Proceedings of WASTEMINZ 10th Annual Conference, November 1998, Rotorua p129-137

INVESTIGATION OF CONTAMINATED SHEEP DIPPING SITES IN THE WAIKATO

Graham McBride, WaiPAC, PO Box 1160, Hamilton

Patrick Holland, Horticulture & Food Research Institute, Ruakura Research Centre

Kristen Wilson, University of Waikato

INTRODUCTION

The Waikato Pesticides Awareness Committee (WaiPAC) was formed in 1989 out of concerns regarding agrichemical use and the effects on public health, the environment and New Zealand's marketing image. It is a multi-stakeholder, voluntary community group, representing sectors affected in some way by agrichemical use or misuse, and has the objective of promoting safe and effective use of agrichemicals. WaiPAC has had a number of outstanding successes not only on the local scene but also nationally and internationally.

The first study in New Zealand to determine the level of soil contamination created by the use of sheep dips was undertaken by WaiPAC in 1994 - 'What's Cooking in the Hangi Pit?' (McBride 1994). Soil samples from seven sheep dip sites in the Waikato and Taranaki regions were tested for residues of arsenic, organochlorine (OC), organophosphate (OP), and synthetic pyrethroid (SP) classes of insecticides, all of which were, or are currently used in dip preparations. The study found that all the sites had moderate to high arsenic contamination. Additionally, dieldrin, and isomers of hexachlorocyclohexane (HCH), plus traces of DDT, DDE, aldrin and endrin, all members of the now banned OC family, were found at most sites. Cypermethrin, a modern SP dipping chemical, was found at significant levels at only one site.

These results were of considerable concern as arsenic is a probable carcinogen and international guidelines for drinking water quality (WHO 1993) recommend a limit of 10ug/L (ppb). Organochlorines such as dieldrin, besides being suspected carcinogens, also may impact on immune systems and are potential endocrine disrupters. They are persistent in the environment and bioconcentrate through the food chain into fatty tissues of higher animals, including humans. These properties led to the banning of their widespread use in most countries over 20 years ago, including New Zealand, but their legacy remains.

History of dipping Legislation

The contamination of sheep dip sites arose through past actions, sanctioned and enforced by legislation. The health of sheep in New Zealand has been a matter of concern and law for nearly 150 years. From 1849 various legislation relating to sheep was enacted until a major review resulted in The Sheep Act of 1890, which aimed to consolidate previous statutes while providing for the "eradication and prevention of parasitic and other diseases in sheep". Offences against the Sheep Act 1890 under section 75 were "punishable by imprisonment with or without hard labour". The Stock Act 1908 introduced compulsory dipping as a further measure to combat the spread of sheep diseases. This required sheep owners "to dip all sheep between the period of 1 October in every year and 30 April following". Failure to dip sheep was an offence punishable by a maximum fine of two shillings per sheep not dipped.

The Stock Act was replaced by the Animals Act 1967. In addition to compulsory dipping, this act required that dipping must be carried out with an effective dip preparation for destroying parasites i.e. preparations that were approved for dipping purposes by the Animals Remedies Board. The Animal Remedies Amendment Act 1982 sought to further clarify this issue by amending section 56(2) to also include "that dipping be carried out in accordance with any other directions given on the approved label". These pieces of legislation have now been superseded by the BioSecurity Act 1993.

Current Study

The 1994 research demonstrated that significant contamination of soil by arsenic and OCs has occurred at dip sites. However the study did not show the distribution of the contamination as it was a scoping exercise using composite soil samples taken from likely deposition areas. As there are estimated to be over 10,000 dip sites in the Waikato, WaiPAC concluded that more information was needed to determine the risk that sheep dip sites pose to the surrounding environment and human health.

In 1997, WaiPAC received funding from Environment Waikato's (EW) Environmental Initiatives Fund for a project to further investigate contaminated dipping sites in the region. Study objectives include determining the likely extent of soil contamination around known sheep dipping sites and evaluating risks to surface and groundwater, grazing animals and human health. Being a voluntary group, WaiPAC's objectives for the research were shaped by time and monetary constraints. The 1994 investigation on sheep dip sites found no detectable levels of organophosphate compounds in soil, and synthetic pyrethroids were only detected in one sample. This study focussed therefore on the more persistent chemicals: arsenic and members of the organochlorine family. The project was collaborative with HortResearch and the University of Waikato providing technical inputs. As part of achieving the study objectives, a Scholarship was awarded to a student to complete a thesis (Wilson 1998) on contaminated dip sites. WaiPAC has also explored the issue of liability for these contaminated sites in view of the compulsory dipping in the past, enforced by Government legislation.

METHODS

The Study Sites

Four sheep dip sites were selected from around the Waikato Region to be included in the study. Sites 2 (Te Kowhai) and 3 (Te Kauwhata) were included in the 1994 WaiPAC scoping study. A crucial factor in selecting sites for this study was the cooperation of the landowners and this has been facilitated by keeping the specific locations of each site confidential.

Site 1 - Ngahinapouri

This site was identified during 1995 when dieldrin residues were found in ground water samples (Hadfield and Smith, 1997). A dip sump on the property is the likely source of contamination. It was operated between 1954 - 1961, dipping 500-600 sheep annually and the spent dip solution was pumped onto land adjacent to the sump. The site is flat and has been extensively cultivated and is currently covered in a deep rooted vegetable crop. The farm water well is located approximately 15m from the dip site and ground water flow from the dip is towards the well. Soils are free draining Horotiu sandy loam.

Site 2 - Te Kowhai

This site was identified by WaiPAC in 1994 as being very heavily contaminated by arsenic, lindane and dieldrin (McBride 1994) and was included in this study in order to focus on the distribution of the arsenic contamination. This site was operated as a sheep farm from around 1932 until 1970. There is evidence that this dip was in communal use. The old dip is clearly visible, situated on the edge of a small gully. The surrounding land is covered in pasture and the soil is Whatawhata clay-loam with moderate drainage characteristics. The out-fall pipe of the dip leads down into the gully where a stream forms and discharges into a nearby river. The stream bed is a muddy channel and soils are from the Waikato series - loamy sand in the top and sand in the lower levels. In recent years the drainage platform from the dip was unknowingly used as a communal hangi pit and barbecue spit area.

Site 3 - Te Kauwhata

The site first came to the attention of WaiPAC in 1993 when two heifers died and others were chronically poisoned by arsenic. Some areas of high arsenic contamination were established (McBride 1994). Nothing is known about the use of sheep dips on the site and the exact location of the dip is unknown. Stockyards have been built on a flat area near the edge of a steep gully in which a small spring-fed stream forms. Most of the area is covered in pasture, except for the head of the gully which is overrun with blackberries and scrub. Hamilton clay soils are evident on the flats surrounding the yards and poorly drained Rotokauri clay loam soils in the gully.

Site 4 - Hamilton

The Hamilton site was included as it lies within the urban boundary, and thus is a potential target for urban development. An old dip and draining mound are clearly visible. It appears that a woolshed existed on the site a long time ago and the dip has not been used for many years. The relatively flat land is completely covered in pasture. Soils are based on Hamilton clay loam, with areas of Te Rapa peaty sand in a nearby shallow gully.

Sampling

Soil samples were collected from the four sites using a 25mm soil corer. At each sampling location three cores to 30cm depth were taken within an area of 1m diameter. The cores were sectioned and composited in 10cm increments.

The main sampling took place in May 1997 with additional samples taken from some sites in the period June - August 1998. Additionally, deep cores were taken from sites 1, 2 and 4 in June 1998 using a Humax soil sampler (5cm diameter). Single cores were taken to 125cm depth at three locations at each of the three sites with samples comprising the five 25cm core depth increments. All soil samples were air dried and ground for chemical analysis. Pasture and surface water samples were collected in June-August 1998.

Residue Analysis

Arsenic was determined by digestion of soil subsamples (2g) with 4N HCl (25mL) for 30 minutes. Arsenic in the filtered digest was determined by flame atomic absorption spectroscopy. For samples with arsenic levels below 50mg/kg hydride generation was used in conjunction with flame AA (Wilson 1998).

Organochlorine insecticide residues were determined by solvent extraction and gas chromatography (GC). Soil subsamples (20g) were moistened with water (4mL) and extracted by shaking with petroleum spirit (BP100-120^{o}C):acetone (50mL 3:2 v/v) for 2 hours followed by washing with water. An aliquot of the organic layer was cleaned up using silica gel column chromatography. Dried and ground pasture samples were processed by a miniaturised version of this method. Water was extracted by solid phase extraction on C18-silica columns with elution by ethyl acetetate. Organochlorine insecticides were determined in the extracts by high resolution gas chromatography using a Hewlett-Packard 5890 Series II instrument equipped with a DB1701 column and electron capture detector. The instrument was calibrated using authentic standards of alpha-HCH, beta-HCH, gamma-HCH, aldrin, o,p-DDE, p,p-DDE, dieldrin o,p-DDT and p,p-DDT. Confirmations of residue identity were carried out on selected extracts using coupled GC-mass spectrometry (Varian Saturn 2000). Aldrin (125 ng/g) was added to each subsample prior to extraction as a surrogate standard. Recovery tests were also carried out by fortification of subsamples of control samples with the analytes prior to extraction.

RESULTS AND DISCUSSION

Maximum acceptable values (MAVs)

The Ministry for the Environment is developing standard New Zealand guidelines for MAVs of OC contaminant levels in the environment which will be released for discussion later this year. As a basis for comparison MAVs were collated from several sources (MfE 1996, MoH 1995, ANZECC 1992, AWQG 1992) and the following values are referred to in this report:

Arsenic	**MAV**	**Source**
Drinking water	10 μg/L	MoH, 1995
Surface waters	50 μg/L	ANZECC 1992
Soil - agricultural use	55 mg/kg	MfE, 1996
- residential use	30 mg/kg	MfE, 1996
- agricultural produce	10 mg/kg	MfE, 1996

Dieldrin, HCH, DDT and metabolites	**MAV**	**Source**
Drinking water	0.03 μg/L	MoH, 1995
Surface waters	1.0 μg/L	ANZECC 1992
Soil - environmental investigation level	0.2 mg/kg	AWQG 1992

Site 1 - Ngahinapouri

The soil samples from adjacent to the dip sump were grossly contaminated by dieldrin with levels exceeding 50mg/kg (ppm) in the top 20cm. HCH was also present at high levels with alpha-HCH predominating over beta and gamma (lindane) isomers. The delta isomer was also present but not quantified. A deep core taken near the sump showed that dieldrin has permeated the profile with 23 - 36mg/kg at 0-75cm, 9.2mg/kg at 75-100 cm and 0.09mg/kg at 100 - 125cm. It is probable that leaching of dieldrin from this area to the ground water at 3 - 4m depth is leading to the dieldrin residues in the well water 15m away of up to 0.09μg/L (MAV for dieldrin of 0.03μg/L). Five further shallow soil samples at distances of 2 - 10m from the sump show a rapid fall-off in dieldrin contamination from

5mg/kg to 0.25 mg/kg (mean levels 0-30cm depth). Arsenic levels were at background levels in all samples indicating arsenical dips had not been used at this site.

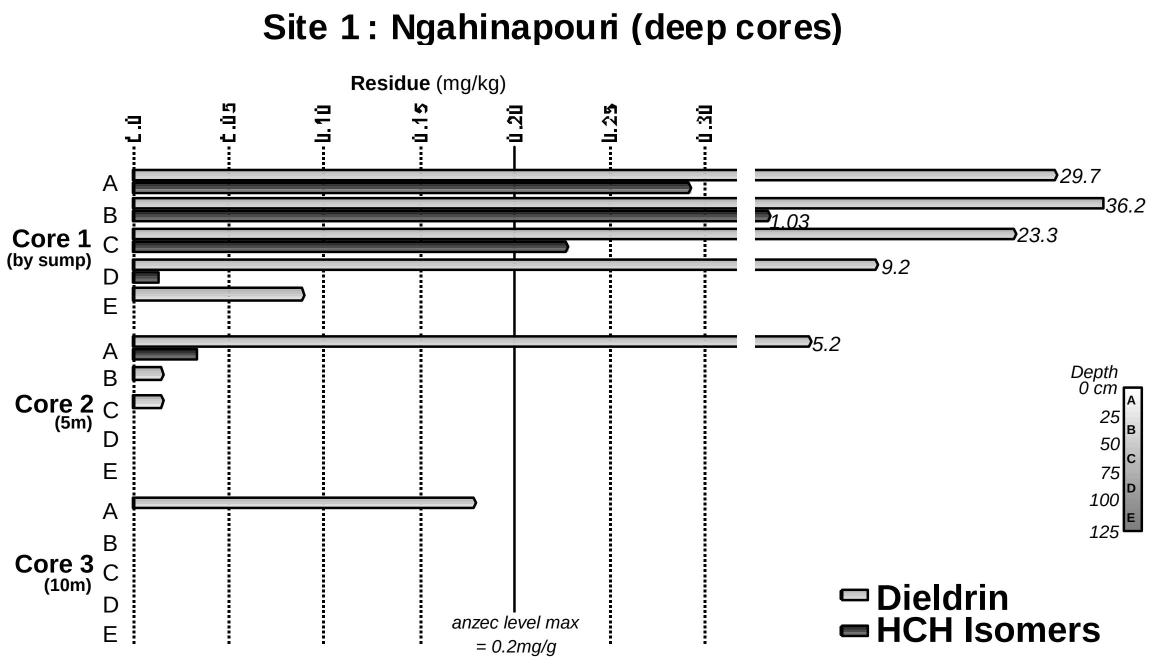

Figure 1: Dieldrin and HCH residues (mg/kg) in deep cores (A-E = 0 - 125cm)

Site 2 - Te Kowhai

Twenty soil samples showed a broad distribution of arsenic contamination from a high of 1200-3500 mg/kg just below the dip outfall, 130-280 in the vicinity of the dip and 20-40 further down the bank towards the stream. Stream bed sediments generally had background levels (1 - 7mg/kg) but a 'hotspot' 100m downstream at 150 - 90mg/kg shows that contamination may be more widespread but eroded or overlaid by sediment.

HCH (1 - 10 mg/kg), and to a lesser extent dieldrin (0.05 - 0.22mg/kg) residues were also present at the site but were more localised to the vicinity of the dip. Deep cores showed that the soil strata in these areas were highly contaminated by arsenic (5 - 3500mg/kg) and HCH with significant residues to depths of over one metre. Pasture samples from surrounding the dip contained arsenic 13mg/kg, dieldrin 0.015mg/kg and HCHs 0.007mg/kg while surface water obtained 20m from the dip outfall contained 0.5μg/L of gamma-HCH (the most soluble HCH isomer).

Site 3 - Te Kauwhata

Soil samples at the head of the gully leading to the stream were heavily contaminated with arsenic (325 - 2620mg/kg) and lesser amounts of dieldrin (0.04 - 0.19mg/kg). The adjacent stockyards and races were also contaminated (arsenic 10 - 167mg/kg, dieldrin 0.05 - 2.1mg/kg). Soil samples from 20 to 100m down the gully showed a generally decreasing trend in arsenic (80 - 4mg/kg) and no significant organochlorine residues. Pasture samples from the sheep yards contained mean values of 0.006mg/kg HCH and 0.02mg/kg dieldrin. A surface water sample from the spring outfall contained HCH 1μg/L and dieldrin 9μg/L.

Site 4 - Hamilton

The soil samples revealed that this site is heavily contaminated by arsenic, dieldrin and HCH over a large area. Adjacent to the large dip bath and race, residues in the 0-30 cm top soil samples were in the range: arsenic 100 - 2560mg/kg (many samples exceeding 300mg/kg), dieldrin 0.15 - 3.1mg/kg, and HCH 0.26 - 10.6mg/kg. The contamination gradually decreases with distance from the dip but samples at 10m still had significant residues (arsenic 14 - 125mg/kg, mean 50; dieldrin 0.01 - 0.45mg/kg, mean 0.07) and a sample in a drainage area 20m distant contained 48 mg/kg arsenic. One area at 7m contained dieldrin at 16 mg/kg (0.9-45 mg/kg). The soil samples indicated there had been physical disturbances in the soil profile in some areas. Herbage samples from beside the dip gave arsenic 6.5 mg/kg, HCH 0.67mg/kg and dieldrin 0.018 mg/kg. However blood tests on cattle grazing this property revealed no significant residues (arsenic 1mg/kg, OCs <0.005 mg/kg).

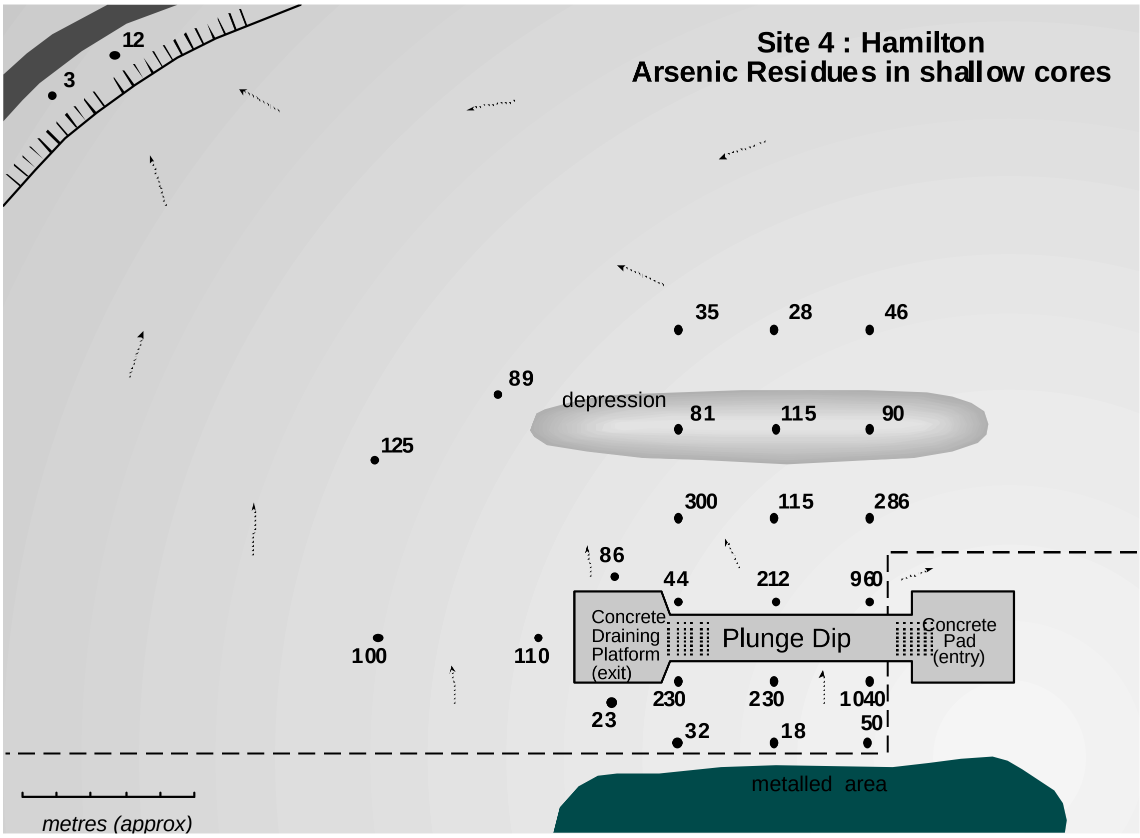

Figure 2: Arsenic contamination (mg/kg) at Hamilton site (mean of 0-30cm depth)

In summary, all four sites close to the original dips were heavily contaminated with either or both arsenic and organochlorine residues and wider areas contained lesser contamination still exceeding MAVs. These residues have persisted for at least 25 years and it is likely that losses by degradation in the soil are proceeding very slowly. At the Ngahinapouri site the dieldrin contamination was severe enough to have lead to contamination of local ground water even though this chemical is relatively immobile in soil. Contamination by arsenic and OCs was extensive at the Hamilton site with topsoil being above MAVs over an area of at least 20 by 40m. At Te Kowhai and Te Kauwhata sites, the movement of arsenic and OCs has occurred down the gullies and into drainage areas. Pasture samples were contaminated and surface water samples also contained residues well above MAVs. The shallow core sections revealed that contamination at all sites was often uniform to 30cm depth, particularly by arsenic. The deep core sections showed that the contamination reached greater depths in areas close to the dip baths.

RECOMMENDATIONS AND RATIONALE

Based on the findings of this study, WaiPAC makes the following recommendations:

1. Site evaluation

That Government establishes and funds a risk assessment programme to provide land owners with detailed, practical advice on site assessment and management.

As the principle legislator for the use and approval of such past dipping practices, the government has a responsibility to ensure residues at dip sites do not cause problems with human and animal health or environmental safety. A programme is required similar to that for timber treatment sites which resulted in the production of health and environmental guidelines (MfE, 1996). During 1998, the Governing Council of the UN Environment Programme (UNEP) will commence negotiations on a global, legally binding instrument on a list of 12 persistent organic pollutants (POPs). The UNEP decision aims to reduce or eliminate discharges to air, water and land of these POPs and remediate environmental reservoirs. Many of the chemicals identified in this dip study are POPs and will qualify under this international agreement (assuming NZ becomes a signatory).

2. Protection of markets for primary produce

That Producer Boards fund a definitive study on contaminated dip sites to establish risks from residues to produce and markets and that site management be included in industry quality assurance programmes.

New Zealand primary producers (dairy, beef, mutton, venison, wool, fruit, vegetables and forestry) must ensure the integrity of these vital industries. WaiPAC has discussed in detail with land owners the risks to produce and animal health from contaminated sites in the two WaiPAC studies. Farmers have not effectively excluded access by livestock to any of the nine sites studied, even where cattle deaths from arsenic poisoning were diagnosed. The closure of the USA and Japanese markets to Australian beef in 1987 was precipitated by unacceptable levels of organochlorine residues in beef. Trace-back of contamination identified dip sites as significant contributors to that crisis.

3. Environmental management

That Territorial Authorities initiate an education programme to encourage responsible actions by landowners to limit soil disturbance and erosion at dip sites.

WaiPAC has observed gross mismanagement of banks and gully bottoms at two sites with soil disturbance by livestock which will hasten the off-site transportation of the persistent contaminants. It is therefore important that contaminated land with gully, stream and ocean frontage be managed to limit, as much as possible, the off-site movement of chemicals (WaiPAC understands that siting of dips on, or adjacent to, beaches was common). This will enhance wildlife, amenity values, aquatic ecosystems and help protect downstream water users.

4. Public exposure

That the Ministry for the Environment give priority to identifying and investigating former dip sites that have residential and recreational access by the public to avoid potential health effects.

With past legislation and strict enforcement by Government inspectors, many dips were associated with rail sidings and stock saleyards. Due to the location of these facilities (usually in towns and cities) significant potential exists for human contact with these former sites. For example residues have been claimed to affect residents of 11 houses surrounding a contaminated dip site in an urban area in Canberra, Australia (News, 1995). A further 16 disused dip sites in the surrounding urban area were also identified as potential sources of contamination.

5. Site remediation

That central government fund research into cost effective dip site remediation options.

All nine sites tested to date have shown moderate to heavy contamination by persistent organochlorine and/or arsenical wastes. WaiPAC has been unable to find a landfill in the Waikato that will accept soil removed from dip sites. That leaves the option of on-site treatment. The ADOX process (Accelerated Decomposition of Organic Halides) is currently the preferred method for decontaminating soil. There are two major problems with the ADOX process:

1) It cannot remove arsenic or other heavy metals. Of the 141 soil samples analysed in the 1998 study, 83 samples (59%) exceeded the arsenic MAV for agricultural use. The most seriously contaminated sample was 64 times the MAV.
2) The costs are very high with indicative figures up to $500 per tonne of soil. As an example, if an area 300 square metres (20x15m) by 1 metre deep was to be treated, then the costs for remediation of a site could be $150,000 (organochlorine only, and exclusive of earth moving, health & safety compliance, analytical tests etc). Environment Waikato has suggested there could be as many as 12,000 such sites in the region (some farms have up to three generations of different dipping facilities). Therefore it is not unreasonable to estimate that there could be 50,000 sites nationally with total costs for ADOX processing exceeding $7.5 billion.

CONCLUSIONS

WaiPAC has taken the lead in research on disused dip sites in New Zealand. Whilst all four sites are located in the Waikato, the results should be indicative of the contamination at the thousands of dip sites in New Zealand.

This legacy from past dip mismanagement was brought about by mandatory requirements and from legitimate attention to animal welfare over many, many years. Landowner's nervousness about the issue is obvious and totally understandable. In many cases they are innocent owners of a site contaminated by previous tenants and neighbouring farmers who sometimes shared dipping facilities. High site assessment costs (up to $10,000 per site) and lack of remediation options will create further fear and uncertainty.

WaiPAC will work with the property owners of the sites studied and suggest management practices to minimise off-site transport of persistent chemicals. However contamination of surface water and groundwater is generally beyond reasonable farmer intervention. New Zealand must face the fact that in the past our nation demanded dipping of livestock, and has benefited from the use of these persistent chemicals. Therefore current landowners must not be penalised by way of site assessment and remediation costs, site closure, interference in conveyancing or loss of economic value.

ACKNOWLEDGMENTS

Environment Waikato provided the Environmental Initiatives Grant in support of this investigation.
Dr Bill Henderson (University of Waikato) and Don McNaughton (HortResearch) assisted in planning and execution of this project.
WaiPAC thanks property owners/occupiers and their families for their access and help.
Thank you Messers Anon, Anon, Anon and Anon.

DISCLAIMER

The recommendations in this report are the views of WaiPAC. Whilst staff from HortResearch, the University of Waikato and Environment Waikato have been involved in the development and/or funding of this project, the recommendations do not necessarily reflect their corporate policies.

REFERENCES

ANZECC (1992) Guidelines for Contaminated Sites. Australia & NZ Environmental Conservation Council.

AWQG (1992) Australian Water Quality Guidelines for Fresh and Marine Waters.

Hadfield, J. and Smith, D. (1997) Pesticide contamination of groundwater: An investigation in the Waikato region. Internal Report, Environment Waikato.

McBride, G. (1994) What's Cooking in the Hangi Pit? - A Case Study of Community Consultation. Proceeding of Waste Management Institute NZ Conference, Christchurch.

MfE (1996) Health and Environmental Guidelines for Selected Timber Treatment Chemicals, Ministry for the Environment, Wellington.

MoH (1995) Drinking Water Standards for New Zealand (1995), Ministry of Health, Wellington.

News (1995) Toddlers' background playground laced with Arsenic. "The Australian" newspaper, 21st February.

WHO (1993) Guidelines for Drinking Water Quality, Volume 1, World Health Organisation, Geneva.

Wilson, T. K. (1998) Historical contamination at the dip sites and associated management issues. M.Sc. Thesis, University of Waikato.