Assessment of Dioxin Contamination at Sawmill Sites

A Report to the Ministry for the Environment

by Tonkin & Taylor Ltd and SPHERE

Acknowledgements

Tonkin & Taylor Ltd and SPHERE wish to acknowledge the assistance and support of the following organisations and individuals:

New Zealand Timber Industry Federation
New Zealand Timber Preservation Council
The individual sawmill sites participating in the study
Dr Simon Buckland (formerly of the Ministry for the Environment
Howard Ellis (Ministry for the Environment)
Jim Maud (formerly of the Ministry of Agriculture and Forestry)
Jerry Nelson (Northland Regional Council)
Marty White (formerly of the Auckland Regional Council)
Robert Brodnax (Environment Waikato)
Paul Futter (Environment BOP)
Fred King (Hawkes Bay Regional Council)
Louise Bennett (Gisborne District Council)
Gary Bedford (Taranaki Regional Council)
Ewen Robertson (formerly of Horizons MW)
Bruce Croucher (formerly of the Wellington Regional Council)
Jenny Easton (Tasman District Council)
Nicky Eade (Marlborough District Council)
Henk Stengs (formerly of the West Coast Regional Council)
Donna Sibley (formerly of the Canterbury Regional Council)
Jenny Lowe (formerly of the Otago Regional Council)
Gretchen Johnston (Southland Regional Council)

Disclaimer

Prepared for release on the Ministry for the Environment website in October 2008.

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Executive Summary

Until its voluntary withdrawal by the timber industry in 1988, pentachlorophenol (PCP) or its sodium salt (sodium pentachlorophenate, NaPCP) was used in a variety of timber treatment processes. In sawmills throughout the country, an NaPCP preparation was applied to the surface of freshly sawn *Pinus* as an antisapstain fungicide, either by spray or dip bath. NaPCP was also commonly included in the dip bath for boron treatment of sawn timber. The use of PCP as a timber preservative (a PCP-–diesel mixture) was mainly carried out at a major facility near Rotorua, with relatively minor use at a few other sites. Commercial-grade PCP contained dioxin impurities, and spills of chemicals or drippage from freshly treated timber generally resulted in localised contamination of the ground with both PCP and its associated dioxin impurities.

There is worldwide concern about organochlorine contaminants in the environment because even low concentrations are reported to contribute in the long term to significant risks to the health of animals and humans. In view of this concern, the Ministry for the Environment commenced a national Organochlorines Programme to carry out research, assess exposure and health risks, and consider issues such as clean-up targets and emission control standards. This report, *Assessment of Dioxin Contamination at Sawmill Sites*, is part of this broader programme of work on dioxin and organochlorine issues.

The purpose of the current study was to provide the Ministry for the Environment with a revised national estimate of dioxin contamination at sawmill sites and to identify options for reducing risk at these sites. From a review of regional council information and the Timber Preservation Authority files, a total of 255 sawmills are thought to have used NaPCP or PCP, and these have been classified as small, medium or high users of PCP based on the available information.

In this study, PCP and dioxin analyses were undertaken on soils sampled from 17 sawmills within the vicinity of the historical application of PCP-containing solutions (antisapstain dip or spray, sorting table, boric dip or spray, chemical storage or mixing area). The sawmills sampled represented small, medium and high PCP users, and the data for each category have been extrapolated for the number of sites in each category.

The total amount of dioxin remaining in soil collectively from the 255 sawmill sites in New Zealand was estimated at November 2002 to be:

- 80–250 grams dioxin toxic equivalents[1] from NaPCP use
- 172 grams dioxin toxic equivalents from PCP in oil use.

These estimates revise those previously published in the *New Zealand Inventory of Dioxin Emissions to Air, Land and Water, and Reservoir Sources* (Ministry for the Environment, 2000).

On a site-by-site basis, risks to human health and the environment from soil contaminated by PCP and dioxin are associated predominantly with the sites (approximately 35) that were relatively large users of PCP. Investigations of some of these sites have shown (although this is not reported in this study) that PCP and dioxin have migrated off site and contaminated, respectively, water bodies and sediment (dioxin is tightly bound to particulate matter in the absence of oil), including two sites where PCP in oil was used as a preservative (Waipa and Hanmer Springs).

[1] Calculated in accordance with World Health Organisation protocols, 1998

Attention to health risk assessment is strongly indicated for such sites if a change from an industrial use to residential use or a life-style block were proposed. Given the scale of operations on these sites and their locations, such changes in land use are unlikely.

Unless the site was a large user of PCP, investigations of PCP contamination by the timber industry and regional councils indicate that little off-site migration of PCP (and by implication dioxins) is likely in either groundwater or surface water. Thus, on a site-by-site basis, if little potential for dioxin entry to the food chain or the aquatic environment is apparent, the potential risk to human health is confined to direct exposure to the soil where PCP has been used.

A database has been compiled of sites that used PCP in New Zealand. This database has been provided to regional councils on a region-by-region basis to assist local government to monitor the use of these sites, particularly in situations involving a change of land use.

1 INTRODUCTION

1.1 Background

Dioxins are widespread in the environment as a result of a number of activities (Ministry for the Environment, 2000) including:

- waste incineration
- metallurgical industries, including smelting, refining and recycling
- industrial and domestic coal and wood combustion
- exhaust emissions from vehicles running on diesel and unleaded petrol
- controlled burn-offs
- uncontrolled and accidental fires
- pesticide use.

There is worldwide concern about organochlorine contaminants in the environment because even low concentrations are reported to contribute in the long term to significant risks to the health of animals (especially those at the top of the food chain, such as predatory birds and marine mammals) and humans. In view of this international concern, the Ministry for the Environment commenced a national Organochlorines Programme[2] to carry out research, assess exposure and health risks, and consider issues such as clean-up targets and emission control standards. This report, *Assessment of Dioxin Contamination at Sawmill Sites*, is part of this broader programme of work on dioxin and organochlorine issues.

1.2 Organochlorine pesticides in New Zealand

A number of organochlorine pesticides were widely used across a variety of industry sectors (agriculture, horticulture, timber processing) in New Zealand from the late 1940s to the late 1980s. These pesticides included herbicides and insecticides such as DDT, dieldrin, chlordane, 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) and pentachlorophenol (PCP). Many of these chemicals, at a technical or commercial grade specification, contained trace levels of impurities. Technical grade PCP typically contained ‘dioxin impurities’. As a result, at locations where PCP was stored or used, there is the potential for the soil to be contaminated with PCP and the dioxin impurities.

PCP in New Zealand

Until its voluntary withdrawal by the timber industry in 1988, PCP (or its sodium salt NaPCP) was used in the industry in a variety of treatment processes. The use of PCP on a site varied from a single occasion up to approximately 35 years. On many sites the locations where the chemicals were used, or where the treated timber was stored, were unpaved. Consequently, spills of chemicals or drippage from freshly treated timber have resulted in soil contamination by PCP and dioxins. To assist with the management of contaminated timber treatment sites, health and environmental guidelines were published in 1997 (Ministry for the Environment and Ministry of Health, 1997).

[2] http://www.mfe.govt.nz/publications/hazardous/#public2

Use of the term PCP in this report

Unless otherwise specified, the use of the term PCP in the text and tables of this report means pentachorophenol as measured in soil samples irrespective of the chemical form used to treat timber.

PCP as a preservative

PCP in diesel oil was used as a permanent timber preservative (in telegraph poles, railway sleepers, etc.), applied either through a pressure treatment process (known as the Rueping process) or through hot and cold dipping in a bath. The Rueping process was used at one site only, Waipa. Although there was a second plant in Christchurch, there is no record of it being used. Three sites used the hot and cold bath method. The concentration of PCP in both of these processes was 5% weight per volume (w/v).

NaPCP as a preservative

A preservative formulation of sodium pentachlorophenate (NaPCP) in water (Immutan B and Tanalith FMP) was also used, again in a pressure treatment process in the late 1960s to mid-1970s. The concentration of pentachlorophenate in the treatment solution was relatively low at 0.06–0.14% w/v PCP. Much less preservative was required for internal building timbers, so lower amounts of preservative were used per unit of wood compared with the above processes. Because the use of this process was not widespread (estimated to be fewer than 20 sites) and only a relatively small amount of timber was treated by this method, contamination associated with this process has not been investigated in this study.

NaPCP as an antisapstain fungicide

Pine species are susceptible to attack by fungi that feed on wood sap, and their excretion may cause discolouration of the timber. NaPCP was used to prevent fungal attack on the timber while it was being dried before further processing. Freshly sawn (green) timber had antisapstain fungicide applied, either in a dip bath or in a spray tunnel as it travelled from the saws to a sorting table. Logs, posts and poles were treated in dip baths or spray tunnels, or by hand or mechanical spraying. The concentration of PCP for sapstain control was generally 0.5% w/v, although in some hand-spraying operations the concentration was up to 1.0% w/v.

In the boron diffusion process, NaPCP was also added to the boron treatment chemicals (applied in a dip bath or spray tunnel). Because the majority of this timber had already been treated in the ‘green chain’ antisapstain process, the concentration of PCP in the boric treatment solution was only 0.2% w/v. If the timber had not been treated at the green chain stage, the concentration may have been raised to 0.5% w/v.

1.3 Purposes of the study

In 2000 the Ministry for the Environment published an inventory of dioxin sources covering a wide range of processes and activities (Ministry for the Environment 2000). This inventory included an estimate of the dioxin reservoir present in soil at sawmill sites. To estimate the reservoir, the soil burdens were calculated for each area at the sites where contaminant concentration data were available. These burdens were then summed to give a total dioxin burden per site, and this burden was multiplied by the estimated number of sawmill sites in the country. In this way, the dioxin reservoir at sawmill sites was estimated to be 310 g, measured as toxic equivalents or TEQ (see section 2.1). It was noted then that this estimate was based on limited data with inherent uncertainty over the national figure.

The current study was initiated by the Ministry for the Environment to provide more definitive data on the level of dioxin contamination at sawmill sites and to better assess the risks such sites may pose.

The four key tasks of the study were to:

1. collect more reliable and nationally representative data on the concentration of dioxins at sawmill sites
2. revise the existing estimate of the dioxin reservoir at sawmill sites
3. detail the types of environmental and risk management conditions that may be found at sawmill sites, and develop a risk profile of these sites
4. identify options for risk reduction measures for residual contamination associated with past usage of PCP at sawmill sites in New Zealand.

1.4 Scope and content of this report

The remainder of this report is structured as follows.

Chapter 2 gives brief background information on dioxins, including their toxicity and the standard means of reporting dioxin concentration using toxic equivalence factors. It then provides a summary of the data on dioxin contamination that was available prior to this study.

Chapter 3 provides details on the study design and methodology.

Chapter 4 presents the results of the site investigation for sites that were classified as small, medium or large users of PCP. The study information is then used to revise the estimate of the dioxin reservoir at sawmill and timber treatment sites. This estimate takes into consideration areas where contamination may have occurred but that were not specifically investigated in the studies, as well as the degree of remediation that may already have taken place.

Chapter 5 looks at the potential risks that may arise from the contaminant levels found. The risk from off-site migration and entry into the food chain is assessed to be low, so the focus is placed on potential on-site risks for three main land uses: ongoing sawmill/industrial use, residential use and agricultural use.

Chapter 6 then examines options for risk reduction for these three uses.

Chapter 7 provides conclusions drawn from the study and the investigation results, and discusses the limitations of the study results.

2 THE STUDY CONTEXT: PREVIOUS DIOXIN DATA AND RESERVOIR ESTIMATES

2.1 Dioxin concentrations

The interpretation of the study's results requires an understanding of the measurement of dioxins in terms of toxic equivalents. Following is a brief explanation of toxic equivalents and the analytical methods used.

Structure

Dioxin is the generic name for two groups of aromatic compounds with very similar molecular structure: the polychlorinated dibenzo-p-dioxins (PCDDs or dioxins) and the polychlorinated dibenzofurans (PCDFs or furans). Both groups of compounds can have up to eight chlorine atoms attached at different carbon atoms, and each individual compound is referred to as a congener. Each specific congener is identified by the number and position of chlorine atoms around the aromatic nucleus. In total, there are 75 possible PCDD congeners and 135 possible PCDF congeners. Congeners with the same number of chlorine atoms are known as homologues.

Toxicity

Congeners containing 1, 2 or 3 chlorine atoms are thought to be of no toxicological significance. However, the 17 congeners with chlorine atoms substituted in the 2,3,7,8-positions are thought to pose a risk to human and environmental health. Toxic responses include dermal toxicity, immunotoxicity, carcinogenicity, and adverse effects on reproduction, development and endocrine functions. Of the 17 congeners, the most toxic, and widely studied, congener is 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). Increasing substitution from 4 to 8 chlorine atoms generally results in a marked decrease in toxicity.

Toxic equivalents

In environmental media, the PCDDs and PCDFs occur as complex mixtures of congeners. To enable a complicated set of analytical results to be reduced to a single number, a system of toxic equivalent factors (TEFs) has been developed. The toxic equivalents method generates a set of weighting factors, each of which expresses the toxicity of a particular PCDD or PCDF congener in terms of an equivalent amount of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). Multiplication of the concentration of a PCDD or PCDF congener by this TEF gives a corresponding 2,3,7,8-TCDD TEQ concentration. The toxicity of any mixture of PCDDs and PCDFs, expressed as 2,3,7,8-TCDD, is derived by summing the individual TEQ concentrations. This is reported as the 'total TEQ' for a mixture.

Although a number of toxic equivalents schemes have been developed, the most widely used is the International Toxic Equivalents Factor (I-TEF) scheme (Kutz et al., 1990). The I-TEF scheme was revised and expanded through the auspices of the World Health Organisation (WHO) by Van den Berg et al. (1998). More recently the WHO TEFs has been amended (van den Berg et al., 2006. This report, however, has not been amended to incorporate these most recent changes because the changes are minor, and the consequential and net effect on the overall TEQ calculation is also thought to be minor. Results of the site investigations in this study are reported using both the I-TEF and initial WHO (1998) TEF schemes to allow comparison with results from previous investigations using the I-TEF scheme and for future studies where the Ministry for the Environment has indicated they favour the use of the WHO TEF scheme.

OCDD screen vs full congener analysis

Because full congener dioxin analysis is expensive, a lower-cost analytical testing method was developed for determining heptachloro and octachloro dioxins and furans (ESR, 1992). Octachlorodibenzo-p-dioxin (OCDD) is the predominant dioxin congener contaminant in the PCP formulations used in New Zealand, and the hepta and octa congeners generally make up more than 95% of congeners found in contaminated soils on sawmill sites. Most results from previous investigations are for full congener analysis, and this should be noted when comparing these with the results from this study. In the calculations of the national reservoir, the 'total TEQ' values for the study results have been adjusted to take into account the difference between screen and full congener analysis.

The OCDD screen was based on USEPA Method 8290, and reproduced in Appendix J, Analytical Methods, in *Pentachlorophenol Risk Assessment Pilot Study* (CMPS&F, 1992). However, the OCDD screen now used by Agriquality laboratory, Gracefield, is consistent with USEPA Method 1613.

2.2 Previous dioxin data and reservoir estimates

The data presented in this section are taken from the *New Zealand Inventory of Dioxin Emissions to Air, Land and Water, and Reservoir Sources* (Ministry for the Environment 2000). The available data on dioxin levels in soils at sites where NaPCP or PCP was used is presented in Table 2.1 and is summarised as follows:

NaPCP use

- Small users (less than 20 tonnes used in total) – very limited dioxin concentration data (see Table 2.1) were available for small NaPCP users (all were believed to have used less than 4 tonnes) in the Canterbury region. The data were from samples taken from the top 200 mm of soil at a limited number of locations (CMPS&F, 1995).
- Medium users (20–100 tonnes used in total) – no data were available.
- Large users (more than 100 tonnes used in total) – no data were available.
- A very large user (about 1000 tonnes in total) – comprehensive data were available for the Waipa site (which was also a very large user of PCP in oil). This information is also provided in Table 2.1.

PCP in oil use

- A large user (about 420 tonnes in total) – some data were available covering a number of different sampling locations for one PCP-in-oil operation (Hanmer Springs). The mean value is given in Table 2.1.
- A very large user (about 2000 tonnes in total) – comprehensive data were available for the Waipa site.

The estimates of areas at the sites potentially affected by dioxin residues are also provided in Table 2.1. For the small NaPCP users the soils analysed for dioxin were composites from sampling to a depth of 0.2 m whereas the PCP depth concentration profiles for the three sites investigated indicated that PCP concentrations extended to approximately 0.5 m below the soil surface. It is well documented that the dioxins and furans, and particularly the more highly chlorinated heptachloro and octachloro congeners, are significantly less mobile in soil than PCP. On this basis, the dioxins were unlikely to have migrated deeper than the upper few centimetres of the soil profile, and it was assumed that they would be completely contained within the 0.2 m sampling depth.

Table 2.1 Parameters used to estimate the total dioxin reservoir in soil at timber treatment sites

Treatment type	Dioxin soil concentration* (µg I-TEQ kg^{-1})	Area affected (m^2)	Depth affected (m)	Reference
Antisapstain treatment (NaPCP)				
Small NaPCP users				
Average surface concentration beneath and immediately adjacent to dip tanks	3.37	100	0.2	CMPS&F, 1995
Average surface concentration beneath sorting tables	0.62	500	0.2	CMPS&F, 1995
Very large NaPCP user (Waipa Mill)				
Surface concentrations associated with:				
• circular mill green chain	1.17	2400	1.05	CMPS&F, 1992
• band mill green chain	1.3	2400	1.05	CMPS&F, 1992
• hot spot under mix room	3300	1	1.05	CMPS&F, 1992
• export squares	3.1	375	1.05	CMPS&F, 1992
• boron dip	0.6	800	1.05	CMPS&F, 1992
• burn pit	4	100	1.05	CMPS&F, 1992
• other areas	0.12	162000	1.05	CMPS&F, 1992
Preservative treatment (PCP in oil)				
Waipa Mill				
Surface concentrations associated with				
• Rueping plant	18.3	1600	1.26	CMPS&F, 1992
• pole yard	21.3	10000	1.26	CMPS&F, 1992
Hanmer Springs				
Mean concentration over depth	12.4 **	2420	1.26	Royd'sGarden/CMPS&F, 1994 Roberts et al., 1996

* Based on site-specific data ** Based on assumptions.

For the very large NaPCP user, the depth of contamination was estimated from a plot of concentrations as a function of depth for each of the affected areas listed in Table 2.1. The surface concentrations given in the table were then used to calculate the average soil concentrations up to the depth at which the dioxins were estimated to have declined to zero.

From the soil concentrations, and the affected area and depth, the total dioxin burden was estimated to be 0.15 g I-TEQ per site for small NaPCP users and 19.2 g I-TEQ for the very large NaPCP user (Table 2.2). Unfortunately, no site information was available for the moderate NaPCP users or the large NaPCP users with respect to either the concentration of dioxin residues present at the site or the likely areas affected by dioxin contamination. Soil burdens for these sites could not therefore be calculated directly. Using the soil burdens for the small NaPCP users and the very large NaPCP user previously described, however, the dioxin burdens for the moderate NaPCP users and large NaPCP users were estimated from a linear regression. On this basis, the total dioxin burden was estimated to be 0.77 g I-TEQ per site for moderate NaPCP users and 2.7 g I-TEQ per site for large NaPCP users (Table 2.2).

Previous national reservoir estimate for NaPCP-derived dioxin

For 270 small users, 11 moderate users, four large users and one very large user, the total dioxin reservoir in soils at timber treatment sites from antisapstain use of NaPCP was estimated to be approximately 80 g I-TEQ, as summarised in Table 2.2.

Table 2.2 Dioxin reservoir in soil from antisapstain treatment (NaPCP)

Site category	Dioxin burden in soil* (g I-TEQ)				Dioxin burden (g I-TEQ per site)	No. of sites	Reservoir (g I-TEQ)
	Dip tanks	Sorting tables	Green chair	Other areas			
Small NaPCP users	0.080	0.075			0.15	270	42
Moderate NaPCP users					0.77**	11	8.5
Large NaPCP users					2.73**	4	11
Very large NaPCP user	0.30		5.80	13.1	19.2	1	19
Total							**80**

* Dioxin burden = (surface concentration/2) x affected area x depth x soil density. The surface concentration is divided by 2 to provide for a linear decrease to zero over the depth of the contamination. This is applied for the Waipa site only, not for Hanmer. The concentrations, affected area and depth are given in Table 2.1. A mean soil bulk density of 1.2 tonne m^{-3} was assumed.

** Dioxin burdens for the moderate NaPCP users and the large NaPCP users were obtained from a linear regression of the data for small and very large PCP users.

Preservative use of PCP in diesel

PCP as a preservative in diesel oil was only used at four sites in New Zealand: the Waipa Mill (where antisapstain treatment also occurred), Hanmer Springs, Christchurch, and a fourth site in Waikoau (Hastings District) which was a comparatively small user. The usage of PCP at the three major sites is estimated to be approximately 2,000 tonnes at the Waipa Mill, 420 tonnes at Hanmer and 275 tonnes at Christchurch (although no dioxin data are available for the Christchurch site).

Concentration data for dioxins at the Waipa site have been reported, and are summarised in Table 2.1. The Hanmer Springs site estimate in Table 2.1 is based on assumptions extrapolated from the Waipa site. The mean dioxin concentration assumption cannot be verified since contaminated soil in the vicinity of the treatment plant was removed and disposed to an unknown location. The estimated areas potentially affected by dioxin residues at both of these sites are also detailed in Table 2.1.

As previously noted for the Waipa site, the depth of contamination was estimated from a plot of dioxin concentrations as a function of depth for each of the affected areas listed in Table 2.1. The surface concentrations given in Table 2.1 were then used to calculate the average soil concentrations up to the depth at which the dioxins were estimated to have declined to zero. On this basis, the depth of contamination at Hanmer was assumed to be the same as that at the Waipa Mill.

Previous national reservoir estimate for dioxins derived from PCP in oil

The estimated burden of preservative-derived dioxins at the Waipa Mill is estimated to be 184 g I-TEQ and at Hanmer 45 g I-TEQ, as summarised in Table 2.3. The total dioxin reservoir in soils at timber treatment sites from preservative use of PCP in oil is estimated to be approximately 230 g I-TEQ.

Table 2.3 Estimated dioxin reservoir in soil from preservative treatment

Timber treatment site	Dioxin burden (g I-TEQ per site)	No. of sites	Reservoir
Waipa Mill	184	1	184
Hanmer Springs	45.3*	1	45
Total			**230**

* Estimated from Waipa Mill data

2.3 Level of confidence in site contamination characterisation and reservoir estimates of the previous study

The level of confidence of the dioxin reservoir estimates for the very large user (PCP in oil and NaPCP) and the large user (PCP in oil) is relatively high, because both sites have been subjected to extensive investigation. The level of confidence of the dioxin reservoir estimate for small NaPCP users is very low because there is only a small amount of data, and this is for composites that were sampled to a depth of 0.2 m and from a limited number of locations. The level of confidence in the dioxin reservoir estimate for medium and large NaPCP users is also very low because mean dioxin burdens have been inferred.

The level of confidence in the dioxin reservoir estimate for PCP in oil sites is medium. There is some uncertainty about the quantities of PCP that were actually used at the sites, but there is good characterisation of dioxin contamination at the two major sites. There is also some uncertainty regarding the extrapolation of the contamination data to a dioxin reservoir estimate for the Hanmer Springs site. Although no dioxin investigations have been undertaken at the third significant user site, PCP investigations have shown only low levels of contamination and it is inferred from this that dioxin contamination will be similarly low. (As the results from the current study suggest, however, this may not necessarily be true.)

The level of confidence in the dioxin reservoir estimate for NaPCP use is low. The quantity of NaPCP use of many of these sites is uncertain and the soil dioxin concentrations and area of contamination are based on only a limited amount of site-specific data, which have then been extrapolated over the whole sector.

A desire to achieve better estimates of the overall dioxin reservoirs at sawmill sites was the major impetus for the current study.

3 METHODOLOGY

3.1 Timber industry consultation

The current sawmilling / timber treatment industry was consulted on a number of occasions through the Timber Industry Federation (TIF). The first consultation was through a questionnaire circulated by the New Zealand Timber Industry Federation to its members, outlining the study and its purpose, and seeking further information on the historical use of PCP and those site owners that were willing to make their sites available for investigation. The TIF membership was also provided with regular updates of the database. Individuals with extensive knowledge of the timber industry were also consulted.

3.2 Data collection and compilation

Over the last 10–15 years a number of site investigations have been undertaken, the majority of which have been PCP rather than dioxin investigations. In a number of regions investigations have been carried out by site owners, principally to establish appropriate remedial works. Although the results of these investigations have not been available for this study, Tonkin & Taylor and SPHERE were aware of many of the results, and this information, combined with that derived from investigations carried out by regional councils/unitary authorities, formed the basis of this study.

In October 2000, each local government authority provided Occupational Safety and Health with information on timber treatment sites in their region where it was believed that PCP or NaPCP had been used. Relevant staff at regional councils and unitary authorities were then contacted at the beginning of this project to provide existing information on sites believed to have used PCP or NaPCP, estimates of the quantities used, results of investigations for PCP or dioxin contamination and any other site information. The information varied from simple lists of sites, to comprehensive reports detailing site investigations. Reports for some regions appeared to be incomplete. Only a few councils provided an estimate of quantities of PCP used on the sites. Council staff were supplied with regular updates of the database as information was gathered from other sources, and provided clarification/confirmation or additional input.

This information was supplemented by reviewing the former Timber Preservation Authority files, which contain data on PCP as a preservative use and NaPCP as a fungicide in boron diffusion processes (during the period when recording the fungicide was required), and some references to NaPCP use for antisapstain.

Based on the available information, the number and geographical distribution of the 255 sites where PCP and/or NaPCP is believed to have been used is as follows. (For a regional breakdown of the results of earlier PCP and dioxin investigations, see Appendix A.)

Although no complete records were ever kept, it is estimated that commencing around 1950 and over the next 40 years, about 5,500 tonnes of PCP were imported into New Zealand for use in the timber industry (Ministry for the Environment, 2000). This present study indicates the use may have been approximately 6,000 tonnes and therefore accords reasonably well with the previous estimate. At the height of its use during the 1970s, approximately 200 tonnes per year were used for antisapstain treatment (Shaw, 1990) and 100 tonnes per year for preservative treatment (Bingham, 1992).

Table 3.1 Number and geographical distribution of sites where NaPCP and/or PCP are believed to have been used

North Island	No. of sites	South Island	No. of sites
Northland	19	Nelson	7
Auckland	16	Tasman	11
Waikato	25	Marlborough	5
Bay of Plenty	15	West Coast	10
Hawke's Bay	9	Canterbury	56
Gisborne	5	Otago	19
Taranaki	14	Southland	7
Manawatu/Wanganui	16		
Wellington	21		
Total	**140**		**115**

The available information has been used to classify the sites based on the quantity of PCP estimated to have been used over the duration of its use on a particular site. This gave the following figures (Table 3.2).

Table 3.2 Estimated number of sites where NaPCP and/or PCP were used, by size

Site size	No. of sites
Very large	1
Large (100–500 tonnes)	6
Medium (20–100 tonnes)	28
Small (less than 20 tonnes)	220
Total	**255**

Although these estimates are similar to earlier estimates of site numbers (Ministry for the Environment, 2000) the following points need to be emphasised.

- The classification into small, medium, large and very large users is based on the best information available; in most cases definitive quantities of PCP use are not available.
- There is a significant degree of uncertainty associated with classifying some sites as small or medium users.
- There may be some small and medium sites included that should not be there, and some sites missing that should be included.
- The very large and large users are probably well identified and none have been overlooked.
- The distribution of sites within the various use categories is consistent with survey returns from the timber industry.
- Information was not available for approximately 40% of the sites. The lack of information is considered to indicate that these sites were small PCP users and/or operated for only a brief period. These sites have been allocated to the medium and small categories in the same ratio as sites for which information is available.

3.3 Contamination investigation design

Two of the tasks for this study were to obtain more definitive and representative information on site contamination and to extrapolate from the results to a national figure for the dioxin reservoir at sawmill and timber treatment sites. The previous estimated reservoir from antisapstain treatment reported in the dioxin inventory (80 g I-TEQ, Ministry for the Environment, 2000) was based on data from one very large user and preliminary data from three small users. The previous calculation assumed a linear relationship between these two data sets and derived values for medium- and large-scale users. Therefore a primary objective of this study was to obtain information on medium- and large-scale users and to supplement that already available on small users (recognising that the majority of the sites in the country were small users).

Within the available budget it was considered that approximately 12 sites could be investigated and that there should be a minimum of three sites per use category. It was also necessary to ensure that there was a good spread of sites investigated throughout the country so that a range of soil types and climatic conditions was covered. A general approach to the industry was made through the New Zealand Timber Industry Federation, with follow-up communication on a one-on-one basis. A key consideration in companies offering sites for investigation was an assurance of anonymity. Seventeen sites (6.7% of the total) were offered, with the following geographical spread. Based on knowledge of the industry, Tonkin & Taylor Ltd and SPHERE consider the sites offered were representative of the levels of contamination most likely to be encountered.

Table 3.3 Geographical spread of the study sites offered

Region	No. of sites	% of sites in region
Northland	1	5
Auckland	1	6
Waikato	6	24
Bay of Plenty	1	6
Taranaki	1	7
Manawatu / Wanganui	1	6
Wellington	1	5
Tasman	1	9
Canterbury	2	4
Otago	2	10

Of these sites, seven were classified as small users, seven medium and three large.[3] Although this did not match the ideal distribution, it was decided that all should be investigated. In practice, on one small site the relevant areas had been extensively modified (and concreted) so that sampling was not possible, and on a second only limited sampling was possible. The one PCP result for this particular site was low, and consequently no dioxin analyses were undertaken.

At the outset it was agreed that individual site contamination information would be treated in confidence. Individual sites are therefore not described in the study.

For each site it was considered that the minimum number of samples to provide a realistic measure of the dioxin contamination on a site was 10 (two depths at five separate locations). The study allowed for 10% of the samples to be subject to a full dioxin congener analysis

[3] No investigation of the very large PCP user was required, since extensive data was already held for this site from previous investigations.

and the remaining 90% an OCDD screen analysis.[4] Soon after the start of site investigations it was decided to also analyse the samples for PCP content to determine if a PCP/dioxin relationship could be established to guide future investigation/remediation work.

3.4 Sampling methodology

At each former NaPCP treatment facility the following was undertaken before collecting the soil samples.

- A meeting was arranged with the site contact and a site-specific health and safety induction was undertaken, as required.
- Long-serving staff members were interviewed (if available) regarding the use of NaPCP on the site, the method of application, the approximate volumes, and whether access to the locations where NaPCP was used was possible or practical.
- A walkover inspection of the general facility was made to develop and record an understanding of the environmental context (including site paving, drainage, etc.).
- A walkover inspection of target NaPCP use areas was made with site personnel to identify possible sampling locations and sampling methodology issues with each location (given that the sampling method was to be manual).

Samples were then collected from each selected sample location (as described below). Soil sampling was carried out in accordance with the *Health and Environmental Guidelines for Selected Timber Treatment Chemicals* (Ministry for the Environment and Ministry of Health, 1997). The sampling protocols detailed in Section 3-8 of the Guidelines were followed.

Samples were collected from spade-excavated pits or hand-augered boreholes at the near surface (0.1 m depth), 0.3 m and, when possible, 0.5 m depth. The samples were taken from approximately 50 mm above and below the specified depth. The soils were collected into glass sample jars, placed in iced chilly bins and transported to the AgriQuality laboratory in Lower Hutt under chain of custody documentation. AgriQuality sub-divided the samples and transferred representative sub-samples to Hill Laboratories (also in iced chilly bins with chain of custody documentation) for PCP analysis.

3.5 Analytical methodology

Dioxin analyses (full congener and OCDD screen) were carried out by the AgriQuality UltraTrace Laboratory using USEPA Method 1613B. (The ‘OCDD screen’ was based on USEPA Method 8290, as reproduced in Appendix J in CMPS&F, 1992. However, the ‘OCDD screen’ now used by AgriQuality is consistent with USEPA Method 1613.) The soils were spiked with a range of istopically labelled standards and extracted with ethanol/toluene, followed by solvent evaporation and exchange into hexane. The hexane extract was purified by column chromatography, reduced in volume and ultimately analysed by high-resolution gas chromatography/mass spectrometry.

PCP (and TCP) analyses were undertaken by Hill Laboratories using an IANZ accredited in-house test. The soils were extracted with acetone / hexane followed by gas chromatography – electron capture GC-ECD analysis.

4 The OCDD analysis is a screening method that quantifies only the heptachlorodibenzo-p-dioxin (HpCDD) and octachlorodibenzo-p-dioxin (OCDD) congeners. These congeners were the most prevalent in PCP formulations and collectively accounted for more than 50% of the total TEQ for a sample.

4 Contamination Investigation Results

4.1 Dioxin data from this study

The dioxin data from the OCDD screen results for this study are summarised in Table 4.1 for the various scales of NaPCP use and use areas. (Note that more detailed results of this investigation (including PCP analyses) are shown in Appendix B.) The data are for WHO (1998) TEQ values only. It should be noted that, based on samples for which a full congener analysis was undertaken, the calculated values of WHO (1998) TEQ were approximately 80% of the corresponding I-TEQ values. The reduction occurs because the toxicity rating of the OCDD congener is an order of magnitude less in the WHO (1998) scheme.

As can be seen in Table 4.1, there is a wide range of concentrations found between sites (and often within sites). Therefore, when considering particular use areas, the data do not fit any regular distribution and caution is needed when using the data. Although they have limitations, the mean values given in the tables are the arithmetic means, except for situations where the arithmetic mean is distorted by one result. In these instances the value in the table is the average of the arithmetic and geometric means.

Table 4.1 Mean WHO (1998) TEQ (ng/g) concentrations in soil for various locations/ scale of use

Small scale (< 20 tonnes, 220 sites)

	Antisapstain dip		Sorting table		Boron dip		Store/mix	
Depth (m)	**0.1**	**0.3**	**0.1**	**0.3**	**0.1**	**0.3**	**0.1**	**0.3**
Site 6					0.05	0.001	0.004	0.005
					0.09	0.001		
					0.14	0.03		
Site 11	0.23	0.004	1.6					
			1.0	2.2				
Site 14	0.14	4.3	0.08	0.01	0.03	0.003		
Site 16			0.01	0.13	0.005	0.002		
			0.02	0.01	0.03	0.01		
Site 17			0.005		2.2	0.005		
			0.005		0.1	0.02		
Range	0.14 – 0.23	0.004 – 4.3	0.005 – 1.6	0.01 – 2.2	0.005 – 2.2	0.001 – 0.03	-	-
Arithmetic mean	0.18	2.15	0.46	0.56	0.33	0.008	-	-
Arithmetic mean	1.17		0.49		0.17		-	
Geometric mean	-	-	0.28	0.27	0.31	0.09	-	-
Geometric mean	-		0.27		0.17		-	

Medium scale (20–100 tonnes, 28 sites)

	Antisapstain dip		Sorting table		Boron dip		Store/mix	
Depth (m)	**0.1**	**0.3**	**0.1**	**0.3**	**0.1**	**0.3**	**0.1**	**0.3**
Site 1	32.4	23.1	11.6	19.9	0.4	0.5		
		7.5	5.6	1.6	0.3	2.2		
			2.0	8.0				
Site 2	0.1	0.2	0.2	0.2	5.9	0.1	10.0	10.3
	0.2							
Site3(1)	2.3	0.2						
	0.5							
	0.001	0.0005						
	0.005							
Site3(2)	1.7	0.2						
	0.2	19.6						
	14.6							
	0.1	3.4						
Site 5					6.0	0.8		
					1.0	4.3		
					2.8	0.4		
					2.0	4.1		
Site 8	9.6	1.9			0.3	1.3		
					0.3	0.4		
Site 13					6.2	4.1		
					12.0	9.5		
					11.8	4.9		
Site 15					26.7	6.5		
					16.7	19.7		
					3.5	1.4		
Range	0.1 – 32	0.0005 – 23.1	0.2 – 11.6	0.2 – 19.9	0.3 – 26.7	0.1 – 19.7	-	-
Arithmetic mean	5.15	6.2	4.85	7.42	6.38	3.45	-	-
Arithmetic mean	5.61		6.14		4.91		-	
Geometric mean	0.69	0.90	1.43	1.52	1.52	1.23	-	-
Geometric mean	0.77		1.48		1.36		-	

Large scale (100 – 500 tonnes, 6 sites)

	Antisapstain dip		Sorting table		Boron dip		Store/mix	
Depth (m)	**0.0**	**0.5**	**0.0**	**0.5**	**0.0**	**0.5**	**0.0**	**0.5**
Site 7	4.9	275	3.3	0.4				
			0.02	0.06				
			5.8	20.6				
			0.2	18.3				
Site 9	16.4	3.1	0.2	0.1				
			0.5	0.1				
			6.0	1.3				
			8.1	1.1				
Site 10	69.9	2.7	123	3.4			3.6	0.03
	39.5	1.9					6.4	11.2
Range	4.9 – 69.9	1.9 – 275	0.02 – 123	0.06 – 20.6	-	-	3.6 – 16.4	0.03 – 11.2
Arithmetic mean	32.68	70.67	16.346	5.05	-	-	5.00	5.62
Arithmetic mean	51.67		10.69		-		5.31	
Geometric mean	3.81	2.48	1.18	0.96	-	-	1.98	0.79
Geometric mean	3.07		1.06		-		1.25	

Note: ng/g = µg/kg

The results in Table 4.1 are summarised in Table 4.3 and for risk assessment purposes can be compared with the interim soil acceptance criteria shown in Table 4.2 (see section 5 of this report).

Table 4.2 Interim soil acceptance criteria

Land use	I-TEQ criteria (µg/kg)	WHO (1998) TEQ criteria (µg/kg)
Agricultural	0.01	0.012
Residential	1.5	1.8
Industrial – unpaved	18	22
Industrial – paved with management plan	90 – not limited	110 – not limited
Maintenance	21	26

Notes on Table 4.2:

1. I-TEQ criteria = dioxin soil acceptance criteria calculated in accordance with I-TEQ scheme and published as ‘interim criteria’ in *Health and Environmental Guidelines for Selected Timber Treatment Chemicals*, Ministry for the Environment and Ministry of Health, 1997. These criteria were first adopted for the study of the Waipa site (CMPS&F 1992).

2. WHO (1998) TEQ criteria = dioxin soil acceptance criteria calculated by adjusting the I-TEQ criteria in accordance with WHO 1998 TEQ scheme as per note 3 below.

3. The main difference between the two schemes is that the OCDD congener under the WHO (1998) TEQ scheme is assigned a TEF that is 1/10th that under the I-TEQ scheme. As the WHO (1998) TEQ is estimated to be 80% that of the I-TEQ, the equivalent WHO (1998) TEQ soil criterion is calculated as follows: eg, for agricultural landuse the WHO (1998) TEQ soil criterion is 0.01/0.80 = 0.012 µg/kg TEQ. The equivalent soil criterion in this table is of interest only to the New Zealand situation involving sawmills where a range of technical grade PCP formulations were used over time. As noted earlier (p11), these calculations do not take into account the WHO TEFs amended in 2005.

4.2 Discussion of results

Small PCP users

Data were collected from five sites classified as small-scale users. Although there is considerable variability in the results, they are all very low. At one site, soil from a former drum storage area was still accessible for sampling. Although mean dioxin concentrations are similar to the residential criterion, the concentrations at a few locations are above this, but well below any of the industrial criteria.

Medium PCP users

Data were collected from seven sites classified as medium users. At one of these sites antisapstain dipping had taken place at two locations. Again there is considerable variation in the results, both within and between sites. The one very high dioxin value (beneath the sorting table at site 10) is associated with a very high PCP concentration and is believed to be correct. The mean values are above the residential criterion and similar to the criterion for an unpaved industrial site or for maintenance work. The concentrations at some locations only meet the criteria for a paved industrial site with a management plan.

Large PCP users

Data were collected from three sites where former use areas were still accessible. There is uncertainty about the one high TEQ result (site 7 antisapstain dip tank), because there is a relatively low PCP concentration in this sample and the full congener analysis gave a considerably lower TEQ result. The mean values are above the residential criterion and similar to the criterion for an unpaved industrial site or for maintenance work. The concentrations at some locations only meet the criteria for a paved industrial site with a management plan.

Overall

In general, the lower the use category, the lower the level of contamination. Dioxin contamination is much lower for small-use sites compared with medium- and large-use sites, and for medium- and large-use sites the average dioxin concentration across all sites and depths is roughly comparable. However, the range of contamination concentrations is much greater at the large-use sites.

In general, both PCP and dioxin concentrations decrease with depth below the ground surface. It is well documented that dioxins, and particularly the more highly chlorinated heptachloro and octachloro congeners, are significantly less mobile in soils than PCP. The results are generally consistent with this, with a more rapid decrease (particularly for the lower-use categories) in dioxin concentrations with depth compared with PCP concentrations. Although there is often a correlation between PCP and dioxin contamination levels at a particular depth (see discussion below), this is not always the case.

Where a full congener analysis has been undertaken, the hepta and octa congeners make up approximately 95% by weight, 56% of the I-TEQ values and 46% of the WHO (1998) TEQ values.

PCP–dioxin relationship

The results of PCP and TEQ (OCDD screen) analyses have been compared (Figures 3.1 and 3.2), and these show a reasonable correlation between the concentrations of the two contaminants at the two different depths. This indicates that, in most instances, PCP could be used as an indicator of likely dioxin contamination. However, there are a number of results with poor correlation between PCP and dioxin levels (and a significant change in the relationship of contamination with depth, due to the different mobility of PCP and dioxins in soil), so it will be necessary to perform some dioxin analyses at both the contamination characterisation stage and for validation of remedial work where this is undertaken.

Figure 3.1 Logarithmic plot of soil PCP vs I-TEQ and WHO (1998) TEQ upper depth

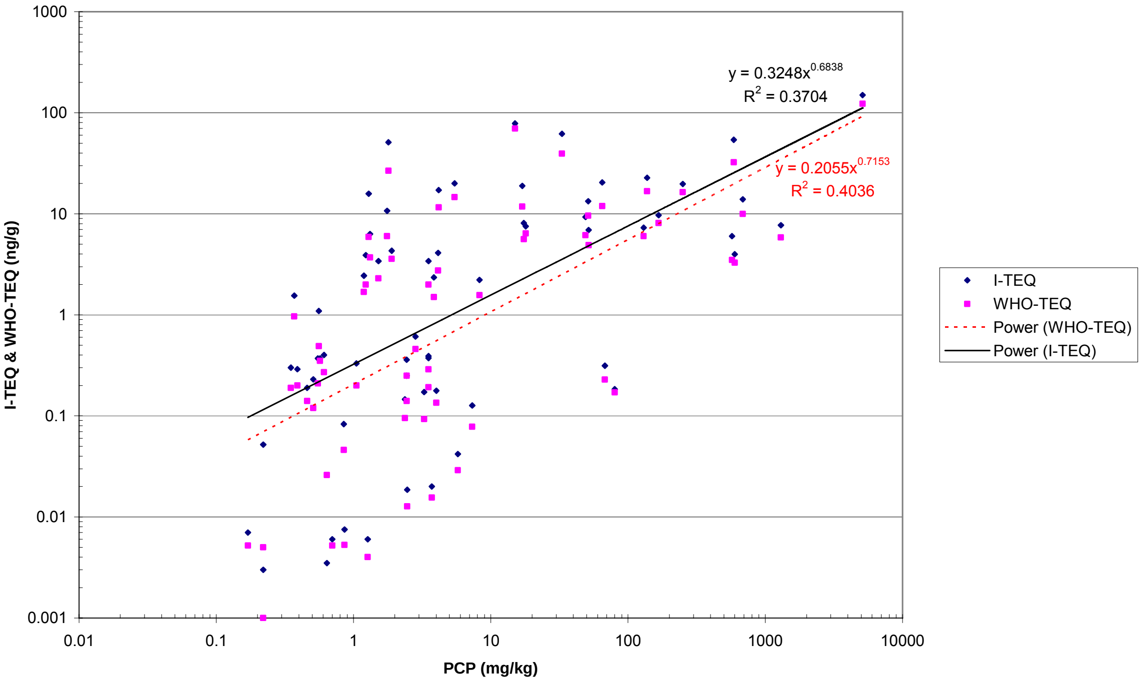
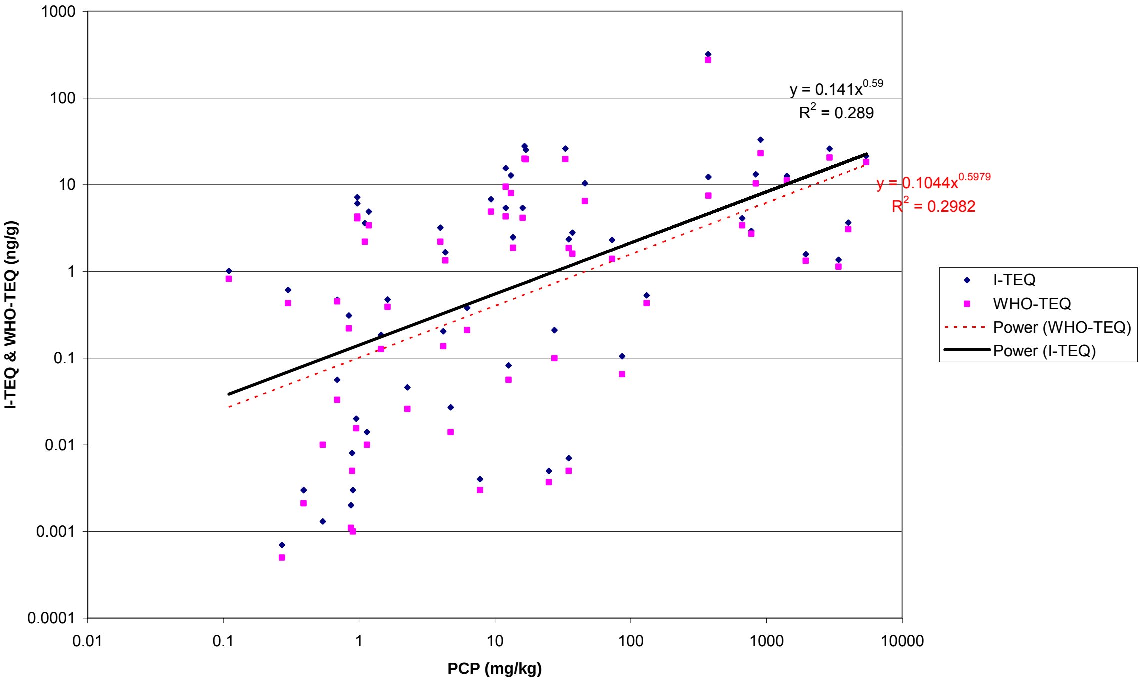


Figure 3.2 Logarithmic plot of soil PCP vs I-TEQ and WHO (1998) TEQ, lower depth



4.3 Revised estimate of the dioxin reservoir

Antisapstain use of NaPCP

The above dioxin data, summarised in Table 4.3, have been used to calculate the contaminant burden in various areas at the different scale-of-use sites. The areas and depths, estimated to be affected at the sites are also provided in Table 4.3.

Based on a count of 220 small-scale users, 28 medium-scale users, six large-scale users and one very large-scale user, the total dioxin reservoir in soils at sawmill sites from antisapstain use of NaPCP is estimated to be in the range 80-250 g WHO (1998) TEQ. This is summarised in Table 4.4 and may be compared with the previous estimate from the existing database of 80 g I-TEQ.

The figures given in Table 4.4 may be an overestimate, because the compiled information indicates that remedial work (excavation and storage/disposal) has taken place on a number of sites (estimated to be up to 20% of the total). In nearly all cases the remediation has been directed at PCP clean-up, but will have resulted in significant dioxin removal. However, the study has not generally investigated low-level dioxin contamination that may exist in areas where treated timber has been stored, nor waste disposal sites. Therefore the estimated reservoir total is considered to be reasonable.

Table 4.3 Parameters used to estimate the total TEQ reservoir from NaPCP use at sawmill sites

Scale of NaPCP use	Mean soil dioxin concentration (μg/kg) WHO (1998) TEQ	Area affected (m^2)	Depth affected (m)
Small			
Antisapstain bath	1.17	100	0.3
Sorting table	0.27–0.49	500	0.3
Boric dip	0.17	200	0.3
Chemical store/mix	0.005	10	0.1
Medium			
Antisapstain bath	0.8–5.6	100	0.5
Sorting table	1.5–6.1	800	0.5
Boric dip	1.4–4.9	200	0.5
Chemical store/mix	10	10	0.6
Large			
Antisapstain bath	3.1–51.7	100	0.75
Sorting table	1.1–10.7	1200	0.75
Boric dip	25*	200	0.75
Chemical store/mix	1.2–5.3	10	0.8

* An arbitrary value, as no former boron dip areas were available for sampling at the large sites.

Table 4.4 Estimated dioxin reservoir in soils from NaPCP antisapstain use

Scale of NaPCP use	Dioxin burden in soil (g WHO (1998) TEQ)	No. of sites	Reservoir (g WHO (1998) TEQ)
Small			
Antisapstain dip	0.04	220	8.8
Sorting table	0.049–0.088	220	10.8–19.4
Boric dip	0.01	86	0.9
Chem store/mix	0.000006	20	0.00012
Total	*0.099–0.138*		
Medium			
Antisapstain dip	0.048–0.336	28	1.3–9.41
Sorting table	0.72–2.93	28	20.2–82.0
Boric dip	0.17–0.59	9	1.5–5.3
Chem store/mix	0.07	10	0.7
Total	*1.01–3.93*		
Large			
Antisapstain dip	0.28–4.65	6	1.7–27.9
Sorting table	1.19–11.56	6	7.1–69.4
Boric dip	2.5	4	10
Chem store/mix	0.012–0.051	6	0.07–0.31
Total	5.98–20.76		
Very large			
Dip tanks	0.23		
Green chain	4.35		
Other areas	9.82		
Total	*14.4*	*1*	*14.4*
Reservoir total			77.5–248.5
Reservoir total (rounded) grams WHO (1998) TEQ			80–250

Notes:
The number of chemical stores is unknown, so the value in the table is an arbitrary estimate, as is the value for the boric dip for large sites. A mean soil bulk density of 1.2 tonne m^{-3} has been assumed.

Preservative use of PCP in diesel

PCP use as a preservative in diesel oil was undertaken at four sites in New Zealand: the Waipa mill (where antisapstain treatment also occurred), Hanmer Springs, Christchurch and Waikoau (which was a comparatively small user). No information is available on the last of these, and only a limited amount of PCP contamination information is available for the site in Christchurch, which indicated a very low level of contamination. Therefore the estimate of the dioxin reservoir is based on the previous estimate for Waipa and Hanmer Springs, adjusted for WHO (1998) TEQ rather than the previous I-TEQ. The estimate is detailed in Table 4.5.

Table 4.5 Dioxin reservoir in soils from PCP preservative treatment (1 site each)

Site	Dioxin burden (g WHO (1998) TEQ per site)	Reservoir (g WHO (1998) TEQ)
Waipa Mill	138	138
Hanmer Springs	34	34
Total		172

4.4 Level of confidence in site contamination characterisation and reservoir estimates

There has been no further investigation at the very large-scale user site and the large PCP-in-oil site, and the level of confidence for these sites remains high.

The level of confidence in the contamination characterisation for NaPCP use is medium to high. Data for the very large user are good, because there has been extensive investigation. The level of confidence for large users is medium because although the majority of sites with large-scale use have been investigated, no data are available for certain use areas, either because they are no longer in existence or are not available for sampling. There is a good data set for about 25% of the medium-scale use sites and similarly a good data set for small-scale use sites.

The level of confidence in the reservoir estimate for NaPCP use is medium, with decreasing confidence in the values for decreasing scale of use. The quantity of NaPCP use at many of the medium- and small-scale use sites is uncertain. The soil dioxin concentrations and areas of contamination are based on a limited amount of site-specific data, which are then extrapolated over the whole sector.

5 POTENTIAL SITE RISKS

5.1 Dioxin risk factors

A number of factors affect the potential risk posed by dioxin contamination at sites that have previously used PCP, including:

- level of contamination
- extent of contamination:
  - lateral
  - vertical
- extent of any remediation
- paved or unpaved surfaces
- management practices
- potential for off-site migration
- the receiving environment, and potential for entry to food chain
- current use and probability of change.

The risks from dioxin contamination can be divided into off-site migration risks and on-site risks.

5.2 Off-site migration and entry into the food chain

There is potential for dioxin contamination of surface water or groundwater. Such contamination is documented for both the Waipa and Hanmer Springs sites, and the groundwater contamination (in particular) is considered to be a direct consequence of the relatively high concentration of PCP used in the preservation process and the greater mobility of the oil carrier through the ground profile.

Previous investigations have focused on PCP contamination, and the investigations have generally shown only low levels of PCP in surface water or sediment on or close to sawmill sites. On this basis, it is expected that dioxin concentrations and the accompanying ecological risk in surface water will be very low. The information collected indicates that there are only two sites – for NaPCP used as a fungicide – where PCP contamination of groundwater has been found.

As with surface water, dioxin contamination of groundwater and ecological risk is expected to be very low. Similarly, apart from the Waipa and Hanmer Springs sites, there is a very low probability of entry to the food chain. Therefore the focus of our discussion is on the potential risk to human health (using the proposed revised criteria) on the sites themselves.

5.3 Potential on-site risks

The ubiquitous nature of dioxin in the environment means that "everyone is exposed to small background levels of dioxin-like compounds when they consume food and, to a much lesser extent, when they breathe air or have skin contact with dioxin-contaminated materials" (Smith and Lopipero, 2001). Risk of exposure may arise from dioxin contamination at a site if at least one of a number of possible exposure pathways is available.

Typically the most relevant human exposure pathways are:

- ingestion of contaminated soil or dust
- inhalation of contaminated soil or dust
- dermal exposure to contaminated soil or dust
- inhalation of vapour if the contaminant is volatile
- ingestion of contaminated produce.

As already mentioned, ingestion of contaminated water is considered to be a very low-probability exposure route.

The relevant exposure pathways were the primary focus of the risk assessment undertaken for the Waipa site in 1992, which established the criteria currently used for dioxin contamination levels for various land uses in New Zealand (see Table 5.1). It should be noted that the criterion for agricultural soil is not based on the same risk assessment approach as for the other land uses, and that the risk assessment was based on the then current WHO tolerable daily intake for dioxins of 10 pg(I-TEQ) per kg bodyweight per day. In the light of more recent data, the WHO in 1998 revised the tolerable daily intake for dioxins down to the range of 1–4 pg(I-TEQ) per kg bodyweight per day. Caution is advisable when applying Table 5.1, since these interim guidelines were developed in 1992 prior to two significant influences that might affect present-day risk calculations: the use of WHO (1998) TEQ in preference to I-TEQ and the WHO revision of the tolerable daily intake.

Table 5.1 Soil dioxin acceptance criteria for various land uses/activities

Population/exposure setting	Existing interim guidelines (μg/kg I-TEQ)
Agricultural	0.01
Residential	1.5
Industrial – unpaved	18
Industrial – paved, no management plan	90
Industrial – paved, with management plan	No limit. Determined on a site-specific basis.
Maintenance	21

Note: for the purposes of this report, equivalent guideline values calculated on the basis of WHO 1998 TEQ are presented in Table 4.2.

The past use of PCP in the timber industry in New Zealand may have resulted in occupational exposure to dioxins for some sawmill workers. The residual dioxin levels in soils at sawmill sites (existing and former) may result in current exposure, and the risk potentially associated with this needs to be considered in three contexts:

- ongoing sawmill use (or some other industrial/commercial use)
- change in use to residential sites
- change in use to agricultural use.

We will now look at each of these in turn.

Ongoing sawmill/industrial use

The following points focus on operating sawmills but are also applicable to situations where the site use has changed to another industrial/commercial use. Current exposure for sawmill, or on-site maintenance, workers may arise from contaminated soil or dust, through ingestion or inhalation, or through dermal absorption.

(a) For former small-use sites, the dioxin concentrations are below the guideline value for an unpaved industrial site.

(b) For medium-use sites, the dioxin concentrations at the majority of locations are below the unpaved guideline value, but where they exceed this value they are well below the guideline value for a paved industrial site.

(c) For large-use sites, 80% of the dioxin concentrations are below the unpaved industrial site guideline value and the concentrations only exceed the guideline value for a paved industrial site at two locations.

It is estimated that the majority of operating sawmill sites have paving covering the more contaminated areas. This is particularly so for the large- and medium-scale users.

Residential use

(a) For small-scale users of PCP, the majority of the study results are below the residential criterion. For the sites with concentrations above the guideline value, a change in land use could increase the risk of exposure but the potential for risk is relatively low.

(b) The results for medium- and large-scale PCP use are generally well above the residential criterion. If the land use were to be changed to residential without any remediation and risk reduction, there would be a significant increase in the risk of exposure.

Agricultural use

(a) Even for small-scale PCP use sites, many of the results are above the criterion.

(b) For the medium- and large-scale-use sites, the criterion is exceeded many-fold for all but three samples. If the land use were to be changed to agricultural without any remediation and risk reduction, there could be a significant increase in the risk of exposure.

6. OPTIONS FOR RISK REDUCTION

Risk reduction is primarily a matter of removing or containing the source of the risk. There are a number of alternatives for preventing exposure, including capping and paving, and these could be applied where appropriate. An analysis of the actual risks posed in particular situations would be required on a site-specific basis to determine the appropriate risk reduction method. In many instances, particularly for medium- and large-scale PCP use sites, removing the source (by excavation) does not appear to be a practicable alternative until an economic means of treatment is available.

Based on the results of the study in considering Table 4.1, the following comments address risk reduction measures in relation to landuse and the scale of PCP use,. These comments are subject to the qualifications outlined in section 5 when taking into account the interim guidelines of Table 5.1.

6.1 Ongoing sawmill/industrial use

Small-scale users

For most areas it appears that the surface could remain unpaved, given that none of the locations investigated had dioxin concentrations above the unpaved industrial criterion.

Medium-scale users

In most areas the surface could remain unpaved. The locations more likely to be contaminated should be paved and some may require a management plan to be developed.

Large-scale users

As for medium-scale sites, in most areas the surface could remain unpaved. The locations more likely to be contaminated should be paved and some may also require a management plan to be developed.

6.2 Residential use

Small-scale users

The dioxin concentrations in most areas of small-scale PCP use sites are likely to be below the residential criterion. For any particular site where it is known that the residential criterion is exceeded, these areas would need to be excavated, unless it could be guaranteed that they would be covered with paving.

Medium- and large-scale users

Most site areas are likely to be above the residential criterion, and it is unlikely to be practicable or economic to clean such sites to meet this criterion. Therefore such sites should not be allowed to have a change in land use to residential, unless there is validated clean-up to the residential criterion. In cases where un-remediated sites are abandoned, they should be fenced and secured against unauthorised occupation. A grass sward should be established and regularly maintained to minimise the run-off of contaminated sediment.

6.3 Agricultural use

Most areas of all sites where PCP has been used will have soil dioxin concentrations above the agricultural guideline value. These sites should not be allowed to have a change in use to agriculture. In cases where such sites are abandoned, they should be fenced and secured against unauthorised use. A grass sward should be established and regularly maintained to minimise the run-off of contaminated sediment.

7 CONCLUSIONS

An investigation of dioxin contamination of soils has been undertaken at 17 of the total estimated 255 sawmill sites that have used PCP. Based on these investigations the dioxin reservoir from NaPCP antisapstain use has been recalculated to be in the range 80 – 250g WHO-TEQ (up to approximately 3 times greater than the previous estimate). The majority of this reservoir is at the medium- and large-scale PCP use sites (28 and six respectively). However, it should be noted that this may be an overestimate of the reservoir, because a number of the medium- or large-scale use sites not investigated in the study have undergone remediation.

On a site-by-site basis, risks to human health and the environment from soil contaminated by PCP and dioxin are associated predominantly with the sites (approximately 35) that were relatively large users of PCP. Investigations of some of these sites have shown (although this is not reported in this study) that PCP and dioxin have migrated off site and contaminated, respectively, water bodies and sediment (dioxin is tightly bound to particulate matter in the absence of oil), including two sites where PCP in oil was used as a preservative (Waipa and Hanmer Springs).

Attention to health risk assessment is strongly indicated for such sites if a change from an industrial use to residential use or a life-style block were proposed. Given the scale of operations on these sites and their locations, such changes in land use are unlikely.

Unless the site was a large user of PCP, investigations of PCP contamination by the timber industry and regional councils indicate that little off-site migration of PCP (and by implication dioxins) is likely in either groundwater or surface water. Thus on a site-by-site basis, if little potential for dioxin entry to the food chain or the aquatic environment is apparent, the potential risk to human health is confined to direct exposure to the soil where PCP has been used.

Small-scale PCP use sites

The majority of the study results representative of these 220 sites are below the criterion for an unpaved industrial site, indicating that they pose little potential risk for a continuing industrial use. If there was a change in use to residential, only a small proportion of the affected areas would have dioxin concentrations above the residential criterion. In these areas there could be some increase in risk of exposure if they were not remediated. If there was a change in site use to agriculture, a considerable portion of the affected areas would have dioxin concentrations above the relevant criterion, and there could be significant potential risk if the areas were not remediated.

Medium-scale PCP use sites

The majority of the study results representative of these 28 sites are below the criteria for a paved or an unpaved industrial site. Only where the dioxin concentrations exceed the unpaved industrial site criteria is there a significant risk for ongoing industrial use. In these situations the most significant contamination should be removed or the affected areas paved and a management plan developed to ensure the integrity of the paving, and for appropriate procedures to be followed should the paving need to be broken through (eg, for maintenance).

The criteria for residential or agricultural use are exceeded for most locations and there would be significant potential for risk if a change to either of these land uses were permitted. Provisions should be made by territorial authorities to ensure that such changes in use are not permitted, unless there is a validated clean-up to the relevant criterion.

Large-scale PCP use sites

The majority of the study results representative of these six sites are below the criterion for a paved industrial site. There is the potential for significant risk for ongoing industrial use in the few locations where the unpaved criterion is exceeded unless this contamination is removed or the affected areas are paved and a management plan developed to ensure the integrity of the paving, and for appropriate procedures to be followed should the paving need to be broken through (eg, for maintenance).

The criteria for residential or agricultural use are exceeded for most locations, and there would be significant potential for risk if a change to either of these land uses were permitted. Provisions should be made by territorial authorities to ensure that such changes in use are not permitted, unless there is a validated clean-up to the relevant criterion.

Limitations on the analysis

A more comprehensive and reliable database of sawmill sites that used PCP in New Zealand has been developed, which will be of assistance to local government in the management of these sites, particularly at times and in situations involving a change in land use. Although considerably more data are now available on PCP and dioxin contamination on these timber treatment sites, our knowledge is still limited from a statistical analysis perspective, for the following reasons.

- Due to the changes that have occurred in the industry and on particular sites in the time since PCP was last used, it is difficult to find locations that are still readily accessible for sampling.
- Many sites had more than one process using PCP, and therefore in trying to characterise contamination at a number of locations per site the total data set is still small.
- Storage and waste disposal areas, which may also have PCP/dioxin contamination, have not been covered in the study investigations.

The data generated from this study has been used to revise the existing estimate of the dioxin reservoir at timber treatment sites. However, for the reasons listed above, it still does not provide a definitive picture of contamination across timber treatment sites throughout New Zealand. As a result there will still be some inherent uncertainty in any reservoir estimate.

Significantly, the study confirms the use of the OCDD screen as an excellent technique to assess dioxin contamination at a site. The data suggest a relationship between PCP and dioxin concentrations which may allow PCP to be used as a useful surrogate for dioxin contamination. However, it will be important for the relationship to be validated on a site-by-site basis.

REFERENCES

Bingham, AG 1992. *National Task Group on Site Contamination, Task Brief 6 – Background Paper on PCP Related Issues.* NECAL service report S92/465. Report prepared for the Department of Health: Wellington, New Zealand.

CMPS&F 1992. *New Zealand National Task Group on Site Contamination from the Use of Timber Treatment Chemicals: Pentachlorophenol Risk Assessment Pilot Study: National Task Group Study Team Report*. Ministry for the Environment and Department of Health: Wellington, New Zealand.

CMPS&F 1995. *Audit of Timber Treatment Sites: Overview Report;* and, *Timber Site Audit Project: Environmental Site Assessment (Reports for Site A, Site B and Site C)*. Canterbury Regional Council, Christchurch.

ESR 1992. = Appendix J of CMPS&F, 1992.

Kutz, FW, Barnes, DG, Bottimore, DP, Greim, H, Bretthauser, EW 1990. The international toxicity equivalency factor (I-TEF) method of risk assessment for complex mixtures of dioxins and related compounds. *Chemosphere* 20: 751–757.

Ministry for the Environment and Ministry of Health, 1997. *Health and Environmental Guidelines for Selected Timber Treatment Chemicals.* Ministry for the Environment and Ministry of Health: Wellington, New Zealand.

Ministry for the Environment 2000. *New Zealand Inventory of Dioxin Emissions to Air, Land and Water, and Reservoir Sources.* Ministry for the Environment: Wellington, New Zealand.

Roberts, AHC, Cameron, KC, Bolan, NS, Ellis, HK, Hunt, SD 1996. Contaminants and the soil environment in New Zealand. *In:* Naidu, R, Kookana, RS, Oliver, DP, Rogers, S, McLaughlin, MJ (eds.) *Contaminants and the Soil Environment in the Australasia-Pacific Region*. Kluwer Academic Publishers: London, United Kingdom, pp. 579–628.

Royd's Garden Environmental Services/CMPS&F 1994. *Site Investigation Report for the Former New Zealand Forest Service Site, Jollies Pass Road, Hanmer Springs*. Report prepared for the Ministry for the Environment, Wellington.

Shaw, CP 1990. *Pentachlorophenol and Chlordane: Timber Preservation Chemicals in the New Zealand Environment.* Report prepared by the Cawthron Institute, Nelson, for the Ministry for the Environment: Wellington, New Zealand.

Smith, AH, Lopipero, P 2001. *Evaluation of the Toxicity of Dioxins and Dioxin-like PCBs: A Health Risk Appraisal for New Zealand*. Ministry for the Environment: Wellington, New Zealand.

Van den Berg, M, Birnbaum, L, Bosveld, ATC, Brunstrom, B, Cook, P, Feeley, M, et al. 1998. Toxic Equivalency Factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. *Environmental Health Perspectives* 106: 775-792.

Van den Berg, M, Birnbaum, L, Denison, M, De Vito, M, Farland, W, Feeley, M, Fiedler, H, Hakansson, H, Hanberg, A, Haws, L, Rose, M, Safe, S, Schrenk, D, Tohyama, C, Tritscher, A, Tuomisto, J, Tysklind, M, Walker, N, and Peterson R. *The 2005 World Health Organization Re-evaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds*. ToxSci Advance Access published July 7, 2006, Oxford University Press on behalf of the Society of Toxicology.

WHO 1998 = Van den Berg et al., 1998 above.

FURTHER SOURCES

Several of the following sources were reports published by the relevant regional council (eg, Waikato, Bay of Plenty, Taranaki). The remainder were reports prepared by consultants for the regional councils, or were correspondence between the regional councils and T&T in response to queries, and are not published documents.

Bay of Plenty Council 1991. *An Overview of Sawmill and Timber Treatment Wastes in the Bay of Plenty Region*. Technical Report No 12.

Hawke's Bay Regional Council. *Ministry for the Environment Project: Assessment of Dioxin Contamination at Sawmill Sites* (letter to Tonkin & Taylor 27/03/02).

Loe Pearce & Associates 1993. *Preliminary Survey of Pentachlorophenol Use in The Timber Industry in Canterbury.* Canterbury Regional Council.

Loe Pearce & Associates 1994a. *Timber Treatment Chemical Use: A Preliminary Investigation of the Use of CCA, Boron, Antisapstain Chemicals at 15 Sites for Canterbury Regional Council. Vol I.*

Loe Pearce & Associates 1994b. *Timber Treatment Chemical Use: A Preliminary Investigation of the Use of CCA, Boron, Antisapstain Chemicals at 23 Sites for Canterbury Regional Council. Vol II.*

Montgomery Watson 1998. *Wellington Regional Council: Timber Treatment Sites Review*.

Northland Regional Council. *Environmental Monitoring Northland Timber Treatment Plants* (letter to Tonkin & Taylor, 22/04/02).

Pattle Delamore Partners 1999. *Timber Treatment Off-Site Investigations in the Wellington Region.*

Taranaki Regional Council 1994. *Investigation of Timber Treatment and Sawmilling Sites in Taranaki*. Technical Report 94-70.

Timber Preservation Authority records.

Works Environmental Management, Canterbury Regional Council. *Pentachlorophenol Contamination Site Investigations.*

OSH information

The following information was provided to the Occupational Safety and Health Service (OSH) from the relevant regional councils / unitary authorities.

- Identification of PCP Contaminated sites in the Hawke's Bay Regional and Gisborne District Council Areas
- Identification of Pentachlorophenol (PCP) Contaminated Sites in the Canterbury/West Coast Region
- Identification of Pentachlorophenol (PCP) Contaminated Sites, LIMs Otago Regional Council
- PCP Sites in Marlborough, Nelson City and Tasman District
- Sawmills and Timber Treatment Sites for Taumarunui and Surrounding Area (Horizons MW)
- Sawmills and Timber Treatment Sites in the Region, Southland Regional Council
- Timber Industry Sites in the Waikato Region
- Timber Treatment Sites on Auckland Regional Council Records, August 2000.

Appendix A. Previous PCP and Dioxin Investigations

Over the last 10–15 years a number of site investigations have been undertaken. The majority of these have been PCP rather than dioxin investigations. In a number of regions investigations have been undertaken by site owners, principally to establish appropriate remedial works. The results of these investigations have not been available for this study, and the results summarised below are based on investigations carried out by regional councils / unitary authorities and made available for this study.

PCP investigations

Northland Regional Council (NRC)

In 1991 the NRC collected and analysed sediment samples from and adjacent to 13 sites. At seven of these sites surface water samples were also taken. Sediment at most of the sites showed PCP levels at or below the detection limit (2 mg/kg). One site had levels up to 1.0 mg/kg, another up to 1.7 mg/kg and a third up to 18 mg/kg. The latter also had PCP concentrations in water up to 20 mg/m^3. Another site had a PCP concentration in water of 2 mg/m^3; all other samples were at or below the detection limit (1 mg/m^3).

In 1994 preliminary site investigations were undertaken by the NRC at six sites. These showed no, or low levels of, PCP in the soil samples and at one site a low level in groundwater.

Auckland Regional Council (ARC)

In 1992/93 the ARC collected and analysed samples from drainage courses on or adjacent to a number of sites. Sediment/soil from six of the sites showed maximum PCP levels ranging from 0.8 to 11.3 mg/kg. One site also had a PCP concentration of 0.008 mg/m^3 in stormwater run-off.

Environment Waikato (EW)

EW has not undertaken a specific programme of PCP investigations.

Environment Bay of Plenty (EBOP)

EBOP has not undertaken a specific programme of PCP investigation. However, the site which was the major user of PCP in the country (Waipa) was subject to investigation (for both PCP and dioxin contamination) by the National Task Group in 1992 (Ministry for the Environment and Department of Health, 1992). Significant levels of contamination were found in the soils on site: in groundwater and receiving environment water, sediment and biota. Further investigations and monitoring have been undertaken by the site owners and by the council. A treatment system has been installed for the interception and clean-up of the contaminated groundwater.

Hawke's Bay Regional Council (HBRC)

HBRC has not undertaken a specific programme of PCP investigation.

Gisborne District Council (GDC)

GDC has not undertaken a specific programme of PCP investigation

Taranaki Regional Council (TRC)

In 1994 the TRC undertook investigations at 33 current and past timber-processing sites with regard to possible discharges from these sites into groundwater or surface water. Samples were taken of soils, sludges, sediments, discharges and receiving waters. No PCP was found in any of the water samples (discharges or receiving environment). Maximum concentrations of PCP found in soils (or sludges where stormwater pools) on 11 sites ranged from 0.1 to 14 mg/kg and in sediments on five sites ranged from 0.2 to 0.5 mg/kg.

Manawatu–Wanganui Regional Council (Horizons-MW)

Horizons-MW has not undertaken a specific programme of PCP investigation.

Wellington Regional Council (WRC)

In 1998 a review was conducted for the WRC on 24 timber treatment sites and 17 sawmill sites. This indicated six priority sites for follow-up investigation. An investigation was undertaken in 1999 to assess the off-site effects of discharges from these sites. No PCP was found in the sediment of samples collected around the periphery at five of the sites. At the remaining site a maximum PCP concentration of 0.3 mg/kg was found. At four of the sites maximum PCP concentrations in surface water run-off ranged from 0.00005 to 0.0117 mg/L.

Nelson City Council (NCC)

At NCC's request, a number of the sites have been investigated by the site owners. NCC reports that at two of the sites very low levels of PCP were detected, and at a third the levels were at an acceptable level for its ongoing use as a sawmill / timber treatment site.

Tasman District Council (TDC)

TDC has not undertaken a specific programme of PCP investigation.

Marlborough District Council (MDC)

MDC has not undertaken a specific programme of PCP investigation.

West Coast Regional Council (WCRC)

WCRC has not undertaken a specific programme of PCP investigation.

Canterbury Regional Council (ECan)

ECan had PCP investigations undertaken at 18 sites in 1994. At three of the sites no PCP was found. On the remaining sites the maximum PCP concentration found in soil generally ranged from 1.0 to 4,500 mg/kg, although at one site a concentration of 25,000 mg/kg was found in sawdust beneath an antisapstain dip tank. Previous work for the council had provided estimates of PCP use at many of these sites. There was no correlation between quantity of PCP estimated to have been used and levels of PCP contamination found.

At about the same time a number of investigations were carried out at the former Forest Service Hanmer Springs site (PCP-in-oil operation). The maximum PCP concentration found in soil in the vicinity of the treatment plant was 830 mg/kg and in the waste disposal area 770 mg/kg. One hot spot (possibly disposed waste) had a PCP concentration of 5,700 mg/kg. The maximum PCP concentration in groundwater was 40 mg/L and in downstream surface water 0.08 mg/L. Results from later investigations were consistent with these results but showed that PCP contamination at one location extended to a depth of approximately 4 metres, a maximum groundwater concentration of 100 mg/L and downstream surface water concentration of 0.007 mg/L.

Otago Regional Council (ORC)

In 1995 the ORC had PCP investigations undertaken at four sites. Maximum PCP concentrations found ranged from less than 0.1 to 12,000 mg/kg in soil, and up to 49 g/m^3 and 0.8 g/m^3 in groundwater and stormwater respectively. Later investigations or monitoring by the ORC have shown low levels of soil or groundwater contamination at a further four sites.

Southland Regional Council (SRC)

SRC has not undertaken a specific programme of PCP investigation.

Dioxin investigations

A number of investigations of dioxin contamination have been undertaken by site owners. However, as mentioned, the results of these investigations are not publicly available. A limited number of sites have been investigated by central or local government. The most comprehensive investigation was carried out by the National Task Group (Ministry for the Environment and Department of Health, 1992). As described above for PCP, dioxin contamination was found in soils, groundwater and surface waters, including sediment and biota. Dioxin contamination of soils associated with the PCP-in-oil process were in the order of 20 µg I-TEQ/kg, and for soils associated with green chain and boric dip antisapstain operations the contamination ranged from 0.1 to 3.1 µg I-TEQ/kg. One hot spot beneath the mix room had a concentration of 3,300 µg I-TEQ/kg. (All TEQ values are based on full congener analysis.)

At the Hanmer Springs site the maximum dioxin contamination found in soil was 3.5µg I-TEQ/kg (full congener analysis). When the plant was decommissioned, a surface layer (250–300 mm) was scraped off the treatment plant and log storage area and disposed of at an unknown location. There is also a plume of PCP/dioxin contaminated oil on the groundwater surface at the site. The dioxin concentration in the oil was measured to be 159 µg I-TEQ/kg.

A preliminary investigation was also undertaken at three sites in the Canterbury region classified as small NaPCP users. Dioxin concentrations in soils on these sites ranged from 0.5 to 4.2 µg I-TEQ/kg.

The sources for this information are as follows:

- CMPS&F 1995a. *Audit of Timber Treatment Sites – Overview Report*. Canterbury Regional Council: Christchurch
- CMPS&F 1995b. *Timber Site Audit Project – Environmental Site Assessment, Site A.* Canterbury Regional Council: Christchurch
- CMPS&F 1995c. *Timber Site Audit Project – Environmental Site Assessment, Site B.* Canterbury Regional Council: Christchurch
- CMPS&F 1995d. *Timber Site Audit Project – Environmental Site Assessment, Site C.* Canterbury Regional Council: Christchurch.

Level of confidence in site contamination characterisation

PCP

In many of the regions the emphasis has been on assessing the extent of PCP migration from the site or the ongoing potential for this to occur. For some councils, the assessment of the potential for ongoing migration has focused on those areas of the site most likely to have higher levels of residual contamination.

With the exception of the Canterbury region, there have been few comprehensive council investigations of PCP contamination at sawmill and timber treatment sites. Therefore the level of confidence that can be placed on PCP contamination characterisation (on the public record) is relatively low. However, a significant number of PCP investigations have been undertaken by site owners and much of this information has been provided to councils in association with proposed remedial works, consent applications or monitoring. These councils will have a higher level of confidence in the characterisation of PCP contamination at sites under their jurisdiction.

Dioxins

The two sites that used PCP in oil (discussed above) have been thoroughly investigated and the dioxin contamination has been well characterised. Given the preliminary nature of the investigation at the three small Canterbury sites, there is only a low level of confidence in the characterisation of dioxin contamination associated with NaPCP antisapstain treatment. As with PCP (see above), there have been a number of dioxin investigations undertaken by site owners and therefore some councils will have a higher level of confidence in the characterisation of dioxin contamination at sites under their jurisdiction.

Appendix B. Detailed Analysis of Results

The analysis results of the investigations of this study are shown in Tables B.1 to B.3.

Table B.1 PCP and dioxin levels in soil – small users

Agri Quality Ref.	T&T Sample No.	Sample location	PCP (mg/kg)	TCP (mg/kg)	OCDD screen I-TEQ (ng/g)	Full congener I-TEQ (ng/g)	OCDD Screen WHO (1998) TEQ (ng/g)	Full congener WHO (1998) TEQ (ng/g)
231/1	6A 0.1	BD	0.85	0.10	0.083		0.046	
231/2	6A 0.3	BD	0.87	0.06	0.002		0.0011	
231/4	6B 0.1	BD	3.27	0.53	0.172		0.093	
231/5	6B 0.3	BD	0.90	< 0.05	0.003		0.001	
231/7	6C 0.1	BD	2.44	0.22	0.25		0.14	
231/8	6C 0.3	BD	2.27	0.08	0.046		0.026	
231/10	6D 0.1	Store	1.27	0.06	0.006		0.004	
231/11	6D 0.3	Store	0.89	< 0.05	0.008		0.005	
266/24	11A 0.1	ST	8.29	0.23	2.22		1.57	
266/25	11B 0.1	ST	3.85	0.29	2.35		1.50	
266/26	11B 0.3	ST	3.96	0.44	3.2		2.2	
266/27	11C 0.1	ASD	68	< 3	0.314		0.229	
266/28	11C 0.3	ASD	25	< 3	0.005		0.0037	
266/38	14A 0.1	BD	5.76	0.28	0.042		0.029	
266/39	14A 0.3	BD	7.76	0.29	0.004		0.003	
266/40	14B 0.1	ST	7.34	0.31	0.127	0.299	0.078	0.243
266/41	14B 0.3	ST	4.73	0.13	0.027		0.014	
266/42	14C 0.1	Spray	4.02	0.49	0.178		0.135	
266/43	14C 0.3	Spray	12	< 3	5.4		4.32	
266/50	16A 0.1	ST	2.46	0.25	0.019	0.060	0.013	0.053
266/51	16A 0.3	ST	1.45	0.22	0.185		0.127	
266/53	16 B 0.1	ST	3.72	0.45	0.02		0.0155	
266/54	16B 0.3	ST	1.14	0.15	0.014		0.010	
266/55	16C 0.1	BD	0.17	< 0.05	0.007		0.0052	
266/56	16C 0.3	BD	0.39	0.08	0.003		0.0021	
266/58	16 D 0.1	BD	0.64	0.10	0.035		0.026	
266/59	16D 0.3	BD	0.54	0.16	0.013		0.010	
266/60	17A 0.1	BD	1.32	0.19	6.3		3.7	
266/60	17A 0.1	BD			3.7	5.2	2.2	3.7
266/61	17A 0.3	BD	35	3	0.007		0.005	
266/63	17B 0.1	BD	2.37	1.18	0.146		0.095	
266/64	17B 0.3	BD	0.95	0.09	0.02		0.0155	
266/66	17C	ST	0.86	0.08	0.0075	0.0598	0.0053	0.0575
266/67	17D	ST	0.70	0.10	0.006		0.0052	
Range			0.17–68	0.05–3	0.001–6.3		0.001–4.3	
Arithmetic mean			6.52	0.43	0.73		0.49	
95% UCL of mean			11.28	0.76	3.48		2.33	

Notes for this and the following tables:

1. Column 1 is the laboratory sample identification number.
2. Column 2 is the site sampling identifier with site number, sample location and depth in metres. For example '6A0.1' is site 6, sample location A, sampling depth 0.1 m (core from 0.05 to 0.15 m). Sampling depth 0.3 m is similarly a core from 0.25 to 0.35 m.
3. Column 3 identifies the sampling area as follows: AD = antisapstain dip or spray; BD = boric dip or spray; ST = sorting table; Store/mix = chemical storage or mixing area.
4. Columns 4 and 5 give PCP and TCP concentrations.
5. Columns 6 and 7 give dioxin TEQ values (for the I-TEF system) based on the OCDD screen and full congener analyses, respectively.
6. Columns 8 and 9 give dioxin TEQ values (for the WHO (1998) TEF system) based on the OCDD screen and full congener analyses respectively. OCDD screen TEQ values include 1,2,3,4,6,7,8-HpCDD as well as OCDD. Where a full congener analysis was conducted the TEQ values recorded under OCCD screen are those for 1,2,3,4,6,7,8-HpCDD and OCDD from the full congener results.
7. TEQ values include the detection limit value for those congeners not detected.
8. Some UCL values are at > 95% confidence limit depending on data distribution.

Table B.2 PCP and dioxin levels in soil – medium users

Agri Quality Ref.	T&T Sample No	Sample location	PCP (mg/kg)	TCP (mg/kg)	OCDD screen I-TEQ (ng/g)	Full congener I-TEQ (ng/g)	OCDD Screen WHO (1998) TEQ (ng/g)	Full congener WHO (1998) TEQ (ng/g)
193/1	1A 0.1	BD	0.57	0.06	0.37		0.35	
193/2	1A 0.3	BD	0.69	0.06	0.47		0.45	
193/5	1B 0.1	BD	0.61	< 0.05	0.40		0.27	
193/6	1B 0.3	BD	1.1	0.07	3.6		2.2	
193/8	1C 0.1	ST	4.17	0.27	17.2		11.6	
193/9	1C 0.3	ST	16.5	1.1	28		19.9	
193/11	1D 0.1	ST	17.4	0.7	8.1		5.6	
193/12	1D 0.3	ST	37.2	1.2	2.8		1.6	
193/14	1E 0.1	ST	3.52	0.23	3.4		2.0	
193/15	1E 0.3	ST	13.1	0.8	12.8		8.0	
193/17	1F 0.15	ASD	590	21	54		32.4	
193/17	1F 0.15	ASD			47	93.7	30.8	72.9
193/18	1F 0.3	ASD	904	37	33		23.1	
193/20	1G 0.3	ASD	374	15	12.3		7.5	
193/23	2A 0.1	ASD	0.51	0.09	0.23		0.12	
193/24	2A 0.3	ASD	6.26	0.29	0.38		0.21	
193/26	2B 0.1	ASD	1.05	<0.05	0.33		0.20	
193/29	2C 0.1	BD	1.29	0.08	15.8		5.9	
193/30	2C 0.3	BD	27.4	0.4	0.21		0.10	
193/32	2D 0.1	BD mix	685	10	13.9		10.0	
193/32	2D 0.1	BD mix			8.7	17.5	4.4	13
193/33	2D 0.3	BD mix	834	8	13.2		10.3	
193/74	2E 0.1	ST	0.55	0.05	0.37		0.21	
193/77	2F 0.1A	ST	0.35	0.06	0.30		0.19	
193/35	3A 0.1	ASD1	1.52	0.12	3.4		2.3	
193/36	3A 0.3	ASD1	0.84	0.05	0.31		0.22	
193/38	3B 0.1	ASD1	0.56	< 0.05	1.09	1.34	0.49	0.71
193/41	3C 0.1	ASD1	0.22	< 0.05	0.003		0.001	
193/42	3C 0.3	ASD1	0.27	< 0.05	0.0007		0.0005	

Table B.2 PCP and dioxin levels in soil – medium users (cont)

Agri Quality Ref.	T&T Sample No	Sample location	PCP (mg/kg)	TCP (mg/kg)	OCDD screen I-TEQ (ng/g)	Full congener I-TEQ (ng/g)	OCDD Screen WHO (1998) TEQ (ng/g)	Full congener WHO (1998) TEQ (ng/g)
193/44	3D 0.1	ASD1	0.22	< 0.05	0.052		0.005	
193/47	3E 0.1	ASD2	1.19	0.05	2.44		1.68	
193/50	3F 0.1	ASD2	0.39	< 0.05	0.29		0.20	
193/51	3F 0.3	ASD2	16.9	1.8	25.3		19.6	
193/53	3G 0.1	ASD2	5.45	0.18	20.0		14.6	
193/53	3G 0.1	ASD2			8.5	20.7	6.5	17.3
193/56	3H 0.1	ASD2	0.46	< 0.05	0.19		0.14	
193/57	3H 0.3	ASD2	1.18	0.07	4.9		3.4	
193/62	5A 0.1	BD	1.76	0.10	10.7		6.0	
193/63	5A 0.3	BD	0.11	< 0.05	1.01		0.82	
193/65	5B 0.1	BD	0.37	0.05	1.55		0.965	
193/66	5B 0.3	BD	0.97	0.10	6.1		4.3	
193/68	5C 0.1	BD	4.13	0.31	4.1		2.75	
193/69	5C 0.3	BD	0.3	< 0.3	0.61		0.43	
193/71	5D 0.1	BD	1.23	0.08	3.9		2.0	
193/71	5D 0.1	BD			3.0	4.69	1.4	2.91
193/72	5D 0.3	BD	0.97	< 0.05	7.2		4.1	
231/32	8A 0.0	ST	3.52	0.59	0.374		0.289	
231/34	8A 0.5	ST	4.31	0.07	1.66		1.34	
231/36	8B 0.0	ST	2.44	0.20	0.36		0.25	
231/37	8B 0.5	ST	1.62	0.10	0.474		0.389	
231/39	8C 0.0	ASD	51.4	2.6	13.3		9.6	
231/41	8C 0.5	ASD	13.6	0.4	2.47		1.87	
266/30	13A 0.1	BD	49	< 3	9.3		6.15	
266/30	13A 0.1	BD			10.4	19.6	5.8	14.6
266/31	13A 0.3	BD	16	< 3	5.4		4.14	
266/33	13B 0.1	BD	65	< 3	20.5		11.95	
266/34	13B 0.3	BD	12	<3	15.5		9.5	
266/36	13C 0.1	BD	17	< 3	18.9		11.8	
266/37	13C 0.3	BD	9.35	0.56	6.8		4.9	
266/44	15A 0.1	BD	1.8	0.1	51		26.7	
266/45	15A 0.3	BD	46	< 3	10.4		6.5	
266/46	15B 0.1	BD	138	7	22.7		16.7	
266/47	15B 0.3	BD	33	< 3	26.2		19.7	
266/48	15C 0.1	BD	573	7	6.0	10.1	3.5	7.2
266/49	15C 0.3	BD	73	<3	2.3		1.4	
Range			0.11–904	0.05–37	0.0007–54		0.005–34	
Arithmetic mean			77.8	2.17	9.3		6.02	
95% UCL of mean			341	6.92	12.8		8.37	

Table B.3 PCP and dioxin levels in soil – large users

Agri Quality Ref.	T&T Sample No	Sample location	PCP (mg/kg)	TCP (mg/kg)	OCDD screen I-TEQ (ng/g)	Full congener I-TEQ (ng/g)	OCDD Screen WHO (1998) TEQ (ng/g)	Full congener WHO (1998) TEQ (ng/g)
231/12	7A 0.0	ST	599	27	3.99		3.28	
231/13	7A 0.5	ST	131	< 3	0.53		0.43	
231/14	7B 0.1	ST	8.9	1.3	0.026		0.016	
231/15	7B 0.3	ST	12.6	1.5	0.082		0.056	
231/18	7C 0.0	ST	1300	50	7.7		5.82	
231/20	7C 0.5	ST	2920	150	26.0		20.6	
231/22	7D 0.0	ST	80	4	0.31		0.18	
231/22	7D 0.0	ST			0.30	0.510	0.165	0.359
231/24	7D 0.5	ST	5430	240	21.4		18.3	
231/27	7E 0.0	ASD	51.6	2.8	6.9		4.9	
231/29	7E 0.5	ASD	372	3	320		275	
231/29	7E 0.5	ASD			25	90	16.9	80.55
231/44	9A 0.0	ST	3.52	0.35	0.390	0.742	0.192	0.524
231/46	9A 0.5	ST	4.17	0.13	0.204		0.137	
231/49	9B 0.0	ST	2.83	0.34	0.61		0.46	
231/51	9B 0.5	ST	86.6	1.8	0.105		0.065	
231/54	9C 0.0	ST	130	8	7.3		6.0	
231/56	9C 0.5	ST	1950	340	1.58		1.33	
231/59	9D 0.0	ST	167	6	9.7		8.1	
231/61	9D 0.5	ST	3400	110	1.36		1.13	
231/64	9E 0.0	ASD	251	10	19.8		16.4	
231/66	9E 0.5	ASD	4010	160	3.65		3.07	
266/1	10A 0.1	Store/mix	1.9	0.18	4.32		3.58	
266/2	10A 0.3	Store/mix	0.69	< 0.05	0.056		0.033	
266/4	10B 0.1	Store/mix	18	< 3	7.5		6.4	
266/5	10B 0.3	Store/mix	1410	140	12.6		11.2	
266/10	10D 0.1	ASD	15	< 3	78.4		69.9	
266/10	10D 0.1	ASD			61	117	42.1	95
266/11	10D 0.3	ASD	775	10	2.92		2.72	
266/13	10E 0.1	ASD	33	< 3	62		39.5	
266/13	10E 0.1	ASD			66	121	43.5	85.6
266/14	10E 0.3	ASD	35	< 3	2.35		1.86	
266/19	10G 0.1	ST	5130	430	150		123	
266/20	10G 0.3	ST	661	27	4.1		3.4	
Range			0.69–5430	0.13–430	0.026–320		0.016–275	
Arithmetic mean			966	57.7	26.7		21.5	
95% UCL of mean			1888	518	48.8		39.6	