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A Report prepared for the
Corangamite Catchment Management
Authority

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Executive Summary

In this study sediment geochemistry combined with mathematical modelling was used to determine the likely proportional contribution of sediments to L. Connewarre from the Barwon, Moorabool and Leigh River basins. The concentrations of major and trace elements in the fine silt/clay sized fraction (<4 µm) of sediments from L. Connewarre have been compared to concentrations of these indicators in sediments from the source streams (incorporating bed sediments, subsoil riverbank soils and erosion gullies).

The results of the present study identify the Moorabool River basin as being the likely source of the majority (56%) of fine (<4µm particle size) surface (0–5 cm) sediments occurring in L. Connewarre, followed by the Barwon (23%) and Leigh (16%) River basins. Sediment inputs from streams draining parts of the Bellarine peninsula accounted for the remaining 5%. Our data indicate that sediment contribution from unsealed roads and road cuttings were insignificant.

While these results appear to be counterintuitive, the physiography of the rivers provides a plausible explanation of the apparent sediment contribution to Lake Connewarre. The long profiles of the rivers show quite distinctive differences. The Barwon River is very steep in its headwaters, but quickly loses elevation as it moves away from the Otway Ranges, allowing the river to drop a proportion of its sediment load well before it reaches the coast. The deposition of the Otway Group sediment occurs along the broad Barwon River valley south of Birregurra, evidenced by the high potassium signal from radiometric imaging. By comparison, the long profiles of both the Moorabool and the Leigh rivers are not as steep in their headwaters, but are more elevated closer to their mouth. All three rivers are similar in distance from their headwaters to the lake, but the Moorabool has the greatest fall along its course and maintains the steepest gradient closest to the lake. During a flood event resulting from widespread rainfall, the flood waters and sediments from the Moorabool River reach the lake first, and have a shorter distance of lower gradients over which to deposit sediment.

Near surface sediments (0–5 cm) were used in this study because, based on average sedimentation rates estimated by Longmore *et al.* (2005), these would potentially provide the best chance of detecting material that had been deposited in recent times (over the last 30–40 years). This rationale does not take into account vertical mixing of the sedimentary layers by reworking of deposited sediments by wind generated wave action, resuspension during high river flow conditions, and burrowing animals.. The extent of this vertical mixing is undetermined, therefore incorporation of sediments deposited prior to this period cannot be excluded and is likely to have occurred.

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Introduction

Geologically, lakes are repositories for mineral and chemical erosion material from their catchments (Edwards and Whittington (2001). The sediment deposited in the receiving waters of a catchment, such as lakes or river floodplains, typically consists of a mixture of materials derived from different locations and different soil types that are found in the catchment. Conceptually, even relatively small areas of a catchment subjected to unusually high erosion could contribute a substantial proportion of the sediments of receiving waters. Therefore, obtaining reliable information on the origin of sediments transported by rivers and streams within a catchment is critical for understanding the nature of and relative importance of the main sediment sources. Crucially, the implementation of appropriate management strategies to control sediment mobilisation and consequent siltation of water bodies relies on the identification of sediment sources.

Classical methods for obtaining information on sediment origin involve both direct and indirect monitoring techniques such as (Peart and Walling 1988, Collins and Walling 2002, Carter *et al.* 2003, Walling 2005):

- visual appraisal from photographs;
- estimation of erosion rates by using erosion pins and erosion plots; or,
- using sediment load measurements to quantify the relative contribution of suspended sediment from different source areas within a catchment.

Obtaining accurate information using such of methods is hampered by a number of spatial and temporal difficulties and operational costs (Peart and Walling 1988, Collins and Walling 2002).

Alternative methods that characterise sediment properties from several potential sediment sources provide a way to fingerprint the sediment sources. Such techniques have gained widespread use. Sediment fingerprinting techniques are founded on two underlying assumptions (Collins and Walling 2002, Walling 2005):

1. potential catchment sediment sources can be distinguished on the basis of their physical, geochemical and biogenic properties (fingerprints); and,
2. comparison of source materials (river sediments, soils) using these properties, in conjunction with multivariate statistical mixing models, permits the relative importance of the potential sources to be determined.

The list of fingerprint properties that has been investigated in published studies that could be employed to ascribe potential sediment sources, is varied, and includes:

- mineralogy and colour (Klages and Hsieh 1975, Grimshaw and Lewin 1980);
- mineral magnetism (Walling *et al.* 1979, Walden *et al.* 1997);
- fallout radionuclides (Peart and Walling 1986);
- mineralogical composition (Wall and Wilding 1976);
- stable isotopes (Clauer 1979);
- geochemical composition (Wallbrink *et al.* 2003, Walling 2005);
- particle size (Walling *et al.* 2000).

No single diagnostic property has been discovered that provides an unequivocal measure of source sediments. Therefore, increasingly source-fingerprinting investigations now commonly employ several diagnostic properties in combination (Collins and Walling 2002). Such composite fingerprinting indicators can comprise a selection of indicators drawn together from a particular group of properties (e.g. elemental composition) in combination with multivariate mixing models. Alternatively, indicators may be drawn from several different groups of properties (e.g. a combination of two or more of the properties listed above). In this study we have used the former procedure, as this has been proven successful to characterise sediment sources into Western Port, Victoria (Wallbrink *et al.* 2003).

Study Region

Lake Connewarre constitutes a large part of the L. Connewarre State Game Reserve that also includes Reedy Lake, Lake Murtnaghurt, Hospital Swamp, Salt Swamp and the lower reaches of the Barwon River Estuary (DCNR 1993). The reserve is located on the Bellarine Peninsula 8 km southeast of Geelong and covers a total area of 3411 hectares and is fed by streams incorporated into the Barwon/Leigh and Moorabool River basins (Figure 1). These river systems drain an area covering some 4,300 km^2

The reserve is a significant wetland on the Bellarine Peninsula and one of the most important bird habitats in South Eastern Australia. Various species of ducks and swans occupy the open water year round and at least 149 species of birds have been recorded. High proportions of the salt marsh plant species occurring in Victoria are found in L. Connewarre. The Reserve is a RAMSAR Convention Site and is also affected by two international agreements: the Japan-Australia Migratory Birds Agreement (JAMBA) and the China-Australia Migratory Birds Agreement (CAMBA). Under these conventions and agreements the Victorian Government is committed to the conservation of the habitat of migratory species (DCNR 1993).

Removal of vegetation for agricultural production in the catchment since European settlement, and the mobilisation of sediments as a result of alluvial mining in the upper catchment of the Moorabool River during the mid to late 1800s, are thought to have contributed to the sedimentation of the L. Connewarre system (Cecil *et al.* 1988, DNRE 1999). In more recent times there has been a concern that a relatively small area (~7%) of the upper Barwon Catchment may contribute up to 50% of the sediment load to the Barwon River (Pers. Comm. J. Turner, CCMA, 2004). Some of the fine suspended sediment carried by the Barwon River, particularly during periods of high flow, would eventually be deposited throughout L. Connewarre. While geologists generally accept that the lake system would with time have infilled naturally, the vast alterations to the lake's catchment basins through poor on-ground management practices have greatly accelerated this process since European occupation of the region (Cecil *et al.* 1988, DCNR 1993).

Eventually accelerated sedimentation leads to the loss of instream habitat and wetland connectivity. Sedimentation also affects the economic and environmental amenities of the associated rivers, steams, lakes, and wetlands by facilitating nutrient mobilisation from the catchment into the lower reaches of the Barwon River, exacerbating the periodic eutrophic episodes. Considerable resources continue to be put into protection works in this area but there is also a need to confirm the source of recent sediments into L. Connewarre as a baseline against which future improvements in the catchment may be judged.

The Corangamite Regional Catchment Strategy (2003-2008) cites the identification of sources of sediments and sediment and nutrient transport processes in the Barwon and Moorabool River catchments as being major management action targets for achieving healthy rivers, streams, lakes, and wetlands.

Regional geology and geomorphology

Lake Connewarre is the ultimate end-of-valley recipient of the waters and sediments from the Moorabool River, Leigh River and Barwon River basins, and the sediment composition is influenced by the geological and geomorphological evolution of each of these basins.

The Leigh and Moorabool rivers drain the dissected uplands of the Victorian Western Uplands (Joyce *et al.* 2004), which are characterised by a variety of interwoven landforms preserved by substantial uplift during the Palaeogene and late Neogene. A lengthy period of weathering and erosion during the Mesozoic and Cainozoic eras resulted in the development of broad valleys between the undulating hills of Palaeozoic sedimentary rocks and granite plutons. Caps of Palaeogene gravels sporadically distributed at various elevations are remnants of an early Cainozoic palaeoplain, and the sands which fringe the Palaeozoic rocks as a dissected tableland in the central parts of the river basins are remnants of the Pliocene marine regression. Volcanic eruptions filled the broad valleys to form elongate basalt plains and a variety of other volcanic landforms during the late Pliocene and Pleistocene (Robinson *et al.* 2003).

Although the geology and geological evolution of the Leigh and Moorabool river basins is quite similar at the regional scale, there are some differences which may influence the sediment sources. In its headwaters, the Moorabool River drains landscapes with a greater area of granitic rocks and basalts than the adjoining Leigh River. In the lower sections of the rivers, the Moorabool has dissected basalts of the Older Volcanics whereas the Leigh has dissected relatively small areas of marine marl and limestone.

By comparison, the upper Barwon River system comprises a greater area of dendritic tributaries which drain the Victorian Southern Uplands, and the mid Barwon River transgresses the landscapes of the Western Plains (Joyce *et al*. 2004). In its headwaters, the sediment is contributed from the lithic sedimentary rocks of the Lower Cretaceous Otway Group composed of fragments of volcanic rocks with calcic feldspars and very little quartz. These rocks are rapidly weathered when exposed to the elements and easily eroded. North of the Otway Group, the Barwon River crosses the foothills of the Otway Ranges, comprising more gently undulating hills formed on Palaeogene and Neogene sediments of terrestrial and marine origins. North of the foothills, the river traverses the Victorian Western Plains, a landscape of undulating plains formed on both volcanic and sedimentary rocks. The basalts and sporadic pyroclastic deposits (scoria and tuff) cover the sands deposited by the Pliocene marine transgression, which appear in 'windows' within the plains where they were not covered by lava from the Newer Volcanic eruptions.

In terms of sediment mineralogy, the Barwon River carries material sourced from very different rocks (and mineral content) to that of the Leigh and Moorabool. In the northern rivers, the sediment is sourced from deeply weathered sedimentary rocks with the most abundant minerals being quartz, illite, and kaolinite. Other contributions are provided by the granites (quartz, kaolinite, illite, magnetite), ferruginised gravels (quartz, limonite, hematite) and basalts (ferromagnesians, montmorillonite and illites). By comparison, the Barwon River drains landscapes that contribute much less quartz and more ferromagnesian minerals, illites and montmorillonites, as well as some calcite, aragonite and other carbonates.

Similarly, the geomorphic evolutions of the landscapes are quite different. Although the Western Uplands are at a higher elevation than the Otway Ranges, their geomorphic evolution is comparatively much older. The Otway Ranges have experienced approximately 175 to 240 metres of uplift in the Late Neogene (Sandiford 2003), which has been partially responsible for the incision of the steep river valleys. The actively eroding landscapes of the Otway Range can be seen by the numerous landslides, many of which are currently active. The largest in historical times is that which blocked the East Branch of the Barwon River and formed Lake Elizabeth in 1952. When the landslide dam was breached (1953) the wall of mud and water was observed as 7 metres high 10 kilometres downstream and an extensive one metre thick layer of silt covered the landscapes as far downstream as Birregurra (Dahlhaus 1991).

Despite natural erosion being much slower in the Leigh and Moorabool River basins, the environmental history of the past 150 years has been responsible for accelerated erosion and sediment generation. The rapid clearing of the native vegetation and gold mining activity in both river basins during the 1850s initiated severe stream bank and gully erosion and created huge sediment loads. The 'sludge' produced from the ore processing plants along the Leigh River was the subject of great concern at the time of mining, with up to 8 metres of sludge filling the valleys around Ballarat. Even in the early 20th century there are reports of up to 200 hectares of river flats at Shelford being covered from a few centimetres to one and a half metres following flood events (Mines and Water Annual Report 1907, Sludge Abatement Board 1909).

Objectives

The assessment of sediment sources can be achieved through pattern recognition techniques using the major and minor element composition of fine sediment particles. In this project, the composition of major and minor elements in fine silt and clay-sized (<4 µm; Lewis 1984) sediments from input streams of the basins that feed into L. Connewarre are compared to the composition of similarly sized sediments from the lake. A statistical mixing model is applied to the data in order to obtain an estimate of the relative contribution from each of the basins to the lake's sediments. This project addresses the following objectives:

1. to provide a ranking of sediment source contributions by the Barwon, Moorabool and Leigh river systems into L. Connewarre (Section 6.1.3; page 57 Corangamite Regional Catchment Strategy 2003-2008);

2. to provide information to resource managers that will allow soil erosion mitigation works to be targeted to those areas that have the greatest impact on the sedimentation of the lake.

3. to contribute to the understanding of sedimentation and sediment transport processes. (Section 6.3.4; page 62 Corangamite Regional Catchment Strategy 2003-2008).

4. to contribute to the knowledge gaps associated with estuarine degradation due to sediments, turbidity, and eutrophication. (Section 6.5.2; page 65 Corangamite Regional Catchment Strategy 2003-2008).

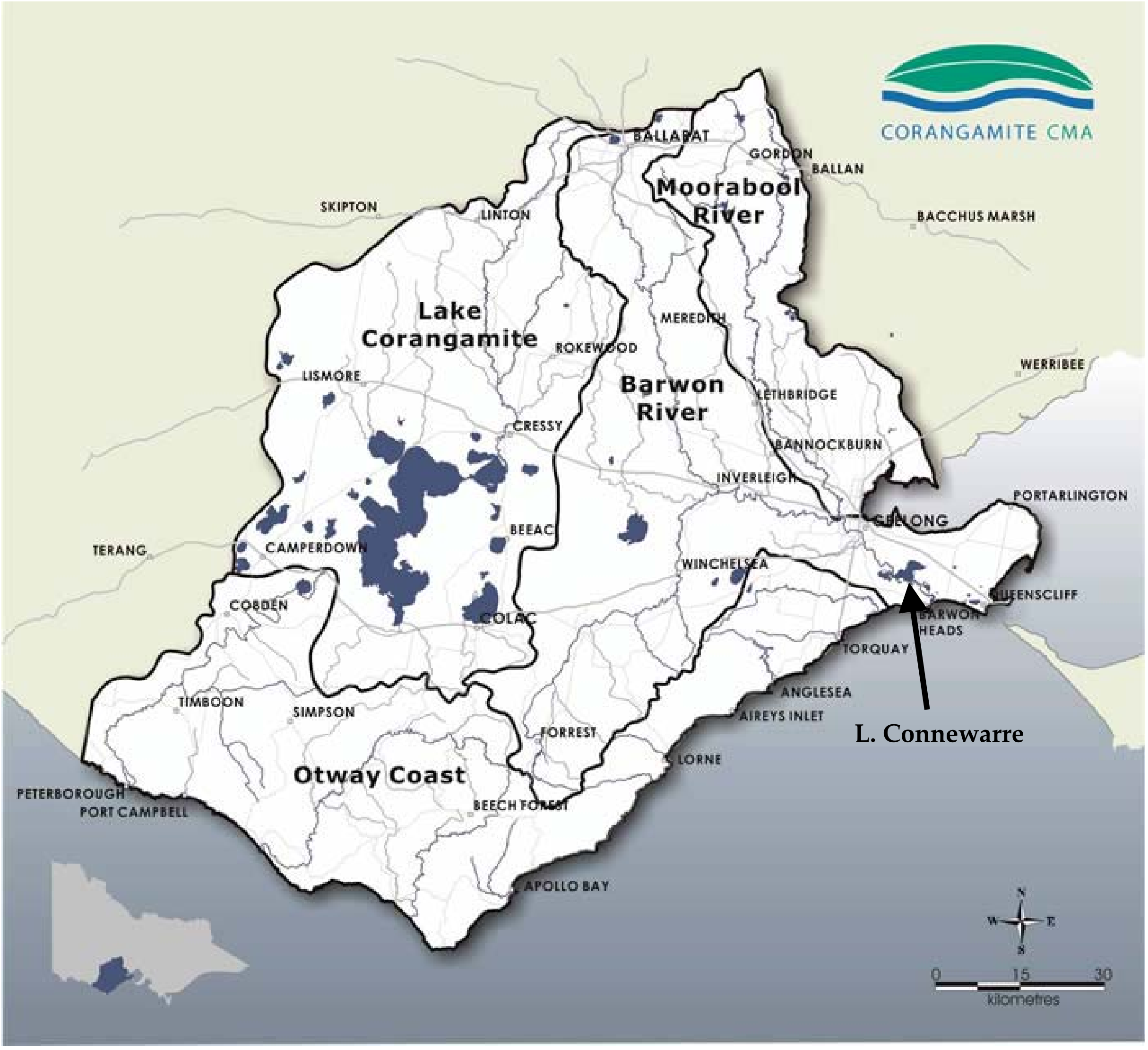

Figure 1 **Corangamite catchment showing the Barwon River and Moorabool River catchments (courtesy of CCMA: www.ccma.vic.gov.au).**

Materials and Methods

Information regarding the source of sediments is an important component leading to the development of sediment control strategies. In this study sediment geochemistry was used to determine the proportional contribution of sediments to L. Connewarre from the Barwon, Moorabool and Leigh River basins. The composition of major and trace elements in the fine silt/clay sized fraction (<4 μm) of sediments from L. Connewarre have been compared to these indicators from sediments from the source streams (incorporating bed sediments, subsoil riverbank soils, and erosion gullies). The contribution from unsealed roads can be significant in agricultural catchments (Motha *et al.* 2004) so these were also considered.

This source identification approach is based on the assumption that the elemental compositions of the deposited sediment reflect those of the component sources (Collins *et al.* 1997). Fluvial transport of sediments result in changes the sediment characteristics due to particle size sorting and abrasion that, in turn produce changes in sediment mineralogy and chemistry (Walling and Woodward 1995, Collins *et al.* 1997). Wallbrink *et al.* (2003) used the clay-sized fraction (<4 μm) from the sediment to minimise the difficulties associated with these processes. The clay-sized fraction is the most likely fraction to be retained in suspension and therefore readily transported and it carries a large proportion of sorbed elements (Förstner 1981, Solomons and Förstner 1984). We followed the same approach in this study.

Sampling

Collection of material to characterise the potential sources of sediment to L. Connewarre were sourced primarily from deposited bed sediments found in quiscent pools in the three rivers (Barwon, Leigh and Moorabool), and some of their tributary creeks (Figure 2 - shows an example of a sampling site in the Barwon River basin), that drain into the lake (Appendix 1).These comprised most of the samples (78%) collected from the three river basins. Sampling sites were selected so as to cover most of the river course in each case, thereby collectively providing representative samples from each basin. Sampling sites from the Barwon River basin included some of the tributary creeks that had been the subject of recent erosion mitigation works (Greg Peters – CCMA personal communication 2005).

Material from randomly selected road cuttings (5 samples), channel banks (2 samples), unsealed roads (3 samples), soil (2 samples) collectively comprised the remaining 22% of samples collected from these three basins. They were collected to provide a fingerprint estimate from these sources to bed sediments. Material from road cuttings, channel banks and unsealed roads were scraped from deposited sediment located in shallow concentrated flow lines (e.g. towards the edge of roads). Additionally, one creek bed sample and three road cutting samples were collected from sites located within 500m of the eastern shores of L. Connewarre. Three of the road cutting samples (sites 74, 77 and 80: Appendix 1) were situated on unmade roads, so these samples probably also included material used to cap the unsealed roads. Two samples of surface soil scrapings from open paddocks (one from the Barwon River basin and one from the Leigh River basin were also taken. Samples collected from L. Connewarre (Figure 3) consisted of single grab samples taken from the surface (0-5 cm) layer

All sediment/soil samples were collected using a 250 mL polycarbonate beaker (5 cm O.D.) attached to the end of a 2 m wooden pole. The sampling equipment was cleaned with water between collections to avoid cross contamination. The top 0-5 cm layers of sediment/soil was collected on each occasion. Samples other than from L. Connewarre were composed of up to 50 sub-samples taken randomly along distances of up to 100m within each site. A minimum of about 2 kg of wet sediment was collected from each site. Ninety samples, 30 from L. Connewarre, 4 from input streams to the north east of L. Connewarre (Wallington), 27 from the Barwon River Basin, 16 from the Moorabool River basin and 13 from the Leigh River basin were collected for this project. A portable GPS navigation receiver (Garmin GPSMAP® 76CS) was used to record the geodetic datum position (GDA96) of all the sample collection sites. Two of these sites (one from L. Connewarre and one from the Barwon River) were subsequently excluded from the statistical computations because not enough < 4 μm material could be obtained for reliable chemical analysis. Latitude and longitude coordinates for each sample site, together with a brief site description, are listed in Appendix 1. The locations of the sampling sites in L. Connewarre and the potential input sources are shown in Figure 4 (a & b, respectively).

Figure 2 Typical tributary creek that occurs in the Barwon River basin.

Figure 3 Lake Connewarre, facing south-west.

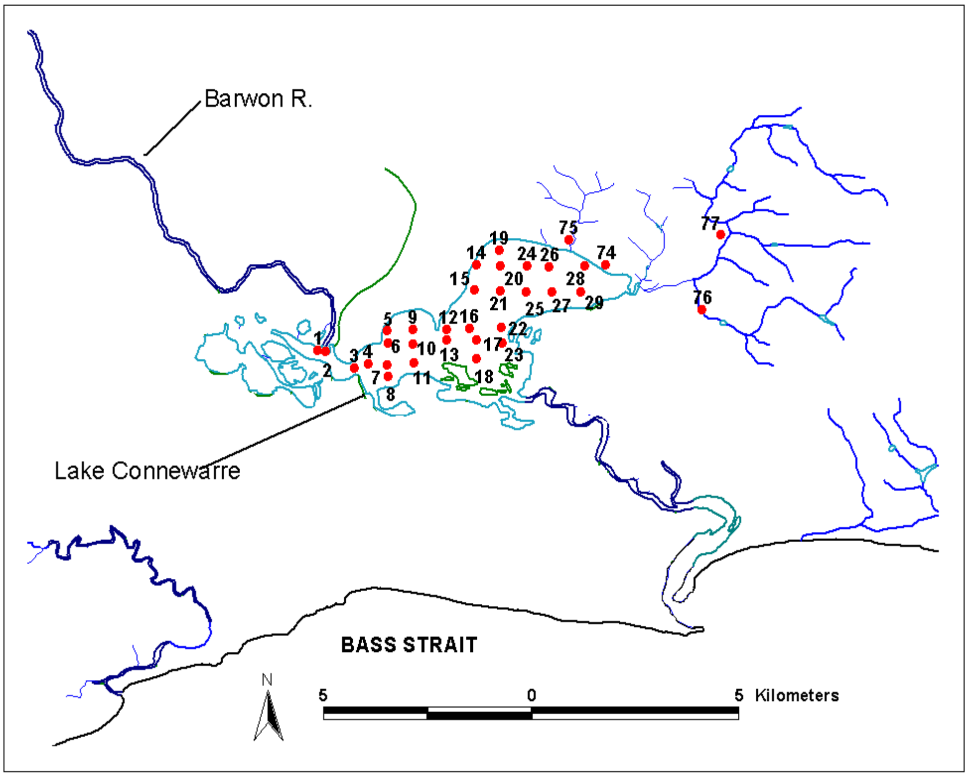

Figure 4a Sample sites located in and around L. Connewarre.

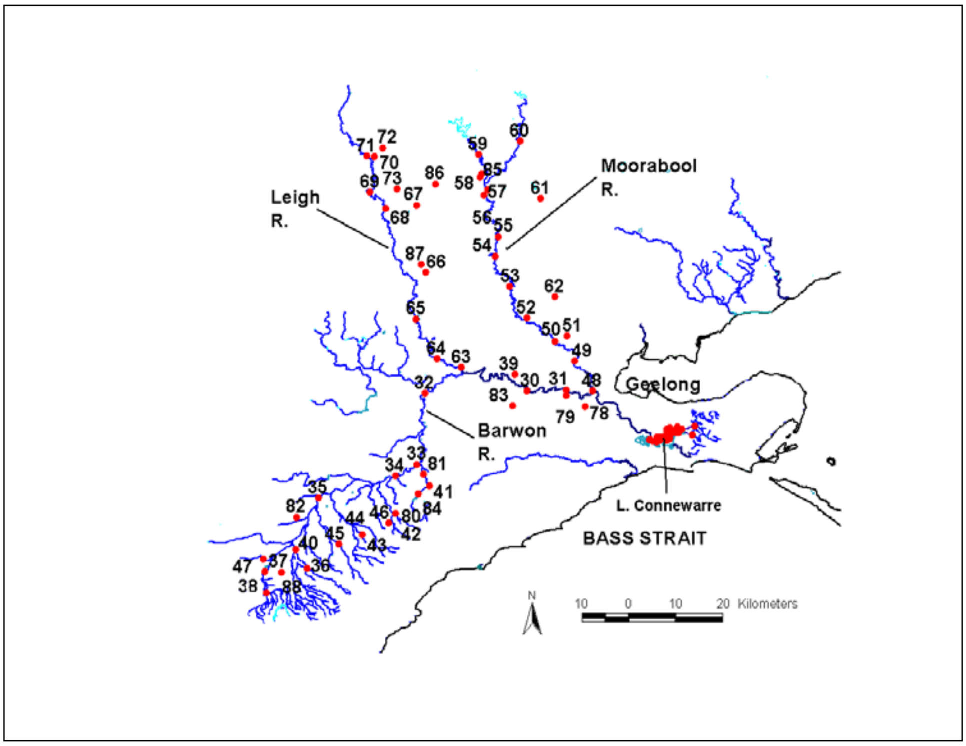

Figure 4b Sample sites located in the Barwon/Leigh and Moorabool River basins.

Extraction of the <4 μm particle size fraction

The particle size composition of fine sediments has a marked influence on the trace element composition (Förstner 1981, Solomons and Förstner 1984). Since small particles generally have a greater surface area to volume ratio than larger particles they have a greater capacity to adsorb trace elements. Therefore, to avoid complications arising from having to apply particle size correction factors, to compensate for differences in particle size distributions between potential sources and sinks, the chemical analyses were performed on the fine silt/clay sized (<4μm) fraction extracted form all samples. In this regard the procedure used in this study follows that of Wallbrink *et al.* 2003 and Walling 2005.

The <4 μm size fraction was extracted from suspension using the settling technique outlined in Lewis (1984). The procedure involved a preliminary separation of fine material by wet sieving a 500 ml, thoroughly mixed slurry of each bulk soil/sediment sample through a 63 μm nylon mesh sieve. The sample was washed through the sieve into a 2 l Pyrex glass beaker using distilled/deionised water (Milli Q gradient A10™). The <4 μm particle size fraction was isolated firstly by thoroughly mixing the <63 μm suspension, then siphoning off and retaining a designated column of suspension (<10 cm) after a predetermined period of time (approximately 2 h; Lewis 1984).

The salinity of the <4 μm suspension was measured with a conductivity meter, and if the salinity was <0.01, then the sample was freeze dried. Otherwise, the suspension was centrifuged. The supernatant liquid was discarded, and the pellet reconstituted with distilled/deionised water. The reconstituted sample was freeze dried if the salinity of the suspension was <0.01, otherwise the centrifugation process was repeated (Figure 5). This procedure ensured that most (>99%) dissolved salts present in the sample were removed, thereby allowing the major ion composition of the sample to be used for the sediment tracing process (Wallbrink *et al.* 2003). The freeze-dried samples were analysed for their elemental composition after acid mineralisation as described below.

Analytical Chemistry Methods

Two instrumental techniques were used for the elemental determinations in the samples. Inductively coupled plasma–emission spectrometry (ICP–ES) was used to determine, principally, the major elements, and inductively coupled plasma mass spectrometry (ICP–MS) for the minor (trace) elements. For consistency, sample solutions obtained using an open beaker nitric–hydrofluoric acid mineralisation procedure were used for both techniques.

All sample preparation was carried out in a metal-free, HEPA air filtered, trace metals clean room. Weights were recorded to four significant figures using a calibrated Mettler model AE200 balance which weighed to 0.1 mg. Volumetric glassware used for preparation of calibration standard solutions and samples was calibrated A class glassware. Piston operated volumetric pipettes used new high purity neutral colour polypropylene (PP) tips, and were calibrated gravimetrically prior to every work period and change in pipette volume. Plastics–ware and glassware was acid washed using high purity acids and rinsed with high purity deionised water (Millipore® Milli-Q™). Oak Longlength® powder free vinyl gloves were used as over–gloves, and were rinsed externally with water prior to use.

Reagents and Equipment

Sub-boiling distilled 69% (w/v) nitric acid was prepared in a Labglass® quartz sub-boiling still from BDH AnalaR® grade 69% (w/v) nitric acid stock, and used for both cleaning and sample mineralisation procedures. Merck VLSI Selectipur® 50% (w/v) hydrofluoric acid was used for cleaning plastics–ware, and Merck Ultrapur® 48% (w/v) hydrofluoric acid was used for sample mineralisation.

Ultra-pure (18.2 MΩ) deionised obtained from a Millipore Milli-Q Element A10 water purification system water was prepared immediately prior to use. Calibration standards were diluted from Spex Certiprep® 1000 μg mL^{-1} single element stock solutions and Inorganic Ventures Custom Grade® Complete Calibration Set (CCS) 1 to 6 (100 μg mL^{-1} mixes). Internal standards were diluted from Spex Certiprep 1000 μg mL^{-1} single element stock solutions and Inorganic Ventures Custom Grade VAR-IS-1 multi element (100 μg mL^{-1} Bi, In, Li, Sc, Tb, Y) stock solutions.

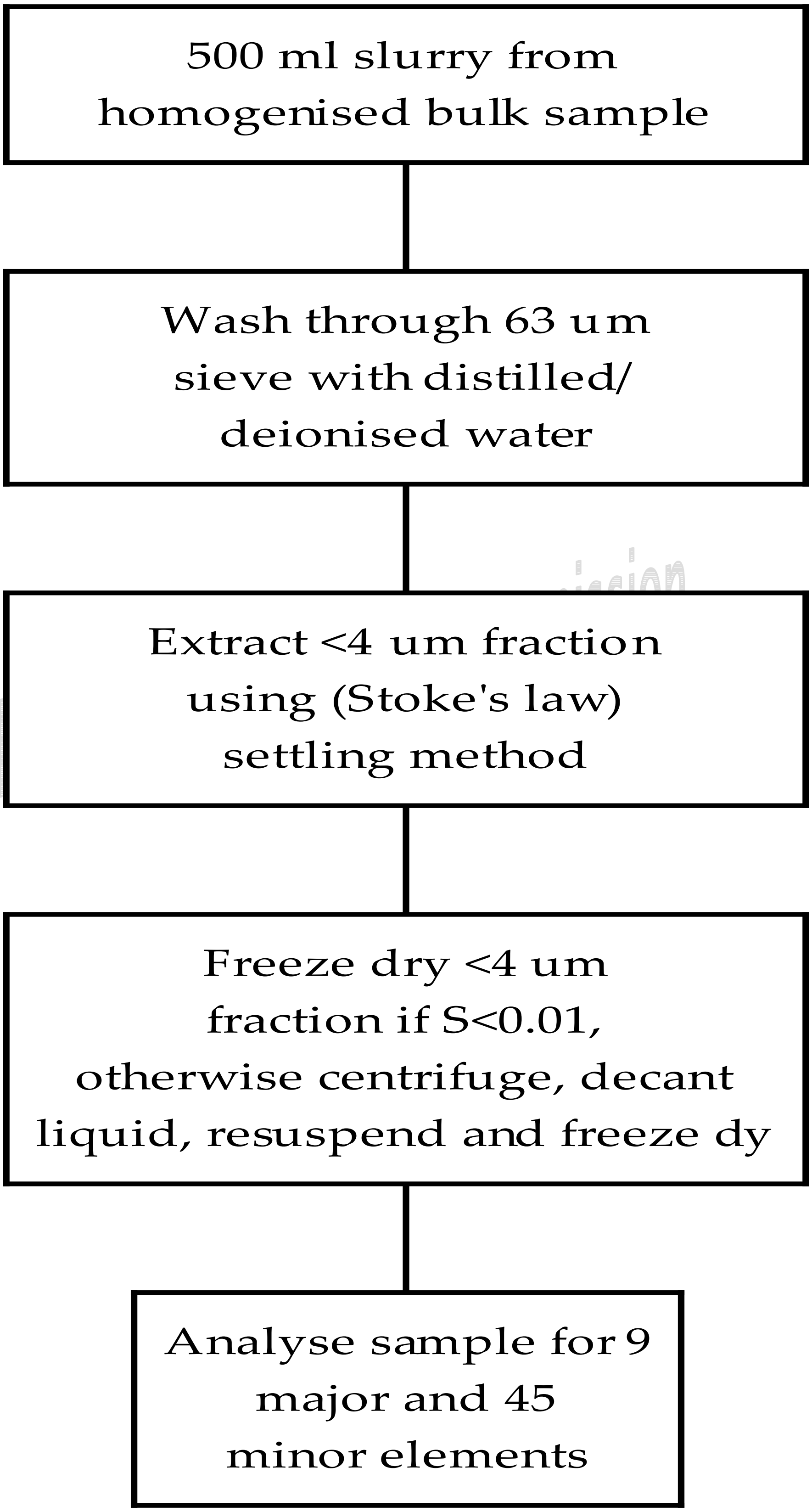

Figure 5 Outline of process for sediment/soil sample preparation

Samples were mineralised in Savillex 22 mL polyfluoroacetate (PFA) screw-cap vials with PFA closures, and on a Scientific Equipment Manufactures Teflon® coated and temperature calibrated hotplate in a plastic fume–hood located in the clean–room. Mineralised samples were kept in Sarstedt 30 mL calibrated PP screw-cap centrifuge tubes with neutral caps. Calibration standards were stored in Nalgene 250 mL low-density polyethylene (LDPE) narrow mouth bottles with PP caps.

The concentrations of trace elements in the samples were determined with a Varian Analytical Instruments UltraMass® ICP-MS, and major element concentrations were determined with a Spectro Instruments SpectroFlame EOP® simultaneous ICP-ES. The operating parameters of both instruments were optimised daily according to the manufacturers' instructions. Sample introduction for both instruments used a Glass Expansion OpalMist® hydrofluoric acid resistant concentric nebuliser with a self aspiration rate of 2 mL min^{-1}, a Varian Sturman-Masters inert spray chamber, and each instrument used a Glass Expansion hydrofluoric acid resistant torch.

Sample Preparation

The sediment samples were crushed as much as possible by rolling a large Texta™ pen over the flattened unopened polyethylene sample bags, and then transferred into labelled anti-static screw-cap PP vials for long term storage in an auto desiccator.

Mineralisation procedure

Each sample was thoroughly mixed and approximately 200 mg of each was weighed into a pre-cleaned PFA screw-cap vial. One mL of 69% nitric acid was added to each vial and the samples pre-digested without lids on a hotplate at 90°C to incipient dryness. The vials were then cooled, and after the addition of 2 mL of 48% hydrofluoric acid, they were capped and the caps tightened until a gas-tight seal was achieved. The vials were then returned to the hotplate and the contents were mineralised overnight at 150° C. Thereafter, the vials were removed from the hotplate and allowed to cool to ambient temperature. The vials were uncapped, ensuring that there were no condensate losses, then returned to the hotplate and evaporated at 130°C until incipient dryness. One mL of 69% nitric acid was added to each vial and the contents were again evaporated to incipient dryness. This step was repeated once more, then 1 mL of 69% nitric acid and 10 mL of ultra–pure water were added and the vials heated at 120 °C until all material was in solution. The resulting solutions were transferred to calibrated vials whilst warm, and after they had cooled they were diluted to 20 mL with ultra–pure water. The final acid concentration was 5% nitric acid with a trace of hydrofluoric acid.

Many of the mineralised samples contained an undigested colloidal residue of organic material, a common feature of HF–HNO_3 mineralisation. This material tended to flocculate and sediment out within about 24 h. This material was not resuspended prior to dilution for analysis as the method work-up had shown that the high carbon content was causing very poor precision on the ICP-MS.

ICP-MS Analyses

The mineralised samples were further diluted 1:100 for initial ICP-MS analysis in a matrix of 1% (w/v) nitric acid to match that of the calibration standard solutions. Internal standards were added to samples as appropriate for each suite of tests, at a solution concentration of 20 ng mL^{-1}. Seven calibration standards and a calibration blank were made to provide external calibration to 100 ng mL^{-1} for each analyte. The instrument was calibrated and the interface cones conditioned with sample solution to compensate for matrix specific drift prior to calibration reslope and sample analysis. Calibration slopes were checked every 10 solutions and adjusted to compensate for further minor drift during the instrument run time (12 h average).

Samples were initially analysed using an autosampler and peristaltic pump for unattended operation. However, several repeat analysis runs also were required, using manual sample introduction and with the nebuliser self aspirating, in order to determine some analytes that would not rinse out from the extended sample introduction system to a sufficiently low and stable background signal.

Calibration standard elemental mixes were as follows:

- CCS-1: Sc, Y, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Th, U;
- CCS-4: Li, Na, K, Rb, Cs, Be, Mg, Ca, Sr, Ba, As, Se, Al, Ga, In, Bi;
- CCS-5: Ti, Zr, Hf, Nb, Ta, Mo, W, B, Ge, P, S, Re, Sn, Sb; and,

- CCS-6: V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd, Ag, Tl, Pb.

Elements having concentrations below the detection limit for the calibration at the 1:100 dilution were re-analysed after a 1:10 dilution of the original mineralised sample solutions. Because the total dissolved solids concentration in these 1:10 diluted samples was well above the recommended value for the instrument, this set of analysis was carried out after all the analyses for the 1:100 diluted samples had been completed. Additionally, a further drift correction was applied to these samples to compensate for the increased signal drift.

Elements having concentrations above the range possible on the ICP-MS, or that suffered severe interference (e.g. Fe) were analysed by ICP-ES.

ICP-ES Analyses

Aliquots of the original mineralised sample solutions were diluted 1:10 in a matrix of 5% (w/v) nitric acid to match that of the calibration standard solutions. Fifteen calibration standard solutions and a calibration blank solution were used. These included any element that initial scans suggested that:

- may have been present at concentrations that were too high to be determined by ICP-MS;
- could not be determined by ICP-MS due to interferences;
- was commonly used as internal standards on the ICP-MS.

Silicon was measured in order to monitor residual Si concentration, in case corrections were needed for the ICP-MS data. The element mixes were as follows:

- Al, Fe, Si: five standards to 150, 100, and 200 μg mL^{-1} respectively;
- Ca, K, Mg, Ti :four standards to 10 μg mL^{-1}; and,
- B, Ba, Be, Ce, Cr, Cu, La, Mn, Na, Sc, Sr, Y, Zn: seven standards to 1 μg mL^{-1}

The results obtained for elements in the third calibration set were mostly below the instrument detection limit and ICP-MS results were reported instead.

Sample solutions were analysed using an autosampler and peristaltic pump for unattended operation, the Ar 430.010 nm line was monitored to track instrument performance, and instrument drift was checked after every 15 solutions had been aspirated. Calibration reslopes were performed where necessary. ICP-ES results are reported only where ICP-MS analyses were not performed, or where ICP-MS results did not adequately pass QC criteria.

Quality Assurance & Quality Control

All samples were analysed at the PIRVic (Werribee) laboratories using National Association of Testing Authorities (NATA) accredited test methods. Analytical results are traceable to US and Australian National Measurement Standards *via* balance calibration reference mass set M13617 and the various US National Institute of Standards and Technology (NIST) spectrometric standard reference materials (SRMs) used in the preparation of the calibration stock solutions.

The samples were digested in batches of 20 to 25. Sufficient process blanks were included in each batch to monitor the background and to check for possible contamination. Method detection limits were calculated using the entire set of blank digests.

Duplicate digests of samples were included in each mineralisation batch to monitor repeatability and sample homogeneity.

A replicate digest of a single sample was included in each mineralisation batch to monitor interim reproducibility. These data were also used to estimate an uncertainty for each analyte.

Spike recoveries were performed at two concentrations for each analyte for ICP-MS analyses only.

Standard reference material duplicates were included in each mineralisation batch to determine precision and accuracy (bias). The SRM materials used for this were manufactured and certified by NIST and the US Geological Survey (USGS). The NBS (now known as NIST) SRMs were selected as they most closely matched the sample matrix, although the river sediment SRM had limited replication due to very high oil content. The USGS SRMs were selected as they had an extensive range of both certified and recommended values.

The reference materials used were:

- NBS SRM 1645 River Sediment;
- NBS SRM 1646 Estuarine Sediment;
- USGS SRM AGV-1 Andesite, Guano Valley; and,
- USGS SRM RGM-1 Rhyolite, Glass Mountain.

The results of these quality control determinations are summarised in Appendix 2, and indicate that acceptable accuracy and precision were obtained for the purposes of this study.

Selection of Tracer Indicators

The use of a single indicator to fingerprint sediment sources is not practicable because while the indicator from a particular sediment source might match that found in sediment from the deposition zone, it does not exclude its origin from other potential sources. The use of several indicators in combination considerably reduces this problem thereby providing a more reliable means of establishing sediment sources. In this study, the indicators have been drawn from a single group (major and minor elemental composition) that comprises alkaline earth elements, transition metals, a non-metal, and metals from the lanthanide and actinide group of elements. This choice of indicators as a composite fingerprinting group should increase the likelihood of achieving a statistical differentiation between source sediments (Collins and Walling 2002, Krause *et al.* 2003). Therefore, each of the sediment samples collected in this study was analysed to determine the concentration of 9 major and 45 minor elements (Table 1) by inductively coupled plasma-mass and emission spectrometry as described above. A similar suite of elements was used successfully by Wallbrink *et al.* (2003) to assess catchment sediment contributions to Western Port.

Table 1 **Elements determined for assessment of catchment sediment contributions**

Major elements	Minor elements
Na, Mg, Al, P	Li, Be
K, Ca, Ti, Fe, Mn	Sc, V, Cr, Co, Ni, Cu, Zn, Ga , Ge, As
	Rb, Sr, Y, Zr, Nb, Mo, Ag, Cd, In, Sn, Sb
	Cs, Ba, Hf, Ta, W, Tl, Pb, Bi
	La, Ce, Pr, Nd, Sm, Gd, Tb, Dy, Ho, Er,Tm, Lu
	Th, U,

Major elements

These include the base cations and metals usually present at higher than trace levels. Phosphorus has been included because it can be a useful component in tracing studies (Hasholt 1988, Walling 2005).

Minor (trace) elements

Sets of acid extractable trace metals have been tested in numerous studies (Walling 2005, Wallbrink *et al*. 2003) and found to provide useful information on sediment source discrimination in varying river basins.

The Mixing Model

Statistical computations were performed using SAS® (SAS Institute Inc. Cary, NC, USA) software. Several related statistical techniques have been applied to the indicator data in order to derive a quantitative assessment of the contribution of each source to the sediment pool in the deposition zone. Non parametric *Monte-Carlo* mixing models have been particularly useful for this (Franks and Rowan 2000, Wallbrink *et al.* 2003, Krause *et al*. 2003). A comprehensive explanation of the model is provided in Collins *et al*. (1997) and Walling *et al.* (1999). Essentially, the technique compares a range of tracer indicators from potential source sediments with the same indicators from the deposition area. In this study the tracer indicators were selected principally on the basis of the work of others (Wallbrink *et al.* 2003). These traces provide statistically ($P<0.05$) significant differences between each of the source areas and are incorporated into a composite fingerprint.

The trace indicators are incorporated in a multivariate mixing model that provides estimates of the relative contribution of the potential sediment sources. A linear equation for each of the tracers in the composite fingerprint relates the concentration measured in the source sediments to that in the mixture that represents the sum of the contributions from the various potential source areas. The mixing model consists of a series of linear equations for each of the tracer indicators. This set of equations is solved using the least squares method in which the relative contributions of the various sources are determined by minimising the sum of the squares of the residuals for each tracer indicator. The model is represented by:

$$R_{es} = \sum_{i=1}^{n} \left(\frac{C_{ss\ i} - \left(C_{si} P_s\right)}{C_{ssi}} \right)^2$$

Where:

R_{es} = the sum of squares of the residuals for the *n* indicator;
C_{ssi} = the concentration of the indicator *i* in the source sediment;
C_{si} = the mean concentration of the indicator from source *s;* and,
P_s = the relative proportion from source *s* and where the following constraints apply:
(a) the source type contributions must all be positive ie. $0 \leq P_s \leq 1$, and
(b) the sum of the *n* source type contributions must equal 1 ie.

$$\sum_{s=1}^{n} Ps = 1$$

The best match between the proportions of input sources (Barwon, Leigh, Moorabool Rivers etc.) and deposition location (L. Connewarre) is obtained when R_{es} is a minimum.

As yet there are no generic guidelines for selection the most appropriate suite of fingerprint indicators for distinguishing spatially defined sediment sources by the methods used in this study. However, it is important to take into account the inherent variability of fingerprint properties associated with individual sources and of the uncertainty associated with the statistical solutions, and so several statistical procedures were used to determine whether subsets of the available indicators could be identified that would provide optimal candidates for composite groups.

Concentrations of some elements were found to be significantly ($P<0.001$) higher (As, Na, Mg, Li and U) or lower (Sb, Ca, Co and Ba) in L. Connewarre sediments than in combined potential source sediments (Figure 6). The source or fate of these elements in the sediments of L. Connewarre has not been accounted for by the sampling scheme used in this study.

Pearson correlation coefficients were used to identify those elements in the sediments that were co-correlated. Inclusion of co-correlated elements provides no additional information to the model. Hence elements that were significantly co-correlated ($R^2>0.85$, Figure 7) across the full range of samples made up a second set of elements (ie. Dy, Er, Eu, Gd, Ho, Nd, Pr, Sm, Tb, Tm, Y, Yb, Lu, Hf, and Zr) that could potentially be excluded from the model.

Apart from considerations highlighted by these statistical analyses, there are geochemical reasons for not including some of the above elements in the mixing model. According to Marx *et al.* (2005) hot plate digestion procedures, as used in this study, do not completely mineralise Zr, Hf and associated heavy rare earth elements. Furthermore, the abundance of Zr and Hf in aeolian sediments is highly variable (Gallet *et al.* 1996), so using the heavy rare earth elements for fingerprinting purposes may be problematic even if samples were fully mineralised. Additionally, Sr could be considered for exclusion because preferential weathering and cation exchange processes (Martin and McCulloch 1999) may affect its concentration in the sediments that are formed in the different basins and after their deposition in L. Connewarre.

After taking these arguments into account, one set of simulations was calculated using the suite of indicators (ie. 6 major elements and 25 minor elements) listed in Table 2

Simulations were also calculated using (*a*) all the available data; (*b*) data with only the outlier elements omitted, and (*c*) data with only co-correlated elements omitted.

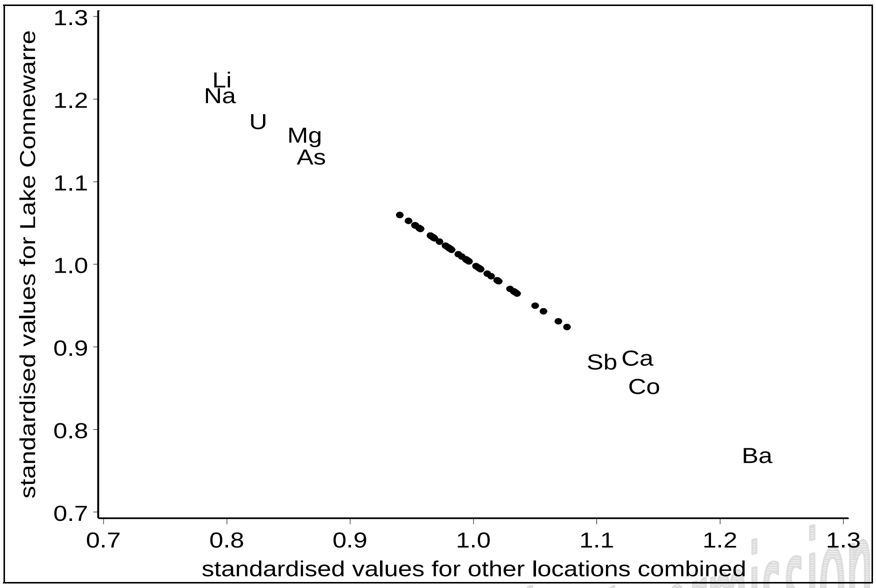

Figure 6 Extreme outlier elements in potential source sediments with respect to L. Connewarre sediments[#]

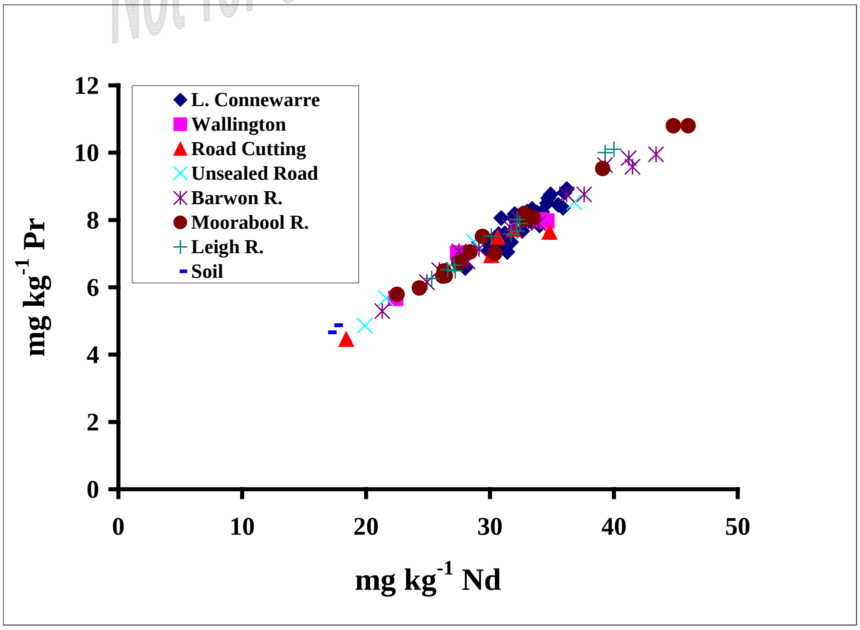

Figure 7 The relationship between Nd and Pr concentrations exemplifies the case where the concentrations of two elements are co-correlated across all sites.

[#] For each element, L. Connewarre mean values (ordinate) were standardised against the combined mean for L. Connewarre and the sum of the mean values for each of the input locations, each weighted by its appropriate proportion obtained from the model. For all other locations (abscissa) the sum of the weighted mean values were similarly standardised.

Table 2 Elements used to assess catchment sediment contributions

Major elements	Minor elements
Al, P	Be
K, Ti, Fe, Mn	Sc, V, Cr, Ni, Cu, Zn, Ga, Ge,
	Rb, Nb, Mo, Ag, Cd, In, Sn,
	Cs, Ta, W, Tl, Pb, Bi
	La, Ce,
	Th,

Results

Major Elements

The concentrations of the major and minor elements in the fine silt/clay sized (<4 µm) fraction from sediments collected from L. Connewarre and potential sediment sources are presented graphically in Figures 6 & 7 respectively. The complete data set is provided in Appendix 3. With the exceptions, discussed previously, the concentrations of most of the major and minor elements in sediments from L. Connewarre generally fall within the range of concentrations from the potential sources.

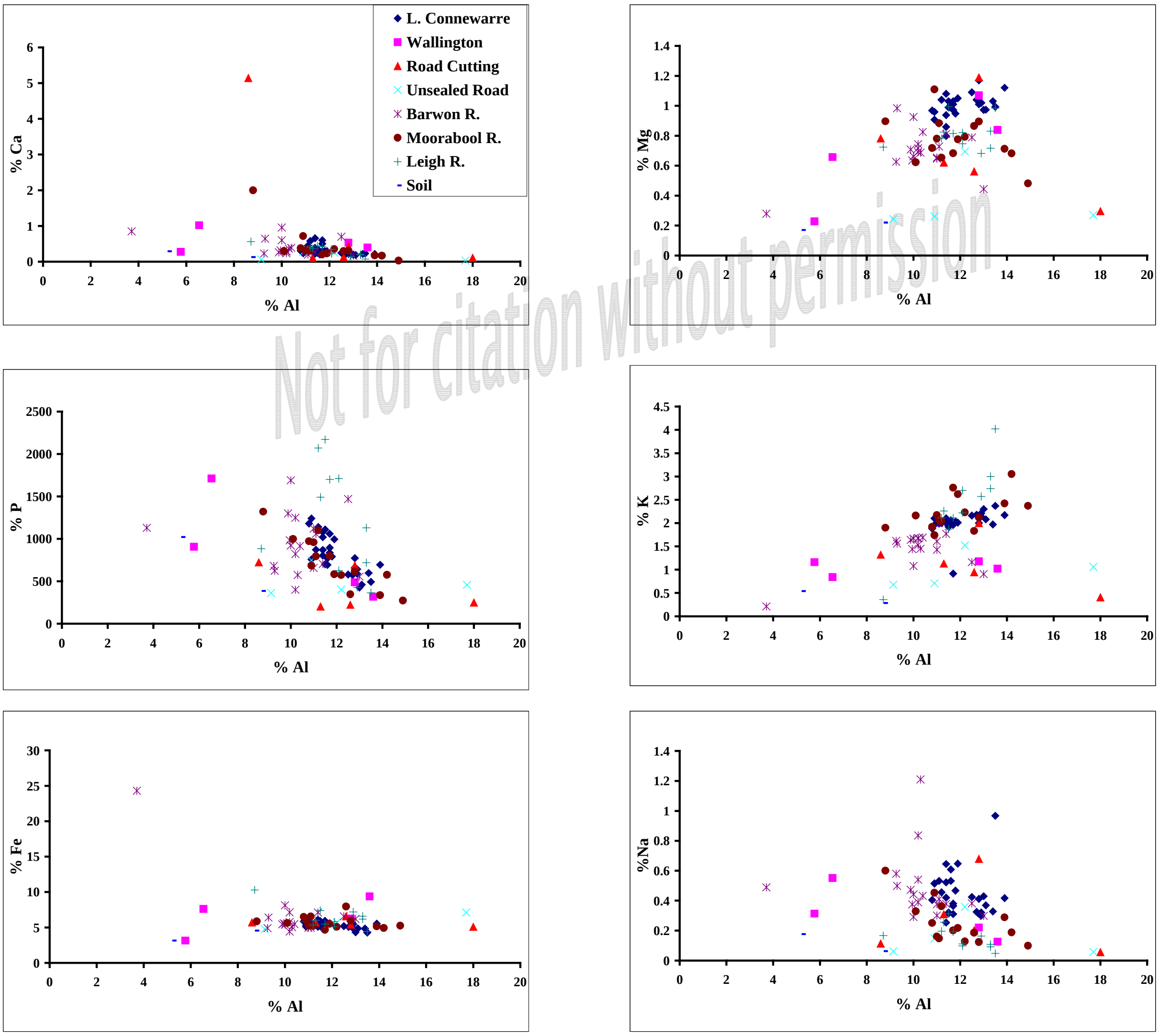

Figure 8 **Major element concentrations in the fine silt/clay sized (<4 µm) fraction of sediments from L. Connewarre and potential sediment sources.**

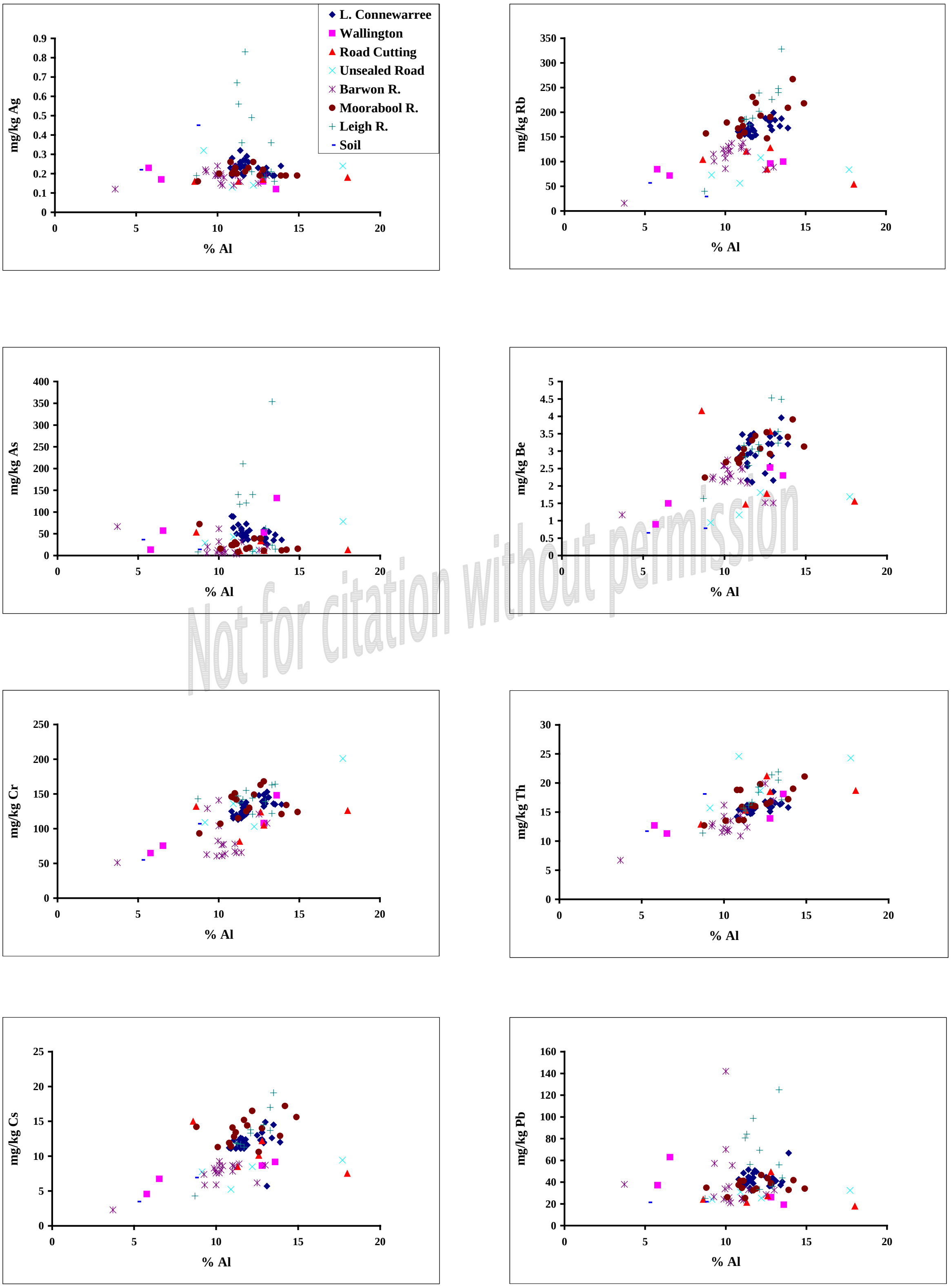

Figure 9 Concentrations of some of the minor elements determined in the fine silt/clay sized (<4 μm) fraction of sediments from L. Conneware and potential sediment sources.

Proportional sediment (<4 µm size fraction) contributions to L. Connewarre

The *Monte-Carlo* mixing model compares measured element concentrations in a mix of sediment derived from the potential sources with the concentrations in sediments from L. Connewarre. The optimum match between the potential source sediments and L. Connewarre sediments, for the condition when co-correlated and outlier elements (as discussed previously) are omitted, was obtained with the proportions of sediments listed in Table 3. Sediments from the Moorabool River make the greatest contribution to the sediment composition of L. Connewarre. The Barwon and Leigh Rivers combined contribute to most of the remainder, with a small contribution originating from the region to the north east of the lake (Wallington). No contributions were attributed to unsealed roads or road cutting material

Table 3 Contributions of fine silt/clay sized (<4 µm) sediments from each source to L. Connewarre using the element list in Table 2.

Source	% Contribution
Moorabool River	56
Barwon River	23
Leigh River	16
Wallington	5
Unsealed Roads	0
Road Cuttings	0

Monte-Carlo simulations that used (*a*) all the available data; (*b*) data with outlier elements omitted, and (*c*) data with co-correlated elements omitted gave a similar overall pattern of contributions with minor variations in the proportions (Table 4)

Table 4 Contributions of fine silt/clay sized (<4 µm) sediments from each source to L. Connewarre using various element groups

Source	% Contribution		
	All elements	Outlier elements omitted	Co-correlated elements omitted
Moorabool River	54	55	60
Barwon River	23	24	20
Leigh River	17	16	15
Wallington	5	5	5
Road Cuttings	0	0	0
Unsealed Roads	1	0	0

Comparison of concordance of the elemental concentrations in L. Connewarre sediments derived from the *Monte-Carlo* simulation with the measured concentrations for selected elements is shown in Figure 10 (all comparisons are shown in Appendix 4). In most cases the range of calculated concentrations closely match the range of measured concentrations. Notable exceptions are observed for outlier elements identified in Figure 6.

The uncertainty in these results for source contributions was assessed by estimating both the mean coefficient of variation (CV) for each element at each source and the overall CV for all element across all sources was calculated as:

$$CV = \sum_{C} \left(\sum_{s} p_s CV_s \right) / N_c$$

where C is the concentration of each element;
S is each source;

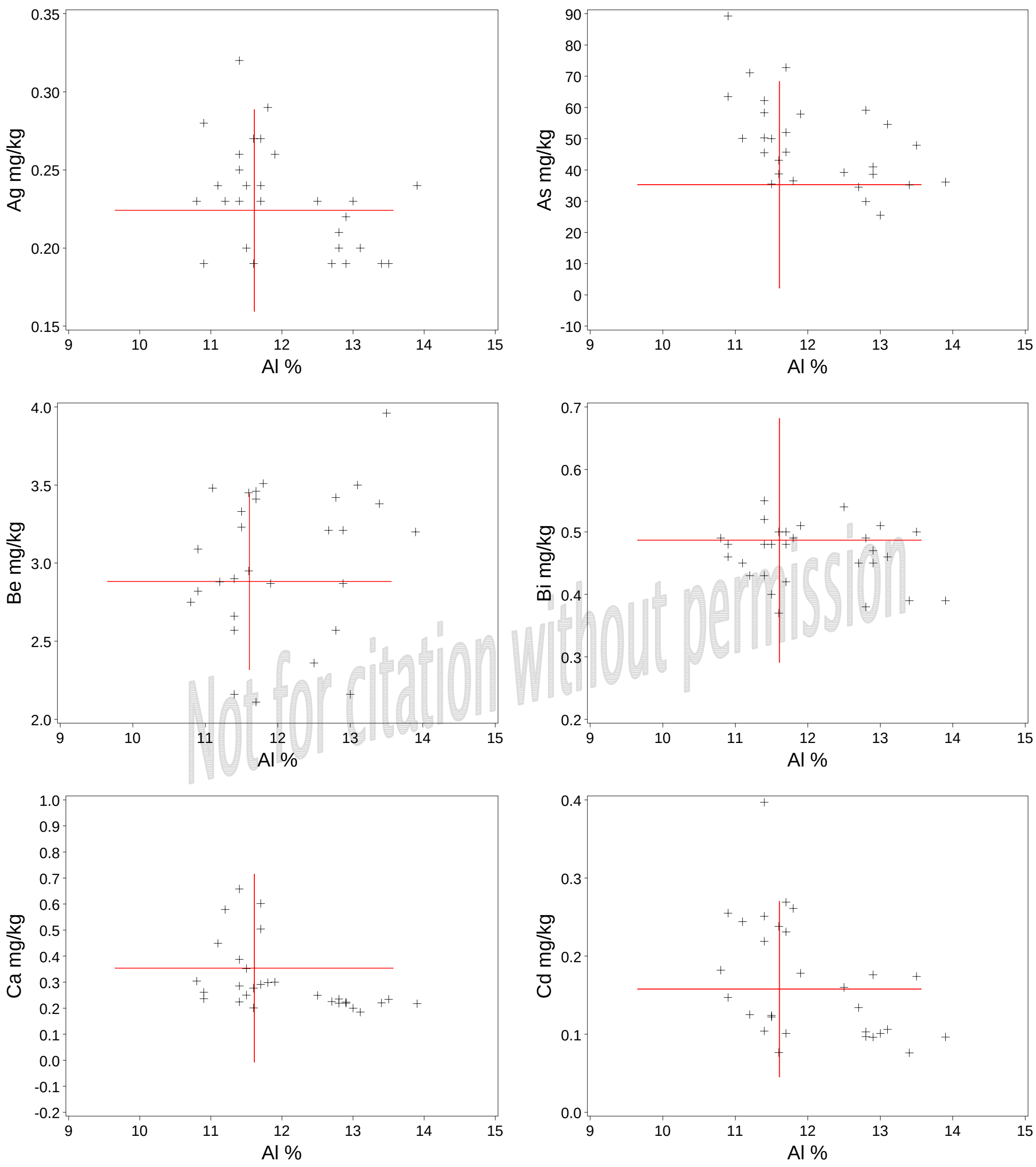

Figure 10 **Comparison of measured element concentrations (small crosses) with mean (centre of red cross) and range (red lines) of values obtained from the simulation. The full set of simulations is shown in Appendix 4.**

P is the proportion contribution of each source;
CVs is CV of mean of each element from each source; and,
Nc total number of elements used

The mean coefficient of variation (CV) for the elements using the proportion from each source as suggested was 7.2% and the mean CV for the selected elements was 6.9%. These results provide some confidence that the observed discrimination between source contributions is plausible given the closely clustered distributions of some elements in Figures 8 & 9, the similarity of the results (Table 4), and the variations in the values of the concentration (appendix 3).

Discussion

Susceptibility to land degradation

Lake Connewarre is part of the Port Phillip Bay (Western Shoreline) & Bellarine Peninsula RAMSAR Site. The Strategic Management Plan for this site states that the issue of increasing sediment loads and levels of nutrients as a result of land clearing and development is of particular concern in the Barwon River catchment where water extraction has added to the adverse impacts on the RAMSAR site. Water flows from the Barwon and Moorabool Rivers are crucial for the health of Reedy Lake and L. Connewarre and associated wetlands. Since European occupation some 85% of the landscape within the Barwon Catchment has been cleared of native vegetation and the land turned over to diverse activities including mining, livestock grazing, dairying, dryland agriculture and forestry (SKM 2005). Catchment based erosion has lead to increased sediment and nutrient loads to the RAMSAR site, decreasing water quality. Degraded surface water resources throughout the CCMA region has lead to, among other issues, "widespread erosion and sedimentation problems" and "The Moorabool and Barwon systems stand out as suffering from both salinity and high levels of nutrients and sediments" (CCMA 2003). The consequence of this accelerated sedimentation includes the loss of instream habitat and wetland connectivity. Sedimentation also affects the economic and environmental amenities of the associated rivers, steams, lakes, and wetlands by facilitating nutrient mobilisation from the catchment into the lower reaches of the Barwon River exacerbating the periodic eutrophic episodes.

The Corangamite Catchment Management Plan provides directions on the control and prevention of erosion in the Barwon River catchment. One of the fundamental measures considered for this has been to identify areas subject to accelerated soil erosion and the investigation of appropriate erosion control methods. This study contributes to the understanding of sedimentation and sediment transport processes and provides information to fill knowledge gaps associated with estuarine degradation due to sedimentation. The project has quantified information of the major sources of sediment to L. Connewarre.

Robinson *et al.* (2003) has described the geology and physiography of the region. Land within the CCMA region has a high inherent susceptibility to a number of land degradation processes. These have been discussed in detail by Robinson *et al.* (2003) and Dahlhaus (2003) and include:

- sheet and rill erosion (27% of the region is rated as having high susceptibility);
- gully and tunnel erosion (32% of the region is rated as having high susceptibility);
- landslides (26% of the region is rated as having high susceptibility);
- wind erosion (12% of the region is rated as having high susceptibility);
- waterlogging (52% of the region is rated as having high susceptibility); and,
- soil structure decline (60% of the region is rated as having high susceptibility)

Landscapes within the region that feature prominently include the Otway Range (sheet and rill erosion, landslides, and soil structure decline) and Western Uplands (gully and tunnel erosion, and waterlogging). Historically, the removal of native vegetation and alluvial mining practices in the upper catchments of the Moorabool River from the 1850s to the early 1900s caused extreme erosion (Cecil *et al.* 1988, Dahlhaus 2003). While many of these areas have since undergone rehabilitation, Dahlhaus (2003) suggests that the techniques used particularly immediately post 1930s, were not as effective as would have been desired.

Siltation and Physiographic factors

Near surface sediments (0–5 cm) were used in this study because, based on average sedimentation rates estimated by Longmore *et al.* (2005), these would potentially provide the best chance of detecting material that had been deposited in recent times (over the last 30–40 years). This rationale does not take into account vertical mixing of the sedimentary layers by reworking of deposited sediments by wind generated wave action, resuspension during high river flow conditions, and burrowing animals. The extent of this vertical mixing is undetermined, therefore incorporation of sediments deposited prior to this period cannot be excluded and is likely to have occurred.

The transport of fine suspended sediment by rivers, particularly during periods of high flow, accounts for the accumulation of fine material throughout L. Connewarre. Cecil *et al.* (1988) observed that there was little evidence for upstream sediment influx into L. Connewarre from the lower Barwon River. They reported that there was ample evidence for silts and clay being transported across the lake system and being deposited on the riverbanks of the lower Barwon. While geologists generally accept that the lake system would have eventually infilled naturally, the vast alterations to the lake's catchment basins through poor on-ground management practices since European colonisation of the region have greatly accelerated this process. Coulson (1935) reported that there was a period of considerable siltation of the lake between 1861 and 1935, during which the depth of water in the centre of L. Connewarre was reduced from about 2.1 metres (1861) to about 1.2 metres (1935). This represents an average deposition rate of about 1.3 cm yr^{-1} during this period. More recently, Longmore *et al.* (2004) used patterns of physico-chemical tracers and presence/absence of exotic pollens to estimate the accumulation rate of sediments in the lake. They concluded that the average sedimentation rate over the past 70–100 years. (i.e. from the turn of the last century to the mid 1930s) was 0.15 cm yr^{-1} (range 0.1–0.28 cm yr^{-1}). This is about one tenth of the rate for the previous 70–75 years. Additionally, while evidence for the impact of the 1952 floods was identified, Longmore *et al*. (2004) found little evidence of changing sediment sources over time. The observations of Cecil *et al.* (1988) suggest that the lake was no shallower in 1986 than it was in 1935.

The results of the present study identify the Moorabool River basin as being the source of the majority (56%) of fine (<4µm particle size) surface (0–5 cm) sediments of L. Connewarre, followed by the Barwon (23%) and Leigh (16%) River basins. Sediment inputs from streams draining parts of the Bellarine peninsula accounted for the remaining 5%. Our data indicate that sediment contribution from unsealed roads and road cuttings were insignificant.

Initially these results appear to be counterintuitive. The landscapes of the upper Barwon River have experienced rapid uplift in recent geological past and are still subject to continued landslides and erosion. In addition, the rainfall in the Barwon River catchment is the highest in the region and the river flows are greater in volume than those of the Moorabool or Leigh. Thus, it might be expected that the Barwon River would be the contributor of the greatest volume of sediment in the recent past. Similarly, since the Leigh River has a history of being filled with large volumes of sludge from ore processing plants associated with the gold mining in the late 19th century (Cecil *et al.* 1988, DNRE 1999) its contribution might be expected to be higher. Added to this is the fact that the Moorabool has been a regulated river for over a century, and the flow volumes of the Moorabool are often much less than those of the Leigh or Barwon. All of these factors suggest that the Moorabool should not be the greatest contributor of sediment into Lake Connewarre in the recent past.

However, the physiography of the rivers provides a plausible explanation of the apparent sediment contribution to Lake Connewarre. The long profiles of the rivers (Figure 11) show quite distinctive differences. The Barwon River is very steep in its headwaters, but quickly loses elevation as it moves away from the Otway Ranges, allowing the river to drop a proportion of its sediment load well before it reaches the coast. The deposition of the Otway Group sediment occurs along the broad Barwon River valley south of Birregurra, and is clearly visible by the high potassium signal in the radiometric image (Figure 12).

By comparison, the long profiles of both the Moorabool and the Leigh rivers are not as steep in their headwaters, but are more elevated closer to their mouth. All three rivers are similar in distance from their headwaters to the lake, but the Moorabool has the greatest fall along its course and maintains the steepest gradient closest to the lake. During a flood event resulting from widespread rainfall, the flood waters and sediments from the Moorabool River reach the lake first, and have a shorter distance of lower gradients over which to deposit sediment.

0 Distance 200 km

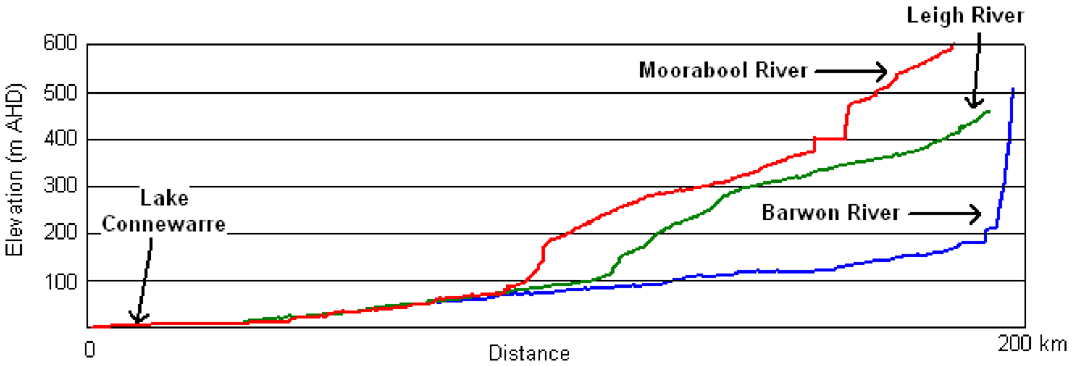

Figure 11. **Long profiles (thalweg) of the three rivers.**
(note: the West Branch of both the Moorabool and the Barwon rivers are included)

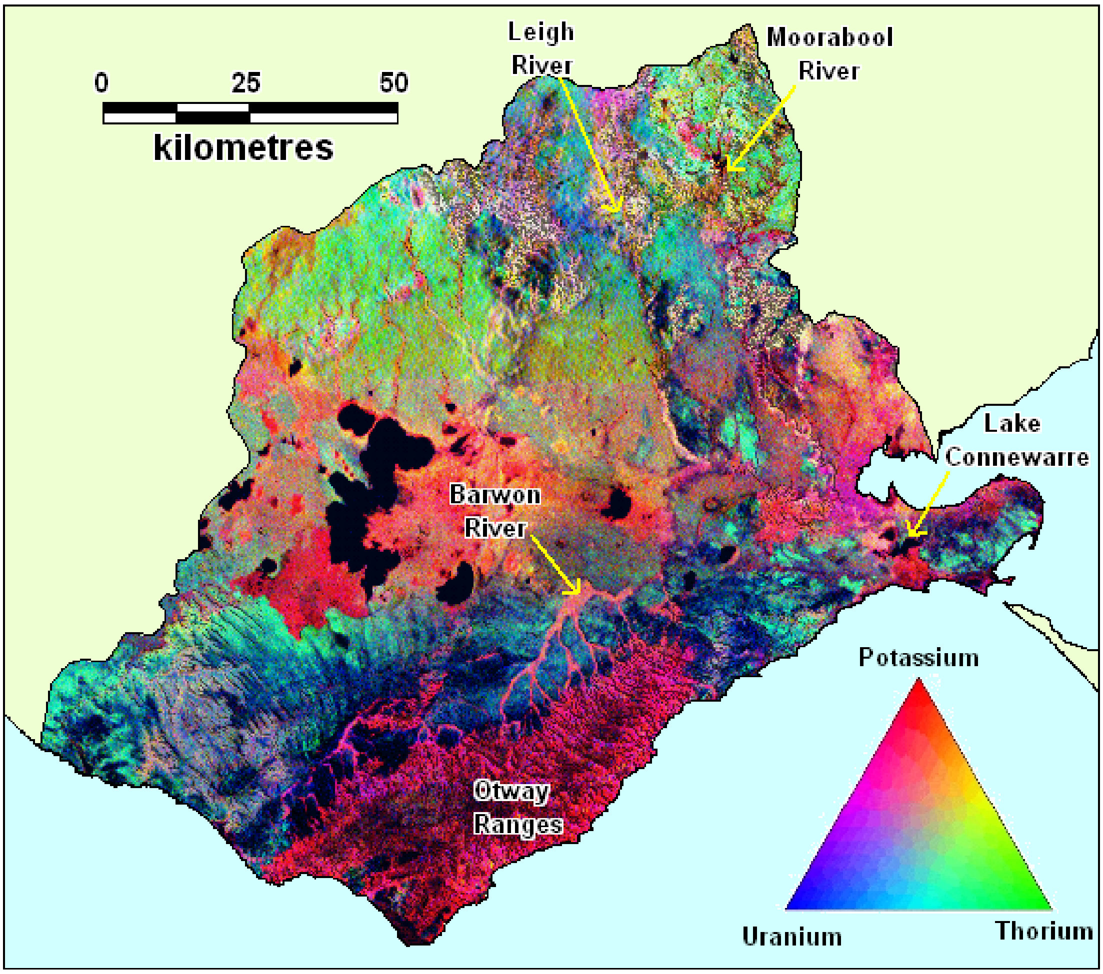

Figure 12. **The sediment from the Otway Ranges along the Barwon River is clearly visible in the radiometric ternary ratio image.**
(note: Radiometric image supplied by GeoScience Victoria, 2000)

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Appendices

Appendix 1: Sampling coordinates for the sediment sources study

Site #	Site Name	Lat S	Long E	Lab #	Comments
1	L. Connewarre	-38.232320	144.420230	45189	L. Connewarre surface (0-5 cm) sediment
2	L. Connewarre	-38.232670	144.421810	45190	L. Connewarre surface (0-5 cm) sediment
3	L. Connewarre	-38.235980	144.428120	45191	L. Connewarre surface (0-5 cm) sediment
4	L. Connewarre	-38.235160	144.431060	45192	L. Connewarre surface (0-5 cm) sediment
5	L. Connewarre	-38.228390	144.435270	45193	L. Connewarre surface (0-5 cm) sediment
6	L. Connewarre	-38.230800	144.435470	45194	L. Connewarre surface (0-5 cm) sediment
7	L. Connewarre	-38.235500	144.435180	45195	L. Connewarre surface (0-5 cm) sediment
8	L. Connewarre	-38.237580	144.435390	45196	L. Connewarre surface (0-5 cm) sediment
9	L. Connewarre	-38.228090	144.440810	45197	L. Connewarre surface (0-5 cm) sediment
10	L. Connewarre	-38.231100	144.440890	45198	L. Connewarre surface (0-5 cm) sediment
11	L. Connewarre	-38.235010	144.440990	45199	L. Connewarre surface (0-5 cm) sediment
12	L. Connewarre	-38.228040	144.448100	45200	L. Connewarre surface (0-5 cm) sediment
13	L. Connewarre	-38.230170	144.448240	45201	L. Connewarre surface (0-5 cm) sediment
14	L. Connewarre	-38.214760	144.454300	45202	L. Connewarre surface (0-5 cm) sediment
15	L. Connewarre	-38.219990	144.454000	45203	L. Connewarre surface (0-5 cm) sediment
16	L. Connewarre	-38.227780	144.452880	45204	L. Connewarre surface (0-5 cm) sediment
17	L. Connewarre	-38.230180	144.454440	45205	L. Connewarre surface (0-5 cm) sediment
18	L. Connewarre	-38.234180	144.454330	45206	L. Connewarre surface (0-5 cm) sediment
19	L. Connewarre	-38.211710	144.459320	45207	L. Connewarre surface (0-5 cm) sediment
20	L. Connewarre	-38.215020	144.459590	45208	L. Connewarre surface (0-5 cm) sediment
21	L. Connewarre	-38.220226	144.459500	45209	L. Connewarre surface (0-5 cm) sediment
22	L. Connewarre	-38.227580	144.459840	45210	L. Connewarre surface (0-5 cm) sediment
23	L. Connewarre	-38.230830	144.459870	45211	L. Connewarre surface (0-5 cm) sediment
24	L. Connewarre	-38.215000	144.465320	45213	L. Connewarre surface (0-5 cm) sediment
25	L. Connewarre	-38.220410	144.465100	45214	L. Connewarre surface (0-5 cm) sediment
26	L. Connewarre	-38.215170	144.470150	45215	L. Connewarre surface (0-5 cm) sediment
27	L. Connewarre	-38.220340	144.470830	45216	L. Connewarre surface (0-5 cm) sediment
28	L. Connewarre	38.215010	144.477800	45217	L. Connewarre surface (0-5 cm) sediment
29	L. Connewarre	-38.220290	144.476990	45218	L. Connewarre surface (0-5 cm) sediment
78	Barwon R	-38.171850	144.297590	45219	Boorabool Rd. road cutting erosion material.
31	Barwon R	-38.141610	144.262340	45220	Merrawapp Rd. Barwon R. river bank erosion material
79	Barwon R	-38.151640	144.261900	45221	Berrawapp Rd. road cutting erosion material
30	Barwon R	-38.144190	144.186690	45222	Polloksford Rd. Barwon R. Waterwatch site.
83	Barwon R	-38.171180	144.160230	45223	Monahans Rd. material from unsealed road
84	Barwon R	-38.332220	143.980510	45224	Unsealed road material- roadside stockpile
32	Barwon R	-38.147720	143.993190	45225	Millar's Lane. Barwon R. bed sediment
33	Barwon R	-38.278630	143.978580	45226	Barwon R. bed sediment
81	Barwon R	-38.296170	143.990770	45227	Road cutting erosion material
80	Barwon R	-38.332220	143.980510	45228	Coalmine Rd. road cutting erosion material
34	Barwon R	-38.299180	143.937260	45229	Kiladeal R. creek bed sediment at floodway
35	Barwon R	-38.339390	143.790270	45230	Bieragurra. Barwon R. bed sediment
82	Barwon R	-38.374960	143.749330	45231	Dunlop Rd. road cutting erosion material.
36	Barwon R	-38.469800	143.768740	45232	Griffins Rd. creek bed sediment

Site #	Site Name	Lat S	Long E	Lab #	Comments
88	Barwon R	-38.477160	143.719380	45233	Seven Bridges Rd. cleared paddock surface soil
37	Barwon R	-38.474630	143.688890	45234	Seven Bridges Rd. creek bed sediment.
47	Barwon R	-38.451610	143.685520	45235	Creek bed sediment
38	Barwon R	-38.514380	143.691640	45236	Night Rd. creek bed sediment
39	Barwon R	-38.114010	144.164060	45237	Bruce's creek bed sediment
74	L. Connewarre	-38.214790	144.482390	45239	Brimeads Rd. drainage ditch deposit
46	Barwon R	-38.385850	143.924100	45240	Ford Outlet Rd. creek bed sediment
76	L. Connewarre	-38.224040	144.503280	45241	Links Rd. creek bed sediment
77	L. Connewarre	-38.208600	144.507280	45242	Edwards Rd. road cutting erosion material
40	Barwon R	-38.434920	143.747710	45243	Dewin's Rd. Barwon R. bed sediment
41	Barwon R	-38.318360	144.002260	45244	Wurdle Rd. creek bed sediment
42	Barwon R	-38.369060	143.937770	45245	Boona -Inlet Rd. creek bed sediment
43	Barwon R	-38.407250	143.874440	45246	Pennyroyal Valley Rd. creek bed sediment
44	Barwon R	-38.407200	143.874390	45247	Pennyroyal Station Rd. creek bed sediment
45	Barwon R	-38.424950	143.829560	45248	Muroon creek bed sediment
48	Moorabool R	-38.143320	144.312360	45249	Fyansford. Moorabool R. bed sediment
49	Moorabool R	-38.089330	144.278380	45250	Batesford. Moorabool R. bed sediment
50	Moorabool R	-38.052360	144.240020	45251	Baker's Bridge Rd. creek bed sediment
51	Moorabool R	-38.044780	144.263050	45252	Steiglitz's Rd. Sutherland Creek bed sediment
52	Moorabool R	-38.011220	144.186650	45253	Lowndes Rd. creek bed sediment
53	Moorabool R	-37.953530	144.154370	45254	Pringle Bridge Moorabool R. bed sediment
54	Moorabool R	-37.898030	144.126630	45255	Sharps crossing, Moorabool R. bed sediment
55	Moorabool R	-37.862070	144.132340	45256	Steiglitz's Rd. Moorabool R. bed sediment
56	Moorabool R	-37.785950	144.104970	45257	Moorabool R. bed sediment
75	L. Connewarre	-38.209600	144.474320	45258	Moller's Lane road cutting erosion material
57	Moorabool R	-37.776740	144.111690	45259	Moorabool R. bed sediment
58	Moorabool R	-37.753200	144.097800	45260	Dolly's creek erosion bank soil
85	Moorabool R	-37.747260	144.100460	45261	Forrest Rd. erosion/deposition site on road
59	Moorabool R	-37.711340	144.094440	45262	Hunt's Bridge. Moorabool R. bed sediment
60	Moorabool R	-37.687000	144.173580	45263	East Moorabool R. bed sediment
61	Moorabool R	-37.792290	144.213580	45264	Geelong Ballan Rd. creek bed sediment.
62	Moorabool R	-37.971970	144.239720	45265	Pringle's Rd. creek bed sediment
86	Leigh R	-37.765860	144.013850	45266	Moorabool Rd. unsealed road stockpile material
63	Leigh R	-38.100400	144.062290	45267	Inverleigh, Leigh R. bed sediment
64	Leigh R	-38.084730	144.016390	45268	Teesdale Rd, Leigh R. bed sediment
65	Leigh R	-38.013430	143.977080	45269	Shelford, Leigh R. bed sediment
66	Leigh R	-37.927320	143.995730	45270	Wimer creek bed sediment
87	Leigh R	-37.913220	143.987120	45271	Baganine plains exposed topsoil
67	Leigh R	-37.804780	143.977890	45272	Creek bed sediment
68	Leigh R	-37.810150	143.918320	45273	Grand Junction Bridge Leigh R. bed sediment
69	Leigh R	-37.781010	143.889310	45274	Kellys Rd. creek bed sediment
70	Leigh R	-37.716140	143.897480	45275	Smith's Bridge creek bed sediment
71	Leigh R	-37.714530	143.882580	45276	Garibaldi, Leigh R. bed sediment
72	Leigh R	-37.699371	143.912980	45277	Finns Rd. creek bed sediment
73	Leigh R	-37.774600	143.939870	45278	Horeshill West Rd. creek bed sediment

Appendix 2: Summary QC data

Element	Ag^{209}	As^{75}	Ba	Be^{9}	Bi^{209}	Cd	Ce^{140}	Co^{59}	Cr^{53}	Cs^{133}	Cu^{65}	Dy^{163}	Er	Eu	Ga^{71}	Gd^{157}	Ge^{74}	Hf	Ho^{165}	In^{115}	La^{139}	Li^{7}	Lu^{175}	Mn^{55}	Mo	Nb^{93}	Nd^{146}	Ni	P^{31}
Units	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
Instrumental Method	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS
Blanks Mean Value	-0.0036	-0.00767	4.4	-0.011	0.0078	-0.00243	0.00361	-0.0672	1.27	0.0255	-0.078	0.012	0.0118	0.000124	-0.405	0.00024	-0.082	0.072	-0.00042	-0.00084	-0.0032	2.8	0.00262	0.516	-0.00245	0.00258	0.00783	4.6	29.6
Blanks Standard Deviation (SD)	0.011	0.0688	2.7	0.089	0.0056	0.00924	0.0253	0.113	1.54	0.123	0.49	0.018	0.01	0.00971	0.673	0.017	0.15	0.056	0.0062	0.0035	0.0344	4.6	0.0206	0.406	0.0169	0.0305	0.113	4.8	25.5
Blanks Limit of Detection	0.033	0.206	8.1	0.27	0.017	0.0277	0.0758	0.34	4.63	0.368	1.5	0.055	0.0301	0.0291	2.02	0.051	0.45	0.168	0.019	0.01	0.103	14	0.0618	1.22	0.0507	0.0915	0.34	14	76.5
Blanks Limit of Reporting	0.11	0.688	27	0.89	0.056	0.0924	0.253	1.13	15.4	1.23	4.9	0.18	0.1	0.0971	6.73	0.17	1.5	0.56	0.062	0.035	0.344	46	0.206	4.06	0.169	0.305	1.13	48	255
SRM NIST 1645																													
Measured Mean	1.5	65.5	360	0.95	6.9	8.62	21.4	8.26	27600	1.23	110	0.9	0.622	0.387	6.35	1.3	4.6	0.992	0.2	0.14	8.21	9.5	0.113	779	19.6	2.84	6.62	51	501
Measured SD	0.39	7.36	13	0.21	0.28	0.27	0.866	0.505	1730	0.136	7	0.075	0.0205	0.0108	1.23	0.082	0.14	0.193	0.012	0.037	0.61	3	0.0186	50.2	0.305	0.175	0.502	17	21.8
Number of Determinations	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Certified Value		66				10.2		10.1	29600		109										9			785				45.8	510
Uncertainty (95%)						1.5		0.6	2800		19													97				2.9	10
SRM NIST 1646																													
Measured mean	0.19	10.5	420	1.6	0.2	0.377	73.1	9.97	70.9	3.74	19	4.9	2.41	1.31	16.5	5.7	1.7	4.65	0.84	0.05	34.6	43	0.376	370	2.12	14.9	32.3	37	617
Measured SD	0.011	0.404	15	0.48	0.015	0.0303	2.86	0.418	3.09	0.227	0.79	0.22	0.0945	0.0436	0.992	0.25	0.26	0.317	0.04	0.0055	1.42	6.7	0.0385	6.43	0.14	0.363	1.52	4.7	33.3
Number of Determinations	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Certified Value		11.6		1.5		0.36	80	10.5	76	3.7	18			1.5			1.4							375	2			32	540
Uncertainty (95%)		1.3				0.07		1.3	3		3													20				3	50
SRM USGS AGV 1																													
Measured Mean	0.15	1.02	1200	2.1	0.057	0.0824	69.4	15.4	8.91	1.26	57	3.9	1.82	1.7	19.9	5.2	1.4	5.03	0.64	0.04	37.9	9	0.29	735	2.19	14.4	32.4	24	2100
Measured SD	0.02	0.469	51	0.11	0.0067	0.0151	0.191	0.461	2.01	0.0446	0.94	0.07	0.065	0.0144	1.57	0.24	0.14	0.0875	0.0041	0.0068	0.502	7.1	0.00764	12.7	0.0763	0.344	0.36	6.2	87.3
Number of Determinations	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Certified Value	0.078	0.88	1230	2.1	0.057	0.069	67	15	10	1.3	60	3.6	1.7	1.64	20	5	1.3	5.1	0.67	0.041	38	12	0.27	710	2.7	15	33	16	2150
Certified SD	0.028	0.11	16	0.4	0.008	0.009	6	1.2	3	0.1	6	0.4	0.2	0.1	3	0.6		0.4	0.1	0.006	2	2	0.03	50	0.9	3	3	3	60
SRM USGS RGM 1																													
Measured Mean	0.12	2.51	820	2.3	0.26	0.0834	46.4	1.8	3.86	9.78	11	3.9	2.18	0.685	16.9	3.7	1.2	5.92	0.71	0.022	23.2	52	0.401	274	2.62	9.09	18.9	4.5	228
Measured SD	0.02	0.633	20	0.11	0.018	0.0143	0.874	0.104	1.24	0.239	0.96	0.14	0.0588	0.0307	1.38	0.14	0.23	0.15	0.036	0.0052	0.578	2.2	0.0299	5.37	0.0443	0.321	0.743	4.6	17.2
Number of Determinations	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Certified Value	0.11	3	810	2.4	0.274	0.065	47	2	3.7	9.6	12	4.08	2.6	0.66	15	3.7	1.25	6.2	0.95	0.15	24	57	0.4	280	2.3	8.9	19	4.4	210
Certified SD	0.008	0.4	46	0.2	0.019	0.01	4	0.2	1.2	0.6	1.4	0.1	0.3	0.8	2	0.4	0.1	0.3	0.22	0.19	1.1	8	0.03	30	0.5	0.6	1	2	15
Reproducibility -	**(Sample from Site 58)**																												
Mean Value (7 replicates)	0.19	12.3	720	3.3	0.67	0.0313	68.3	13.2	125	14.7	24	4.4	2.27	1.09	35.9	4.6	3.1	3.94	0.78	0.096	34.6	49	0.352	55.4	1.82	19.8	26.5	50	240
SD	0.017	0.735	25	0.12	0.017	0.00643	2.61	0.259	5.71	0.494	1.2	0.12	0.0753	0.0208	2.76	0.25	0.23	0.0717	0.032	0.0076	1.81	4.8	0.0215	1.42	0.0355	0.246	0.952	6.2	18.1
Coefficient of Variation (%)	8.9	5.95	3.5	3.7	2.5	20.6	3.82	1.96	4.59	3.36	4.9	2.7	3.32	1.91	7.69	5.4	7.4	1.82	4.1	8	5.23	9.8	6.11	2.56	1.95	1.24	3.59	12	7.57
Recovery from spiked	**samples**																												
High spike (%)	95	104	96	101	89	102	103	104	102	102	100	115	101	100	103	105	103	101	98	99	101	105	103	101	107	110	95	99	109
Low spike (%)	96	101	94	93	90	102	102	101	99	100	98	115	100	100	101	107	101	100	98	100	102	104	105	99	108	108	95	103	105

Shaded figures (eg. 10.8) indicated recommended values

Appendix 2: Summary QC data (cont…)

Element	Pb	Pr^{141}	Rb^{85}	Re	Sb^{121}	Sc^{45}	Sm	Sn	Sr^{88}	Ta^{181}	Tb^{159}	Th^{232}	Ti	Tl^{205}	Tm^{169}	U^{238}	V51	W	Y^{89}	Yb	Zn^{66}	Zr	Na	Mg	Al	K	Ca	Fe
Units	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	%	%	%	%	%	%
Instrumental Method	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-MS	ICP-ES	ICP-ES	ICP-ES	ICP-ES	ICP-ES	ICP-ES
Blanks Mean Value	-0.153	-0.00338	0.0181	-0.00869	-0.00066	0.81	0.0054	0.01	0.78	0.00271	-0.0046	0.0045	0.522	-0.00038	0.0021	0.0068	0.0193	-0.0071	0.036	0.00801	-0.14	-0.0278	0.00131	6.82E-05	0.00345	0.00071	0.000373	0.0131
Blanks Standard Deviation (SD)	0.0773	0.0286	0.135	0.0345	0.0171	0.74	0.038	0.26	0.27	0.002	0.026	0.0372	0.884	0.0051	0.0051	0.024	0.116	0.016	0.023	0.0156	0.61	0.0886	0.00402	3.01E-05	4.25E-11	0.000463	0.000227	1.7E-10
Blanks Limit of Detection	0.232	0.0858	0.404	0.103	0.0514	2.2	0.11	0.78	0.82	0.006	0.077	0.112	2.65	0.015	0.015	0.072	0.347	0.0481	0.07	0.0468	1.8	0.266	0.0121	9.02E-05	1.28E-10	0.00139	0.000681	5.1E-10
Blanks Limit of Reporting	0.773	0.286	1.35	0.345	0.171	7.4	0.38	2.6	2.7	0.02	0.26	0.372	8.84	0.051	0.051	0.24	1.16	0.16	0.23	0.156	6.1	0.886	0.0402	0.000301	4.25E-10	0.00463	0.00227	1.7E-09
SRM NIST 1645																												
Measured Mean	769	1.64	38.8	-0.00757	31.2	7.4	1.3	410	870	0.204	0.15	1.78	640	1.2	0.087	1.2	23.7	1.79	6.4	0.605	1700	35.2	0.541	0.688	2.41	1.31	2.94	11.1
Measured SD	64	0.062	1.13	0.0365	1.18	3.5	0.018	16	25	0.0206	0.041	0.228	12.1	0.03	0.0057	0.05	1.39	0.195	0.24	0.00913	120	7.31	0.0108	0.00622	0.106	0.0309	0.0733	0.223
Number of Determinations	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Certified Value	714					2						1.62		1.44		1.11	23.5				1720		0.54	0.74	2.26	1.26	2.9	11.3
Uncertainty (95%)	28											0.22		0.07		0.05	6.9				170		0.01	0.02	0.04	0.05		1.2
SRM NIST 1646																												
Measured mean	28.2	7.74	88	0.0354	0.432	13	6.3	3.4	160	1.16	0.85	8.97	4760	0.54	0.35	2.9	94.6	1.14	25	2.36	130	162	1.91	0.988	6.27	1.97	0.755	3.1
Measured SD	0.581	0.35	2.54	0.0401	0.0256	1.4	0.32	0.33	3.5	0.119	0.07	0.344	171	0.017	0.023	0.14	2.04	0.0643	2.4	0.117	3.5	11.3	0.0887	0.0245	0.301	0.0309	0.0167	0.0733
Number of Determinations	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Certified Value	28.2		87		0.4	10.8						10		0.5			94				138			1.09	6.25		0.83	3.35
Uncertainty (95%)	1.8																1				6			0.08	0.2		0.03	0.1
SRM USGS AGV 1																												
Measured Mean	35.1	7.51	63.5	0.00668	4.39	13	5.8	4.2	660	0.971	0.69	6.37	6230	0.34	0.25	2.1	123	0.626	19	1.66	90	225	3.11	0.769	8.78	2.36	3.27	4.19
Measured SD	0.884	0.162	2.9	0.0292	0.129	0.066	0.053	0.35	20	0.0317	0.0042	0.466	168	0.01	0.0091	0.077	4.47	0.0544	0.2	0.0436	2.1	3.11	0.125	0.00832	0.326	0.0122	0.064	0.0707
Number of Determinations	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Certified Value	36	7.6	67	0.00038	4.3	12	5.9	4.2	660	0.9	0.7	6.5	6300	0.34	0.34	1.92	120	0.55	20	1.72	88	227	3.16	0.92	9.07	2.42	3.53	4.73
Certified SD	5	1.1	1		0.4	1	0.4	1.1	9	0.09	0.1	0.5	300	0.06	0.13	0.15	11	0.09	3	0.2	9	18	0.08	0.06	0.08	0.07	0.1	0.12
SRM USGS RGM 1																												
Measured Mean	23.7	4.82	147	0.00283	1.29	5.5	3.9	4.2	110	1.08	0.64	14.8	1540	0.9	0.35	5.9	11.4	1.55	24	2.39	33	219	2.99	0.131	6.9	3.46	0.713	1.09
Measured SD	0.751	0.0914	6.91	0.0246	0.0361	1.1	0.13	0.2	3.3	0.103	0.064	0.418	24.3	0.011	0.026	0.13	0.536	0.0642	2.5	0.0628	2.8	2.42	0.127	0.0029	0.126	0.0728	0.0196	0.0207
Number of Determinations	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Certified Value	24	4.7	150	<10	1.3	4.4	4.3	4.1	110	0.95	0.66	15	1600	0.93	0.37	5.8	13	1.5	25	2.6	32	220	3.02	0.166	7.26	3.57	0.82	1.3
Certified SD	3	0.5	8		0.1	0.3	0.3	0.4	10	0.1	0.6	1.3	150	0.22	0.04	0.5	2	0.18	4	0.3	6	20	0.11	0.016	0.1	0.08	0.05	0.04
Reproducibility -																												
Mean Value (7 replicates)	32.7	6.5	204	-0.0129	1.83	23	5.1	7.1	58	1.64	0.73	20.6	6030	1.3	0.34	3.5	167	4.47	25	2.29	63	137	0.0923	0.463	14.4	2.47	0.0306	4.33
SD	0.723	0.0786	6.04	0.0384	0.046	2.2	0.12	0.27	1.7	0.151	0.03	0.409	124	0.032	0.022	0.12	3.71	0.202	3.3	0.0618	3.9	1.47	0.00346	0.0055	0.174	0.0259	0.000714	0.0551
Coefficient of Variation (%)	2.21	1.21	2.96		2.52	9.7	2.3	3.8	2.9	9.21	4.2	1.98	2.05	2.4	6.4	3.3	2.22	4.53	13	2.7	6.2	1.07	3.75	1.19	1.21	1.05	2.33	1.27
Recovery																												
High spike (%)	99	95	98	100	104	108	101	100	106	126	96	105	113	105	99	103	104	95	102	100	104	102						
Low spike (%)	99	102	99	99	101	110	101	99	101	127	97	104	119	105	100	103	101	93	103	101	98	101						

Shaded figures (eg. 10.8) indicated recommended values

Appendix 3: Concentrations of major and minor elements in all sediment samples

Element		Ag^{208}	Al	As^{75}	Ba	Be^{9}	Bi^{209}	Ca
Units		mg kg^{-1}	%	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	%
Site #	Site Name							
1	L. Connewarre	0.24	11.1	50.1	460	3.48	0.45	0.449
2	L. Connewarre	0.32	11.4	50.3	460	2.57	0.55	0.658
3	L. Connewarre	0.29	11.8	36.5	410	3.51	0.49	0.298
4	L. Connewarre	0.27	11.7	72.8	390	3.46	0.5	0.602
5	L. Connewarre	0.28	10.9	63.5	370	2.82	0.48	0.236
6	L. Connewarre	0.27	11.6	38.7	370	3.45	0.5	0.277
7	L. Connewarre	0.19	13.5	47.9	460	3.96	0.5	0.234
8	L. Connewarre	0.26	11.4	62.2	410	2.9	0.52	0.224
9	L. Connewarre	0.24	11.5	50	370	3.23	0.48	0.25
10	L. Connewarre	0.24	11.7	52	370	3.41	0.48	0.291
11	L. Connewarre	0.25	11.4	45.5	400	2.66	0.43	0.285
12	L. Connewarre	0.19	10.9	89.3	430	3.09	0.46	0.261
13	L. Connewarre	0.23	10.8	90.4	380	2.75	0.49	0.304
14	L. Connewarre	0.2	13.1	54.6	400	3.5	0.46	0.185
15	L. Connewarre	0.19	12.7	34.5	400	3.21	0.45	0.225
16	L. Connewarre	0.19	12.9	41	430	3.21	0.47	0.223
17	L. Connewarre	0.2	11.5	35.5	380	3.33	0.4	0.352
18	L. Connewarre	0.23	11.2	71.1	370	2.88	0.43	0.579
19	L. Connewarre	0.21	12.8	29.9	390	2.57	0.49	0.219
20	L. Connewarre	0.23	12.5	39.2	410	2.36	0.54	0.249
21	L. Connewarre	0.19	11.6	43.1	380	2.95	0.37	0.201
22	L. Connewarre	0.23	11.4	58.3	370	2.16	0.48	0.387
23	L. Connewarre	0.23	11.7	45.7	370	2.11	0.42	0.504
24	L. Connewarre	0.23	13	25.5	490	2.16	0.51	0.2
25	L. Connewarre	0.2	12.8	59.1	380	3.42	0.38	0.235
26	L. Connewarre	0.19	13.4	35.2	380	3.38	0.39	0.22
27	L. Connewarre	0.26	11.9	57.9	350	2.87	0.51	0.3
28	L. Connewarre	0.22	12.9	38.6	360	2.87	0.45	0.219
29	L. Connewarre	0.24	13.9	36.1	360	3.2	0.39	0.217
74	Wallington	0.12	13.6	132	240	2.3	0.36	0.398
75	Wallington	0.16	12.8	52.6	270	2.53	0.42	0.532
76	Wallington	0.17	6.54	57.2	160	1.5	0.43	1.02
77	Wallington	0.23	5.77	13.3	290	0.895	0.37	0.278
78	Road cutting	0.17	12.8	11.5	410	3.57	1.7	0.43
79	Road cutting	0.16	8.6	53.3	420	4.16	0.59	5.14
80	Road cutting	0.16	11.3	11	640	1.47	0.36	0.108
81	Road cutting	0.2	12.6	33.4	270	1.78	0.52	0.129
82	Road cutting	0.18	18	13	92	1.56	0.43	0.109
83	Unsealed road	0.13	10.9	43.1	210	1.17	0.47	0.277
84	Unsealed road	0.14	12.2	11.1	530	1.81	0.56	0.259
85	Unsealed road	0.32	9.14	28.8	190	0.946	0.45	0.0599
86	Unsealed road	0.24	17.7	78.2	320	1.69	0.49	0.0322
30	Barwon R	0.21	9.3	20	570	2.26	0.24	0.645
31	Barwon R	0.24	10	31.9	440	2.12	0.41	0.959
32	Barwon R	0.15	12.5	12.4	270	1.52	0.35	0.701
33	Barwon R	0.2	9.95	11.7	470	2.58	0.26	0.313
34	Barwon R	0.19	10.2	13.3	460	2.75	0.26	0.298
35	Barwon R	0.24	11	6.75	510	2.54	0.29	0.303
36	Barwon R	0.22	9.26	5.54	670	2.2	0.28	0.232
37	Barwon R	0.19	11.1	3.16	630	2.48	0.26	0.2

Element		Ag^{208}	Al	As^{75}	Ba	Be^{9}	Bi^{209}	Ca
Units		mg kg^{-1}	%	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	%
Site #	Site Name							
38	Barwon R	0.14	11	6.18	490	2.14	0.25	0.276
39	Barwon R	0.19	10	61.4	210	2.58	0.35	0.602
40	Barwon R	0.18	10.4	7.8	610	2.28	0.28	0.39
41	Barwon R	0.14	10.3	15.2	480	2.35	0.31	0.366
42	Barwon R	0.2	10.2	8.66	490	2.22	0.28	0.29
43	Barwon R	0.19	13	20.6	270	1.51	0.4	0.171
44	Barwon R	0.19	9.88	6.09	540	2.17	0.31	0.262
45	Barwon R	0.16	11.4	31.3	500	2.08	0.31	0.269
46	Barwon R	0.15	10.2	5.2	500	2.47	0.3	0.238
47	Barwon R	0.12	3.71	66.6	230	1.17	0.15	0.848
48	Moorabool R	0.26	12.2	39.2	660	3.07	0.6	0.356
49	Moorabool R	0.2	10.9	23.7	550	2.66	0.41	0.718
50	Moorabool R	0.23	11.1	26.5	690	2.89	0.44	0.353
51	Moorabool R	0.26	10.8	23.8	510	2.76	0.51	0.379
52	Moorabool R	0.21	11	30.1	750	2.81	0.37	0.305
53	Moorabool R	0.22	12.8	11	760	2.92	0.49	0.309
54	Moorabool R	0.21	11.7	15.4	880	3.31	0.48	0.201
55	Moorabool R	0.23	11.9	18	910	3.44	0.52	0.234
56	Moorabool R	0.16	8.8	72.1	580	2.24	0.37	2
57	Moorabool R	0.19	14.2	13.3	1100	3.91	0.61	0.171
58	Moorabool R	0.19	14.9	15.5	760	3.13	0.72	0.0317
59	Moorabool R	0.2	10.1	15.7	740	2.68	0.41	0.297
60	Moorabool R	0.2	11.2	8.16	600	3.06	0.37	0.303
61	Moorabool R	0.19	13.9	11.7	760	3.41	0.43	0.176
62	Moorabool R	0.19	12.6	39	510	3.54	0.69	0.299
63	Leigh R	0.49	12.1	140	650	2.99	0.82	0.346
64	Leigh R	0.36	13.3	354	720	3.56	2.5	0.207
65	Leigh R	0.36	11.5	211	590	2.59	0.55	0.446
66	Leigh R	0.18	12.9	62.1	790	4.53	0.49	0.145
67	Leigh R	0.19	8.71	8.52	180	1.64	0.22	0.565
68	Leigh R	0.56	11.3	118	740	2.84	0.67	0.373
69	Leigh R	0.67	11.2	140	660	3.16	0.71	0.411
70	Leigh R	0.21	13.3	23.8	860	3.23	0.53	0.19
71	Leigh R	0.83	11.7	121	640	3.06	0.69	0.422
72	Leigh R	0.16	13.5	14.6	1100	4.49	0.6	0.074
73	Leigh R	0.21	12.1	9.3	860	3.19	0.44	0.227
87	Soil	0.22	5.23	36.4	180	0.65	0.29	0.293
88	Soil	0.45	8.74	13.9	130	0.78	0.56	0.127

Element		Cd	Ce^{140}	Co^{59}	Cr^{53}	Cs^{133}	Cu^{65}	Dy^{163}
units		mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
Site #	Site Name							
1	L. Connewarre	0.244	74.4	21.6	120	12.3	32	5.4
2	L. Connewarre	0.397	79.4	19.6	121	11.9	36	6.1
3	L. Connewarre	0.261	79.3	20.2	125	12.4	36	5.7
4	L. Connewarre	0.269	74.8	21	121	11.1	32	5.7
5	L. Connewarre	0.255	83.6	19.9	118	11.1	32	6.7
6	L. Connewarre	0.238	84.7	18.6	123	11.4	29	6.1
7	L. Connewarre	0.174	70.5	17.3	135	14.5	31	5.4
8	L. Connewarre	0.251	82.6	22.3	124	12.3	29	6.4
9	L. Connewarre	0.124	78.1	19.9	130	11.1	28	5.7
10	L. Connewarre	0.231	77.8	20.5	133	11.8	32	6.3
11	L. Connewarre	0.219	68.8	18.4	115	11.5	28	5.3
12	L. Connewarre	0.147	71.2	19	115	11.6	23	5.1
13	L. Connewarre	0.182	72.7	20.9	125	11.2	26	5.6
14	L. Connewarre	0.106	71.1	17.3	145	5.7	29	5.5
15	L. Connewarre	0.134	76.8	18.1	139	12.3	25	6
16	L. Connewarre	0.0961	78.5	17.7	143	12	31	5.6
17	L. Connewarre	0.122	69.7	17.3	135	12.6	28	5.7
18	L. Connewarre	0.125	65.9	18.8	113	11.1	23	4.6
19	L. Connewarre	0.103	78.9	21	149	13.4	28	5.8
20	L. Connewarre	0.16	80.3	19.4	148	13	29	5.6
21	L. Connewarre	0.0764	72.8	16.1	119	12.5	24	5.4
22	L. Connewarre	0.104	75.1	20.2	137	11.7	27	5.5
23	L. Connewarre	0.101	68.3	19.9	138	12.1	27	5.2
24	L. Connewarre	0.101	83	16.9	153	14.9	34	5.9
25	L. Connewarre	0.0969	73.9	17	132	12.4	25	5.9
26	L. Connewarre	0.0761	75.4	15.8	136	12.6	27	5.4
27	L. Connewarre	0.178	79.7	20.7	128	11.6	31	5.9
28	L. Connewarre	0.176	75.2	18	136	11.9	29	5.6
29	L. Connewarre	0.0963	75.7	18.1	135	12	26	6.1
74	Wallington	0.0497	87	22	148	9.17	6.4	5.9
75	Wallington	0.0246	82.3	19.3	108	8.65	16	5.2
76	Wallington	0.464	58.1	26.6	75.5	6.74	35	4.1
77	Wallington	0.184	68.9	8.34	64.9	4.56	16	4.3
78	Road cutting	0.137	65.6	16.4	105	12.2	41	5.8
79	Road cutting	0.157	86.2	31.5	132	15	13	5.1
80	Road cutting	0.0148	67.8	13.9	81.6	8.49	16	5.7
81	Road cutting	0.0126	93.6	14.8	124	10.1	9	4.6
82	Road cutting	0.0556	42	14.9	126	7.52	5.5	3.3
83	Unsealed road	0.113	51.5	10.1	136	5.22	16	3.2
84	Unsealed road	0.0327	85	17.6	103	8.48	23	6.2
85	Unsealed road	0.0466	61	8.18	109	7.74	19	4.5
86	Unsealed road	0.0387	102	7.5	201	9.43	43	4
30	Barwon R	0.188	85.9	29.7	129	5.86	29	7.4
31	Barwon R	0.477	70.3	18.6	104	7.58	32	4.8
32	Barwon R	0.171	65.7	26.6	121	6.17	68	4.9
33	Barwon R	0.163	84.1	27	82.3	7.91	25	5.5
34	Barwon R	0.172	94.2	39.7	76.8	7.59	26	5.5
35	Barwon R	0.0659	91.9	19.7	78.1	8.68	28	6.4
36	Barwon R	0.136	79.4	23.5	62.7	7.38	25	5.5
37	Barwon R	0.0998	82.3	20.7	65.2	8.53	30	5.9

Element units Site #	 Site Name	Cd mg kg^{-1}	Ce^{140} mg kg^{-1}	Co^{59} mg kg^{-1}	Cr^{53} mg kg^{-1}	Cs^{133} mg kg^{-1}	Cu^{65} mg kg^{-1}	Dy^{163} mg kg^{-1}
38	Barwon R	0.144	78.9	31.9	67.3	7.83	22	5.2
39	Barwon R	0.159	93.1	33.7	141	5.89	22	6.5
40	Barwon R	0.0798	80.6	22.2	63.9	8.6	28	6.6
41	Barwon R	0.14	68.6	26.3	77.4	8.01	17	4.7
42	Barwon R	0.124	65.9	28.2	61.2	8.69	25	4.8
43	Barwon R	0.163	54.8	11.7	108	8.71	17	3.9
44	Barwon R	0.243	66	23.2	60.5	8.27	29	5.1
45	Barwon R	0.115	74.9	20.8	65.7	8.9	27	5.5
46	Barwon R	0.0618	93.1	21.7	61.3	9.25	23	6.3
47	Barwon R	0.164	67.8	37.4	51.2	2.28	11	3.3
48	Moorabool R	0.121	101	21.5	149	16.5	35	6.4
49	Moorabool R	0.119	69.9	33.3	145	11.4	38	5.7
50	Moorabool R	0.136	90.3	30.1	142	12.8	37	6.7
51	Moorabool R	0.126	78.2	23.9	146	11.9	38	5.6
52	Moorabool R	0.148	66.6	22	151	14.1	36	4.8
53	Moorabool R	0.0861	74.7	27.1	168	14	37	6.1
54	Moorabool R	0.149	62.2	21.2	125	15.2	28	4.3
55	Moorabool R	0.139	61.5	27.3	130	14.4	30	4.7
56	Moorabool R	0.0606	62.1	24.3	93.1	14.2	21	3.8
57	Moorabool R	0.0967	79.9	22.6	134	17.2	36	5.6
58	Moorabool R	0.0346	70.4	13.7	124	15.6	26	4.5
59	Moorabool R	0.125	57.6	21.1	107	11.3	28	3.9
60	Moorabool R	0.0989	64.5	19.9	115	13.4	23	4.1
61	Moorabool R	0.0413	119	32.9	121	12.9	22	7.3
62	Moorabool R	0.116	69.3	35.1	163	10.6	45	5.4
63	Leigh R	0.668	77.3	21.4	144	13.3	51	4.9
64	Leigh R	0.261	77.2	29	163	17	58	4.5
65	Leigh R	0.347	85.7	23.7	142	11.7	34	5.5
66	Leigh R	0.102	77.5	19	139	14.5	19	5.4
67	Leigh R	0.142	67.9	31.9	143	4.28	19	4.9
68	Leigh R	0.753	67.2	23.4	137	11.8	44	4
69	Leigh R	0.679	68.7	24	147	11.9	47	4.1
70	Leigh R	0.154	106	21.1	122	13.7	29	5.7
71	Leigh R	1.29	67.5	27.1	155	11.3	52	4
72	Leigh R	0.117	79.7	9.57	164	19.1	27	4.9
73	Leigh R	0.0667	101	15.9	121	13.8	18	6.3
87	Soil	1.19	47.2	4.29	55	3.47	12	3.3
88	Soil	0.0635	48	5.28	107	6.91	13	4.3

Element		Er	Eu	Fe	Ga^{71}	Gd^{157}	Ge^{74}	Hf
units		mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
Site #	Site Name							
1	L. Connewarre	2.5	1.44	5.57	29	5.8	2.1	4.2
2	L. Connewarre	2.87	1.63	5.73	27	6.5	2.4	4.01
3	L. Connewarre	2.77	1.6	5.6	31	6.1	2.5	4.35
4	L. Connewarre	2.54	1.53	5.91	32	5.9	2	4.12
5	L. Connewarre	3.08	1.84	5.09	29	7.1	2.2	4.31
6	L. Connewarre	2.8	1.67	5.13	31	7.1	2.5	4.17
7	L. Connewarre	2.44	1.41	4.28	37	5.4	3.2	4.21
8	L. Connewarre	3.08	1.72	5.11	29	6.7	2.8	4.45
9	L. Connewarre	2.69	1.51	5.91	31	6	2.2	4.44
10	L. Connewarre	2.64	1.57	5.57	33	6.5	2.1	4.18
11	L. Connewarre	2.89	1.47	5.22	28	5.7	1.8	4.2
12	L. Connewarre	2.46	1.34	5.27	27	5.3	2.7	3.85
13	L. Connewarre	2.63	1.43	5.86	31	5.7	2.4	4.26
14	L. Connewarre	2.56	1.34	4.86	37	5.7	2.6	4.34
15	L. Connewarre	2.64	1.43	5.07	34	6.1	2.6	4.63
16	L. Connewarre	2.68	1.48	4.89	35	6	2.7	4.65
17	L. Connewarre	2.72	1.47	5.46	33	5.5	2.8	4.42
18	L. Connewarre	2.3	1.28	5.45	27	4.8	2.1	3.77
19	L. Connewarre	2.84	1.64	5.81	28	6.6	2.6	4.58
20	L. Connewarre	2.84	1.65	5.19	26	6.6	2.5	4.55
21	L. Connewarre	2.65	1.45	4.86	28	5.7	1.7	4.02
22	L. Connewarre	2.72	1.59	6.09	24	6	2.3	4.41
23	L. Connewarre	2.5	1.43	5.93	24	5.8	2.3	4.25
24	L. Connewarre	2.9	1.53	4.32	27	6.5	2.8	4.6
25	L. Connewarre	2.71	1.55	5.15	32	6.1	2.7	4.02
26	L. Connewarre	2.57	1.53	4.84	32	5.9	2.6	4.02
27	L. Connewarre	2.87	1.69	5.6	29	6.4	2.3	4.03
28	L. Connewarre	2.76	1.55	5.47	31	6.4	2.4	4.09
29	L. Connewarre	2.83	1.64	5.54	32	6.2	2	4.61
74	Wallington	2.64	1.6	9.38	32	6.5	2.2	4.87
75	Wallington	2.54	1.46	6.26	32	6.1	2.3	4.61
76	Wallington	2.08	0.978	7.61	19	4.4	1.7	3.05
77	Wallington	2.24	1.02	3.14	14	4.6	1.5	3.82
78	Road cutting	3.14	1.35	5.4	31	5.9	1.8	5.82
79	Road cutting	2.42	1.47	5.71	22	6	2	3.66
80	Road cutting	2.82	1.57	5.68	26	6	2.5	5.29
81	Road cutting	2.64	1.25	6.57	32	5	2.4	5.85
82	Road cutting	1.88	0.739	5.09	38	3.1	3.1	5.94
83	Unsealed road	1.79	0.753	6.31	25	3.2	2.3	6.61
84	Unsealed road	2.93	1.71	5.72	30	6.2	2.8	5.77
85	Unsealed road	2.45	0.789	4.77	24	4	4	5.78
86	Unsealed road	2.05	1.1	7.12	37	4.2	4.7	6.03
30	Barwon R	3.31	2.19	6.41	22	8.2	1.7	4.71
31	Barwon R	2.56	1.37	5.4	24	5.2	1.7	4.48
32	Barwon R	2.3	1.26	6.57	25	4.8	2.8	5.22
33	Barwon R	2.8	1.52	5.61	23	5.8	2	4.9
34	Barwon R	2.77	1.66	7.13	28	6	1.8	4.17
35	Barwon R	3.23	1.92	4.97	29	7.1	2.2	4.77
36	Barwon R	2.71	1.74	4.91	23	6.2	2	5.03
37	Barwon R	2.99	1.78	4.97	29	6.3	1.8	4.86

Element units Site #	Site Name	Er mg kg^{-1}	Eu mg kg^{-1}	Fe mg kg^{-1}	Ga^{71} mg kg^{-1}	Gd^{157} mg kg^{-1}	Ge^{74} mg kg^{-1}	Hf mg kg^{-1}
38	Barwon R	2.41	1.53	6.37	27	5.6	2.1	3.98
39	Barwon R	2.93	1.95	8.12	26	7.2	2.5	4.85
40	Barwon R	3.14	1.89	5.49	28	7.4	2	4.67
41	Barwon R	2.32	1.27	5.06	27	5.2	2.1	4.08
42	Barwon R	2.47	1.36	5.75	25	5.1	1.8	4.17
43	Barwon R	2.05	0.872	6.2	33	3.8	2.4	5.29
44	Barwon R	2.54	1.43	5.45	27	5.3	2.1	4.01
45	Barwon R	2.75	1.54	7.11	29	5.9	1.7	4.25
46	Barwon R	2.93	1.74	4.42	27	7.7	2.4	4.29
47	Barwon R	1.37	1.14	24.3	11	4.4	0.93	1.87
48	Moorabool R	2.99	1.94	5.09	32	7.4	2.9	4.54
49	Moorabool R	2.6	1.45	6.03	28	6.1	2.2	3.73
50	Moorabool R	2.88	1.82	6.56	27	7.7	2.2	3.84
51	Moorabool R	2.53	1.37	6.49	27	6.2	2.3	4.43
52	Moorabool R	2.26	1.32	5.29	30	5.4	1.4	3.64
53	Moorabool R	2.79	1.58	5.98	32	6.9	2.5	4.26
54	Moorabool R	2.2	1.21	4.66	31	4.8	1.8	3.15
55	Moorabool R	2.29	1.27	5.5	32	4.9	1.8	3.26
56	Moorabool R	1.7	0.984	5.86	24	4.5	2.2	2.3
57	Moorabool R	2.45	1.53	4.93	37	6.4	3.3	3.34
58	Moorabool R	2.32	1.14	5.25	38	4.9	3.4	4.09
59	Moorabool R	1.86	1.11	5.63	26	4.2	1.6	3.3
60	Moorabool R	1.91	1.14	5.2	27	4.6	2.7	3.46
61	Moorabool R	3.26	2.05	5.15	33	8.2	2.3	4.25
62	Moorabool R	2.57	1.49	7.95	29	5.6	2.2	4.21
63	Leigh R	2.19	1.32	5.81	29	5.5	1.8	3.74
64	Leigh R	2.19	1.27	6.61	33	5.7	2.8	4.46
65	Leigh R	2.35	1.47	7.4	29	6	2.4	3.75
66	Leigh R	2.55	1.37	7.19	36	5.5	2.6	4.26
67	Leigh R	2.19	1.38	10.3	24	4.9	1.8	4.18
68	Leigh R	2	1.23	6.01	30	5	2.7	3.5
69	Leigh R	2.01	1.13	5.34	31	5	1.9	3.75
70	Leigh R	2.59	1.57	6.17	33	6.9	2.2	3.65
71	Leigh R	1.97	1.24	5.48	32	5.1	2.3	4.04
72	Leigh R	2.45	1.19	4.43	35	5.4	2.2	2.75
73	Leigh R	2.9	1.57	5.11	32	7.5	1.8	3.68
87	Soil	1.76	0.74	3.15	14	3.1	1.3	3.82
88	Soil	2.57	0.803	4.55	22	3.7	1.6	7.97

Element		Ho^{165}	In^{115}	K	La^{139}	Li^{7}	Lu^{175}	Mg
units		mg kg^{-1}	mg kg^{-1}	%	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	%
Site #	Site Name							
1	L. Connewarre	0.91	0.083	1.99	35.1	70	0.351	0.882
2	L. Connewarre	0.99	0.08	2.09	37.9	54	0.43	0.798
3	L. Connewarre	1	0.079	2.03	37.9	74	0.397	0.948
4	L. Connewarre	0.9	0.086	0.916	35.3	74	0.357	0.972
5	L. Connewarre	1.1	0.077	1.96	39.6	63	0.438	0.907
6	L. Connewarre	1	0.084	2.06	39.5	78	0.433	1.01
7	L. Connewarre	0.89	0.092	2.37	35.4	98	0.362	0.993
8	L. Connewarre	0.99	0.095	2.1	39.1	69	0.448	0.859
9	L. Connewarre	0.96	0.084	1.92	36.3	74	0.388	0.989
10	L. Connewarre	0.95	0.093	1.96	35.6	83	0.399	1.01
11	L. Connewarre	0.96	0.076	2.08	33	67	0.434	0.938
12	L. Connewarre	0.8	0.085	2.1	32.6	66	0.358	0.959
13	L. Connewarre	0.85	0.09	1.88	34.6	80	0.376	0.968
14	L. Connewarre	0.9	0.093	2.08	34.5	100	0.387	0.974
15	L. Connewarre	0.98	0.09	2.18	37	95	0.363	1.04
16	L. Connewarre	0.98	0.1	2.21	37.1	93	0.44	1.02
17	L. Connewarre	0.91	0.083	2.05	32.8	92	0.375	1.03
18	L. Connewarre	0.8	0.086	2	31.3	68	0.365	1.04
19	L. Connewarre	0.95	0.084	2.11	38.4	93	0.399	1.17
20	L. Connewarre	0.98	0.077	2.16	39.1	91	0.392	1.09
21	L. Connewarre	0.88	0.086	2.05	35.5	82	0.385	0.986
22	L. Connewarre	0.93	0.084	2	36.3	76	0.374	1.08
23	L. Connewarre	0.9	0.071	2.01	32.8	85	0.384	1.03
24	L. Connewarre	0.98	0.085	2.3	41	91	0.443	0.972
25	L. Connewarre	0.97	0.084	2	35.1	82	0.406	1.01
26	L. Connewarre	0.95	0.08	1.97	36.5	85	0.363	1.03
27	L. Connewarre	0.98	0.083	2.01	37.3	76	0.396	1.05
28	L. Connewarre	0.96	0.079	2.14	36.5	80	0.392	1.02
29	L. Connewarre	1	0.089	2.17	35.3	88	0.381	1.12
74	Wallington	0.98	0.089	1.02	37.5	66	0.386	0.839
75	Wallington	0.87	0.091	1.18	37.5	55	0.372	1.07
76	Wallington	0.76	0.054	0.84	27.3	37	0.299	0.657
77	Wallington	0.69	0.042	1.16	33.9	49	0.381	0.228
78	Road cutting	1	0.093	2	31.9	71	0.455	1.19
79	Road cutting	0.86	0.069	1.32	35.8	55	0.436	0.782
80	Road cutting	1	0.071	1.13	33.9	50	0.479	0.621
81	Road cutting	0.85	0.1	0.945	34.5	17	0.454	0.561
82	Road cutting	0.62	0.089	0.405	23.3	57	0.325	0.296
83	Unsealed road	0.59	0.078	0.707	25.3	27	0.31	0.262
84	Unsealed road	1	0.076	1.52	39	44	0.452	0.694
85	Unsealed road	0.81	0.073	0.678	36.9	36	0.409	0.243
86	Unsealed road	0.68	0.11	1.06	55	28	0.307	0.271
30	Barwon R	1.2	0.077	1.56	44.3	37	0.479	0.984
31	Barwon R	0.95	0.061	1.67	33.3	49	0.335	0.663
32	Barwon R	0.84	0.072	1.16	32.5	34	0.343	0.789
33	Barwon R	0.98	0.071	1.44	38.1	39	0.402	0.635
34	Barwon R	0.99	0.078	1.53	36.9	41	0.406	0.691
35	Barwon R	1.1	0.069	1.43	44.7	49	0.482	0.647
36	Barwon R	0.97	0.07	1.62	37.7	33	0.427	0.626
37	Barwon R	1	0.09	2	39.6	47	0.433	0.728

Element units Site #	 Site Name	Ho^{165} mg kg^{-1}	In^{115} mg kg^{-1}	K %	La^{139} mg kg^{-1}	Li^{7} mg kg^{-1}	Lu^{175} mg kg^{-1}	Mg %
38	Barwon R	0.85	0.074	1.61	36.8	42	0.383	0.654
39	Barwon R	1.1	0.072	1.08	44.1	57	0.411	0.925
40	Barwon R	1.1	0.073	1.69	40.6	48	0.466	0.825
41	Barwon R	0.85	0.073	1.45	34.7	45	0.325	0.687
42	Barwon R	0.87	0.07	1.67	32.5	41	0.385	0.717
43	Barwon R	0.64	0.087	0.905	27.7	28	0.351	0.444
44	Barwon R	0.87	0.059	1.64	34	39	0.341	0.708
45	Barwon R	0.96	0.087	1.77	35	34	0.448	0.812
46	Barwon R	1	0.071	1.68	45.5	24	0.45	0.744
47	Barwon R	0.51	0.037	0.211	28.9	12	0.208	0.279
48	Moorabool R	1.1	0.1	2.23	50.1	69	0.443	0.793
49	Moorabool R	0.85	0.091	1.74	34.4	51	0.35	1.11
50	Moorabool R	1	0.094	2.06	44.5	49	0.449	0.884
51	Moorabool R	0.85	0.094	1.92	39	52	0.391	0.718
52	Moorabool R	0.78	0.084	2.17	33.3	51	0.354	0.78
53	Moorabool R	0.97	0.087	2.12	38.5	64	0.382	0.895
54	Moorabool R	0.75	0.086	2.76	31.5	67	0.32	0.683
55	Moorabool R	0.77	0.099	2.62	31.3	65	0.353	0.776
56	Moorabool R	0.61	0.072	1.9	29.9	35	0.227	0.896
57	Moorabool R	0.86	0.087	3.05	39.8	65	0.429	0.682
58	Moorabool R	0.79	0.1	2.37	35.2	47	0.357	0.482
59	Moorabool R	0.66	0.073	2.16	29	47	0.282	0.623
60	Moorabool R	0.7	0.075	2.04	32.4	50	0.33	0.654
61	Moorabool R	1.2	0.088	2.42	52.4	100	0.46	0.713
62	Moorabool R	0.87	0.093	1.83	33.7	62	0.377	0.865
63	Leigh R	0.75	0.087	2.22	37.2	57	0.346	0.821
64	Leigh R	0.74	0.11	3	37.6	88	0.394	0.83
65	Leigh R	0.82	0.094	1.87	38.1	58	0.347	0.993
66	Leigh R	0.83	0.091	2.57	37.1	60	0.371	0.682
67	Leigh R	0.79	0.07	0.358	29.1	30	0.306	0.724
68	Leigh R	0.74	0.086	2.26	32.1	49	0.295	0.824
69	Leigh R	0.73	0.094	2.11	32.8	48	0.308	0.782
70	Leigh R	0.94	0.086	2.74	48.8	72	0.38	0.717
71	Leigh R	0.71	0.091	2.11	32.4	43	0.29	0.815
72	Leigh R	0.89	0.095	4.02	41.6	52	0.389	0.985
73	Leigh R	1.1	0.085	2.7	47.8	56	0.34	0.747
87	Soil	0.58	0.047	0.539	25.4	25	0.255	0.17
88	Soil	0.81	0.07	0.281	26	41	0.436	0.22

Element units Site #	 Site Name	Mn^{55} mg kg^{-1}	Mo mg kg^{-1}	Na %	Nb^{93} mg kg^{-1}	Nd^{146} mg kg^{-1}	Ni mg kg^{-1}	P^{31} mg kg^{-1}
1	L. Connewarre	567	1.04	0.532	19.3	32.2	53	873
2	L. Connewarre	476	1.35	0.254	21.7	34.2	50	1020
3	L. Connewarre	417	1.68	0.467	21	34.2	67	792
4	L. Connewarre	830	1.23	0.311	18.9	31.2	63	1060
5	L. Connewarre	384	2.73	0.514	20.8	35.5	47	759
6	L. Connewarre	365	2.83	0.532	20.2	36.2	57	693
7	L. Connewarre	345	1.31	0.967	21.4	30.1	53	494
8	L. Connewarre	290	1.62	0.523	21.4	35.9	57	803
9	L. Connewarre	385	1.35	0.315	18.3	33.4	68	1110
10	L. Connewarre	392	1.55	0.38	19.3	33	60	837
11	L. Connewarre	563	1.27	0.42	18.9	30	58	870
12	L. Connewarre	4550	1.32	0.515	18.6	29.9	53	1240
13	L. Connewarre	1470	1.27	0.405	18	30.7	57	1180
14	L. Connewarre	246	1.62	0.369	20.1	30.8	60	460
15	L. Connewarre	269	1.14	0.325	19.5	34	63	575
16	L. Connewarre	300	1.11	0.299	20.7	33.5	55	642
17	L. Connewarre	240	1.27	0.321	19.1	31.7	57	701
18	L. Connewarre	1330	1.38	0.456	16.9	28	61	1140
19	L. Connewarre	387	1.28	0.312	20.5	34.6	71	662
20	L. Connewarre	299	1.44	0.424	20.6	34.7	59	580
21	L. Connewarre	335	1.42	0.608	18.7	32.6	59	770
22	L. Connewarre	421	1.27	0.645	19.3	33.3	63	1080
23	L. Connewarre	582	1.27	0.365	17.5	31.4	61	895
24	L. Connewarre	242	1.17	0.43	23.1	36	68	426
25	L. Connewarre	538	1.9	0.412	18.5	30.9	63	772
26	L. Connewarre	215	1.5	0.328	19	31.9	57	597
27	L. Connewarre	523	1.65	0.647	19.5	34.9	60	995
28	L. Connewarre	225	2.15	0.321	19.8	33.8	59	589
29	L. Connewarre	271	1.21	0.417	19.5	32	66	694
74	Wallington	97.3	2.71	0.126	19.7	34.6	65	319
75	Wallington	274	0.842	0.22	20.8	34	51	488
76	Wallington	509	2.65	0.551	19.7	22.4	77	1710
77	Wallington	108	2.37	0.313	30.1	27.4	40	906
78	Road cutting	481	1.94	0.679	21.9	30.1	60	687
79	Road cutting	2020	2.22	0.113	17.8	31.9	86	723
80	Road cutting	80.8	1.69	0.309	23.5	34.8	35	203
81	Road cutting	83.9	1.86	0.201	27.5	30.6	50	223
82	Road cutting	40.8	2.05	0.0558	26.5	18.4	71	250
83	Unsealed road	148	2.79	0.148	20	19.9	57	748
84	Unsealed road	257	3.36	0.359	20.6	36.8	63	404
85	Unsealed road	117	3.75	0.062	38.1	21.6	50	362
86	Unsealed road	51.1	8.52	0.0571	31.3	28.7	48	458
30	Barwon R	494	1.48	0.499	21.8	43.4	73	624
31	Barwon R	345	2.08	0.442	23.1	27.5	54	1690
32	Barwon R	637	5.47	0.382	22.9	25.9	82	1470
33	Barwon R	1060	1.44	0.375	18.9	32	45	984
34	Barwon R	1200	1.26	0.39	17	32.4	46	1250
35	Barwon R	643	1.13	0.376	21.3	41.5	31	658
36	Barwon R	787	1.54	0.58	23.9	33.9	24	681
37	Barwon R	1360	0.806	0.411	18.2	36.2	49	1060

Element		Mn^{55}	Mo	Na	Nb^{93}	Nd^{146}	Ni	P^{31}
units		mg kg^{-1}	mg kg^{-1}	%	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
Site #	Site Name							
38	Barwon R	845	1.06	0.301	15.1	33.1	36	1120
39	Barwon R	830	1.79	0.291	22.6	41.2	78	922
40	Barwon R	966	1.3	0.432	18.6	37.6	43	916
41	Barwon R	2040	1.83	1.21	17	28.2	49	575
42	Barwon R	1560	1.55	0.54	18.8	28.1	30	821
43	Barwon R	159	2.91	0.298	26.2	21.3	42	555
44	Barwon R	703	1.29	0.472	16.8	29.1	31	1300
45	Barwon R	615	1.9	0.379	18.2	31.6	34	705
46	Barwon R	552	0.965	0.836	16.3	39.3	34	400
47	Barwon R	917	1.22	0.489	9.51	24.9	42	1130
48	Moorabool R	401	1.12	0.128	26	44.8	72	574
49	Moorabool R	938	1.13	0.453	18.5	29.4	83	684
50	Moorabool R	490	1.29	0.148	23.1	39.1	73	795
51	Moorabool R	356	1.68	0.251	26.3	33.5	77	972
52	Moorabool R	398	1.31	0.161	19.3	28.4	84	960
53	Moorabool R	366	1.21	0.123	21.1	32.8	73	616
54	Moorabool R	831	1.04	0.201	17.8	26.3	47	799
55	Moorabool R	1530	1.24	0.217	17.6	26.4	67	583
56	Moorabool R	902	2.5	0.6	13.5	24.3	47	1320
57	Moorabool R	307	1.12	0.188	18.4	32.8	50	576
58	Moorabool R	57	1.91	0.0988	20.9	27.5	44	272
59	Moorabool R	897	1.17	0.329	22.4	22.5	56	999
60	Moorabool R	638	1.28	0.363	22.7	26.2	48	1100
61	Moorabool R	227	1.35	0.289	23.9	46	53	336
62	Moorabool R	467	2.05	0.186	21.9	30.4	94	347
63	Leigh R	467	1.18	0.111	22.1	30.1	54	1710
64	Leigh R	451	1.63	0.0918	26.3	31.7	62	1130
65	Leigh R	585	1.21	0.313	18.6	32.4	59	2170
66	Leigh R	347	1.54	0.164	20.3	32.2	55	428
67	Leigh R	975	1.58	0.166	27.9	25.3	72	885
68	Leigh R	667	1.25	0.257	21.1	26.6	59	1490
69	Leigh R	1180	1.34	0.196	21.8	27.1	53	2070
70	Leigh R	378	1.17	0.108	22.7	40	45	719
71	Leigh R	1590	1.37	0.192	23.9	27.2	65	1700
72	Leigh R	172	0.629	0.0478	20.6	32.2	39	366
73	Leigh R	359	1.26	0.0976	23	39.3	43	627
87	Soil	395	2.28	0.176	27.9	17.5	25	1020
88	Soil	95.5	4.04	0.0619	65.3	17	50	385

Element		Pb	Pr^{141}	Rb^{85}	Sb^{121}	Sc^{45}	Sm	Sn
units		mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
Site #	Site Name							
1	L. Connewarre	48.4	8.12	164	1.29	22	6.3	6.1
2	L. Connewarre	51.4	8.12	156	1.37	25	7	6.9
3	L. Connewarre	50.6	8.24	162	1.3	24	6.6	6.8
4	L. Connewarre	48.2	7.6	150	1.34	22	6.4	5.9
5	L. Connewarre	38.7	8.45	152	1.07	24	7.4	5.5
6	L. Connewarre	42.8	8.92	150	1.2	26	7.4	5.8
7	L. Connewarre	40.3	7.38	187	1.25	28	5.9	6.2
8	L. Connewarre	44.8	8.36	166	1.3	26	7.3	6.4
9	L. Connewarre	43.9	8.33	161	1.21	23	6.7	5.4
10	L. Connewarre	44.2	8.25	164	1.32	23	6.6	5.6
11	L. Connewarre	40.3	7.24	160	1.27	24	6.1	5.8
12	L. Connewarre	36.9	7.1	162	1.47	19	5.9	5.5
13	L. Connewarre	42.5	7.58	161	1.17	22	6.3	4.5
14	L. Connewarre	41.1	7.21	184	1.11	25	6	6
15	L. Connewarre	36.4	7.84	183	1	24	6.7	5.5
16	L. Connewarre	39	8.25	186	1.24	23	6.5	5.8
17	L. Connewarre	34.6	7.34	176	1.02	24	6	5.2
18	L. Connewarre	37.3	6.57	155	1.15	21	5.2	12
19	L. Connewarre	42.6	8.5	183	1.03	26	7.2	6
20	L. Connewarre	44.6	8.65	188	1.03	24	7.2	6.2
21	L. Connewarre	32.2	7.67	174	0.944	23	6.2	5.4
22	L. Connewarre	42.3	7.96	160	1.12	22	6.9	5
23	L. Connewarre	38.9	7.05	166	1.12	24	6.2	5.3
24	L. Connewarre	42.3	8.81	199	1.2	25	7.1	5.8
25	L. Connewarre	36.7	8.06	172	1.18	22	6.5	5.5
26	L. Connewarre	37.3	8.06	172	1.07	23	6.8	5.3
27	L. Connewarre	49.5	8.76	154	1.39	22	7	5.9
28	L. Connewarre	44	8.22	164	1.11	25	7.2	5.7
29	L. Connewarre	66.8	8.18	168	1.08	26	7.1	5.2
74	Wallington	19.3	7.97	99.9	1.56	27	7.3	5.4
75	Wallington	26.2	8.01	96.1	1.24	21	6.6	4.4
76	Wallington	63	5.67	71.7	1.22	12	4.6	6.4
77	Wallington	37.2	7.02	84.4	1.12	11	5.1	4
78	Road cutting	49.4	6.95	128	0.762	24	6.1	11
79	Road cutting	24.1	7.72	104	1.22	18	6	6.8
80	Road cutting	21.3	7.64	121	0.806	20	7.1	3.5
81	Road cutting	27.4	7.49	84.5	1.26	25	5.8	5.1
82	Road cutting	17.9	4.46	54	0.746	27	3.2	5.7
83	Unsealed road	31	4.86	56.2	1.41	21	3.8	5.1
84	Unsealed road	25.4	8.53	108	1	23	7.1	5.2
85	Unsealed road	24.1	5.68	72.9	1.16	18	4.1	5.3
86	Unsealed road	32.4	7.36	83.6	2.28	48	5.1	5.7
30	Barwon R	57.3	9.95	101	1.3	23	9.3	4.8
31	Barwon R	70.1	7.07	107	1.68	19	6	6.2
32	Barwon R	28.6	6.51	83.4	1.02	22	5.3	4.4
33	Barwon R	33.8	7.9	117	0.759	19	6.3	4.3
34	Barwon R	35.9	8.01	121	0.666	20	6.8	3.7
35	Barwon R	24.7	9.58	131	0.644	23	7.9	4.2
36	Barwon R	26.5	7.91	115	0.691	21	6.6	4
37	Barwon R	23.5	8.76	138	0.558	23	7.3	4

Element		Pb	Pr^{141}	Rb^{85}	Sb^{121}	Sc^{45}	Sm	Sn
units		mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
Site #	Site Name							
38	Barwon R	25.4	7.97	127	0.592	20	6.3	4
39	Barwon R	142	9.84	85.5	2.46	24	8.1	5
40	Barwon R	55.5	8.76	137	0.599	20	7.8	3.6
41	Barwon R	21	6.77	122	0.705	17	5.5	4.2
42	Barwon R	25.7	6.8	131	0.614	21	5.4	3.7
43	Barwon R	32.7	5.29	88.5	0.971	20	4	5.1
44	Barwon R	24.3	7.14	125	0.639	19	6	3.6
45	Barwon R	33	7.79	120	0.748	23	6.3	4.3
46	Barwon R	22.7	9.63	131	0.566	21	7.8	3.8
47	Barwon R	38	6.15	15.7	0.879	8.5	4.5	7.7
48	Moorabool R	46.5	10.8	193	2.02	27	8.5	7.1
49	Moorabool R	41.1	7.51	152	1.43	20	6.3	5.5
50	Moorabool R	41.2	9.53	172	1.31	23	8.1	5.3
51	Moorabool R	37.4	8.08	167	1.91	23	6.5	5.9
52	Moorabool R	34.7	7.05	185	1.73	25	5.7	5.8
53	Moorabool R	39	8.01	190	1.21	27	7.1	6.4
54	Moorabool R	32.5	6.48	231	1.68	22	5.2	6.4
55	Moorabool R	34.1	6.34	219	1.59	25	5.3	6.3
56	Moorabool R	34.9	5.98	157	1.69	21	4.8	5.6
57	Moorabool R	41.8	8.2	267	1.97	23	6.9	6.8
58	Moorabool R	34	6.73	218	1.9	23	5.3	7.3
59	Moorabool R	26.1	5.79	179	1.45	21	4.8	5.6
60	Moorabool R	25.3	6.33	159	0.932	22	5.2	5.6
61	Moorabool R	32.8	10.8	209	0.931	30	8.7	6.4
62	Moorabool R	43.6	7.01	147	1.2	25	6.1	5.7
63	Leigh R	69.3	7.52	202	2.33	23	6.2	8.2
64	Leigh R	125	7.58	248	5.35	26	6.2	7.5
65	Leigh R	56.3	7.9	175	2.19	22	6.8	5.8
66	Leigh R	36	7.67	226	2.47	24	6.4	7.2
67	Leigh R	25	6.26	40	0.423	21	5.4	3.8
68	Leigh R	84.2	6.52	186	2.63	19	5.2	7.4
69	Leigh R	80.6	6.66	185	2.54	27	5.5	8.3
70	Leigh R	55.9	10.1	240	2.13	22	7.6	7.3
71	Leigh R	98.7	6.49	188	2.28	29	5.3	9
72	Leigh R	43.9	8.02	328	1.89	24	6	9.1
73	Leigh R	33.3	10	239	1.26	30	8	6.5
87	Soil	21.4	4.87	56.8	0.982	8.4	3.5	4.9
88	Soil	21.9	4.66	29.1	1.39	13	3.5	6.4

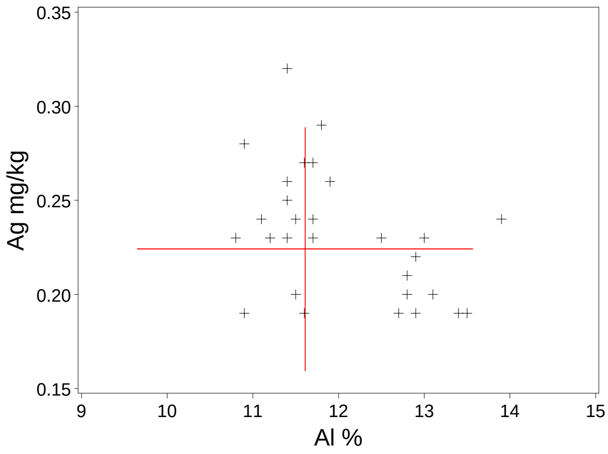
Element		Sr^{88}	Ta^{181}	Tb^{159}	Th^{232}	Ti	Tl^{205}	Tm^{169}
units		mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
Site #	Site Name							
1	L. Connewarre	120	1.65	0.97	15.4	6650	0.88	0.34
2	L. Connewarre	120	1.67	0.91	15.5	7380	0.91	0.46
3	L. Connewarre	92	1.66	0.96	16.1	7160	0.89	0.4
4	L. Connewarre	120	1.57	0.86	15.2	6450	0.88	0.38
5	L. Connewarre	87	1.62	1.1	15.4	7110	0.87	0.43
6	L. Connewarre	86	1.72	0.96	16.1	6880	0.86	0.43
7	L. Connewarre	84	1.86	0.89	16.5	6960	1	0.38
8	L. Connewarre	87	1.68	1	16.2	7320	0.92	0.46
9	L. Connewarre	91	1.47	1	15.6	6270	0.86	0.39
10	L. Connewarre	93	1.59	0.99	15.6	6280	0.91	0.4
11	L. Connewarre	100	1.4	0.92	14.9	6530	0.84	0.37
12	L. Connewarre	110	1.38	0.84	13.9	6070	0.84	0.34
13	L. Connewarre	110	1.44	0.97	14.2	6030	0.82	0.37
14	L. Connewarre	81	1.62	0.91	16.6	6490	1	0.37
15	L. Connewarre	84	1.6	0.93	16	6430	0.93	0.42
16	L. Connewarre	86	1.67	0.94	16.9	6730	0.97	0.43
17	L. Connewarre	100	1.44	0.91	15.3	6240	0.89	0.38
18	L. Connewarre	130	1.43	0.69	13.5	5650	0.86	0.31
19	L. Connewarre	90	1.51	0.99	16.9	6710	0.92	0.41
20	L. Connewarre	92	1.59	1.1	16.8	6900	0.92	0.42
21	L. Connewarre	92	1.49	0.88	14.7	6330	0.86	0.39
22	L. Connewarre	110	1.5	0.91	15.3	6560	0.85	0.38
23	L. Connewarre	110	1.29	0.81	14.8	6060	0.84	0.38
24	L. Connewarre	89	1.86	1	18.5	7450	1	0.39
25	L. Connewarre	89	1.38	0.93	15.1	6370	0.92	0.41
26	L. Connewarre	81	1.39	0.93	16.3	6410	0.95	0.41
27	L. Connewarre	88	1.46	1.1	15.7	6600	0.86	0.41
28	L. Connewarre	79	1.61	1.1	15.9	6640	0.96	0.41
29	L. Connewarre	82	1.51	1	15.8	6630	0.95	0.39
74	Wallington	150	1.53	1	18.1	6080	0.71	0.41
75	Wallington	120	1.51	0.95	13.9	6170	0.56	0.39
76	Wallington	130	1.58	0.63	11.3	5400	0.41	0.26
77	Wallington	76	2.27	0.72	12.7	9470	0.53	0.31
78	Road cutting	94	2.84	0.98	18.5	5680	0.75	0.47
79	Road cutting	150	1.78	0.84	12.9	4920	0.67	0.35
80	Road cutting	68	1.75	0.86	15.3	8700	0.76	0.45
81	Road cutting	95	2.19	0.86	21.2	9850	0.97	0.43
82	Road cutting	39	2.01	0.47	18.7	9470	0.39	0.3
83	Unsealed road	66	1.9	0.52	24.6	6000	0.37	0.26
84	Unsealed road	85	1.93	1	18.7	6540	0.57	0.46
85	Unsealed road	57	3.09	0.76	15.7	13500	0.65	0.36
86	Unsealed road	69	2.38	0.68	24.3	8270	0.61	0.29
30	Barwon R	110	1.69	1.2	13	7350	0.53	0.47
31	Barwon R	110	1.83	0.74	14.3	7360	0.68	0.34
32	Barwon R	140	1.89	0.68	19.9	6800	0.45	0.32
33	Barwon R	110	1.3	0.79	12.3	6970	0.66	0.37
34	Barwon R	110	1.33	0.98	12.1	6580	0.7	0.4
35	Barwon R	120	1.65	1.1	14.4	8750	0.79	0.48
36	Barwon R	130	1.95	0.81	12.6	10100	0.69	0.41
37	Barwon R	130	1.48	1	13.7	7910	0.75	0.41

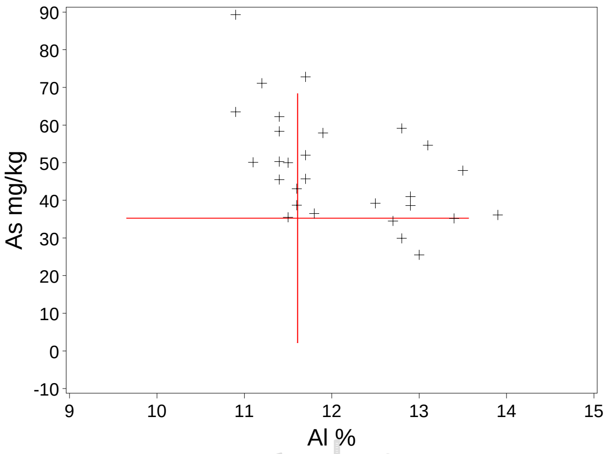
Element		Sr^{88}	Ta^{181}	Tb^{159}	Th^{232}	Ti	Tl^{205}	Tm^{169}
units		mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
Site #	Site Name							
38	Barwon R	130	1.29	0.86	10.9	6730	0.66	0.38
39	Barwon R	200	1.63	1	16.2	7320	0.54	0.42
40	Barwon R	120	1.41	1.1	13.5	7300	0.8	0.44
41	Barwon R	140	1.28	0.77	11.9	5680	0.69	0.33
42	Barwon R	100	1.36	0.85	11.7	7330	0.72	0.37
43	Barwon R	92	1.96	0.68	17	9110	0.57	0.29
44	Barwon R	100	1.32	0.88	11.5	6850	0.67	0.37
45	Barwon R	92	1.31	0.95	12.4	7060	0.72	0.41
46	Barwon R	140	1.1	0.98	11.7	6360	0.67	0.45
47	Barwon R	140	0.792	0.46	6.73	3080	0.17	0.17
48	Moorabool R	120	2	1.1	19.8	7990	1.2	0.42
49	Moorabool R	140	1.42	1	13.6	6160	0.91	0.35
50	Moorabool R	120	1.76	1.1	15.9	7470	1	0.4
51	Moorabool R	93	2.21	0.9	18.8	7430	0.91	0.39
52	Moorabool R	100	1.55	0.74	18.8	6330	1.1	0.32
53	Moorabool R	99	1.69	0.91	16.7	7270	1.1	0.39
54	Moorabool R	77	1.44	0.68	16.1	5430	1.4	0.31
55	Moorabool R	84	1.46	0.84	16	5480	1.3	0.33
56	Moorabool R	280	0.97	0.65	12.7	4300	0.9	0.26
57	Moorabool R	95	1.4	0.96	19	5420	1.6	0.41
58	Moorabool R	63	1.75	0.78	21.1	6380	1.4	0.38
59	Moorabool R	87	1.61	0.65	13.5	5680	1.1	0.25
60	Moorabool R	110	1.64	0.68	13.6	6190	1	0.28
61	Moorabool R	81	1.79	1.3	17.2	7850	1.2	0.48
62	Moorabool R	78	1.62	0.86	16.4	6520	0.96	0.35
63	Leigh R	88	1.77	0.76	18.4	6940	1.1	0.31
64	Leigh R	88	2.06	0.79	21.9	8450	1.3	0.32
65	Leigh R	100	1.4	0.91	16.2	5940	0.98	0.33
66	Leigh R	68	1.54	0.88	21.4	6130	1.4	0.38
67	Leigh R	81	1.89	0.74	11.4	9710	0.29	0.3
68	Leigh R	88	1.74	0.61	15.2	6490	1.1	0.3
69	Leigh R	87	1.69	0.67	15.7	6530	1	0.27
70	Leigh R	62	1.76	0.95	20.5	6530	1.4	0.37
71	Leigh R	88	1.87	0.74	16.7	7020	0.98	0.28
72	Leigh R	40	1.8	0.83	17.1	5720	1.9	0.36
73	Leigh R	73	1.84	0.98	19.3	6940	1.3	0.4
87	Soil	66	2.32	0.51	11.7	9320	0.35	0.24
88	Soil	51	4.97	0.56	18.1	22200	0.33	0.41

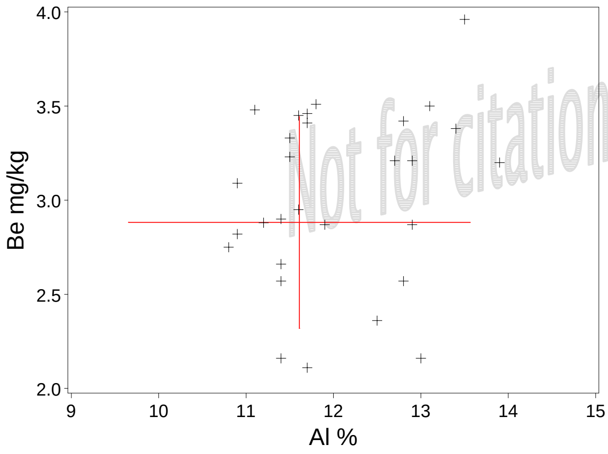
Element		U^{238}	V^{51}	W	Y^{89}	Yb	Zn^{66}	Zr
units		mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
Site #	Site Name							
1	L. Connewarre	5	171	3.18	27	2.39	180	140
2	L. Connewarre	5.1	166	3.41	35	2.68	230	155
3	L. Connewarre	5.5	171	3.31	30	2.6	180	153
4	L. Connewarre	4.4	171	2.85	28	2.5	190	145
5	L. Connewarre	6.3	159	2.86	37	2.81	140	159
6	L. Connewarre	5.8	163	2.95	34	2.88	150	152
7	L. Connewarre	4.9	161	3.48	28	2.35	110	156
8	L. Connewarre	6.9	174	3.09	37	2.9	130	162
9	L. Connewarre	4.1	175	3.08	29	2.51	160	149
10	L. Connewarre	5.6	177	3.02	28	2.55	160	151
11	L. Connewarre	6.6	169	2.8	30	2.46	150	144
12	L. Connewarre	4.4	162	3.06	24	2.29	130	138
13	L. Connewarre	3.3	173	2.86	27	2.43	160	142
14	L. Connewarre	4.8	174	3.32	26	2.59	100	155
15	L. Connewarre	4.1	172	3.19	28	2.69	110	157
16	L. Connewarre	5	173	3.52	28	2.55	120	164
17	L. Connewarre	3.8	173	2.8	29	2.42	130	149
18	L. Connewarre	2.9	171	2.65	25	2.09	150	136
19	L. Connewarre	3.9	191	3.53	29	2.69	130	160
20	L. Connewarre	4.4	183	3.77	29	2.74	130	159
21	L. Connewarre	6.6	161	2.95	30	2.47	110	146
22	L. Connewarre	4.2	186	3.24	27	2.81	150	155
23	L. Connewarre	3.6	191	3.02	25	2.52	150	143
24	L. Connewarre	4.2	173	4.48	27	2.76	100	172
25	L. Connewarre	6.8	170	3.03	26	2.54	120	145
26	L. Connewarre	5.3	164	3.15	26	2.56	110	153
27	L. Connewarre	6.6	184	3.12	29	2.68	140	152
28	L. Connewarre	5.4	172	3.21	29	2.56	130	154
29	L. Connewarre	6.3	186	2.98	29	2.54	120	158
74	Wallington	2.6	295	3.58	27	2.69	45	166
75	Wallington	2.7	345	2.58	29	2.42	100	168
76	Wallington	2.1	172	2.82	20	2.08	150	117
77	Wallington	2.7	129	4.04	22	2.23	43	150
78	Road cutting	5.6	153	15.1	33	3.14	110	188
79	Road cutting	2.7	204	5.76	25	2.38	91	133
80	Road cutting	3.8	169	2.89	28	2.98	34	192
81	Road cutting	3.5	226	3.89	24	2.78	38	222
82	Road cutting	3.2	150	3.01	21	1.86	26	223
83	Unsealed road	3.1	184	4.5	17	1.84	62	220
84	Unsealed road	3.5	164	5.21	28	3.07	69	211
85	Unsealed road	3.6	157	5.57	26	2.51	26	220
86	Unsealed road	5.5	254	9.46	19	1.96	48	256
30	Barwon R	2.7	176	2.25	38	3.07	110	175
31	Barwon R	2.8	164	3.74	26	2.39	270	170
32	Barwon R	3.9	148	3.37	23	2.2	100	193
33	Barwon R	4.4	176	2.23	29	2.5	140	159
34	Barwon R	3.7	184	2.18	29	2.61	130	149
35	Barwon R	3.5	184	2.55	37	3.01	89	178
36	Barwon R	3.5	151	2.67	31	2.68	95	180
37	Barwon R	3.3	162	2.22	32	2.86	140	167

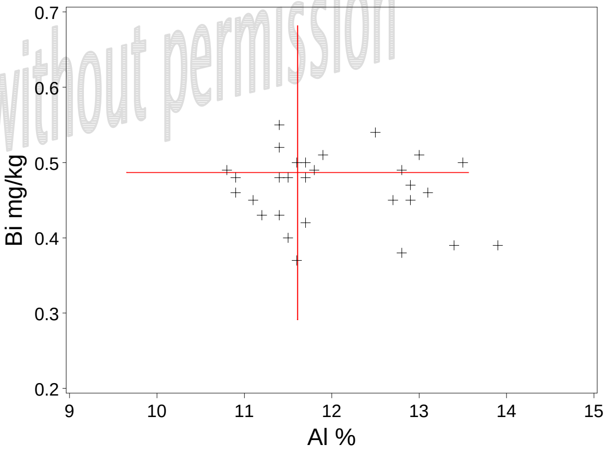
Element		U^{238}	V^{51}	W	Y^{89}	Yb	Zn^{66}	Zr
units		mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
Site #	Site Name							
38	Barwon R	2.6	163	2.01	27	2.45	130	145
39	Barwon R	1.6	221	3	34	2.73	100	171
40	Barwon R	3.3	161	2.14	32	2.88	130	165
41	Barwon R	3.3	142	2.65	24	2.34	140	142
42	Barwon R	2.7	152	2.34	28	2.32	120	156
43	Barwon R	3.4	189	3.63	19	2.1	99	189
44	Barwon R	2.9	139	2.28	27	2.48	130	143
45	Barwon R	3.1	169	2.33	28	2.69	150	155
46	Barwon R	3.3	138	1.86	32	3.07	82	158
47	Barwon R	1.8	126	1.09	15	1.26	91	63.3
48	Moorabool R	6.3	170	5.26	35	2.69	92	160
49	Moorabool R	3.3	171	3.21	24	2.34	100	136
50	Moorabool R	3.6	171	4.26	30	2.62	120	145
51	Moorabool R	3.8	169	4.53	26	2.37	120	168
52	Moorabool R	3.6	164	3.7	24	2.13	120	147
53	Moorabool R	4.2	180	3.92	29	2.54	110	148
54	Moorabool R	3.5	156	3.58	24	2.22	97	104
55	Moorabool R	3.6	162	3.63	25	2.24	110	116
56	Moorabool R	2.7	111	3.68	25	1.6	71	87.4
57	Moorabool R	4.1	169	4.59	26	2.51	120	116
58	Moorabool R	3.7	173	4.71	23	2.41	69	141
59	Moorabool R	3.2	133	2.82	22	1.72	84	122
60	Moorabool R	4.3	131	8.04	24	1.75	100	128
61	Moorabool R	4.5	184	3.15	43	2.97	83	161
62	Moorabool R	2.5	203	3.25	28	2.38	84	153
63	Leigh R	3.5	159	3.7	22	2.11	270	138
64	Leigh R	4.8	177	5.99	23	2.22	210	156
65	Leigh R	2.9	178	2.91	24	2.19	200	133
66	Leigh R	3.6	220	4.33	23	2.5	76	163
67	Leigh R	2.3	142	2.01	22	2	96	175
68	Leigh R	4.6	135	3.59	19	1.89	400	130
69	Leigh R	2.9	132	3.64	26	1.82	420	133
70	Leigh R	4.4	153	4.1	27	2.48	110	129
71	Leigh R	3.1	141	3.64	28	1.79	490	147
72	Leigh R	3.5	154	5.58	26	2.48	160	90.8
73	Leigh R	3.7	167	3.89	40	2.57	67	134
87	Soil	2.6	115	3.99	17	1.86	330	147
88	Soil	5.1	176	6.9	26	2.77	27	300

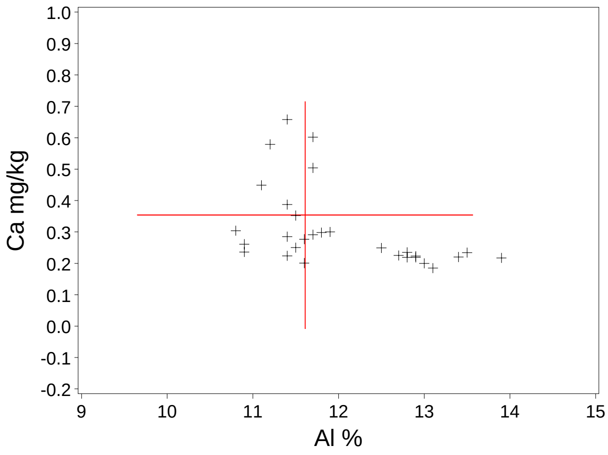
Appendix 4: Comparison of measured element concentrations with concentrations calculated by the *Monte-Carlo* simulation.

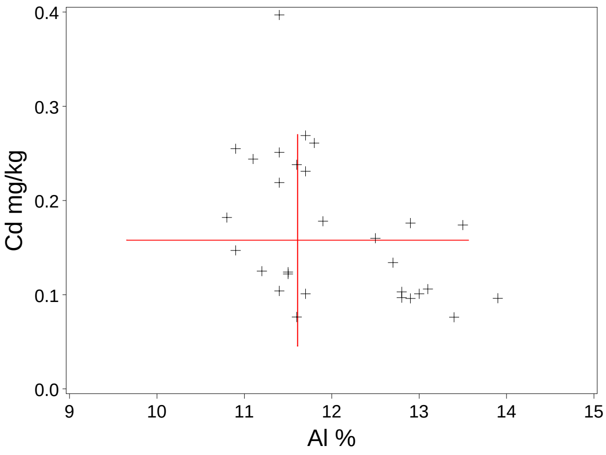


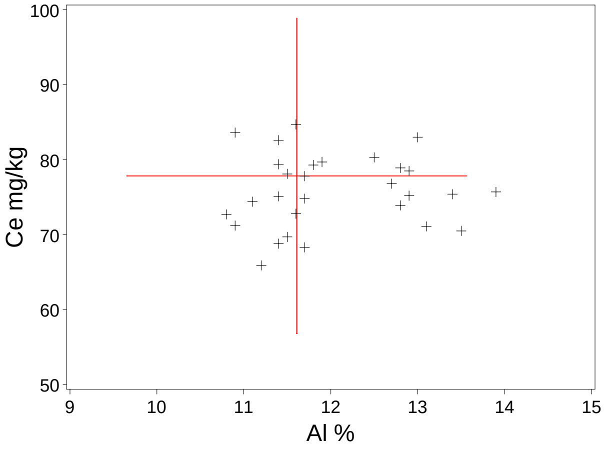


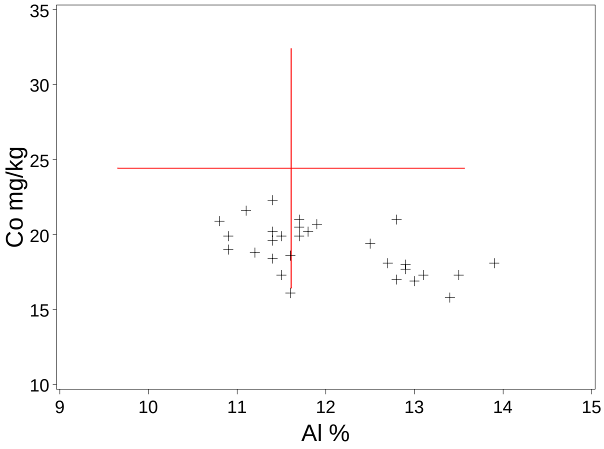


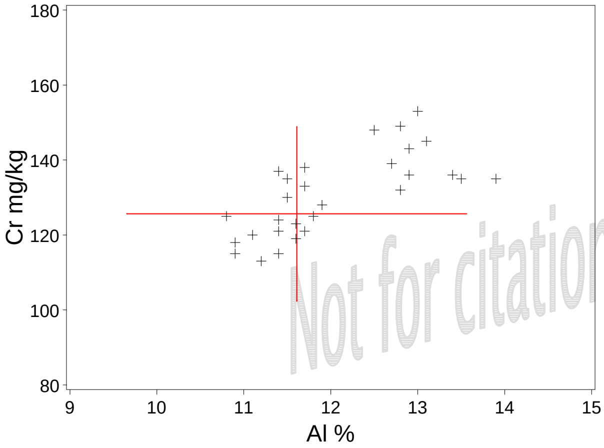


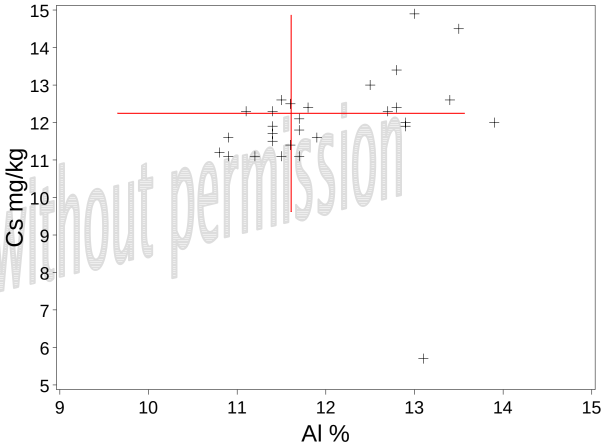


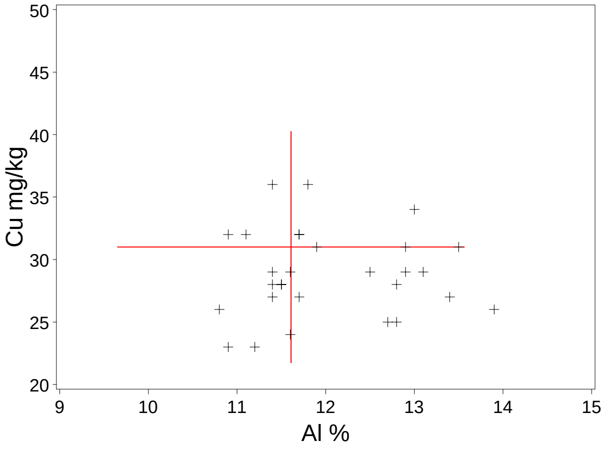


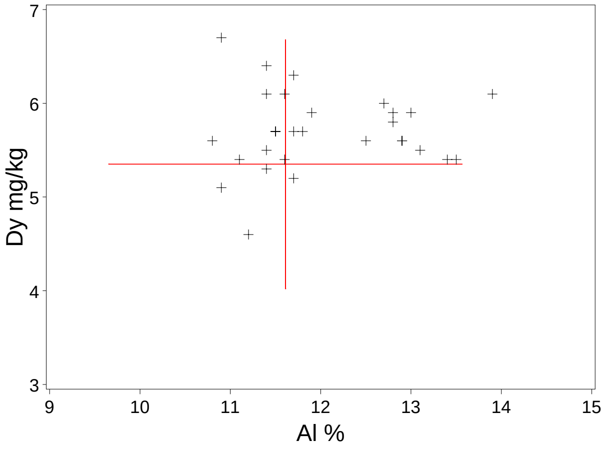

Ce mg/kg
100
90
80
70
60
50
9
10
11
12
13
14
15
Al %

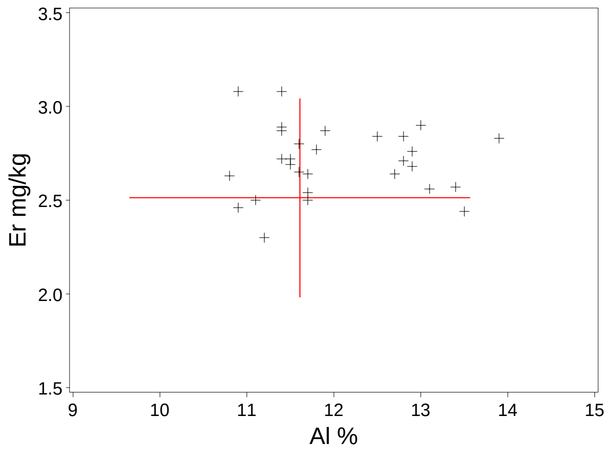

Co mg/kg
35
30
25
20
15
10
9
10
11
12
13
14
15
Al %

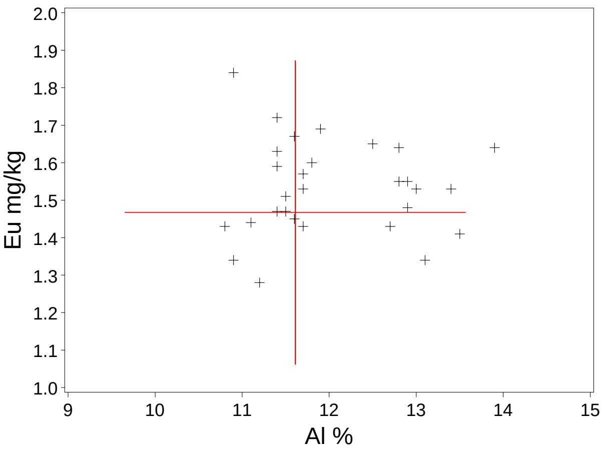

Cr mg/kg
180
160
140
120
100
80
9
10
11
12
13
14
15
Al %

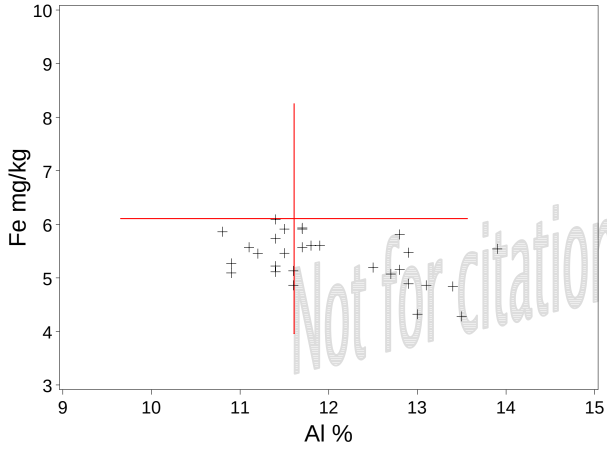

Cs mg/kg
15
14
13
12
11
10
9
8
7
6
5
9
10
11
12
13
14
15
Al %

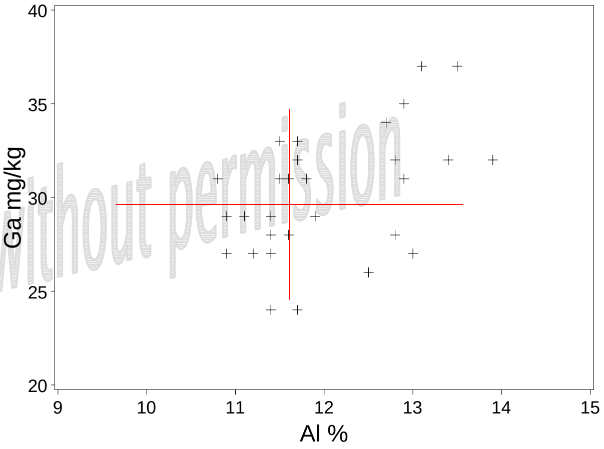

Cu mg/kg
50
45
40
35
30
25
20
9
10
11
12
13
14
15
Al %

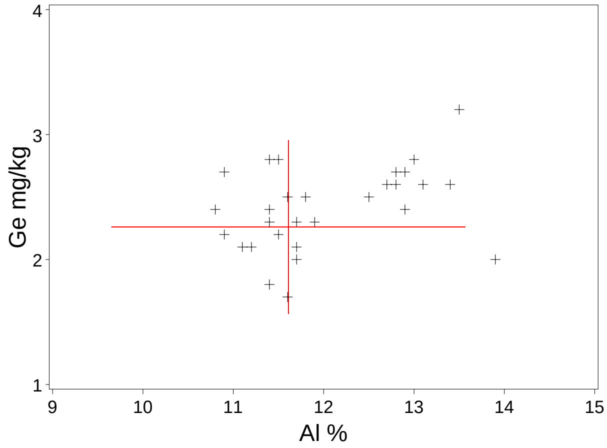

Dy mg/kg
7
6
5
4
3
9
10
11
12
13
14
15
Al %

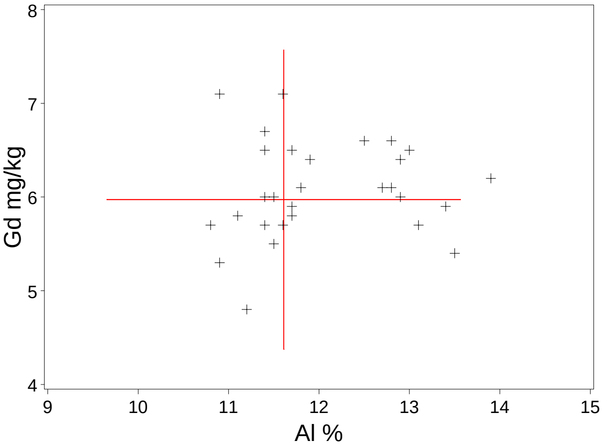

Er mg/kg
3.5
3.0
2.5
2.0
1.5
9
10
11
12
13
14
15
Al %

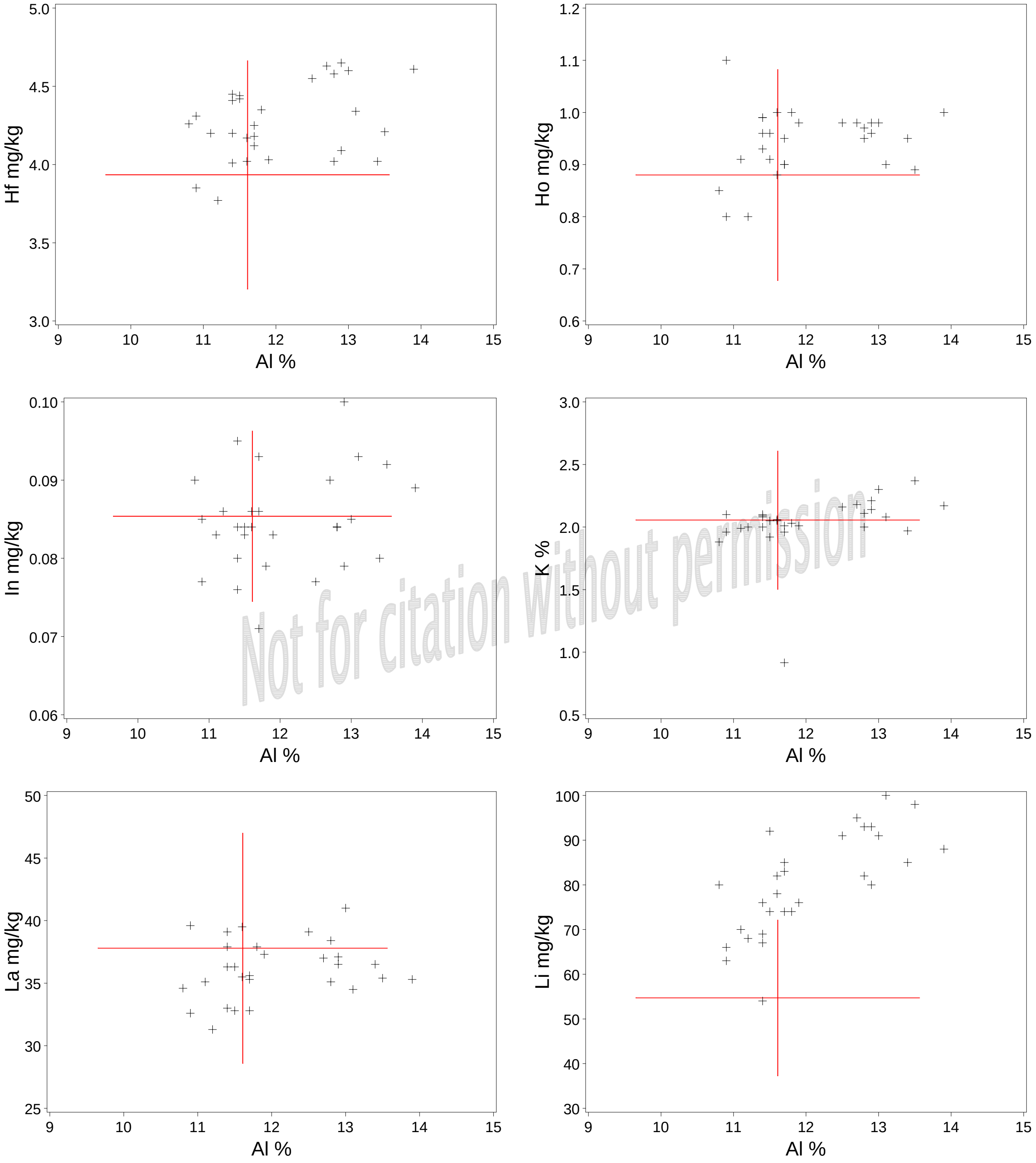

Eu mg/kg
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
9
10
11
12
13
14
15
Al %

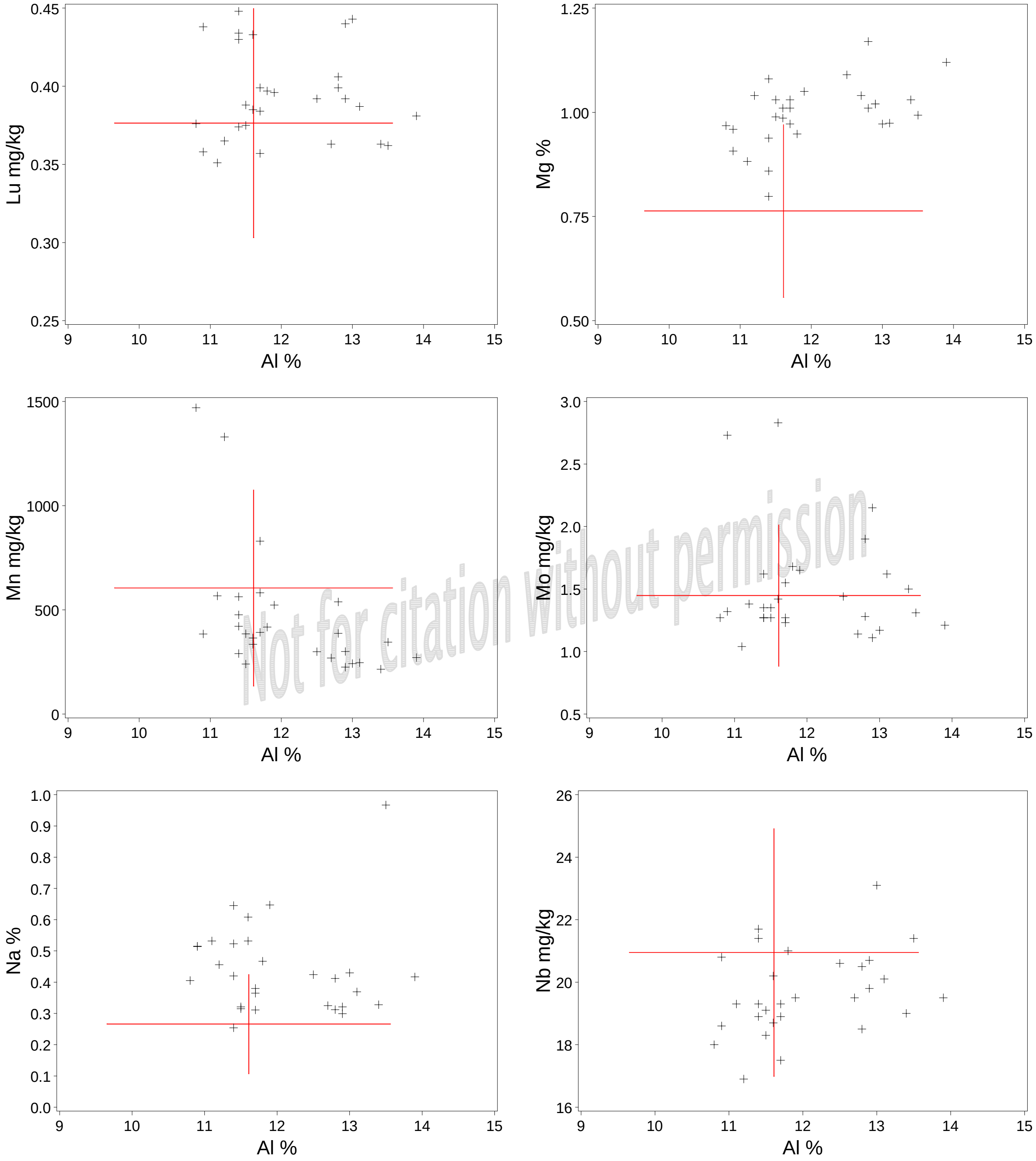

Fe mg/kg
10
9
8
7
6
5
4
3
9
10
11
12
13
14
15
Al %

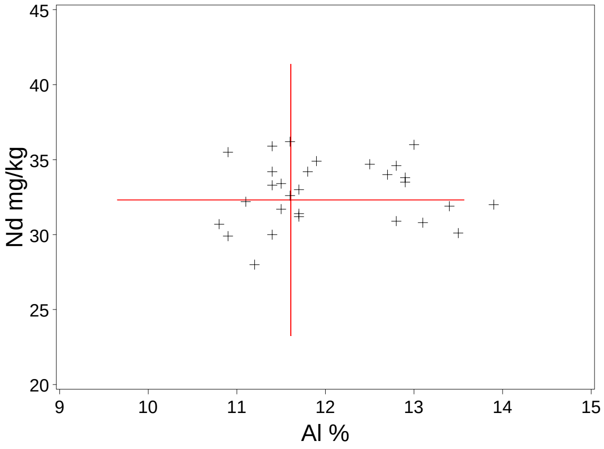

Ga mg/kg
40
35
30
25
20
9
10
11
12
13
14
15
Al %

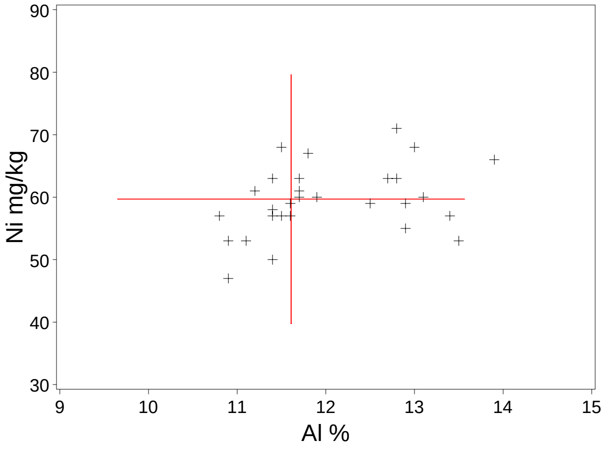

Ge mg/kg
4
3
2
1
9
10
11
12
13
14
15
Al %

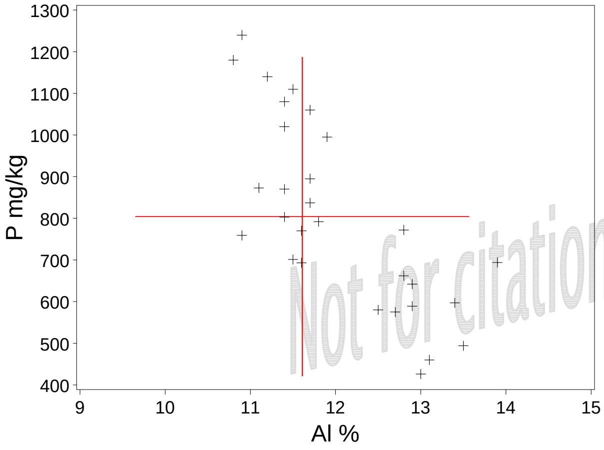

Gd mg/kg
8
7
6
5
4
9
10
11
12
13
14
15
Al %

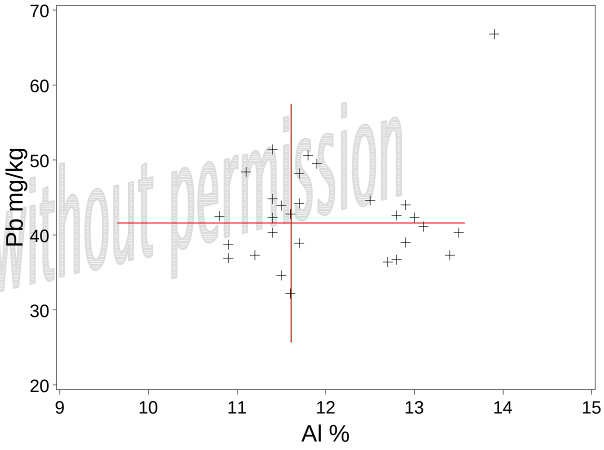

Hf mg/kg
5.0
4.5
4.0
3.5
3.0
9
10
11
12
13
14
15
Al %
Ho mg/kg
1.2
1.1
1.0
0.9
0.8
0.7
0.6
Al %
In mg/kg
0.10
0.09
0.08
0.07
0.06
Al %
K %
3.0
2.5
2.0
1.5
1.0
0.5
Al %
La mg/kg
50
45
40
35
30
25
Al %
Li mg/kg
100
90
80
70
60
50
40
30
Al %

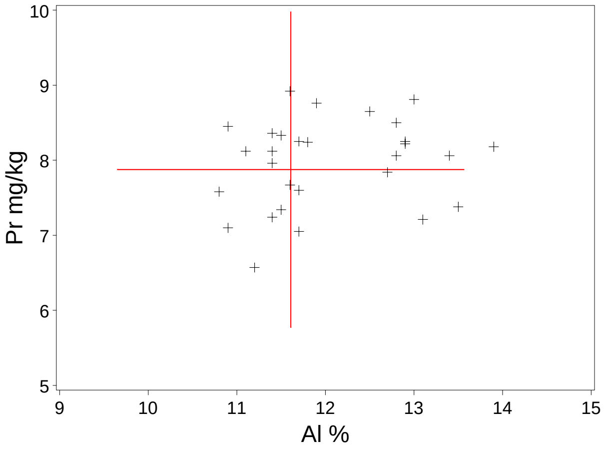

Lu mg/kg
0.45
0.40
0.35
0.30
0.25
Al %
9
10
11
12
13
14
15
Mg %
1.25
1.00
0.75
0.50
Al %
Mn mg/kg
1500
1000
500
0
Al %
Mo mg/kg
3.0
2.5
2.0
1.5
1.0
0.5
Al %
Na %
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Al %
Nb mg/kg
26
24
22
20
18
16
Al %

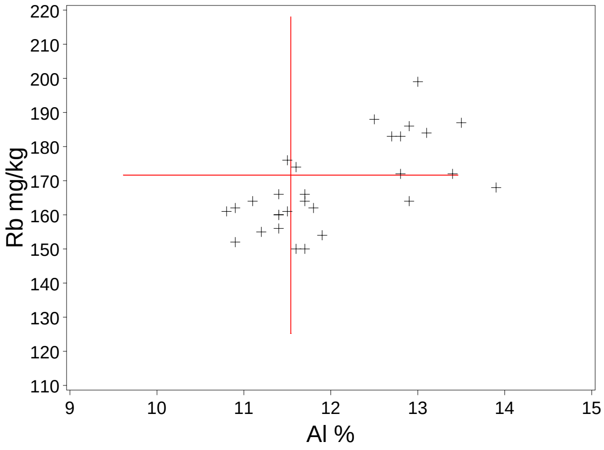

Nd mg/kg
45
40
35
30
25
20
9
10
11
12
13
14
15
Al %

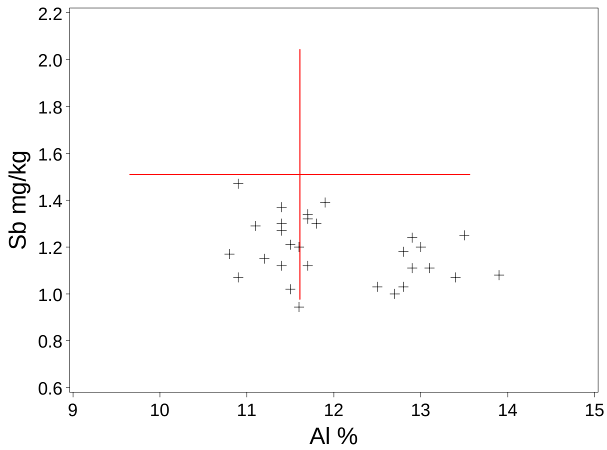

Ni mg/kg
90
80
70
60
50
40
30
9
10
11
12
13
14
15
Al %

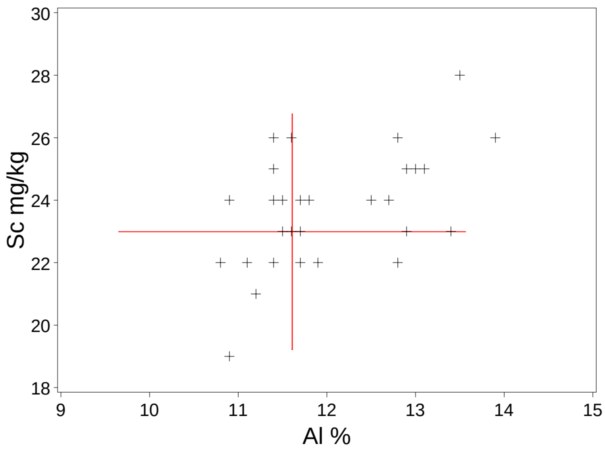

P mg/kg
1300
1200
1100
1000
900
800
700
600
500
400
9
10
11
12
13
14
15
Al %

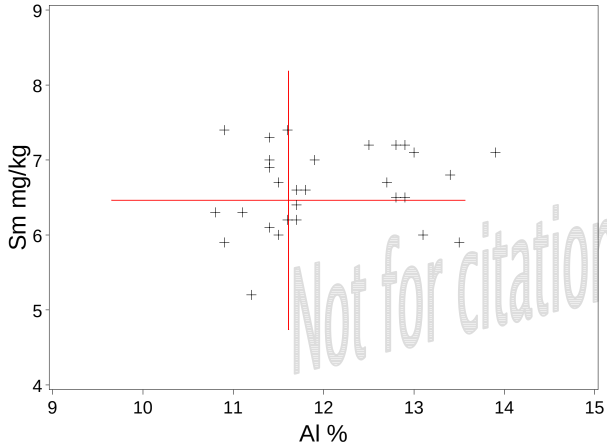

Pb mg/kg
70
60
50
40
30
20
9
10
11
12
13
14
15
Al %

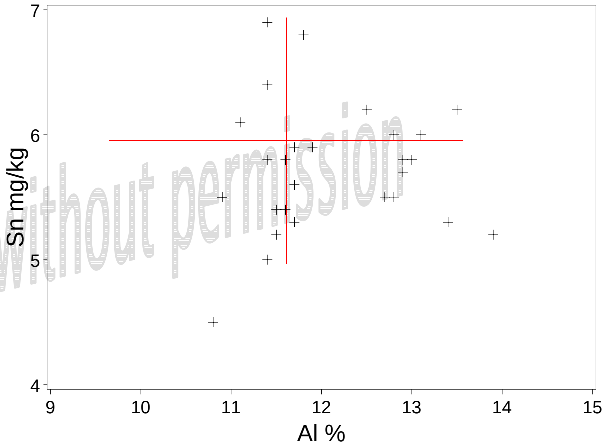

Pr mg/kg
10
9
8
7
6
5
9
10
11
12
13
14
15
Al %

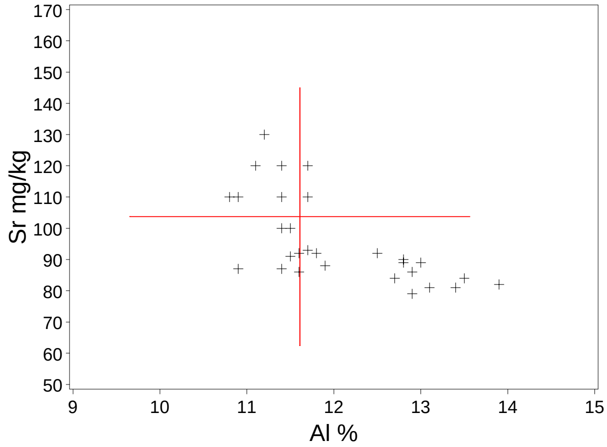

Rb mg/kg
220
210
200
190
180
170
160
150
140
130
120
110
9
10
11
12
13
14
15
Al %

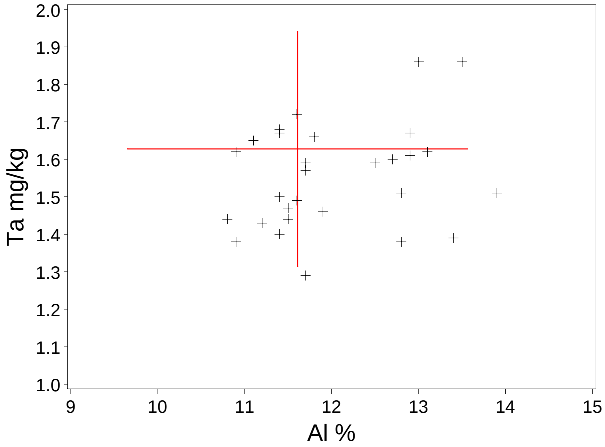

Sb mg/kg
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
9
10
11
12
13
14
15
Al %

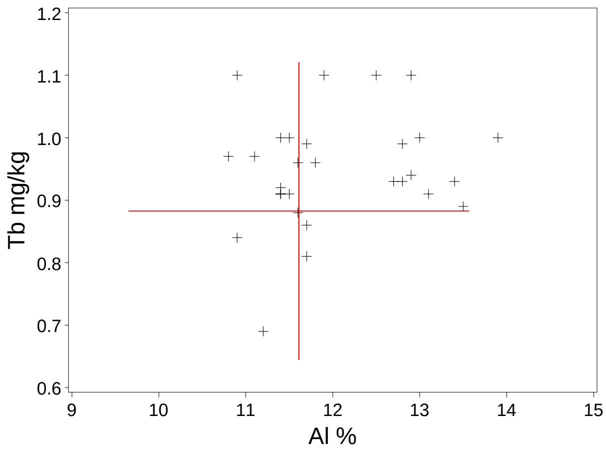

Sc mg/kg
30
28
26
24
22
20
18
9
10
11
12
13
14
15
Al %

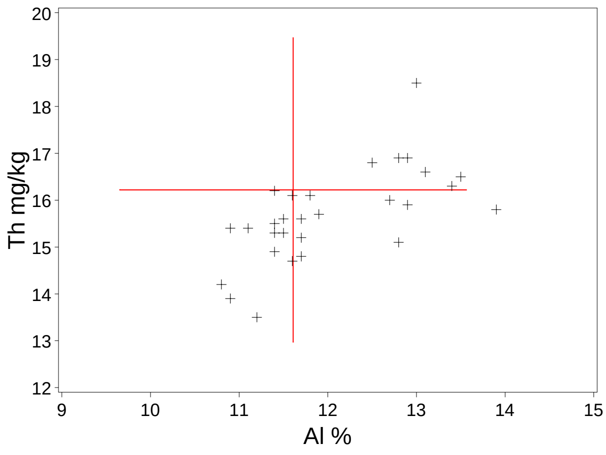

Sm mg/kg
9
8
7
6
5
4
9
10
11
12
13
14
15
Al %

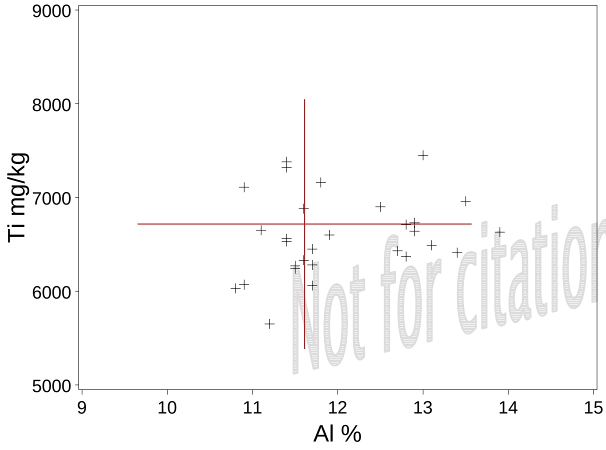

Sn mg/kg
7
6
5
4
9
10
11
12
13
14
15
Al %

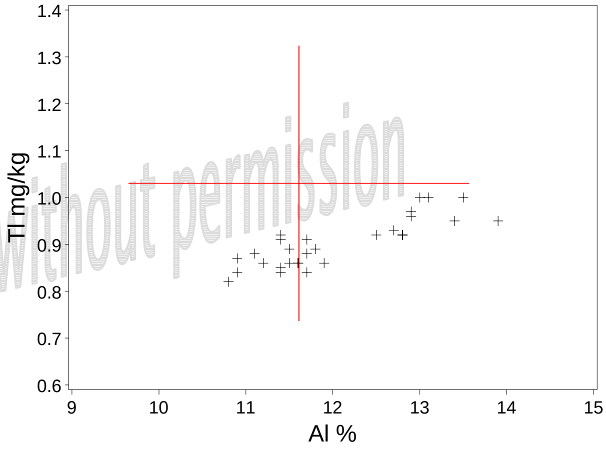

Sr mg/kg
170
160
150
140
130
120
110
100
90
80
70
60
50
9
10
11
12
13
14
15
Al %

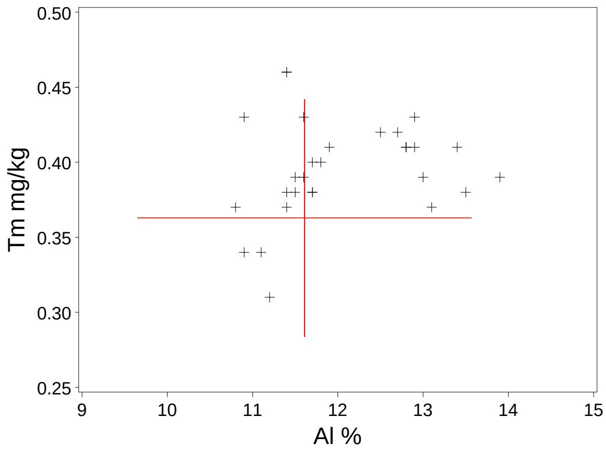

Ta mg/kg
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
9
10
11
12
13
14
15
Al %

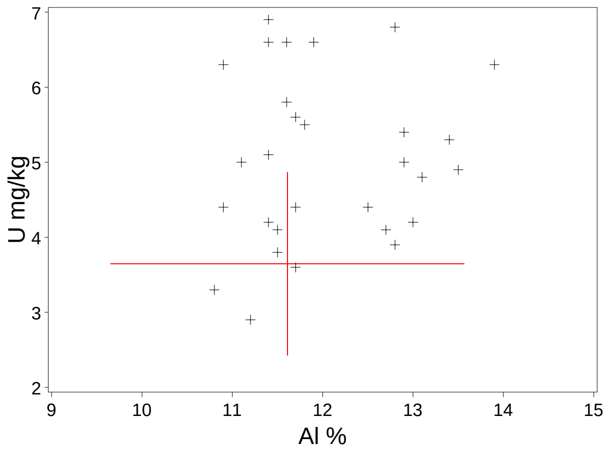

Tb mg/kg
1.2
1.1
1.0
0.9
0.8
0.7
0.6
9
10
11
12
13
14
15
Al %

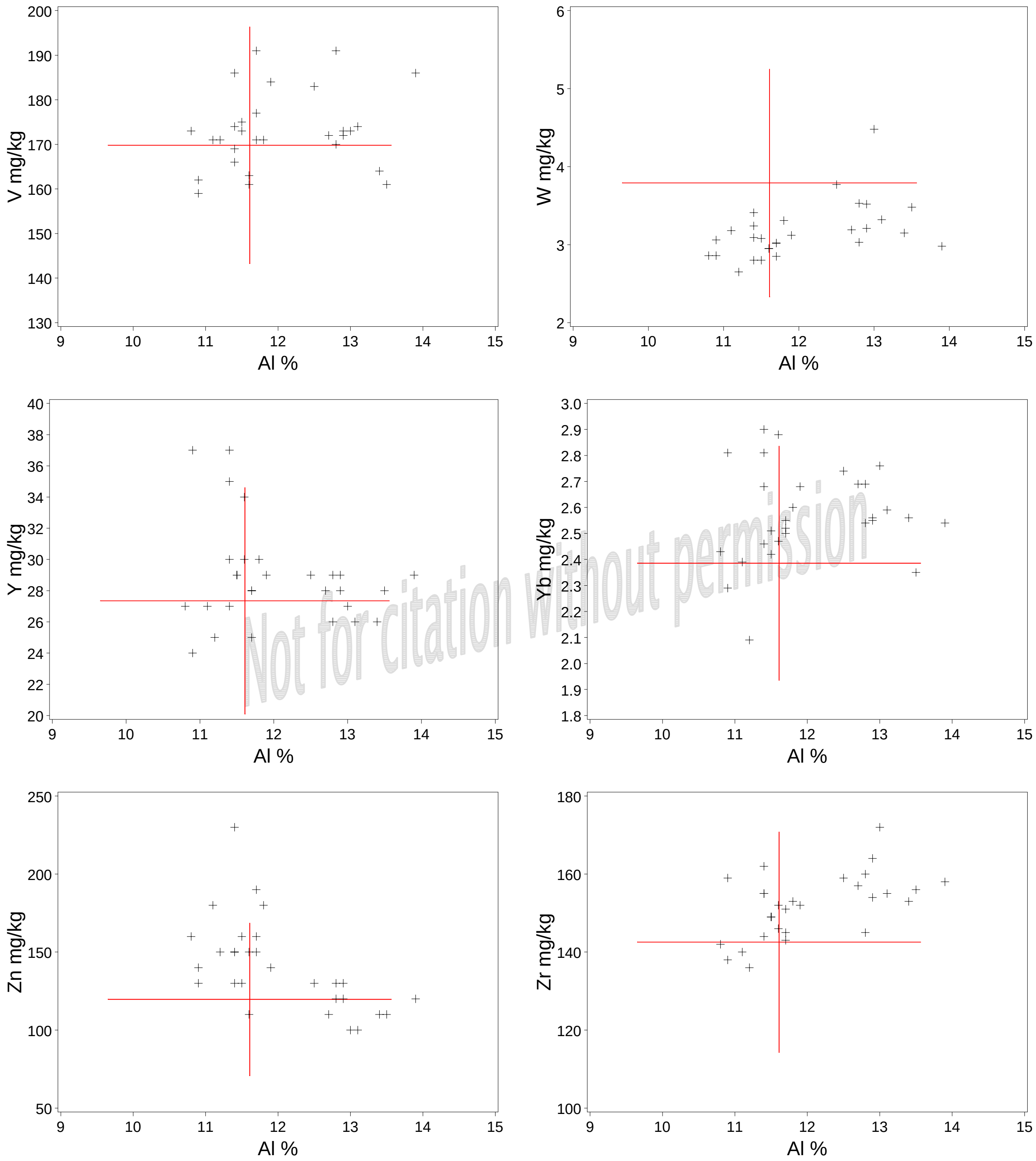

Th mg/kg
20
19
18
17
16
15
14
13
12
9
10
11
12
13
14
15
Al %


Ti mg/kg
9000
8000
7000
6000
5000
9
10
11
12
13
14
15
Al %


Tl mg/kg
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
9
10
11
12
13
14
15
Al %


Tm mg/kg
0.50
0.45
0.40
0.35
0.30
0.25
9
10
11
12
13
14
15
Al %


U mg/kg
7
6
5
4
3
2
9
10
11
12
13
14
15
Al %


V mg/kg
200
190
180
170
160
150
140
130
9
10
11
12
13
14
15
Al %
W mg/kg
6
5
4
3
2
Al %
Y mg/kg
40
38
36
34
32
30
28
26
24
22
20
Al %
Yb mg/kg
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
Al %
Zn mg/kg
250
200
150
100
50
Al %
Zr mg/kg
180
160
140
120
100
Al %