National Environmental Standards for Air Quality (where the threshold value for urban PM_{10} is higher than ideal), and several of the environmental and human health 'bottom lines' set in the National Policy Statement for Freshwater Management 2014.

The relevance of this to methamphetamine is the extent to which in any *future* guideline development or revision process, allowance should be made for background prevalence and expected concentration ranges of trace methamphetamine on the interior surfaces of residential properties where it has not been manufactured. A related question is whether specific surveying (or analysis of available data) should at least be undertaken to reliably determine background prevalence and concentration statistics.

A further consideration may be how this type of trace-level exposure may compare with background exposures that could theoretically exist through contact with other common items that are transferred between people in a community and carried into homes.

Banknotes are a commonly-encountered item in this category.

A range of studies have shown that traces of various illicit drugs can be found on a significant proportion of banknotes that are in circulation, often with geographical differences reflecting drug use within a given population. A brief review of this area may provide some wider context from which to view traces of methamphetamine residues on interior walls of non-laboratory sites. This review is provided in **Appendix 2** (**Section 5.2**).

Internationally, detection of drug residues including methamphetamine on banknotes has not been interpreted as a direct cause for public health alarm, and there is no prospect of any jurisdiction requiring that banknotes be decontaminated between users.

In a hierarchy of relative health hazards and risks, contaminated banknotes and houses where methamphetamine has been smoked would be at the low end of any scale. Former methamphetamine laboratories would be at the high end, as would households within which methamphetamine is still being smoked.[6]

2.4 Section summary

The current remediation guideline for methamphetamine residues from surfaces of "a dwelling that has been used as a clan meth lab," as recommended by the Ministry of Health in the NZ Methamphetamine Guidelines [**1**], is 0.5 µg/100 cm^2. This is:

- A preliminary ('current') recommended figure rather than a mandatory standard;
- A 'risk-based' guideline adopted from Australian work which was (at the time) still in draft form;
- One of two risk-based guidelines which could have been selected from overseas at the time, the other being 1.5 µg/100 cm^2 which had been adopted in a US jurisdiction.

Part of the rationale for selection of a conservative guidelines for known chemical residues associated with methamphetamine manufacture is that they can be used as a markers for other chemical residues that may have been produced and deposited on surfaces as a by-product of the operation. This reasoning does not apply to a smoking scenario.

[6] In any reformulation of wider health priorities, it might be usefully appreciated that the greatest involuntary exposure risks are to children who are living in households with current methamphetamine smokers, in contrast to children living in houses where methamphetamine was previously smoked. The former group are the more likely to experience habitual and potentially health-significant exposures to methamphetamine through all three main intake routes.

The meaning of the phrase 'risk-based' in the context of guidelines is commonly misunderstood, and refers to the nature of the methodology that was followed when a guideline is developed, rather than consequences of one being exceeded.

Risk-based guidelines are set at levels that are so low that long-term exposure could carry no appreciable, nor quantifiable, health risk. For this reason exceeding a surface methamphetamine loading of either 0.5 µg/100 cm^2, or 1.5 µg/100 cm^2, would not denote the sudden onset of any discernible health risk. Guidelines like these are not set at values just below where a health-risk begins. They are set at values which are many times lower than the point where a health risk could become quantifiable.

In application, the currently recommended remediation guideline for methamphetamine has seen considerable 'scope-creep.' The NZ Methamphetamine Guidelines [**1**] were developed to provide advice to support the remediation of clandestine laboratories that had been used for the manufacture of methamphetamine. In this wider context, the recommended methamphetamine guideline does not exist in isolation, but is one of many precautionary guidelines set for a range of chemical residues that can exist at drug manufacturing sites at relatively high concentrations. At the time the NZ Methamphetamine Guidelines [**1**] were written it was not anticipated that the 0.5 µg/100 cm^2 methamphetamine guideline might be widely applied – almost in isolation – to cases where methamphetamine may have been smoked within the walls of a dwelling.

'Forensic-levels' of trace contamination on interior surfaces that can result from smoking methamphetamine are not dissimilar in concept to the common existence of drug residues on banknotes, which reflect local use patterns within a community.

In a hierarchy of relative health hazards and risks, contaminated banknotes and houses where methamphetamine has been smoked would be at the low end of any scale. Former methamphetamine laboratories would be at the high end, as would households within which methamphetamine is still being smoked.

The recommended remediation guideline for methamphetamine does not fall into the category of being a 'New Zealand risk-based guideline,' and one of these has not yet been developed. However, New Zealand could at any time develop its own risk-based guideline of this type, which would supersede the currently adopted value. In any future guideline development process it would be advisable to have regard to any constraints set by the background prevalence and (where detected) distribution of methamphetamine loadings on the interior surfaces of various types of dwellings.

3 Assessment of the lowest 'health-relevant' surface loading

3.1 Context and question

As discussed in **Section 2** of this report, the current remediation guideline for methamphetamine residues from surfaces, as recommended by the Ministry of Health in the *NZ Methamphetamine Guidelines* [**1**] is 0.5 µg/100 cm^2, as developed in Australia. Based on the same toxicological reference dose but with perhaps more realistic exposure modelling, the California EPA OEHAA/DTSC adopted a standard of 1.5 µg/100 cm^2 as being sufficiently protective to make properties safe for human occupancy. Both figures represent the same general order-of-magnitude and compliance with either number is designed to ensure safety based on absence of any appreciable health risk, rather than indicate presence or absence of a potential for actual harm.

Due to the nature of toxicological reference doses and the emphasis on ensuring absence of potential for harm in guideline development, and marginal exceedance of either figure can not be taken to indicate the onset of a quantifiable health hazard.

This raises the question of what surface concentration may correspond to onset of harm becoming plausible to the most sensitive receptor, assuming that all of the exposure assumptions are aligned and operative. The question can be put as:

Is it possible to estimate the lowest surface concentration at which adverse health effects could become plausible?

3.2 General approach

A technical paper is available in the peer-reviewed scientific literature [**7**] which can be adapted to provide an estimate of this quantity. This paper, a copy of which will be provided with this report, is identified as reference [**7**]:

- Hammon, T. L., & Griffin, S. (2007). Support for selection of a methamphetamine cleanup standard in Colorado. *Regulatory Toxicology and Pharmacology*, *48* (1), 102-114.

Briefly, the approach will be to compare modelled estimates of potential exposures that could be experienced by the most sensitive receptor with a health-based reference value that was derived by Hammon and Griffin [**7**], rather than a toxicological reference dose (RfD). Whereas an RfD provides a level at which long-term exposure is without appreciable risk, a health-based reference value provides the lowest level at which the first onset of the

most sensitive possible health effect may begin to occur, still taking uncertainties into account. This approach is possible here because the specific purpose of the research described by Hammon and Griffin [**7**] was to establish whether several technology-based guidelines for methamphetamine residues on surfaces (including a figure of 0.5 µg/100 cm^2) would in fact be *health-protective*. The paper's authors were employed by the Colorado Department of Public Health and Environment (Hammon), and US Environmental Protection Agency (Griffin), and were conversant with established USEPA protocols. To establish a credible and documented answer to this question Hammon and Griffin [**7**] presented a complete analysis which includes both a detailed exposure assessment, and derivation of a health-based reference value for methamphetamine. The authors make a clear distinction between the purpose and design of their approach and the procedure used for developing a (more protective) reference dose (RfD) [**7**]:

> "The intent of this effort is to compare the intakes expected from the range of proposed cleanup standards to a health-based reference value to determine if the proposed cleanup standards are adequately protective for children and adults. […] For this reason, we are using a process similar to the U.S. Environmental Protection Agency's (USEPA) Reference Dose process to develop a health-based reference value for methamphetamine. It should be noted that this is not a Reference Dose for methamphetamine and should not be construed as such."

3.3 Derivation of the health-based reference value

The health-based reference value derived by Hammon and Griffin [**7**] was based on the (lower) 95% confidence limit of benchmark dose levels (called the BMDL) associated with a 10% effect (the BMD_{10}), as calculated according to the EPA's Reference Dose Methodology. This gave a BMDL range of 1.5 to 20 mg/kg body weight/day, with the most sensitive toxicological endpoint (1.5 mg/kg body-weight/day) being decreased fetal weight. Consistent with other work, these authors also then applied an uncertainty factor of 300[7] to the BMDL. This step is probably conservative for the context of attempting to estimate actual likelihood of a measureable effect to any given individual, but appropriate because the uncertainties that are accommodated in this way (see footnote 7) are still genuine

[7] The factor of 300 itself includes:

- Division of the BMDL of 1.5 mg/kg-bw by 10 for interspecies variability, because the critical studies in this case were in experimental animals.
- A further division by 10 for inter-individual variation in population response, and
- A further division by 3 to allow for incompleteness in the database.

Although the first factor applied for both the RfD and health-based reference value was 10, reasons for use of this first factor differed. In the RfD this factor was for extrapolation from a human LOAEL to a NOEL; here it was to account for differences between animals and humans. Reasons for second and third factors of 10 and 3 were as for derivation of the RfD. As with the RfD derivation, no additional factor was found to be necessary to allow for differences between short and long-term exposure, due to the nature of the toxicological responses (here, reproductive and developmental studies).

uncertainties. The safety factor of 300 provides an assurance that appropriate caution has been exercised in allowing for the possibility of the onset of a health effect. As with other derivations, the authors also focused on infants as the most sensitive receptor class.

With the uncertainty factor applied, the lowest health-based reference value linked to onset of a possible effect was then estimated [**7**] as 0.005 mg/kg-body weight/day (which is 1.5 mg/kg body-weight/day, divided by the factor of 300). Estimated exposures are compared with this health-based reference value by Hammon and Griffin [**7**] in their Table 5.

3.4 Relationship between surface loading and exposure dose

I have reviewed the methodology applied by Hammon and Griffin [**7**] and established to my own satisfaction that estimated intakes produced by their exposure model are directly proportional to the surface methamphetamine residue loading, as can also be seen in the results provided in their Table 5. In other words, although the exposure modelling is reasonably complex in its internal detail, there is a linear relationship between the surface methamphetamine loading and the dose estimates produced by the exposure model.

For example, for a surface methamphetamine loading of 0.05 µg/100 cm^2 the estimated potential intake for an infant is 0.00002 mg/kg-bw/day. When the surface loading of methamphetamine is increased by a factor of 10 (to 0.5 µg/100 cm^2) the corresponding estimated intake value also increases by a factor of 10 (to 0.0002 mg/kg-bw/day). At a further tenfold increase in surface methamphetamine loading to 5 µg/100 cm^2, the estimated intake value would be 0.002 mg/kg-bw/day. At surface loadings in the microgram (*e.g.* 0.05-50 µg) per 100 cm^2 range, there would be no specific reason to expect any significant deviation from this linear relationship between loading and estimated dose.

Three estimates of each quantitiy provided by Hammon and Griffin [**7**], and three pairs of extrapolated values, are provided in **Table 1**.

Table 1. Relationship between surface loading of methamphetamine and the estimated daily intake of an infant (the most sensitive receptor).

Surface loading (µg/100 cm^2)	Infant intake dose (mg/kg body weight / day)
0.05	0.00002
0.1	0.00004
0.5	0.0002
5.0	*0.002*
10.0	*0.004*
12.5	*0.005*

Note: rows 1-3 from [**7**]; rows 4-6 (*italicised*) extrapolated from data in [**7**] based on the linear relationship between surface loading and estimated intake dose.

3.4 Lowest plausible health-effects concentration

3.4.1 Estimated value

As can be seen from the data in **Table 1**, the derived health reference value of 0.005 mg/kg body-weight/day would be reached at a surface methamphetamine concentration of 12.5 µg/100 cm^2. For what follows I will round this surface loading figure down to 12 µg/100 cm^2.

In my opinion, 12 µg/100 cm^2 represents a lowest surface methamphetamine loading at which adverse health effects could become remotely plausible in the most sensitive receptor (infants). My estimates based on the exposure modelling carried out by Hammon and Griffin [**7**] indicate that this is the surface concentration at which the health-based reference dose could first be reached assuming that all identified exposure pathways were operative.

As new toxicological information becomes available various improvements can be made to models like these which can change this type of estimate in either direction. It is possible that new lower effects levels (BMD_{10}, NOEL, etc.) may be found and incorporated in databases which result in a revision and reduction of the reference dose. In my opinion based on the range of toxicological endpoints already considered and consistency of responses to methamphetamine, I think that this is unlikely. On the other hand it is possible (perhaps probable) that gradual improvements in the toxicological database over time will eventually reduce the need to apply some uncertainty factors, resulting in the flexibility to revise reference or health dose estimates in an upward direction.

For these and other reasons outlined above, I would be most comfortable presenting both the recommended clean-up guidelines (**Section 2** of this report) and the health-based estimate that I have presented here based on extrapolation from Hammon And Griffin [**7**] as indicating relative orders-of-magnitude.

Surface methamphetamine loadings in the range 0.5-1.5 µg/100 cm^2 (including the Australian IL recommended in the NZ Methamphetamine Guidelines [**1**]) represent levels at which risk is neither appreciable nor quantifiable. The lowest point of potential for a plausible health effect in infants from on-going exposure appears to be about 10 times (one order-of-magnitude) higher than this *range* (or 20 times higher than the 0.5 µg/100 cm^2 guideline). These ideas are illustrated in **Figure1**.

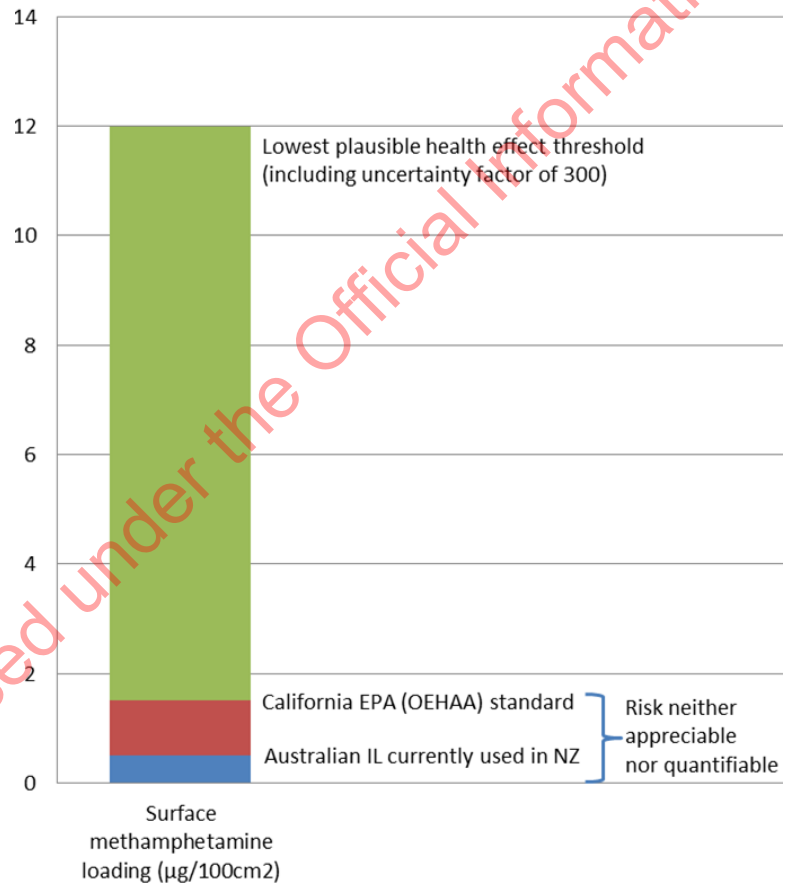

Figure 1. Graphical representation showing relative ranges of methamphetamine clean-up targets compared with the 'lowest plausible' health threshold as estimated here.

3.4.2 A hidden precautionary factor

A hidden precautionary factor in these estimates is that in the exposure modelling, it is assumed that a given surface methamphetamine loading will remain at a constant level indefinitely, so that a child will be exposed to the same amount day-after-day for weeks and months. In reality this is very unlikely to happen in any specific case once the external source of methamphetamine has been removed. The expected pattern would be one of decline, for three reasons. These are as follows.

1. Each assumed exposure event necessary removes a proportion of methamphetamine from the surfaces that were contacted (*e.g.* carpets, walls), making less methamphetamine available for subsequent release. Based on standard guidance, transfer efficiencies assumed in Hammon and Griffin [**7**] were 5% for carpets and 10% for hard surfaces.

2. Surface methamphetamine will undergo some natural rate of loss through degradation and/or fixation processes, as well as transfer and loss routes that do not lead to absorption by a child (for example transfer of methamphetamine to clothes rather than skin, where clothes are subsequently put through a washing machine).

3. In cases where significant methamphetamine has previously been absorbed by a porous surface and may migrate out again in response to surface loss (creating a diffusion gradient), the expected pattern is not one that would result in a higher concentration on the surface than was present on the surface to begin with.

3.4.3 Comparison to doses used for treatment of ADHD in children

In the US, methamphetamine is legally produced as a prescription medicine (Desoxyn®),[8] for use in treatment of ADHD in children (age 6 or older), narcolepsy, and short-term weight loss [**7**, **1**]. This is classified as a controlled substance, being subject to control under DEA schedule II (substances with a high potential for abuse which may lead to severe psychological or physical dependence). Dextroamphetamine (Dexedrine®), and methylphenidate (trade name Ritalin®), both of which are available in New Zealand under restriction,[9] are classified in the same way.[10] The first of these, also known as dexamphetamine, is an amphetamine (*i.e.* this is its chemical class).

[8] Drugs.com, 2016. Desoxyn (methamphetamine hydrochloride). See: http://www.drugs.com/pro/desoxyn.html

[9] New Zealand Medicines and Medical Devices Safety Authority (MedSafe), 2016. Medicines: Restrictions on the Supply, Prescribing or Administration of Medicines under the Medicines Act 1981 and Misuse of Drugs Regulations 1977. See: http://www.medsafe.govt.nz/profs/riss/restrict.asp

[10] US Department of Justice, Office of Diversion Control, 2016. Controlled Substances Schedules. See: http://www.deadiversion.usdoj.gov/schedules/#define

In cases where methamphetamine is prescribed for children an initial dose is set at one or two 5 mg tablets per day. This dose has documented side-effects which can include anxiety, difficulty falling asleep and reduced appetite; but the therapeutic use of methamphetamine provides an external point of reference regarding orders-of-magnitude. Methamphetamine is not prescribed for infants, but for a 6 year old child (assumed weight 21.7 kg), one 5 mg tablet of Desoxyn® per day would translate to a dose of 0.23 mg/kg body weight per day. The health reference value of 0.005 mg/kg body-weight/day derived by Hammon and Griffin (2007) is 46 times lower than this figure.[11]

Therefore to a first approximation the potential dose that could be transferred from surface methamphetamine loadings of 10-12 µg/100 cm^2 (corresponding to the health reference value) is about 1/50th of the dose used in cases where methamphetamine is intentionally prescribed for the treatment of ADHD.

3.4.4 Use of the words 'contamination' and 'contaminated'

Exceedance of a methamphetamine surface loading of 0.5 µg/100 cm^2 by up to 20 times does not denote the onset of any health risk. All that can be said is that a very conservative guideline value has been exceeded. For this reason, properties where methamphetamine residues are less than 12 µg/100 cm^2 should really not be referred to as 'contaminated' by methamphetamine.

They could only be considered to be contaminated following a particular scientific usage which does not apply here,[12] and is not the sense that is commonly being expressed in public. In public discourse including media statements, phrases such as 'methamphetamine contamination of properties' and 'houses contaminated by methamphetamine' are commonly being used, and the clear connotation is that methamphetamine residues are present at levels that are hazardous to human health. This connotation is misleading.

[11] If for a hypothetical calculation, the therapeutic dose is scaled down to allow for infant weight (11.2 kg) , the factor of 46 remains the same. (This is because the scaled-down dose becomes 2.6 mg/day; and the health reference value for a 11.2 kg infant translates to 0.056 mg per day.)

[12] In environmental chemistry (and as a non-universal but widely-applied practice) the term 'contamination' refers to the presence of a substance that either (a) does not occur naturally, or (b) (if natural) occurs noticeably higher levels than its natural concentration range. By this scientific meaning, almost every aspect of our modern environment, indoors and outdoors, would be regarded as contaminated; so the definition is not very useful. When levels of contamination have become high enough to cause actual adverse effects, the environment is referred to as being 'polluted.' Under the Resource Management Act, the term 'contaminated land' maps to the scientific concept of 'polluted land.'

However this issue extends beyond communications to the regulatory environment. Under Section 2 of the Resource Management Act (RMA, 1991):

> **contaminated land** means land that has a hazardous substance in or on it that—
> (a) has significant adverse effects on the environment; or
> (b) is reasonably likely to have significant adverse effects on the environment

...where 'the environment' is always taken to include people,[13] and land has a wider meaning than only soil.[14] The RMA definition of contaminated land carries the same sense of 'significant harm' as the popular use of a 'meth contaminated property', but sets this effects-based threshold in a regulatory context. Relative to guideline values, there is a high threshold before a property can be deemed to meet the RMA definition of 'contaminated land.'

To reach or exceed that threshold, we would need to be reasonably confident that the hazardous substance is present at levels that would actually, or would be reasonably likely to, cause significant adverse effects on people or the wider environment. Not negligible or less-than-minor, and not minor, but significant. 'Significant' is the strongest term of this type used in the RMA.[15]

In my opinion no property at which methamphetamine has only been smoked is likely to meet the RMA definition of contaminated land, which carries the same sense of significant harm as the popular usage.

For these reasons I would recommend that public agencies stop referring to properties as 'meth **contaminated**' (or similar phrasing) if the only basis for this classification is that the 0.5 µg/100 cm^2 remediation guideline for methamphetamine residues on surfaces has been exceeded.

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[13] **environment** includes—(a) ecosystems and their constituent parts, including people and communities; and (b) all natural and physical resources; and (c) amenity values; and (d) the social, economic, aesthetic, and cultural conditions which affect the matters stated in paragraphs (a) to (c) or which are affected by those matters

[14] **land**—(a) includes land covered by water and the airspace above land…

[15] In regulatory practice, the contaminated land aarea is about managing potentially contaminated sites in relation to conservative Soil Contaminant Standards (SCS values) and other guideline values, in the context of controls set out in a National Environmental Standard. To date there has not been a need to establish that the RMA definition of contaminated land has ever been reached. Most potentially contaminated sites which are tested and subsequently remediated would *not* meet the threshold.

3.5 Section summary

Surface methamphetamine loadings in the range 0.5-1.5 µg/100 cm^2 represent levels at which risk is neither appreciable nor quantifiable. In my opinion, the lowest surface loading with the potential for a plausible health effect in infants from daily exposure appears to be about 10-20 times higher than this range (10-12 µg/100 cm^2).

Exceedance of a methamphetamine surface loading of 0.5 µg/100 cm^2 by up to 20 times does not denote the onset of any health risk. All that can be said is that a very conservative guideline value has been exceeded.

When applied to cases where methamphetamine has not been manufactured, use of phrases such as 'methamphetamine contamination of properties' and 'houses contaminated by methamphetamine' are misleading because they imply that methamphetamine residues are present at levels that are hazardous to human health.

At a regulatory level, Section 2 of the Resource Management Act (1991) defines 'contaminated land' in a very specific way relating to likelihood of significant adverse effects occurring. If applied here this definition would (rightly) preclude most houses where methamphetamine has been smoked but not manufactured.

4. References cited

1. Ministry of Health (2010). *Guidelines for the Remediation of Clandestine Methamphetamine Laboratory Sites*. Wellington: Ministry of Health. Available from: http://www.health.govt.nz/publication/guidelines-remediation-clandestine-methamphetamine-laboratory-sites.

2. Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011. Available from: http://www.legislation.govt.nz/regulation/public/2011/0361/latest/DLM4052228.html

3. Ministry for the Environment (2011). *Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health.* Wellington: Ministry for the Environment. Available from: http://www.mfe.govt.nz/publications/hazards/methodology-deriving-standards-contaminants-soil-protect-human-health

4. Ministry for the Environment (2011). *Toxicological Intake Values for Priority Contaminants in Soil*. Wellington: Ministry for the Environment. Available from: http://www.mfe.govt.nz/publications/hazards/toxicological-intake-values-priority-contaminants-soil

5. Australian Government Attorney-General's Department (2011). *Clandestine Drug Laboratory Remediation Guidelines.* Commonwealth of Australia, 2011. Available from: https://www.ag.gov.au/CrimeAndCorruption/Drugs/Documents/Clandestinedruglaboratoryremediationguidelines.pdf

6. Ministry for the Environment (2003, revised 2011). *Contaminated Land Management Guidelines No. 2: Hierarchy and Application in New Zealand of Environmental Guideline Values (revised 2011).* Wellington: Ministry for the Environment. Available from: http://www.mfe.govt.nz/publications/land-hazards/contaminated-land-management-guidelines-no-2-hierarchy-and-application-new

7. Hammon, T. L., & Griffin, S. (2007). Support for selection of a methamphetamine cleanup standard in Colorado. *Regulatory Toxicology and Pharmacology*, *48* (1), 102-114.

8. Salocks, C. (2009). *Development of a Reference Dose (RfD) for Methamphetamine.* California Environmental Protection Agency. Office of Environmental Health Hazard Assessment. Integrated Risk Assessment Branch.

9. Environmental Risk Sciences (2009). *Derivation of Risk-Based Investigation Levels, Clandestine Drug Laboratory, Site Investigation Guidelines.* Prepared for the Australian Crime Commission, Ref: ACC/09/R001, 6 October 2009. Available from: http://www.enrisks.com.au/wp-content/uploads/2012/12/Derivation-of-Risk-Based-Guidelines-for-Website.pdf

10. Saint-Jacques, N., Parker, L., Brown, P., & Dummer, T. J. (2014). Arsenic in drinking water and urinary tract cancers: a systematic review of 30 years of epidemiological evidence. *Environmental Health*, *13*: 44 (32 pages).

11. Piper, J., and Kim, N.D. (2006). Arsenic in Groundwater of the Waikato Region. Waikato Regional Council technical report 2006/14. ISSN: 1172-4005. Available from: http://www.waikatoregion.govt.nz/TR200614/

12. Kim, N. D. (2010). Box 5.2 Arsenic in Bed Sediments. In K. J. Collier, D. P. Hamilton, W. N. Vant, & C. Howard-Williams (Eds.), *The Waters of the Waikato* (pp. 80). Environment Waikato and the Centre for Biodiversity and Ecology Research (The University of Waikato).

13. Järup, L., & Åkesson, A. (2009). Current status of cadmium as an environmental health problem. *Toxicology and Applied Pharmacology*, *238*(3), 201-208.

14. Alexander, J., D. Benford, A. Cockburn, J. P. Cravedi, E. Dogliotti, and A. D. Domenico. (2009). Cadmium in food-scientific opinion of the panel on contaminants in the food chain. *EFSA Journal* 980 (2009): 1-139.

15. Satarug, S., Baker, J. R., Urbenjapol, S., Haswell-Elkins, M., Reilly, P. E., Williams, D. J., & Moore, M. R. (2003). A global perspective on cadmium pollution and toxicity in non-occupationally exposed population. *Toxicology Letters*, *137*(1), 65-83.

16. McDowell, R. W., Taylor, M. D., & Stevenson, B. A. (2013). Natural background and anthropogenic contributions of cadmium to New Zealand soils. *Agriculture, Ecosystems & Environment*, *165*, 80-87.

17. Jourdan, T. H., Veitenheimer, A. M., Murray, C. K., & Wagner, J. R. (2013). The quantitation of cocaine on US currency: survey and significance of the levels of contamination. *Journal of Forensic Sciences*, *58*(3), 616-624.

18. Seneviratne, S. (2016). Drugs on your money? *Journal of Interdisciplinary Science Topics*, *5*. The Centre for Interdisciplinary Science, University of Leicester.

19. Wimmer, K., & Schneider, S. (2011). Screening for illicit drugs on Euro banknotes by LC–MS/MS. *Forensic science international*, *206*(1), 172-177.

20. Lavins, E. S., Lavins, B. D., & Jenkins, A. J. (2004). Cannabis (marijuana) contamination of United States and foreign paper currency. *Journal of Analytical Toxicology*, *28*(6), 439-442.

21. Jenkins, A. J. (2001). Drug contamination of US paper currency. *Forensic Science International*, *121*(3), 189-193.

22. Fultz, B. A., Mann, J. A., & Gardner, E. A. (2012) Methamphetamine Contaminated Currency in the Birmingham, Alabama Metropolitan Area. *Microgram Journal*, *9*(2), 57-60.

23. Lahoda, K. G., Collin, O. L., Mathis, J. A., LeClair, H. E., Wise, S. H., & McCord, B. R. (2008). A survey of background levels of explosives and related compounds in the environment. *Journal of Forensic Sciences*, *53*(4), 802-806.

24. Lowe, A. M., Crowson, C. A., Cullum, H. E., & Hiley, R. W. (1996). A survey of high explosives traces in public places. *Journal of Forensic Science*, *41*(6), 980-989.

25. Clausen, J., Robb, J., Curry, D., & Korte, N. (2004). A case study of contaminants on military ranges: Camp Edwards, Massachusetts, USA. *Environmental Pollution*, *129*(1), 13-21.

Signed

(Dr Nick D Kim)

13 June 2016

5. Appendices

5.1 Appendix 1. Overview of my expertise in 'Brief of Evidence' format

1. My full name is Nicholas Duncan Kim.

2. I live in Wellington.

3. I am a senior lecturer in the School of Public Health, Massey University Wellington, a position I have held since 2012.

4. I hold the degrees of BSc(Hons) (First Class) in Chemistry from the University of Canterbury (1987), and PhD in Environmental Analytical Chemistry from the University of Canterbury (1990).

5. Previous positions I have held have included employment as a Lecturer (1991-1997) and Senior Lecturer (1998-2001) in Chemistry at the University of Waikato, and employment as an environmental chemist (2002-2011) by the Waikato Regional Council.

6. At the University of Waikato (1991-2001) I undertook teaching and research in Environmental, Analytical and Forensic Chemistry. My activities included supervision of postgraduate (MSc, MPhil and PhD) research projects, and coordination and development of courses in *Advanced Analytical Chemistry* and *Environmental, Forensic, and Toxicological Chemistry* (both at undergraduate level) and *Applied and Environmental Analytical Chemistry* (at masters level).

7. At the Waikato Regional Council (2002-2011) my main roles were the provision of technical advice in relation to a range of chemical contamination issues, identification and management of contaminated sites, and coordination of research projects relating to trace chemical contamination of soil, sediment, air and water.

8. At Massey University (2012 to present) I am major leader for the undergraduate teaching programme in Environmental Health, and teach into a number of areas related to chemistry, human health and risk assessment including the papers *Chemistry in the Environment*, *Toxic Substances, Human Health and the Environment*, and *Environmental Monitoring and Investigative Techniques*. I continue to carry out research and supervise postgraduate research students.

9. I have co-authored or authored over 40 scientific papers in peer-reviewed journals or as book chapters, along with 8 peer-reviewed technical reports, and about 50 other

scientific publications or conference presentations, and provided significant written content to 5 national guidelines.

10. I have supervised or co-supervised about 45 postgraduate (MSc, MPhil and PhD) research projects, and routinely act as an external examiner for masters and doctoral research theses from other New Zealand Universities. Some of these have been in the area of methamphetamine contamination and decontamination.

11. Overall I have 29 years experience in environmental chemistry, analytical chemistry, forensic chemistry, toxicology and risk assessment, resource management, and regulatory policy development.

12. Of these, my core area of professional expertise is the technical appraisal, risk assessment and management of chemical contamination issues.

13. Over time I have contributed to a number of national projects relating to management of contaminated land, trace contaminants, hazardous substances, and air quality. These involvements include, but are not limited to:

    - Member of Ministry for the Environment's technical advisory groups on development of contaminated sites classification guidelines (2002-3), a contaminated land risk screening system (2004), and sampling and analysis guidelines (2004, 2008);

    - Member of Ministry for the Environment's Technical Advisory Group and Toxicological Advisory Groups relating to development of a National Environmental Standard (NES) for contaminants in soil (2005, 2007-10);

    - Member of the Ministry for the Environment's Policy Advisory Group on agricultural/horticultural land contamination (2002-6);

    - Member of the national Cadmium Working Group (convened by the Ministry of Agriculture and Forestry) (2005-10);

    - Member of the steering committee for the Sustainable Management Fund project to develop management guidelines for old sheep dip sites (2002-5);

    - Technical policy advisor for amendments required to improve workability of the Hazardous Substances and New Organisms (HSNO) Act (2003-4).

14. I have made written or other contributions to the development of eight New Zealand best practice guidelines and national assessments in areas that include contaminated sites management and environmental sampling and monitoring, and I was a member of Ministry for the Environment's technical advisory groups that oversaw development of technical documents that support the ***Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011***.

15. In relation to this evidence it is mainly relevant that I provided some technical input by way of peer review to the content of the ***Guidelines for the Remediation of Clandestine Methamphetamine Laboratory Sites*** (Ministry of Health, 2010), ***Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health*** (Ministry for the Environment, 2011) and ***Toxicological Intake Values for Priority Contaminants in Soil*** (Ministry for the Environment, 2011).

16. I have previously provided expert evidence at resource consent hearings, in the Environment Court, and District Court.

17. I am certified to serve as an independent hearings commissioner meeting accreditation as referenced in Resource Management Act (1991) sections 39A to 39C, and have acted in this capacity on one occasion in December 2015, on behalf of Tasman District Council.

5.2 Appendix 2. Trace-level contamination of banknotes

One aspect of the history of forensic science is that once testing is carried out for various chemical compounds at trace and ultra-trace levels, many unusual substances can be found in a range of unexpected locations.

The majority of banknotes in the US, the UK and Europe contain traces of cocaine and opiates [**17**, **18**, **19**]. The concentrations are not high, but the trace contamination is very widespread. Seneviratne [**18**] calculated that to be *technically* prosecutable for possession of 100 milligrams of cocaine, a UK citizen would need to carry £17,575 in £5 notes. To accumulate the same amount of cocaine on US $1 bills the total came to $3,782 (USD).[16]

In a US study which included several foreign currency denominations, Lavins et al. [**20**] found that 9 out of 10 samples of New Zealand currency contained Δ^9-tetrahydrocannabinol (THC) and CBN, which are both markers of cannabis (marijuana) contamination. The authors note:

> "For the foreign currency notes in the study the highest amounts of THC and CBN detected were 0.065 and 0.197 µg/bill, respectively. These constituents were found exclusively in the New Zealand currency."

This finding is unlikely to represent all New Zealand banknotes, but will rather reflect habits of a local community. In this case it may well be relevant that all ten of the New Zealand banknotes tested in the international study cited above were sourced from Whangaroa in Northland.

More significantly in the context of this report, a range of other drugs including methamphetamine are occasionally detected on banknotes when they are tested for these, with geographical variation in results thought to relate to patterns of drug use in the local community that become reflected in a local currency pool [**20**].

Jenkins [**21**] analysed 50 randomly collected US$1 notes (10 from each of five cities) for cocaine, heroin, 6-acetylmorphine (6-AM), morphine, codeine, methamphetamine, amphetamine and phencyclidine (PCP). Codeine was not detected in any of the bills, but all of the other drugs listed were detected. Results showed that paper currency was most often contaminated with cocaine (92% of the bills tested, average loading 28.75 µg per note). However, in addition [**21**]:

[16] Average loadings per bill were assumed to be 28.75 µg of cocaine per note, with calculations taking into account that 99% of UK banknotes and 92% of US dollar bills have cocaine traces on them.

> "Heroin was detected in seven bills in amounts ranging from 0.03 to 168.50 µg per bill: 6-AM and morphine were detected in three bills; methamphetamine and amphetamine in three and one bills, respectively, and PCP was detected in two bills in amounts of 0.78 and 1.87 µg per bill." (Jenkins, 2001).

One research paper specifically reports the sudden appearance of methampetamine contamination in a community, in US banknotes sourced from the Birmingham Alabama Metropolitan Area. Fultz et al. [**22**] found that 42% percent of bills collected from within this community in 2012 were contaminated with methamphetamine, more than has been previously reported for any drug other than cocaine in the United States. These authors commented [**22**] that:

> "The high percentage of contamination detected in this study, and its sudden appearance, indicates a significant change in the pattern of drug contamination of currency around Birmingham, probably reflecting higher methamphetamine abuse in the local populace. This conclusion is in agreement with and complements the findings reported in the National Substance Abuse Index, which states that methamphetamine abuse currently exceeds that of cocaine throughout the state of Alabama […] The results of this study suggest that it is possible to track significant changes in methamphetamine abuse in a specific region over time."

Traces of methamphetamine have also been detected on Euro banknotes [**19**].

Parallels exist for other categories of chemical compounds, where local activities and use patterns result in characteristic 'forensic levels' of environmental contamination. For example, like methampetamine and most drugs, high explosives are also organic compounds. Traces of high explosive residues are rare in public places in the US and UK [**23**, **24**]; as might be expected because most members of the public are not in routine contact with high explosives such as nitroglycerine, trinitrotoluene (TNT), pentaerythritol tetranitrate (PETN), or cyclotrimethylene trinitramine (RDX). By contrast, nitroglycerine, which is associated with firearm use, was more commonly detected at UK police sites [**24**], and going a step beyond this, traces of a range of high explosives can be found at any operational military range [**25**].

Based on this ability of banknotes to carry a trace history of drug use within a local population, it would be expected that if testing were to be carried out, low concentrations of methamphetamine would be detectable in a proportion of New Zealand banknotes, reflecting current use of this drug in the New Zealand community.

An interesting implication of this likelihood is that traces of methampetamine may exist within the walls of most households in New Zealand at least some of the time, on banknotes carried in by the occupants.