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20 November 2023

Enquiries: Tess Brothersen
Project No: 31024790

Dunedin City Council
50 The Octagon
Dunedin 9058

Attention: Alan Worthington, Resource Consent Manager

Dear Alan

RE: Residential Lead Paint Review

Dunedin City Council (DCC) has requested Stantec New Zealand (Stantec) to review the available information and data about the potential for soil contamination resulting from use of lead-based paint on residential buildings and to provide guidance around when such contamination constitutes Hazardous Activities and Industries List (HAIL)[1], and recommendations for consenting requirements.

Background

Prior to 1965, many paints sold in New Zealand contained high levels of lead, with the highest concentrations typically seen in paints manufactured prior to 1945 when the use of white lead (up to 50% lead by weight) as a paint pigment began to be phased out[2]. Restrictions on the lead content of paint were introduced in New Zealand beginning in 1957 and the use of white lead (which could contain up to 50% lead by weight) in paint was banned in the Toxic Substances Act 1979[3]. The lead content in paint is currently regulated under the Group Standards for Surface and Coatings and Colourants, Hazardous Substances and New Organisms Act 1996, with a maximum allowable lead concentration of 0.1% w/w.

While the level of lead in current residential paints is now regulated, lead is a persistent pollutant, which once released into the environment does not degrade. Therefore, weathering and/or improper removal of pre-1980 paints can result in contamination of the soils close to the house[4,5]. These soils, often referred to as the 'halo' of the building, may contain elevated lead concentrations. Soil lead from deteriorated lead-based paint has been shown to be an important exposure pathway for human health impacts[6].

Human health effects of chronic exposure of lead include neurological, cardiovascular, haematological, immunological, reproductive, and developmental effects[7]. Children, particularly pre-schoolers, are at greater risk from lead exposure due to increased uptake via higher levels of hand-to-mouth activity and higher gastrointestinal absorption of ingested lead[8].

[1] Ministry for the Environment. 2011. Hazardous Activities and Industries List (HAIL). https://environment.govt.nz/assets/Publications/HAIL.pdf
[2] Kāinga Ora 2022. *Residential Preoprty – Soil Sampling and Analysis Plan, Final Version 7*.
[3] Ibid.
[4] Ministry of Health. 2021. *The environmental case management of lead-exposed persons*. Wellington: Ministry of Health.
[5] Mielke, H.R. 1998. "Soil is an important pathway of human lead exposure." *Environmental Health Perspectives*. Vol. 106, Supplement 1:217-229.
[6] Ibid.
[7] Agency for Toxic Substances and Disease Registry. 2020. *Toxicological Profile for Lead*. Washington DC: Agency for Toxic Substances and Disease Registry. pp. 5-7.
[8] Agency for Toxic Substances and Disease Registry. 2020. *Toxicological Profile*. pp. 5-7.

New Zealand Residential Lead Data

Recent New Zealand Data

Lead is a naturally occurring element in soils. Background concentrations vary by soil type, with mean predicted background concentrations for New Zealand soil types ranging from 5.59 – 154.62 mg/kg [9].

Lead concentrations also vary across a residential property, with the highest concentrations typically found in soils close to the house. These soils are sometimes referred to as the halo or curtilage. The Ministry of Health states that the highest concentrations of lead are found within 1-2m of the house [10]. Data from Kāinga Ora's housing stock (built between 1950 to 1980s) indicates that the highest concentrations are found within 1m of the building [11].

Several studies undertaken in New Zealand have found that older houses have higher lead concentrations in soils. Ahrazadeh *et al.* found that lead concentrations in pre-1950s residential gardens were significantly higher than in post-1950 gardens, with a mean concentration of 282 mg/kg [12], which is above the soil contaminant standard (SCS) for Residential (10% produce) land use (210 mg/kg). The mean concentration for all ages of houses in the study was 137 mg/kg.

Turnbull *et. al.* conducted a survey of soil metal concentrations across the city of Dunedin [13]. Sampling was grid-based and included commercial, industrial, recreational, and residential properties. Lead concentrations in all samples ranged from 3.5 – 2533.7 mg/kg, with a geometric mean of 153.2 mg/kg. When samples were grouped based on land use (exotic forest, rural, school, urban residential, commercial/industrial, recreational, natural background, and high producing exotic grassland), urban residential soils had significantly higher lead concentrations than rural soils. The authors suggest that lead-based paint from buildings is a significant contributor to the elevated lead concentrations found in urban soils.

In a study of single residential properties in Palmerston North built prior to 1980, soils within the halo (within 1 m of the exterior of the house) of 34 properties were sampled [14]. The mean lead concentration was 642.7 mg/kg, and the geometric mean was 207.6 mg/kg for all properties and ranged from 19.6 - 9571.0 mg/kg. When sample results were broken down by decade the house was built, properties built in the 1950s and earlier had both mean and geometric mean concentrations above the SCS for Residential (10% produce) land use (210 mg/kg). In addition, the study looked at the concentrations of lead in houses built before 1945, when the use of white lead in paint began to be phased out, and houses built after 1945. The mean soil lead concentration in samples from houses built prior to 1945 was 1560 mg/kg, whilst the mean was 114 mg/kg for homes built after 1945.

A study of 44 pre-1940s houses in Canterbury found that 95% of the properties had lead concentrations above the SCS for Residential (10% produce) land use (210 mg/kg) [15]. Typical lead concentrations ranged from 300-600 mg/kg and a maximum concentration of 5946 mg/kg was noted.

A large study with more than 4,500 soil samples from 1960-1980s residential properties across New Zealand found lead concentrations ranging in soil from 1.6-12,500 mg/kg, with a mean concentration of 108.4 mg/kg and a geometric mean of 53.3 mg/kg [16]. Looking at samples collected in soil within 1 m of the house resulted in a range of 5.2-5,200 mg/kg, a mean of 224 mg/kg and a geometric mean of 105.1 mg/kg. For both data sets, the mean lead concentrations were below the SCS for Residential (10% produce). However, looking at a broader data set of houses built between the 1930s and the 1980s found that the proportion of soil samples above the SCS (210 mg/kg)

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[9] LRIS Portal. https://lris.scinfo.org.nz/data/?q=pbc. Accessed 11 September 2023.
[10] Ministry of Health. 2021. *The environmental case management*.
[11] Kāinga Ora. 2022. *Residential Property.*
[12] Ashrafzadeh S. et al. 2018. "Heavy metals in suburban gardens and the implications of land-use change following a major earthquake." *Applied Geochemistry*, Vol. 88, Part A, pp. 10-16.
[13] Turnbull *et. al.* 2019. "Human impacts recorded in chemical and isotopic fingerprints of soils from Dunedin City, New Zealand". *Science of the Total Environment.* Vol. 673, pp. 455-469.
[14] Blunden J.G. 2020. "Investigation of Lead-Based Paint Contamination in Residential Soils within Urban and Suburban Areas of Palmerston North City, New Zealand" (master's thesis, Massey University), https://mro.massey.ac.nz/bitstream/handle/10179/15960/BlundenMScThesis.pdf
[15] Malloch Environmental Limited. 2018. "Lead Contamination Prevalence – Will bioavailability testing add value for the client?" *ALGA New Zealand Contaminated Land Conference 2018.* Christchurch: Australasian Land and Groundwater Association.
[16] EHS Support. 2023. "Kāinga Ora Ultra Data & Indoor Lead." *WasteMINZ Residential Lead Workshop*. Hamilton, 25-26 May 2023.

increased with increasing age of the residential house, with over 70% of all soil samples collected from properties with 1930s houses exceeding the guideline value, but only approximately 40% of soils samples from properties with 1940s houses exceeding.

A recent study of Canterbury residential properties found that soil lead concentrations increased with increasing age of the oldest known building on the property[17]. In addition, the Canterbury study looked at soil sample results by age of the oldest known building (pre-1900, 1900-1930, 1940-1949, 1950-1959, 1960-1969, and 1970-1979) and found that the mean lead concentrations in soils for all but the 1970-1979 grouping exceeded the SCS for Residential (10% produce) land use and that soil lead concentrations typically ranged from 400-1,000 mg/kg.

Variation in Residential Soil Lead Concentrations

Factors that have been identified which influence the concentration of lead within residential soils include:

- Presence of groundcover adjacent to the house[18],
- Presence of grass cover adjacent to the house[19],
- Soil disturbance within vegetable or ornamental gardens[20], and
- Redevelopment of the site[21].

In addition, lead readily sorbs to finer particles, such as clays, meaning that soil type can also have an impact on lead concentrations in residential soils. These factors and others, such as thickness of the lead paint layer or layers and lead content of the paint, contribute to the variation in lead concentrations found in the halo around houses of similar construction and age.

Summary of Key Research Findings

Key research findings regarding residential lead in New Zealand are as follows:

- Both the mean and geometric mean of the soil lead concentrations around houses built in the 1950s and earlier exceeded the SCS for Residential (10% produce) land use[22].
- The mean of the soil lead concentrations around houses built prior to 1945 (when white lead in paint began to be phased out) exceeded the SCS for Residential (10% produce) land use by a factor of 7[23].
- 95 percent of pre-1940s houses had soil lead concentrations above the SCS for Residential (10% produce) land use[24].
- Over 70% of soil samples collected around 1930s houses exceeded the SCS for Residential (10% produce) land use[25].
- Mean soil lead concentrations for properties with houses built prior to 1970 exceeded the SCS for Residential (10% produce) land use.
- Several factors influence lead concentrations in residential soils including, presence of ground cover or grass cover adjacent to the dwelling, soil type, soil disturbance, and redevelopment of the site.

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[17] Momentum Environmental Limited. 2023. "Residential Lead – Canterbury Dataset." *WasteMINZ Residential Lead Workshop*. Hamilton, 25-26 May 2023.
[18] Turner A. and Lewis M. 2018. "Lead and other heavy metals in soils impacted by exterior legacy paint in residential areas of south west England.' *Science of the Total Environment.* Vol 619-620, pp. 1206-1213.
[19] Fergusson, J.E. 1986. Ead: Petrol lead in the environment and its contribution to human blood lead levels." *The Science of the Total Environment.* Vol. 50, pp. 1-54.
[20] Rouillon, M., Harvey, P.J., Kristensen, L.J., George, J.F., and Taylor, M.P. 2017. "VegeSafe: a community science program measuring soil-metal contamination, evaluating risk and providing advice for safe gardening." *Environmental Pollution.* Vol. 222, pp. 557-566.
[21] Malloch Environmental Limited. 2018. "Lead Contamination Prevalence".
[22] Blunden. 2020. "Investigation of Lead-Based Paint Contamination"
[23] Ibid.
[24] Malloch Environmental Limited. 2018. "Lead Contamination".
[25] EHS Support. 2023. "Kāinga Ora".

Regulatory Framework Implications

The Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 (NESCS) were developed to provide nationally consistent standards for regional councils and territorial authorities to identify, investigate, remediate, and monitor contaminated land. The NESCS applies to land on which an activity or industry described in the HAIL is being or has been undertaken, or it is more likely than not it is being or has been undertaken. The Ministry for the Environment's NESCS Users' Guide interprets 'more likely than not' to mean if there is more than a 50 per cent likelihood of a HAIL activity having taken place[26].

While soil contamination resulting from lead-based paint is not specifically covered in the HAIL, category I includes *'Any other land that has been subject to the intentional or accidental release of a hazardous substance in sufficient quantity that it could be a risk to human health or the environment'*. Based on this, sampling of soils within the building halo is necessary to determine whether category I applies to a given site. In most cases, the halo extends 2 m from the outer walls of the building. However, if significant soil disturbance has occurred around the building perimeter the area of lead contamination may extend further.

In addition, the Ministry for the Environment released guidance on interpreting the HAIL in March 2023[27]. This guidance states that category I applies when:

1) *the land is not HAIL, and*
2) *it has been subject to a confirmed on-site release of hazardous substances or contaminants, and*
3) *the contamination is likely to be, or have been, at or above the applicable soil contaminant standard and environmental guideline value for the land.*

The second point implies that a release must be confirmed for category I to apply, which contradicts R7(c) of the NESCS, which states that a piece of land is land that *'it is more likely than not that an activity or industry described in the HAIL is being or has been undertaken on it.'* Given this contradiction between the Ministry's guidance and the regulations, the test within the regulations should take precedence. Therefore, given recent data indicating that sites with older residential buildings are more likely than not to have soil lead concentrations above the SCS which could pose a risk to human health, DCC may apply HAIL category I to such sites. Guidance around the age of buildings which category I should be applied to is given in the recommendations section.

Discussion

Stantec has conducted a review of the available New Zealand residential soil lead data. Three recent studies[28,29,30] looked at soil lead concentrations in relation to building age and found that soil lead concentrations increased with increasing age of the house or oldest building. All three studies showed that soil lead concentrations exceeded the SCS for Residential (10% produce) land use in more than 50% of samples for older housing stock/buildings, although the exact ages for which this was true varied between the studies.

As one study indicated only soils around houses built prior to 1940 are likely to pose a risk[31], one showed that soils near houses built in the 1940s or earlier are likely to[32], and one concluded that soils around pre-1970s houses are likely to pose a risk[33]. Stantec recommends using 1945, when the use of white lead in paint became less prevalent, as a conservative and pragmatic cutoff when considering whether HAIL category I applies to low-density [Rural Residential (25% produce) or Residential (10% produce) land use] residential sites. This is because there is a higher

[26] Ministry for the Environment. 2012. *Users' Guide: National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health.* Wellington: Ministry for the Environment.
[27] Ministry for the Environment. 2023. *Hazardous Activities and Industries List guidance: Identifying HAIL land.* Wellington: Ministry for the Environment.
[28] Blunden. 2020. "Investigation of Lead-Based Paint Contamination".
[29] EHS Support. 2023. "Kāinga Ora".
[30] Momentum Environmental Limited. 2023. "Residential Lead".
[31] EHS Support. 2023. "Kāinga Ora".
[32] Blunden. 2020. "Investigation of Lead-Based Paint Contamination".
[33] Momentum Environmental Limited. 2023. "Residential Lead".

probability of encountering elevated soil lead levels adjacent to buildings established when white lead was in common usage. This is consistent with the findings of the studies to date.

It should be noted that two of the studies were limited to properties with weatherboard housing stock[34],[35]. The third study[36] found that the mean lead concentration in soil near weatherboard houses was 1167 mg/kg, whilst the mean concentrations for soil around brick and stucco clad houses were both below the SCS for Residential (10% produce) land use. Stantec therefore concludes that residential soils within the halo (soils within 2 m of the exterior of the building) of older (pre-1945), weatherboard buildings are more likely than not to have concentrations of lead in sufficient quantity that could pose a risk to human health or the environment for Rural Residential (25% produce) and Residential (10% produce) land uses, and thus qualifies as HAIL category I in these cases.

Stantec deems there is insufficient evidence that lead concentrations in soil adjacent to brick clad houses are more likely than not to exceed the SCS for Residential (10% produce) land use. However, it is noted that unlike brick buildings, stucco surfaces do require regular painting and although the third study found soil around stucco houses to be significantly less than weatherboard, conservatively, pre-1945 stucco houses should be included as possible HAIL category I, until further studies can confirm otherwise.

While features of brick clad houses, such as windows, baseboards, and soffits, may have or have had lead-based paint, the area of these features is relatively small compared to the wall area. Any soil contamination resulting from these features is likely to be limited to small, localized area and is deemed unlikely to pose a significant risk to human health.

In addition, two of the three studies[37],[38] specifically looked at soil lead concentrations around ancillary buildings (e.g., garages, sheds, etc.) built prior to 1945. Both studies found soil lead concentrations above the SCS for Residential (10% produce) land use in soils adjacent to these structures.

Therefore, low-density residential sites with known existing or historic buildings (including ancillary structures such as garages or sheds) constructed prior to 1945 may be considered potential or unverified HAIL sites when considering resource consent applications. Soil testing is the most practical means of determining if HAIL category I applies.

Studies have shown that soil contamination from lead-based paint is typically limited to 1-2 meters from the exterior of the building[39],[40],[41]. Based on these studies, it is recommended that soils within 2 m of the building be considered the building 'halo'. Therefore, testing of surface soils (0-0.1 m below ground level [bgl]) within 2 m of the building(s) be undertaken to determine whether HAIL category I applies to a site. It should be noted that mobilisation of lead is dependent on soil type and chemistry. Therefore, if lead contamination is encountered in surface soil, delineation sampling (both vertical and horizontal) should be conducted to determine the area and depth of contamination.

Stantec notes that it is not uncommon for lead contamination to extend throughout the vertical profile of the topsoil layer and recommends that vertical delineation samples be collected throughout the topsoil layer or to a at least 0.3 m bgl if topsoil is not present.

It should be noted that Stantec deems there to be insufficient evidence at this time to consider it more likely than not that contamination due to lead-based paint from buildings of any age poses a risk to human health for High-density Residential (0% produce) land use. This recommendation is based on use of the SCS for High-density residential exposure scenario as defined in the Ministry for the Environment's 'Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health'[42]. The methodology states that for this exposure scenario *'Significant growing of vegetables is not expected. The high-density residential scenario will therefore have lower soil ingestion*

[34] Momentum Environmental Limited. 2023. "Residential Lead".
[35] EHS Support. 2023. "Kāinga Ora".
[36] Blunden. 2020. "Investigation of Lead-Based Paint Contamination".
[37] Ibid.
[38] Blunden. 2020. "Investigation of Lead-Based Paint Contamination".
[39] Ministry of Health. 2021. *The environmental case management*.
[40] O'Connor D., Hou D., Ye J., Zhang Y., Sik OK Y., Song Y., Coulon F., Peng T., and Tian L. 2018. "Lead-based paint remains a major public health concern: A critical review of global production, trade, use, exposure, health risk and implications." *Environment International.* Vol. 121, pp. 85-101.
[41] Turner and Lewis. 2018. "Lead and other heavy metals". pp. 1206-1213
[42] Ministry for the Environment. 2011. *Methodology for Deriving Standards for Contaminants in soil to Protect Human Health.* Wellington: Ministry for the Environment.

rates than standard residential, and not include home-grown vegetable consumption.' In addition, the methodology states that estimates suggest that household gardens as small as 9-10 m^2 can produce 10 per cent of a household's produce consumption.

Stantec recommends that terraced housing or other developments where there is potential for household gardens of any size or where community gardens are proposed should be assessed against the SCS for Residential (10% produce), and that in these circumstances HAIL category I may apply.

Stantec considers that a soil contamination assessment with preliminary sampling of the building halo (soils within 2 m of the exterior of the building), overseen by a Suitably Qualified and Experienced Practitioner (SQEP), is sufficient to confirm whether soil lead levels pose a risk to human health and that a Preliminary Site Investigation (PSI) is not necessarily required to make this determination. Note that a PSI may be necessary to determine if other HAIL activities are being, have been or are likely to have been undertaken on a site and whether the site qualifies as a piece of land under the NESCS.

Recommendations

In summary Stantec makes the following recommendations in relation to the potential for soil contamination resulting from use of lead-based paint on residential buildings:

- Low-density (Rural Residential (25% produce) or Residential (10% produce) land use) residential sites with known existing or historic weatherboard buildings (including ancillary structures such as garages or sheds) constructed prior to 1945 may be considered potential or unverified HAIL sites when considering resource consent applications.
- Soil testing is the most practical means of determining if HAIL category I applies to such sites.
- Surface soils (0-0.1 m bgl) within 2 m of the building(s) should be tested. If initial testing indicates the presence of lead concentrations above the SCS for Residential (10% produce) land use, horizontal and vertical delineation of the contamination should be undertaken.
- Sites with pre-1945 brick houses, and/or ancillary structures, do not qualify as HAIL category I.
- Soil contamination resulting from painted features of brick clad houses (e.g., windows, baseboards, soffits, etc.) is likely to be limited to small, localized area and is deemed unlikely to pose a significant risk to human health.
- Terraced housing or other developments where there is potential for household gardens of any size or where community gardens are proposed should be assessed against the SCS for Residential (10% produce).

The following limitations to these recommendations are noted:

- There is insufficient data to determine if residential lead concentrations are likely to pose a risk to human health for land uses other than Residential (10% produce) or Rural Residential. Therefore, HAIL category I should not be considered to apply for sites with any other existing or proposed land use.
- The Natural and Built Environment Act 2023 (NBA) was enacted on 23 August 2023. As the provisions of NBA come into effect, these recommendations should be reevaluated to determine their relevance under the new regulatory framework.

Please do not hesitate to contact the undersigned if you have any queries.

Yours sincerely

Stantec New Zealand

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