Waka Kotahi New Zealand Transport Agency
Majestic Centre, 100 Willis Street
Wellington 6011

16 September 2021

Attention: **Greg Haldane, Programme & Standards, Manager Assurance**

RE: **External review panel – soil contamination, Te Onewa / Stokes Point**

Our Reference: 2063

Dear Greg,

Summary

This report has been prepared for Waka Kotahi New Zealand Transport Agency (Waka Kotahi) by site contamination specialists Dr Dave Bull of HAIL Environmental Limited (HAIL Environmental) and Kevin Tearney of SLR Consulting NZ Limited (SLR). It presents an independent review of information concerning the potential for bridge maintenance activities undertaken on the Auckland Harbour Bridge (AHB) to have caused contamination of soil within residential properties at Te Onewa / Stokes Point; and which, as a result, would pose an unacceptable risk to residential occupiers of those properties. These bridge maintenance activities include removing damaged paint and repainting. The formulation of these paints has changed over time, although zinc is the major active ingredient, with lesser amounts of other metals including chromium and lead.

Waka Kotahi further requested our opinion on what additional studies or investigations are required to confirm the findings of our review.

For this review, Waka Kotahi provided us with reports and other information on the way bridge maintenance activities are undertaken, including controls to minimise discharges of removed paint and washwater and results of monitoring to assess the efficacy of the controls, and the make-up (composition) of paints used both historically and currently.

Waka Kotahi also provided soil contamination studies undertaken on public land within Te Onewa / Stokes Point, some prepared for Waka Kotahi and others for Auckland Council. These investigations, which began in 2001, found elevated concentrations of metals such as zinc, chromium and lead in shallow soil. Those investigations did not definitively identify the source of the contamination but suggested a link to the AHB since the same metals present in soils were also present in bridge paints. They raised a potential risk from lead in soil to nearby residents, even though none of the investigations actually took samples from the residential properties.

This information is publicly available on the Waka Kotahi website at www.nzta.gvt.nz/projects/auckland-harbour-bridge/te-onewa-pa-stokes-point/.

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We also undertook a walkover of the Te Onewa / Stokes Point area and discussed bridge maintenance with AHB Maintenance Alliance staff. During our walkover, we observed occasional flakes of paint on the ground below the northernmost (Te Onewa) section of the AHB.

Our review initially focussed on the composition of the paints used on the Te Onewa / Stokes Point section of the AHB and the total and relative concentrations of key ingredients, including zinc, chromium and lead, and mechanisms for their potential release to the environment. We compared the paint concentrations to the concentrations found in soil samples taken from public land at Te Onewa / Stokes Point and elsewhere in Northcote; and we considered other probable sources of contamination including natural background, vehicles, building materials and uncontrolled fill.

On this basis, we conclude that there is evidence for soil contamination by zinc and chromium from bridge maintenance activities below the Te Onewa section and within the AHB 'drip zones', with a smaller contribution from transport-derived contaminants. However, elevated lead, which is present at higher concentrations than chromium, cannot be explained by bridge maintenance activities, because lead-based paints do not appear to have been used on this part of the bridge. We consider that lead is most likely principally from historic leaded petrol use.

In terms of risk to human health, we consider lead to be the contaminant of concern. Based on investigations to date, lead residues appear only to exceed residential land use standards under or immediately adjacent to the 'drip line' area on each side of AHB.

As lead has long been removed from petrol, very little further accumulation of lead is expected.

In terms of the requirement for additional studies or investigations, as we see no evidence that bridge maintenance has currently or historically resulted in soil contamination that poses an unacceptable risk to the health of residents on nearby properties, we do not think that the risk of contamination from bridge maintenance activities obliges Waka Kotahi to undertake a new health risk assessment or investigation of individual properties. This does not constitute advice to individual property owners whether or not to investigate or assess their own properties. Generally speaking, some degree of contamination can be encountered on any older urban property and those that have been close to major traffic routes.

Preamble

Waka Kotahi New Zealand Transport Agency (Waka Kotahi) operates the iconic Auckland Harbour Bridge (AHB) linking Auckland City with the suburb of Northcote on the North Shore. Waka Kotahi holds investigation reports indicating that various contaminants are present in surface soils around the northern end of the AHB, at Te Onewa / Stokes Point. Waka Kotahi is concerned about health risks to nearby residents, specifically if those risks arose from its historic bridge maintenance programme.

Accordingly, Waka Kotahi has engaged site contamination specialists from HAIL Environmental Limited (HAIL Environmental) and SLR Consulting NZ Limited (SLR) to:

- Review and assess existing information on soil contamination at Te Onewa / Stokes Point potentially arising from bridge maintenance activities; this information is publicly available on the Waka Kotahi website at www.nzta.gvt.nz/projects/auckland-harbour-bridge/te-onewa-pa-stokes-point/,
- Jointly report on the likelihood that bridge maintenance may have caused unacceptable health risks at nearby residential properties, and
- Recommend what further action, if any, Waka Kotahi should take to confirm whether or not this has occurred.

This report presents our jointly agreed opinions on these matters.

Auckland Harbour Bridge

Brief History of the AHB

The AHB was constructed between 1955 and 1959, connecting Point Erin in Auckland with Te Onewa / Stokes Point on the North Shore. Originally it was a steel box truss bridge conveying a four-lane motorway, some 1,020 m long and reaching a height of 64 m above mean high water. Traffic volumes began at 11,000 vehicles per day and rose rapidly, regularly outstripping projections. In 1969, to provide more capacity, two lanes (colloquially termed 'clip ons') were added on each side, cantilevered off the original piers. Currently the daily average is nearly 200,000 vehicle crossings.

The paint system

The AHB's steelwork is coated in zinc to protect it from the corrosive maritime environment; the zinc coating is in turn protected by a paint system. According to reports supplied by Waka Kotahi (Refs: AHB1-3, TBS, Works Consultancy):

- A 600 m² area of Span 7 at the southern end of the AHB, as well as the insides of the box girders and internal chords, did not have the zinc coating; these areas were therefore painted with a readily identifiable bright orange 'red lead' primer.
- The Bridge as a whole received three coats of primer, namely zinc chromate in an alkyd binder, and two topcoats of micaceous iron oxide pigment in an alkyd or phenolic binder. The micaceous iron oxide is not known to contain any toxic components.
- From circa 1994, zinc phosphate replaced zinc chromate, which we understand was due to concerns around chromate toxicity in occupational use (bridge maintenance). Binders also seem to have been modernised, however the paint scheme remained generally similar to the original.
- Waka Kotahi has advised the current scheme has three layers; zinc phosphate primer, moisture cured urethane and ferrox topcoat.

As of 1993 the average paint thickness was 0.77 mm. Over the full 110,000 m² of protected surface, the AHB then bore 4.4 m³ of metallic zinc, 43 m³ of primer, and 37 m³ of topcoat, as well as 0.6 m³ of red lead predominantly on Span 7 (Ref: Works Consulting).

In practice, the thickness of primer varies somewhat from point to point. Recent paint sampling (Refs: AH1-AH3) from fifteen selected sites along the AHB, averaged across the full thickness of the paint layer, found:

- Lead (Pb) in the range 160-1,400 mg/kg, except on Span 7 at 5.0 % w/w
- Chromium (Cr) at 0.01-1.4 % w/w
- Zinc (Zn) at 3-24 % w/w
- Copper (Cu) was reported at 60-120 mg/kg
- No arsenic or cadmium (above method reporting limits).

Reported ratios of lead, chromium and zinc in dust samples vary but are roughly consistent with these findings (Refs: AH1-AH3), being (excluding Span 7):

- Zn:Pb range 32 to 1138, average of 302
- Cr:Pb range 2 to 40, average of 12

- Zn:Cr range 7 to 1240, average of 88.

No comparable dust sample data are available for copper.

In sum, zinc is the major active ingredient; minor chromium is widespread; while AHB paints in the vicinity of Te Onewa / Stokes Point are not technically 'lead-based', lead seems to have been present as a trace constituent or impurity. Copper may also be present as a trace constituent.

Bridge maintenance

The AHB has never been completely stripped and repainted. Instead, the maintenance philosophy is to patch the paint system as and when necessary. Where rust patches appear, abrasive blasting is used to take the surface back to bare metal, removing deteriorated paint and corrosion products, and providing a roughened substrate suitable for repainting. Dry blasting with garnet sand abrasive (or historically, crushed basalt) is the appropriate method for the majority of the AHB. Span 7 is treated by wet blasting to minimise discharges of lead. Lead testing is undertaken before blasting, and if lead paint is present, no more than 10 m² per year is blasted.

The full three coats of paint are then replaced across the treated area. Currently about 1 % of the AHB is repainted annually (Ref: AHB3). Since zinc chromate is being progressively removed and not replaced, the total chromium content must be dropping; to put it another way, the average chromium content of the paint system must have been higher in the past.

Paint maintenance inside the hollow box girders and chords is not a regular activity. These areas are enclosed, and a chemical stripping methodology has generally been used to remove paints from areas requiring repair/strengthening. Abrasive blasting was used on a small portion of the 2008 box girder strengthening works, prior to switching to the chemical stripping methodology.

Complete containment overland has been required at Te Onewa / Stokes Point and Point Erin since 2014. It is impractical to completely contain blasting on the lower overarch, suspended high above the Waitematā Harbour.

In 2001, discharges from external paint maintenance works came under the control of a resource consent package issued by Auckland Regional Council under the Resource Management Act 1990. A replacement consent package was granted by Auckland Council in 2011, and again in late 2014, which among other things:

- Requires a maintenance works log to be reported.
- Limits the amount of garnet sand, paint and zinc discharged to coast.
- Provides a wind speed limit within which paint maintenance works may be carried out.
- Provides for buffer zones – calculated at 183 m from land for chromium, 216 m for zinc, and 343 m for lead – within which paint maintenance is subject to wind direction controls.
- Requires environmental incidents, noise and odour complaints to be reported.
- Washwater discharged to stormwater must be filtered through geotextile.

Span 7, at the southern end of the AHB, is more than 800 m from Te Onewa / Stokes Point – much more than the prescribed buffer.

Waka Kotahi has provided us with compliance inspection reports dated 27 November 2013 (discharge to air), 24 August 2015 (coastal discharge), and 8 February 2017 (discharge to air). On each occasion, a rating of 'full compliance' was given.

Transport-derived contaminants

It is important to consider that maintenance is not the only possible source of soil contamination around the AHB. Transport itself generates characteristic contaminants:

- Up until the 1990s, lead compounds were added to petrol. After combustion, all the lead content became tailpipe emissions, depositing close to the roadway.
- Brake pads are made largely of copper, and are thought to be the major source of copper to Auckland stormwater (Ref: ARC1). Historically, some heavy vehicle brake pads also contained asbestos.
- Tyres contain around 1 % zinc as a curing agent, and are thought to be a major source of zinc to Auckland stormwater (Ref: ARC1) and also contain traces of polycyclic aromatic hydrocarbons (PAH).
- Galvanised vehicle bodies release zinc as they corrode.
- Old roadways may have been formed using coal tar binders, which have moderate to high levels of PAH. The PAH are not readily leachable but would be released over a long period of time with road wear and tear, and any resurfacing work. (The bitumen binders that replaced coal tar have much lower PAH content.)

Accordingly, we expect to see elevated copper and zinc in road dust, soil, runoff and sediment along any major road, probably in the hundreds of mg/kg range (Refs: Kennedy1, ARC1). If a major road dates back before the 1990s, lead will also be elevated in these media: Ward and others found over 3,000 mg/kg of lead in the Auckland Motorway median strip in 1977. The contamination drops to background within 20-30 m of a highway (Refs: Ward1, Ward2).

However, the AHB is a special case. It is elevated above the surrounding land, presumably allowing vapour, dust and splash to disperse further before settling to ground. Stormwater and entrained road dust from the bridge has been collected, drained and discharged to sea, which should have further reduced transport contaminant load to neighbouring properties. Nonetheless, the sheer volume of traffic crossing the AHB must have resulted in some soil contamination in nearby properties.

Urban contaminants

There are other common sources of soil contaminants in the urban environment:

- Galvanised roofs are major sources of zinc to Auckland stormwater (Ref: ARC1), while iron roofs were painted with lead-based paints until recently. Older roofs may also have lead flashings and be secured with lead-headed nails.
- House paints historically contained lead, especially before 1950 when weatherboard paints could be 50 % lead by weight. When older houses were repainted, the old paint was typically sanded or 'burnt' off, creating lead-rich dust (Ref: Cameron), leading to a halo of lead contamination in soil around the house. (If the original paint was removed in accordance with Master Painters New Zealand guidelines, or is still present and in good condition, then soils may not have been affected.)
- Outdoor treated timber contains arsenic, chromium and copper, which can be released when the timber is burnt, sawn, or otherwise deteriorated.
- Similarly, asbestos-containing materials such as 'Super Six' cement sheet roofing tend to release asbestos fibres as they deteriorate.

- Ordinary domestic activities such as vehicle maintenance, fires (chimney emissions and hearth ash), spraying fruit trees and so on can also result in significant contamination, including metals and PAH.

Historically, lead in the urban environment has been a particular concern for health authorities. Unsurprisingly, the extent of contamination varies hugely between properties and within properties. Individual samples containing as much as 11 % lead in soil (110,000 mg/kg), or 15 % in house dust, have been reported (Ref: Cameron). In Auckland, some studies have shown house paint has a bigger overall effect on urban soil quality than transport (Refs: Kjellstrom, Kennedy2). Similarly, in pre-war Christchurch suburbs with much lead-based paint, house dust averaged twice as much lead as post-war suburbs (Ref: Fergusson). A South Canterbury study of pre-1940s buildings reported that 44 out of 46 had soils exceeding the 210 mg/kg residential soil contaminant standard (SCS), with typical lead levels of 300-600 mg/kg, higher values under driplines, and a highest single sample of 6,000 mg/kg (Ref: Malloch).

Northcote is generally an older suburb with many weatherboard houses, so properties around the AHB could be expected to exhibit elevated lead and other urban contaminants, in addition to any effects from bridge maintenance and transport.

Natural background

All soils naturally contain a wide range of heavy metals such as arsenic, chromium, copper, lead and zinc, typically at low concentrations. Background concentration ranges for such trace elements in Auckland soils have been established by Auckland Council (Ref: ARC2). The ranges are based on statistically validated minimum and maximum values of analytical results for undisturbed volcanic and non-volcanic soils tested from the Auckland Region. The document acknowledges that some anthropogenic impact to the soils sampled may be present, which was minimised by careful sampling site selection. Soils were not collected and analysed from urban areas. The non-volcanic parent soils comprise seven soil types; 'Waitematas', Quaternary sediments, Sands, Greywacke, Limestone, Onerahi Chaos Breccia and Manukau Breccia. Te Onewa / Stokes Point overlies the East Coast Bays Formation of the Waitematā Group; background concentrations of trace elements for non-volcanic soil type therefore apply.

Te Onewa / Stokes Point

Area of interest

For the purposes of this review, the area of interest is the ca. 230 m section of the AHB between the southern tip of Te Onewa / Stokes Point, and the point where the carriageway returns to ground. It is convenient for us to distinguish two sections within this area, which we will refer to as Te Onewa and Princes St:

- **Te Onewa section**: The elevated section predominantly of painted steel between Te Onewa / Stokes Point and North Anchorage, the first anchor point for the AHB on the northern side of the Waitematā Harbour. This section overlies the southern end of Stokes Park Reserve, an open grassed area containing the former Te Onewa pā site.
- **Princes St section:** The lower section north of North Anchorage, predominantly of concrete with less painted steel. The ground below this part of the AHB is currently paved with asphalt and is used for vehicle parking; we understand this was unpaved prior to the 2000s. Stormwater from this area is currently directed into reticulated stormwater drains.

The surrounding area of interest includes Stokes Point Reserve, which comprises open grassed land to the east and west of the AHB – here the 'eastern park' and 'western park'. North of the reserve there are residential properties on both sides of the area of interest: potentially Nos. 1-9 Princes Street (6 and 8 are west of the AHB) and 1-9 Queen Street. #9 Princes Street is owned and occupied by the AHB Maintenance Alliance that includes Waka Kotahi. This area is shown in the aerial photograph below (Figure 1).

Figure 1: Te Onewa / Stokes Point area of interest (from Auckland Council Geomaps)

Site inspection

We undertook a site inspection of Te Onewa / Stokes Point in the company of Waka Kotahi on 2 February 2021. The purpose was to familiarise ourselves with the Te Onewa / Stokes Point section of the AHB in relation to the physical environment and the locations of sampling points previously used (since 2001) to obtain soil samples for analysis as part of investigations of soil contamination within Stokes Park Reserve, including the Te Onewa section. We also met with staff from the AHB Maintenance Alliance who confirmed our understanding of bridge maintenance activities gained from our review of documents supplied by Waka Kotahi, as discussed above.

Photographs obtained during the site inspection are presented in **Appendix A** of this report.

Key observations from the site inspection were:

- The Te Onewa section comprises a relatively level area of land with sparse grass cover and occasional patches of bare earth. The area appears to have been graded or cut, presumably during bridge construction, to expose natural clay soils. A trench associated with the former pā is also present, exposing the top 1 m or so of the soil profile. Although we observed some shell debris, possibly midden, it was evident that imported fill soils are not present. The area is also almost entirely covered by the AHB and the soils were also very dry, inferred to be the result of the shelter afforded by the AHB. The over-arching bridge structure comprised predominantly painted steel. We also observed occasional large paint flakes on the ground (some > 1 cm diameter). North Anchorage is a painted steel structure.
- The western part of Stokes Point Reserve comprises a mown grass area sloping down to the west. The eastern edge of the park underlies the western edge (drip line) of the north-bound 'clip on' lane of the AHB, located some estimated 3m to 4m overhead, decreasing in elevation to the north. The balance of the park area is uncovered. A formed path leads to the ferry wharf in Shoal Bay. It is understood that the current path replaced a former asphalt path that may have contained coal tar binders. Fragments of degraded footpath seal were observed. The AHB above and adjacent to this area comprises less steel infrastructure than the Te Onewa section. The residential property at #1 Queen Street is located at the northern end of this area.
- The eastern part of Stokes Point Reserve is located on the eastern side of the AHB within the Princes Street Section. The park comprises a generally level area of mown grass between the eastern edge of Princes Street and asphalt hardstand below the AHB, to the north of North Anchorage, extending to tree lined cliffs on the edge of the Waitematā Harbour. The western edge of the park is adjacent to (not directly below) the eastern edge (drip line) of the south-bound 'clip on' lane of the AHB, which decreases in elevation towards the north where it joins State Highway 1. The section of the AHB adjacent (west) to the park comprises less steel infrastructure than the Te Onewa section. The residential property at #1 Princes Street borders the park in the north.
- Residential properties within the area of interest comprise a mix of housing types, including wooden villas and later built, brick and tile houses and units. The closest residential properties to AHB appeared to be at #1 Queen Street and #1-7 Princes Street.

Existing ground investigations

Investigations of soil contamination within the Te Onewa / Stokes Point Reserve have been undertaken for Waka Kathi and Auckland Council since 2001. A summary of these investigations based on reports provided by Waka Kotahi is presented below:

1. Ref: Opus1: This 2001 investigation comprised sampling of surface samples (~30 mm depth) at seven locations (#1-#7), with analysis for metals. Five samples (#1-#5) were taken from soil the Te Onewa section (former Te Onewa pā site). Two 'background' samples were taken from Jean Sampson Reserve located some 350 m to the north (the location of the reserve is shown on Figure 1). The stated objectives were to assess the concentrations of elements in surface soils below this section of the AHB prior to bridge maintenance, to quantify the environmental impact of maintenance on soils by comparison with post maintenance sampling results.

2. Ref: Opus2: This 2010 investigation comprised sampling of surface samples and analysis of for metals and PAH at 20 locations (AHB1 to AHB6, AHB7a and 7b and AHB8-AHB19), including resampling at six locations within the Te Onewa section, for comparison with data from 2001. Samples were also taken within Stokes Point Reserve and below the western chord of the AHB for additional soil benchmarking.
3. Ref: Tonkin + Taylor (T+T1): This 2011 investigation for Auckland Council was an extension of the Opus 2010 investigation, designed to further characterise soil contamination in Stokes Point Reserve. The information was also used as the basis of a human health risk assessment for Te Onewa / Stokes Point Reserve, prepared by T+T for Auckland Council in 2011 (Ref: T+T2). Samples were collected at 24 locations (HA1-HA24) at generally near surface (0.15 m), with additional samples at depths of 0.25 m and 0.5 m.
4. Ref: Opus3: This 2016 report prepared for Waka Kotahi was part of the preliminary assessment for pile foundations for a walkway adjacent (eastern side) to North Anchorage. Soil samples were obtained from three pile foundation boreholes (Pile 16, Pile 22, Pile 26), with analysis for metals and PAH.
5. Ref: Beca: This 2020 report documents investigations in 'Zone B' for Waka Kotahi associated with planned walkway and cycling path (northern walkway). The purpose was to investigate soil contamination to inform soil management requirements during proposed construction works. Zone B included boreholes within and adjacent to Stokes Point Reserve.

The investigations undertaken between 2001 and 2011 were directed at establishing the concentrations (benchmarking) of metals and PAH in soils in public areas within the study area. Initially, the sampling targeted soils in the Te Onewa section only. This survey was repeated in 2010 in an attempt to assess the impact of bridge maintenance within the Te Onewa section, which provided inconclusive results. The 2010 work also comprised sampling below the drip lines of the AHB and also extended to the eastern park of Stokes Point Reserve to benchmark park soils. The investigation in 2011 increased the number of sampling locations within the public land to the east and west of the AHB. No samples have been collected from hardstanding areas below the AHB to the north of North Anchorage.

These sampling locations are presented as reported (Ref: T+T1) in **Appendix B** to this report.

The investigations demonstrated the of presence of anthropogenically sourced metals in shallow soil (0-150 mm) generally decreasing with depth within the eastern and western parks and the presence of fill contaminated by metals and PAH, in particular within shallow soils in the western park of Stokes Point Reserve.

Tabulated data (2001 to 2011) and data plots for key contaminants are presented in **Appendix C** to this report.

There has been no soil sampling in residential properties as part of these investigations.

Waka Kotahi concerns

Waka Kotahi requested us to address four specific issues:

- The likely sources of individual soil contaminants at Te Onewa / Stokes Point.
- The conceptual model for potential soil contamination at residential properties arising from AHB maintenance activities.
- Whether it is more likely than not than any soil contamination at Te Onewa / Stokes Point arising from bridge maintenance activities has caused unacceptable health risk at nearby Northcote residential properties.

- Whether a new health risk assessment or update to the existing health risk assessment should be undertaken based on existing data.

We address those issues below. We stress that our interpretation and advice are based on information obtained from existing studies undertaken between 2001 and 2011. These existing studies were not intended to, and were not well designed for, assessing either soil contamination deposition from bridge maintenance, or soil contamination risks to residents.

Sources of soil contaminants at Te Onewa / Stokes Point

As set out above, there appears to be a wide range of soil contaminant sources at Te Onewa / Stokes Point, in addition to natural soil background, including:

- Bridge paint residues containing low levels of lead, moderate levels of chromium, and high levels of zinc.
- Sixty years of high-frequency vehicle traffic, discharging moderate levels of zinc, copper and historically lead.
- Building materials containing lead, zinc, chromium, copper, arsenic and possibly asbestos.
- Degraded footpath seal in Stokes Park that may contain PAH.
- Imported fill in parts of Stokes Park Reserve.

Bridge paint residues can be expected in the Te Onewa section, especially at the pā site, which is directly under the AHB and where large flakes of paint were observed on the ground. There is little steel in the Princes St section and hence little paint removal should have occurred. Paint residues should have a characteristic zinc » chromium » lead signature, with more chromium in older paint.

Traffic impact can be expected on both sides of the AHB, principally in the 'drip zone' and decreasing rapidly with distance away from the edge – remembering that the AHB was half its current width for the first ten years of operation and the 'drip zone' would then have been under the current AHB. Traffic impact should entail roughly similar levels of copper, lead and zinc, complicated by differing modes of emission (copper and zinc as dust from brake and tyre wear, lead vapour in tailpipe emissions) and the removal of lead from petrol in the mid-1990s.

While Stokes Park Reserve has clearly been partly filled and recontoured, based on our observations and on soil logs from ground investigations, it is not clear where the fill came from, and therefore what contaminants (if any) might be expected. Certain soil samples from the western side of Stokes Park Reserve exhibited PAH concentrations that were previously assessed as unacceptable (Ref: T+T2). Based on our observations of occasional fragments of degraded footpath seal in and on soil, and noting that the analytical chromatograms suggested a gasworks tar source, we interpret these results as deriving from localised contamination with coal tar binder. Certainly these results are not connected with the AHB, which should not be a significant source of PAH, and from which they are topographically separated by a steep surface water flow path.

Table 1 collates existing investigation data and contrasts it with background concentrations and the residential SCS (and recreational SCS for interest). From this data, we calculate:

- Average concentrations in shallow soil of 110 mg/kg chromium, 110 mg/kg copper, 280 mg/kg lead, and 1,900 mg/kg zinc at Te Onewa section,
- Average concentrations in shallow soil of 100 mg/kg chromium, 65 mg/kg copper, 390 mg/kg lead, and 1,700 mg/kg zinc within the drip zones, decreasing northwards as expected,

- Average concentrations in shallow soil of 35 mg/kg chromium, 40 mg/kg copper, 240 mg/kg lead, and 340 mg/kg zinc within the remainder of park soils, and
- Sampling in Jean Sampson Reserve, more than 100 m west of the northern motorway and approximately 350 m from Te Onewa Stokes Point, suggests the urban "background" for Northcote soils is on the order of 20 mg/kg chromium, 130 mg/kg lead and 200 mg/kg zinc. Copper was not determined in these samples.

If the Jean Sampson Park samples are indeed representative of urban background, lead has generally been enriched perhaps 40-90 mg/kg over natural background of 65 mg/kg, with little or no enrichment of chromium or zinc. Given the location of Jean Sampson Park, we believe that urban contribution to the natural background mostly likely mainly comes from historic leaded petrol use.

In our view, the presence of chromium and much zinc, well above natural background levels in Te Onewa section and within the drip zones, is a marker for bridge paint residues from maintenance activities. But this cannot explain elevated lead, which is present at higher concentrations than chromium, since paint samples contain much less lead than chromium, except at the other end of the AHB. Similarly, paints used on the AHB are not known to contain much copper. Therefore, in our view, the 'urban' lead at the Te Onewa section and within the drip zone principally comes from historic leaded petrol use; copper and some zinc arises from traffic braking. Neither of these are related to bridge maintenance. The elevated lead in eastern park soils is likely also sourced mainly from historic leaded petrol use, with slightly higher concentrations compared with Jean Sampson Park since it is closer to the motorway.

Conceptual site model for Stokes Point residential property

In contaminated land practice, we seek to form 'conceptual site models' relating the contaminant **sources**, transport **pathways**, and sensitive **receptors** present at a site. A 'contaminant linkage' is said to be present if a sensitive receptor could be exposed to a contaminant discharged from a source. If there are no complete contaminant linkages, the site is highly unlikely to pose a threat to health or the environment.

Considering Te Onewa / Stokes Point residential properties, the residents themselves are of course sensitive receptors. In the standard residential model, residents may be exposed to soil contaminants through incidental ingestion of soil-derived dust, through eating vegetables grown in their soil, and to a minor extent through skin contact with soil. Inhaling dust and vapour has been evaluated and is not believed to be an effective exposure pathway for most soil contaminants (Ref: MfE).

Considering the contaminants of interest, we believe lead is the only contaminant of concern:

- **Lead** is considered toxic, especially to children. The residential SCS for lead is 210 mg/kg (Ref: MfE).
- The properties of **chromium** depend on its chemical form. 'Zero-valent' metallic chromium is nontoxic, 'trivalent' green chromic ion has low toxicity, and 'hexavalent' orange chromate ion has high toxicity and is carcinogenic. Geological chromium is predominantly trivalent, as is the chromium in treated timber, while chromate paints are hexavalent. The residential SCS for hexavalent chromium is 460 mg/kg, considerably higher than any reported concentration at Stokes Point. The residential SCS for trivalent chromium is greater than 10,000 mg/kg, so it is not considered a risk to human health.

- **Copper** and **zinc** are toxic to aquatic life, and at elevated concentrations may be harmful to plants; but they are not considered to pose risks to human health. The residential SCS for copper is greater than 10,000 mg/kg, and zinc is not even considered a priority contaminant.
- **PAH** do not have a AHB-related source. Elevated PAH concentrations in soil samples from parts of Stokes Point Reserve appear to be related to a deteriorated sealed pathway, which is a localised issue unlikely to affect residential properties.

The standard residential model which underpins the SCS shown in **Table 1** suggests lead and chromium are primarily harmful through **dust ingestion**, **vegetable consumption** being a secondary route, and not at all absorbed through the skin (Ref: MfE). The location of any vegetable garden within a given residential property is therefore relevant but not critical. However, we note that this standard model includes 10 m² of vegetable garden per household, no children with pica (geophagia – deliberate soil consumption), no keeping chickens, etc. We did not check these assumptions during our site inspection. The SCS for lead increases to 250 mg/kg in the absence of a vegetable garden.

In our view, sources of lead in residential properties at Te Onewa / Stokes Point include natural background, and urban background principally from historic leaded petrol use, but also from building materials such as lead-based paints. At Jean Sampson Park, some 350 m north of Te Onewa/Stokes Point and some 100 m west of the northern motorway, natural and urban background together appear to account for around 60 % of the SCS, increasing with proximity to AHB.

Nonetheless, based on investigations to date, lead residues appear only to be potentially significant (consistently exceed the residential land use SCS) under or immediately adjacent to the 'drip line' area on each side of AHB, potentially including parts of some residential properties on Princes Street and one property on Queen Street. We conclude that the urban lead component principally comes from historic leaded petrol use. The other properties in the area of interest are further from the AHB and are therefore less likely to be as affected by traffic sources, though they may still have their own issues around building materials. Helpfully, none of these properties currently have vegetable gardens within the 'drip line', a site-specific consideration that decreases the actual risk.

As lead has long been removed from petrol, very little further accumulation of lead is expected.

Residual health risks from bridge maintenance

Existing investigations collected no data from residential properties. Accordingly, it is not possible to give an unequivocal opinion on residual health risks.

Nonetheless, based on the information available, we see no evidence or mechanism to indicate that historic or ongoing bridge maintenance poses a risk to residents' health, because:

- The Princes Street section close to residents contains relatively little paint.
- Paint constituents have only been found under or close to the AHB – they have not been distributed far from painted steel.
- Current paint removal is subject to a range of controls including partial enclosure, wind strength and wind direction limits.
- The principal contaminant in the paint system appears to be zinc, which is of little concern from a health perspective.

- Chromium, a secondary contaminant, is toxic but has not been found in either soils or paint in concentrations likely to have an adverse effect on residents' health. As zinc chromate paint has been progressively removed through many cycles of spot maintenance, very little further accumulation of chromium is expected.
- Lead concentrations in paint are low except at Span 7 at the other end of the AHB, too far away to have any impact at Stokes Point.

Existing health risk assessments

There have been two health risk assessments for the Te Onewa / Stokes Point area:

— *Stokes Point Reserve, Northcote: Soil Contamination, Human Health Risk Assessment*, report to Auckland Council Environmental Services Unit, Tonkin and Taylor Limited, Auckland, 2011 (Ref: T+T2).
— *Te Onewa Point: Human Health Risk Assessment*, report to Waka Kotahi, GHD Limited, Auckland, 2013 (Ref: GHD).

The T+T assessment relates to the Stokes Point Reserve. T+T concluded that lead concentrations in near surface soils are not unacceptable, but that there is a limited area of PAH contamination that should be isolated. As we have set out above, we believe this PAH contamination is not from the AHB; therefore, we do not see any need for Waka Kotahi to conduct any further assessment or take any further action in relation to this.

The GHD report attempts to infer risks to residents around Te Onewa / Stokes Point. GHD assumed that T+T soil samples from the reserve, supplementary Opus samples from the reserve, and GHD samples from the southern end of the bridge, were representative of soils within residential properties. GHD considered that lead exceeded generic residential SCS 'consistently' across these areas, which suggested to GHD that there was a potential risk to residents' health; GHD proceeded to do some detailed quantitative risk assessment that indicated the inferred risk was generally within acceptable bounds.

As we have set out above, we do not think GHD's assumption was reasonable; we consider that lead residues appear to be significant (in relation to the SCS) only under the AHB or in the 'drip line' area on each side of it. We also see no reason why soil concentrations at the south end of the AHB (where lead-based paint was used on nearby Span 7) should be representative of soils at the north end (where it was not used). Therefore, we disagree that soil lead concentrations at Te Onewa / Stokes Point 'consistently' exceed SCS. Accordingly, it should not be assumed that residential properties are also above SCS. We therefore do not think GHD's health risk assessment is valid. We do not mean to imply that GHD was wrong and that there *is* an unacceptable risk to residents' health; simply that the information that GHD had was not sufficient to reach a conclusion one way or the other.

Should a new health risk assessment be undertaken?

Our assessment has identified the potential for lead in soil at concentrations close to or exceeding the SCS, to be present within residential properties adjacent to AHB at Te Onewa / Stokes Point. We believe that the urban lead contribution in these soils principally comes from the historic use of leaded petrol, and potentially other urban sources such as lead based paints. No significant contribution from bridge maintenance activities is anticipated.

Accordingly, we do not think that the risk of contamination from bridge maintenance activities obliges Waka Kotahi to undertake a new health risk assessment or investigation of individual properties. This does not constitute advice to individual property owners whether or not to investigate or assess their own properties. Generally speaking, some degree of contamination can be encountered on any older urban property and those that have been close to major traffic routes.

Undertaking a contaminant source attribution investigation is complex and would require investigation of individual properties. Such investigations would need to be designed to distinguish between potential sources such as the AHB / traffic, historic building materials and imported fills. In our view transect sampling at several depths would be the best approach. Ideally 'control' properties on Northcote Point but further from the AHB would be included.

Conclusions

Our interpretation and advice are based on existing studies that were not designed for assessing either soil contamination deposition from bridge maintenance, or soil contamination risks to residents. There has been no sampling directly from residential properties. With these caveats, in our expert opinion:

- We see no evidence or mechanism to indicate that historic or ongoing paint maintenance poses a risk to residents' health via contaminants in soil.
- Bridge paint maintenance activities have had localised impact on Te Onewa / Stokes Point, but most likely confined to the areas underneath and immediately adjacent to the AHB, in particular within the Te Onewa section.
- The principal soil contaminants from paint maintenance have been zinc and chromium. Zinc is of little concern from a health perspective. Chromium has not been observed to approach residential soil contaminant standards.
- Within the same area, there appears to have been soil contamination from other sources, notably lead from the historic use of leaded petrol.
- We expect that building materials such as leaded paint, galvanised roofing and treated timber decking may also have made contributions within individual properties.
- In terms of the contribution to risk from bridge maintenance activities, we consider that no further investigations are required.

We do not consider that Waka Kotahi is obliged to undertake any further assessment of the health risk to residents arising from contamination of soil from bridge maintenance activities.

Limitations

This memorandum has been prepared for Waka Kotahi by HAIL Environmental and SLR in accordance with the purpose and scope set out above, and the usual care and thoroughness of the consulting profession. Any use of any part of this letter by any other party, or in any other context, is the responsibility of the user.

A detailed review of the site and surrounding area in relation to potential hazardous activities and industrial land uses was not included in this limited assessment. Information from cited sources has not been independently verified unless specifically stated, and HAIL Environmental and SLR assume no responsibility for any inaccuracy or omission therein.

This memorandum does not purport to give legal or financial advice.

Yours sincerely,

Dr. Dave Bull CEnvP-SC CChem
Site Contamination Specialist, Director
HAIL Environmental

Kevin Tearney CEnvP-SC
Principal
SLR Consulting NZ Limited

Table 1. Contaminants of concern at Stokes Point

	Natural background (Non-Volcanics)	Urban background (Jean Sampson Park)	Te Onewa Pā	Drip Zone	Rest of Stokes Point Reserve	Residential SCS	Recreational SCS
Chromium	2-55	19,19	44-171	36-220	14-87	**>10,000 (trivalent) 460 (hexavalent)**	**>10,000 2,700**
Copper	1-45	Not determined	26-510	23-220	9-161	**>10,000**	**>10,000**
Lead	<1.5-65	108,157	150-**644**	106-**570**	19-**410**	**210**	**880**
Zinc	9-180	192,208	746-6,100	420-5,500	75-640	**Not assessed**	**Not assessed**
PAH*	Not determined	Not determined	0.1	0.2-8.6	0.4-**83**	**10**	**40**

All concentrations in mg/kg. Results exceeding residential SCS in **bold**. Results exceeding recreational SCS in **orange.**

* PAH concentrations expressed as benzo[a]pyrene (‘BaP’) toxic equivalents. Not determined in one investigation (Ref: Opus2).

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Works Consultancy: Auckland Harbour Bridge: assessment of effects on the environment of steelwork maintenance by abrasive blasting methods. Works Consultancy Services, Auckland. 1993.

Appendix A – Site inspection: selected photographs

2 February 2021. Te Onewa Section; LHS – view to north towards North Anchorage; RHS – View to south from trench adjacent to North Anchorage showing Waitematā soils.

2 February 2021. Te Onewa Section; LHS – view to west from Anchorage; RHS – Paint flakes

2 February 2021. Western Park; LHS – view to north towards #1 Queen Street from North Anchorage; RHS – view to south showing North Anchorage.

2 February 2021. Western Park; LHS – view to west; RHS – former path to ferry wharf showing Waitematā soils.

2 February 2021. LHS – residential property #1 Queen Street; RHS – view to north east of hard stand area below AHB between eastern and western parks.

2 February 2021. LHS – view to south east showing North Anchorage; RHS – view to south of bridge under-structure.


2 February 2021. LHS – view to east along Princes Street towards eastern park (Stokes Point Reserve); RHS – view to north of bridge under-structure and hard stand area.


2 February 2021. LHS – view to south along Princes Street towards eastern park (Stokes Point Reserve); RHS – view to west from Stokes Point Reserve.

2 February 2021. LHS – view to north along Princes Street towards residential property at #6 Princes Street; RHS – view to south showing residential property at #6 Princes Street.

Google Maps Street View. – View to south from close to #20 Princes Street.

Appendix B – Sampling locations (from Ref: T+T1)

Appendix C – Tabulated data and plots

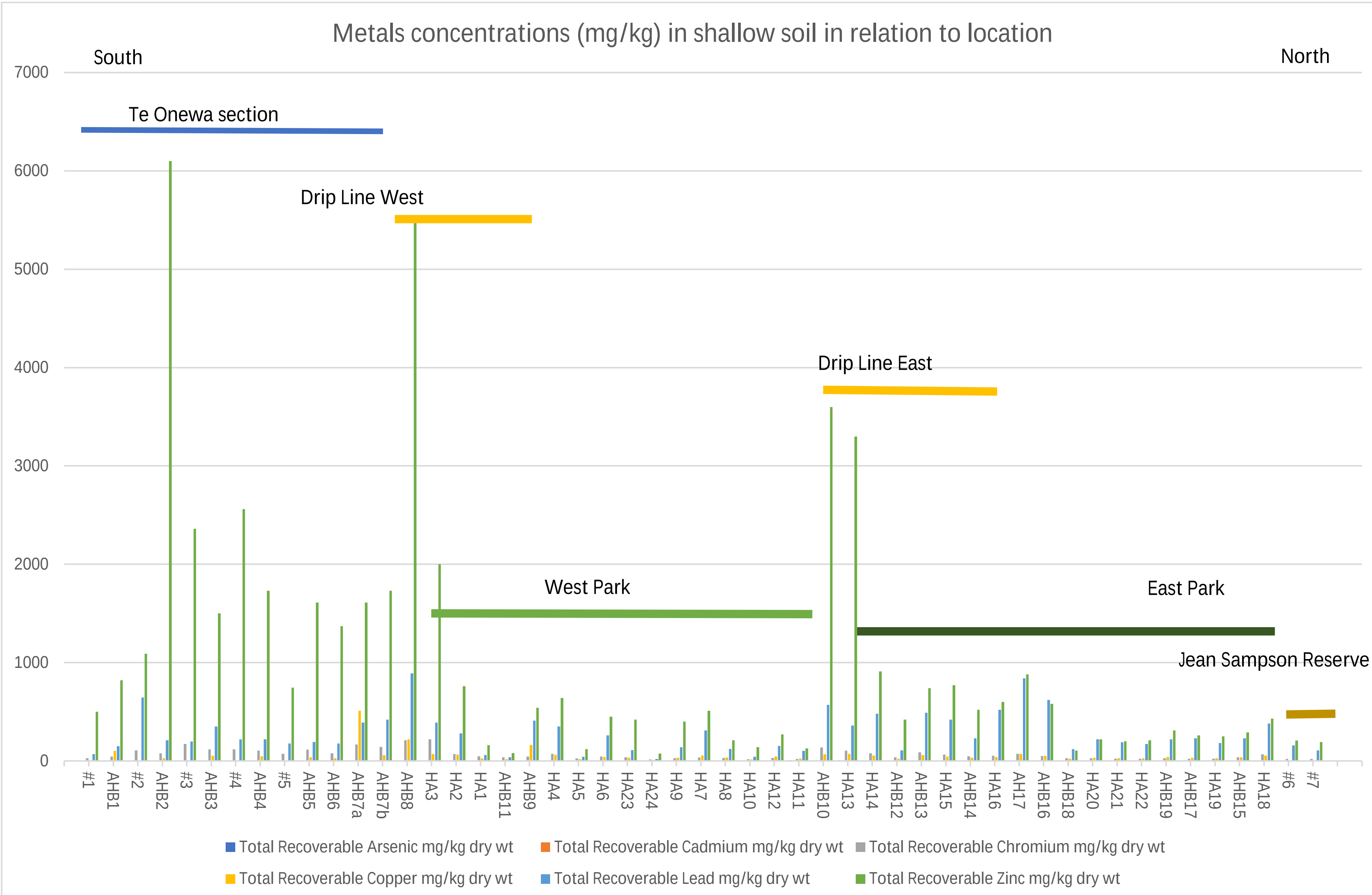
Location		#1	#2	#3	#4	#5	#6	#7
Opus 2001							Jean Sampson Reserve	
Total Recoverable Chromium	mg/kg dry wt	26	106	171	117	71	19	19
Chromium VI	mg/kg dry wt	<0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total Recoverable Lead	mg/kg dry wt	69.6	644	197	219	176	157	208
Total Recoverable Zinc	mg/kg dry wt	501	1090	2630	2560	746	108	192

Location		AHB1	AHB2	AHB3	AHB4	AHB5	AHB6	AHB7a	AHB7b	AHB8	AHB9	AHB11	AHB10	AHB12	AHB13	AHB14	AHB15	AHB16	AHB17	AHB18	AHB19
Opus 2010																					
Total Recoverable Arsenic	mg/kg dry wt																				
Total Recoverable Cadmium	mg/kg dry wt																				
Total Recoverable Chromium	mg/kg dry wt	44	76	116	105	115	76	168	141	210	44	38	136	36	87	48	38	49	23	26	26
Total Recoverable Copper	mg/kg dry wt	101	27	52	47	36	26	510	57	220	161	18	67	23	60	31	36	53	33	23	40
Total Recoverable Lead	mg/kg dry wt	150	210	350	220	193	176	390	420	890	410	36	570	106	490	230	230	620	230	119	220
Total Recoverable Zinc	mg/kg dry wt	820	6100	1500	1730	1610	1370	1610	1730	5500	540	79	3600	420	740	520	290	580	260	104	310
B(a)P/B(a)Peq	mg/kg dry wt	0.07		0.06			0.08						8.6				2.01			5.95	

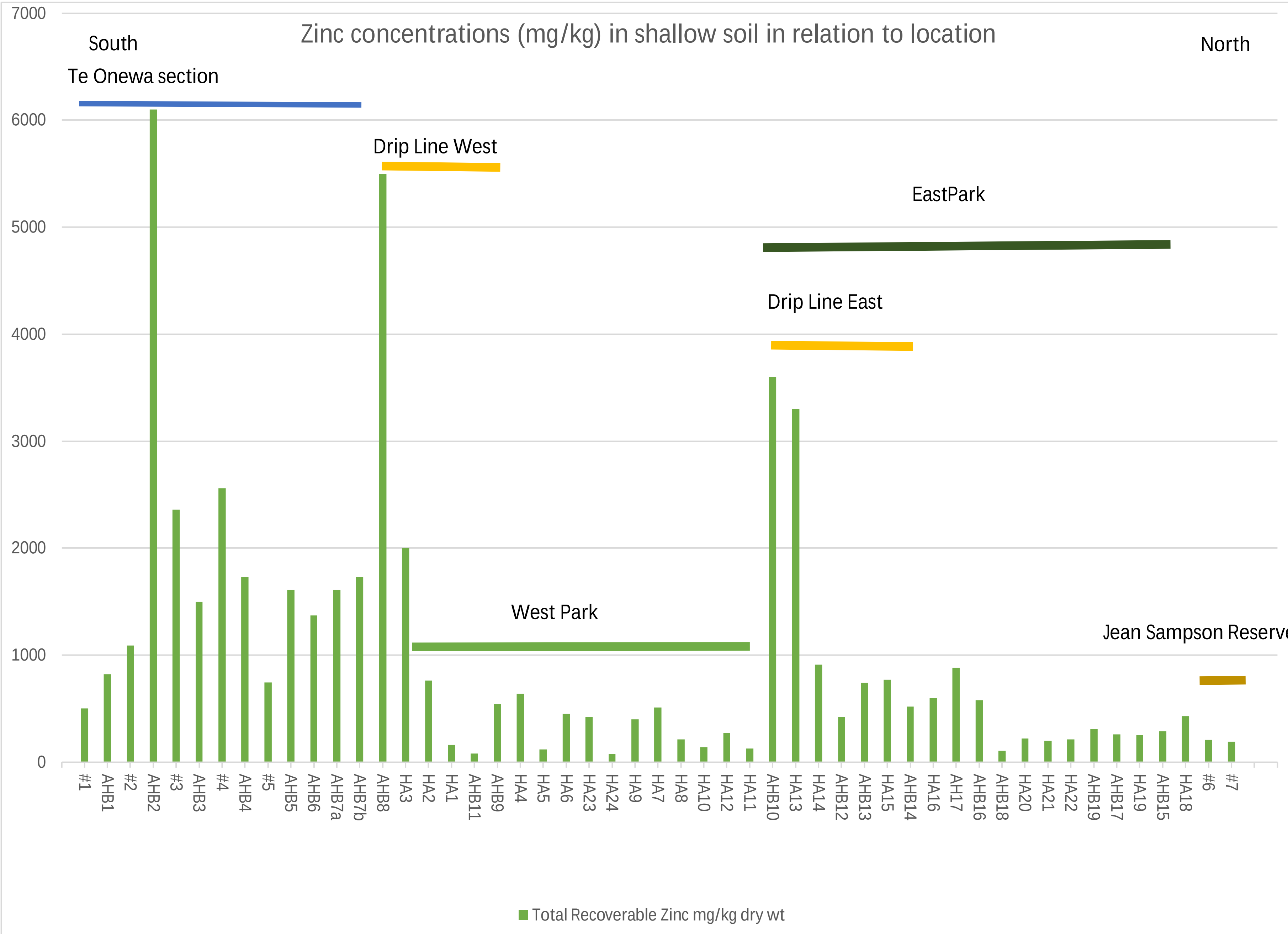
Location		HA1	HA2	HA2	HA3	HA4	HA4	HA5	HA5	HA5	HA6	HA7	HA6	HA7	HA7	HA8	HA8	HA8	HA9	HA9	HA10
T+T 2011																					
Sample ID		S1	S1	S2	S1	S1	S2	S1	S2	S3	S1	S1	S2	S2	S3	S1	S2	S3	S1	S2	S1
Soil Type		TS	TS	ZC c shell	Fill	TS	S	TS	Fill	SZ	TS	TS c shell	Z	ZC c clinker	ZC	TS c clinker	Z	Z	TS c clinker	ZC c clinker	TS
Depth (m bgl)	Unit	0	0	0.25	0	0	0.25	0	0.25	0.5	0	0	0.25	0.25	0.5	0	0.25	0.5	0	0.25	0
Heavy Metals																					
Total Recoverable Arsenic	mg/kg dry wt	4	5	<2	2	5		3	5		4	4		3		4			4		4
Total Recoverable Cadmium	mg/kg dry wt	0.38	1.3	<0.1	0.74	1.1		0.21	0.5		0.46	0.6		<0.10		0.32			0.32		0.14
Total Recoverable Chromium	mg/kg dry wt	48	69	10	220	72		24	27		45	35		9		30			27		18
Total Recoverable Copper	mg/kg dry wt	24	64	6	69	63		17	36		40	55		6		34			32		15
Total Recoverable Lead	mg/kg dry wt	60	280	13.3	390	350	94	42	460	31	260	310	36	15.8	12.4	123	9.4	9.8	139	15.6	41
Total Recoverable Nickel	mg/kg dry wt	25	38	6	122	54		16	25		30	37		22		79			22		19
Total Recoverable Zinc	mg/kg dry wt	160	760	34	2000	640	155	120	360	35	450	510	59	15	9	210	4	7	400	25	139
B(a)P/B(a)Peq	mg/kg dry wt	0.4/0.61	0.73/1.11	<0.03/0.04	0.12/0.18	2.8/4.08	2.1/2.98	0.77/1.12	9.1/13.39	0.42/0.60	2.1/3.07	5.9/8.76	0.69/0.98	9.4/13.97	32/45.94	56/82.97	0.21/0.30	0.19/0.27	6.5/10.07	4.8/6.88	16.4/24.77

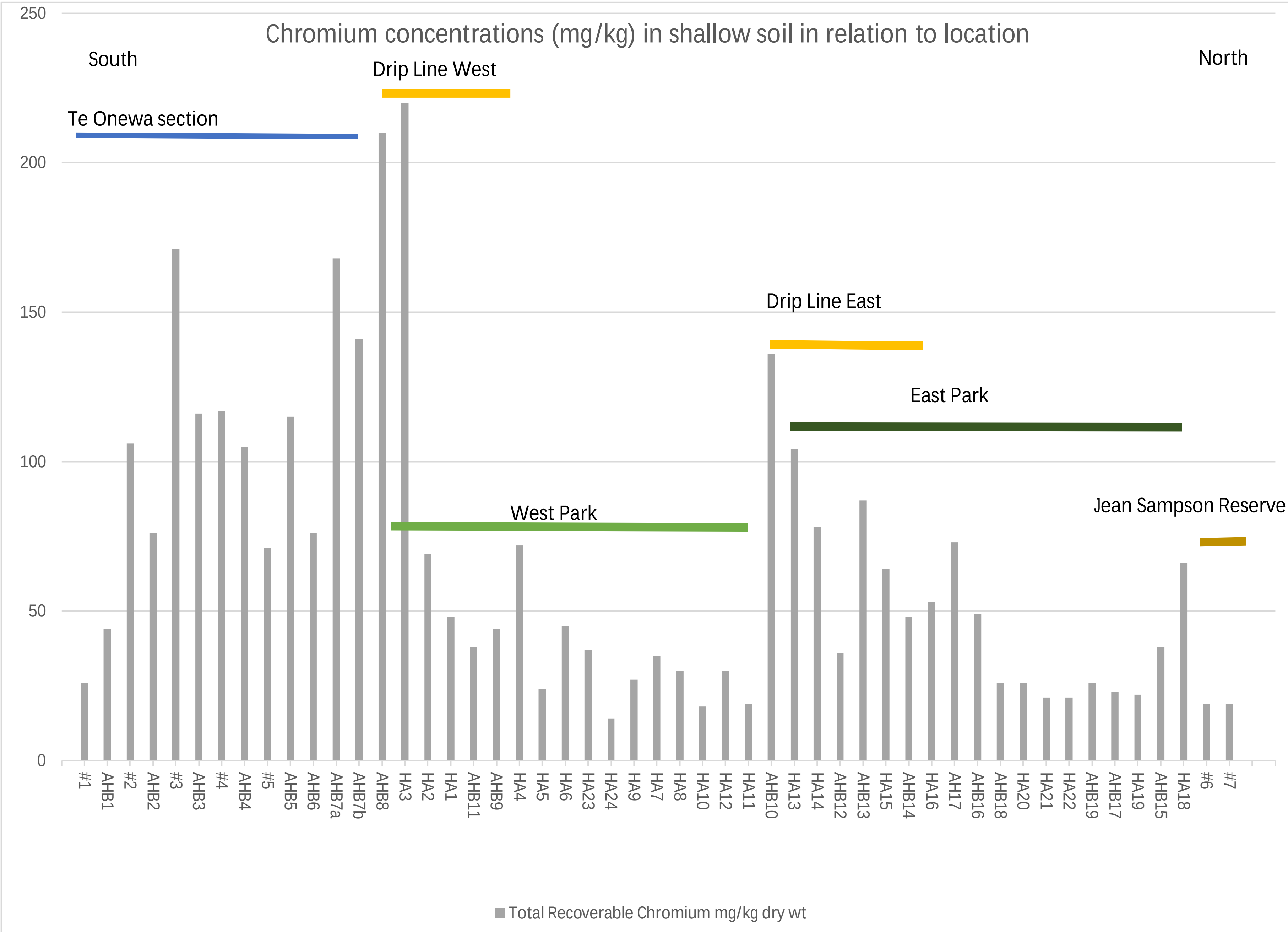
Location		HA10	HA11	HA11	HA11	HA12	HA12	HA12	HA13	HA13	HA14	HA15	HA15	HA16	HA17	HA17	HA17	HA18	HA18	HA19	HA19
T+T 2011																					
Sample ID		S2	S1	S2	S3	S1	S2	S3	S1	S2	S1	S2	S1	S1	S1	S2	S3	S1	S2	S1	S2
Soil Type		Z c charcol	Z c ash	Z	Z	TS	Z c clinker	Z	TS	Z	TS	S c shell	TS	TS	TS	SZ	ECBF	TS c fill	C	TS	SZ
Depth (m bgl)	Unit	0.25	0	0.25	0.5	0	0.25	0.5	0	0.5	0	0.25	0	0	0	0.25	0.5	0	0.25	0	0.25
Heavy Metals																					
Total Recoverable Arsenic	mg/kg dry wt		6			5	2		7	2	4	3	3	3	3	2		4		<2	<2
Total Recoverable Cadmium	mg/kg dry wt		0.21			0.42	<0.10		1.18	0.14	1	0.27	1.52	0.68	1.09	0.16		0.55		0.22	<0.10
Total Recoverable Chromium	mg/kg dry wt		19			30	11		104	19	78	64	64	53	73	21		66		22	11
Total Recoverable Copper	mg/kg dry wt		25			45	9		72	18	55	27	44	40	70	17		55		26	3
Total Recoverable Lead	mg/kg dry wt	10.2	103	32	12.8	152	11	8.7	360	65	480	79	420	520	840	109	5.4	380	93	183	11.2
Total Recoverable Nickel	mg/kg dry wt		130			45	6		58	15	41	45	27	27	47	45		36		10	6
Total Recoverable Zinc	mg/kg dry wt	11	126	30	14	270	15	20	3300	103	910	320	770	600	880	102	4	430	260	250	10
B(a)P/B(a)Peq	mg/kg dry wt	6.5/9.38	20/30.47	9.7/14.09	1.98/2.85	4.4/6.78	6.4/9.69	0.07/0.24	1.22/2.00	0.05/0.08	1.20/1.85	1.24/1.93	2.33/3.44	1.14/1.74	2.3/3.46	7.3/10.95	<0.03/0.04	1.41/2.14	1.75/2.56	0.18/0.29	<0.03/0.04

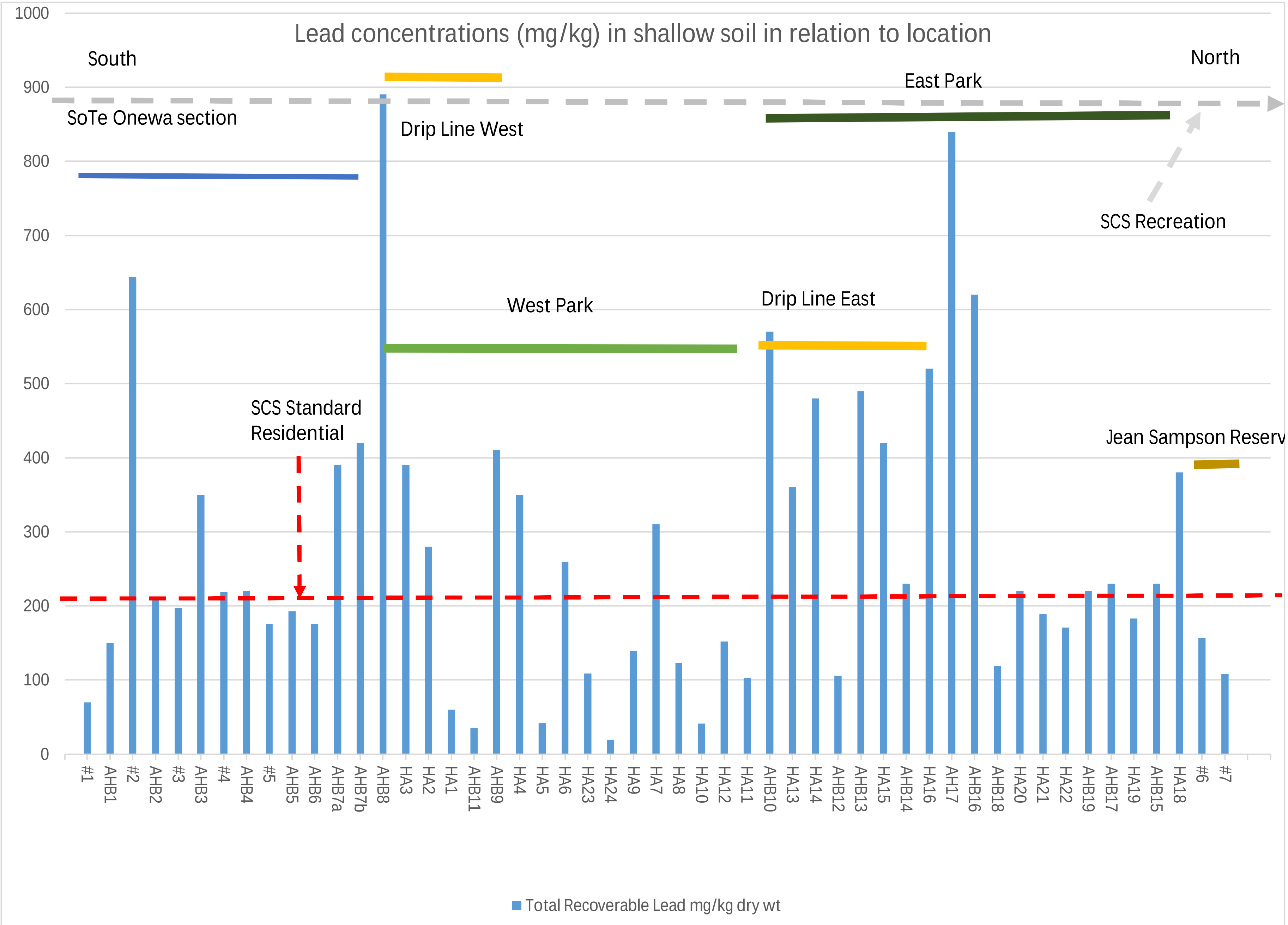
Location		HA20	HA20	HA21	HA22	HA22	HA23	HA24
T+T 2011								
Sample ID		S1	S2	S1	S2	S3	S1	S1
Soil Type		TS	SZ	SZ	CZ	ZC	organic matter	ZC
Depth (m bgl)	Unit	0	0.25	0	0	0.5	0	0
Heavy Metals								
Total Recoverable Arsenic	mg/kg dry wt	2		<2	2	<2	3	3
Total Recoverable Cadmium	mg/kg dry wt	0.27		0.24	0.24	<0.10	0.27	<0.01
Total Recoverable Chromium	mg/kg dry wt	26		21	21	14	37	14
Total Recoverable Copper	mg/kg dry wt	31		27	27	3	32	9
Total Recoverable Lead	mg/kg dry wt	220	68	189	171	7.5	109	19.1
Total Recoverable Nickel	mg/kg dry wt	36		14	10	6	51	4
Total Recoverable Zinc	mg/kg dry wt	220	70	200	210	14	420	75
B(a)P/B(a)Peq	mg/kg dry wt	2.06	2.69	1.71	0.59	0.04	1.56	0.44



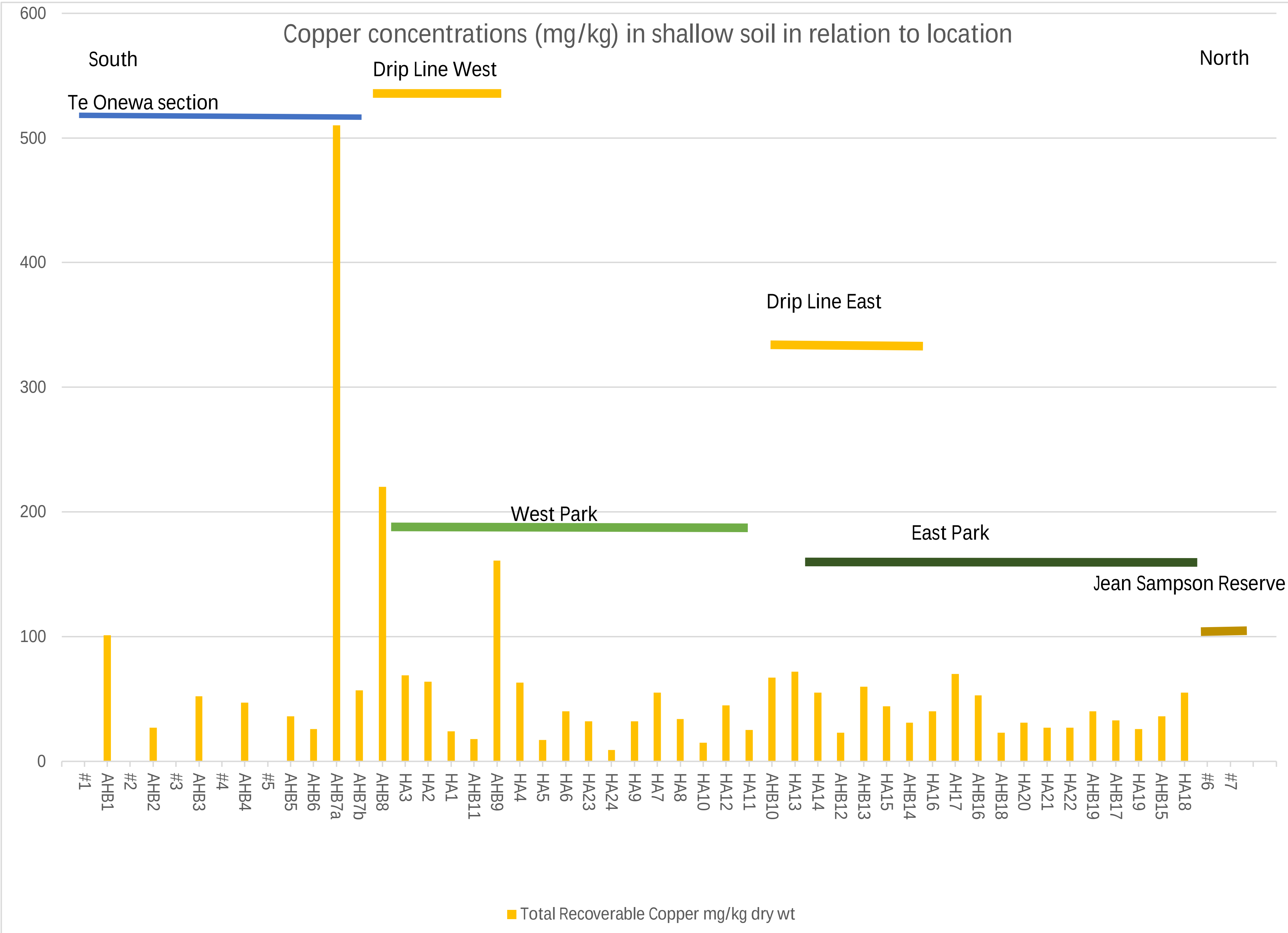
Metals concentrations (mg/kg) in shallow soil in relation to location
South
North
Te Onewa section
Drip Line West
Drip Line East
West Park
East Park
Jean Sampson Reserve
7000
6000
5000
4000
3000
2000
1000
0
#1
AHB1
#2
AHB2
#3
AHB3
#4
AHB4
#5
AHB5
AHB6
AHB7a
AHB7b
AHB8
HA3
HA2
HA1
AHB11
AHB9
HA4
HA5
HA6
HA23
HA24
HA9
HA7
HA8
HA10
HA12
HA11
AHB10
HA13
HA14
AHB12
AHB13
HA15
AHB14
HA16
AH17
AHB16
AHB18
HA20
HA21
HA22
AHB19
AHB17
HA19
AHB15
HA18
#6
#7
Total Recoverable Arsenic mg/kg dry wt
Total Recoverable Cadmium mg/kg dry wt
Total Recoverable Chromium mg/kg dry wt
Total Recoverable Copper mg/kg dry wt
Total Recoverable Lead mg/kg dry wt
Total Recoverable Zinc mg/kg dry wt


Zinc concentrations (mg/kg) in shallow soil in relation to location
South
North
Te Onewa section
Drip Line West
EastPark
Drip Line East
West Park
Jean Sampson Reserve
7000
6000
5000
4000
3000
2000
1000
0
#1
AHB1
#2
AHB2
#3
AHB3
#4
AHB4
#5
AHB5
AHB6
AHB7a
AHB7b
AHB8
HA3
HA2
HA1
AHB11
AHB9
HA4
HA5
HA6
HA23
HA24
HA9
HA7
HA8
HA10
HA12
HA11
AHB10
HA13
HA14
AHB12
AHB13
HA15
AHB14
HA16
AH17
AHB16
AHB18
HA20
HA21
HA22
AHB19
AHB17
HA19
AHB15
HA18
#6
#7
Total Recoverable Zinc mg/kg dry wt

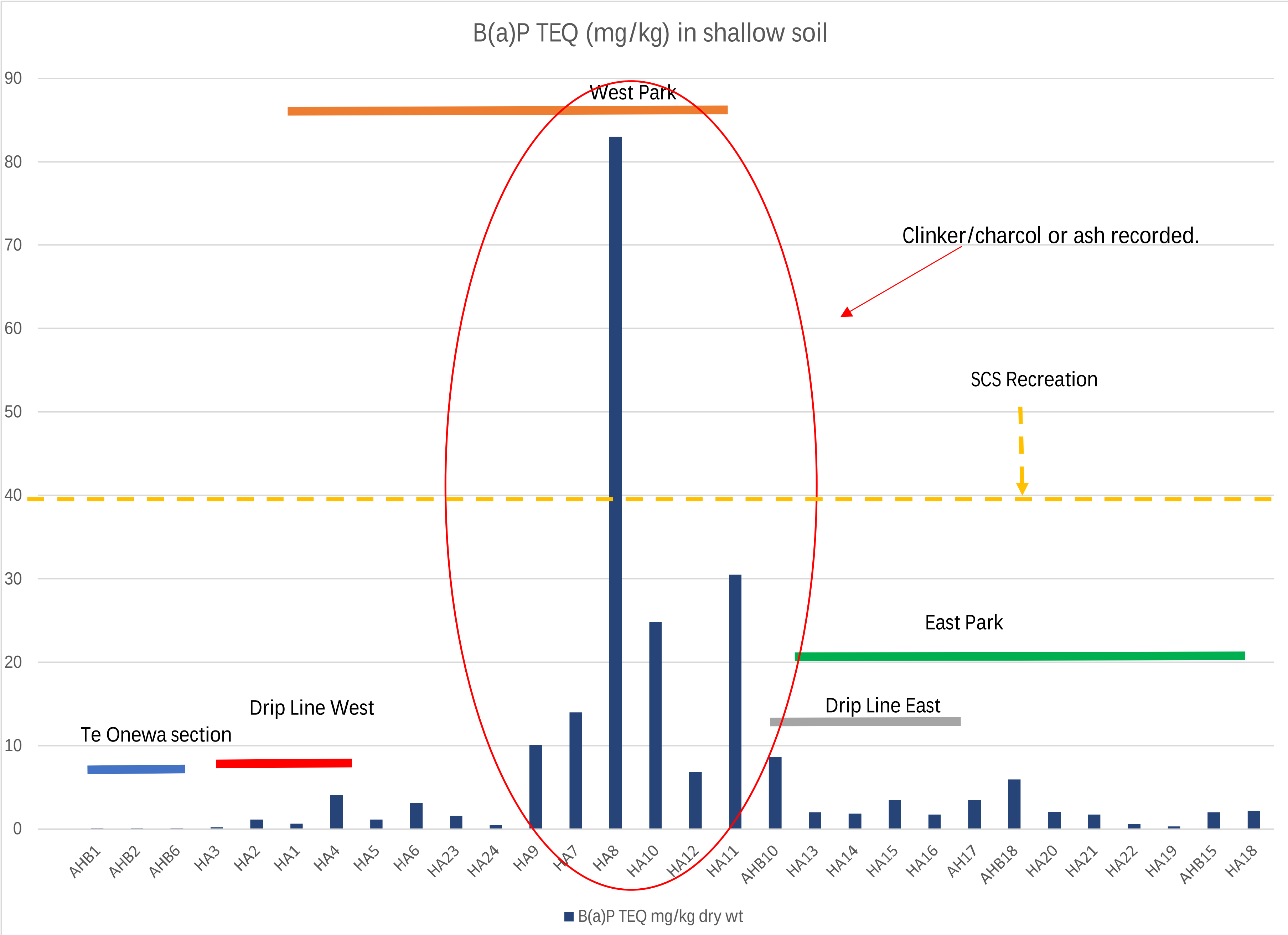

Chromium concentrations (mg/kg) in shallow soil in relation to location
South
North
Drip Line West
Te Onewa section
Drip Line East
East Park
West Park
Jean Sampson Reserve
250
200
150
100
50
0
#1
AHB1
#2
AHB2
#3
AHB3
#4
AHB4
#5
AHB5
AHB6
AHB7a
AHB7b
AHB8
HA3
HA2
HA1
AHB11
AHB9
HA4
HA5
HA6
HA23
HA24
HA9
HA7
HA8
HA10
HA12
HA11
AHB10
HA13
HA14
AHB12
AHB13
HA15
AHB14
HA16
AH17
AHB16
AHB18
HA20
HA21
HA22
AHB19
AHB17
HA19
AHB15
HA18
#6
#7
Total Recoverable Chromium mg/kg dry wt



Lead concentrations (mg/kg) in shallow soil in relation to location
South
North
SoTe Onewa section
Drip Line West
East Park
SCS Recreation
West Park
Drip Line East
SCS Standard Residential
Jean Sampson Reserv
1000
900
800
700
600
500
400
300
200
100
0
#1 AHB1 #2 AHB2 #3 AHB3 #4 AHB4 #5 AHB5 AHB6 AHB7a AHB7b AHB8 HA3 HA2 HA1 AHB11 AHB9 HA4 HA5 HA6 HA23 HA24 HA9 HA7 HA8 HA10 HA12 HA11 AHB10 HA13 HA14 AHB12 AHB13 HA15 AHB14 HA16 AH17 AHB16 AHB18 HA20 HA21 HA22 AHB19 AHB17 HA19 AHB15 HA18 #6 #7
Total Recoverable Lead mg/kg dry wt



Copper concentrations (mg/kg) in shallow soil in relation to location
South
North
Te Onewa section
Drip Line West
Drip Line East
West Park
East Park
Jean Sampson Reserve
600
500
400
300
200
100
0
#1 AHB1 #2 AHB2 #3 AHB3 #4 AHB4 #5 AHB5 AHB6 AHB7a AHB7b AHB8 HA3 HA2 HA1 AHB11 AHB9 HA4 HA5 HA6 HA23 HA24 HA9 HA7 HA8 HA10 HA12 HA11 AHB10 HA13 HA14 AHB12 AHB13 HA15 AHB14 HA16 AH17 AHB16 AHB18 HA20 HA21 HA22 AHB19 AHB17 HA19 AHB15 HA18 #6 #7
Total Recoverable Copper mg/kg dry wt



B(a)P TEQ (mg/kg) in shallow soil
90
80
70
60
50
40
30
20
10
0
West Park
Clinker/charcol or ash recorded.
SCS Recreation
East Park
Drip Line West
Drip Line East
Te Onewa section
AHB1
AHB2
AHB6
HA3
HA2
HA1
HA4
HA5
HA6
HA23
HA24
HA9
HA7
HA8
HA10
HA12
HA11
AHB10
HA13
HA14
HA15
HA16
AH17
AHB18
HA20
HA21
HA22
HA19
AHB15
HA18
B(a)P TEQ mg/kg dry wt