

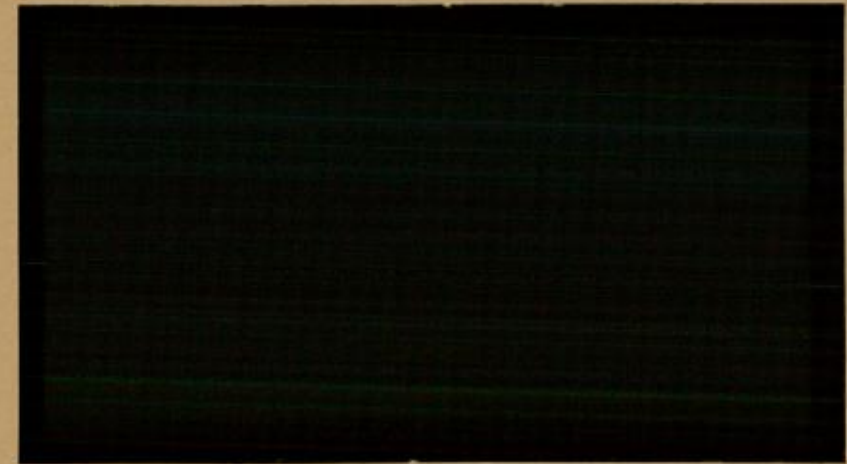
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Environmentally Hazardous
Chemicals Act, 1985

**Assessment Report
and
Chemical Control Order**



State Pollution Control Commission

In N.S.W...another win for the environment

ASSESSMENT OF POLYCHLORINATED BIPHENYL
(PCB) WASTES

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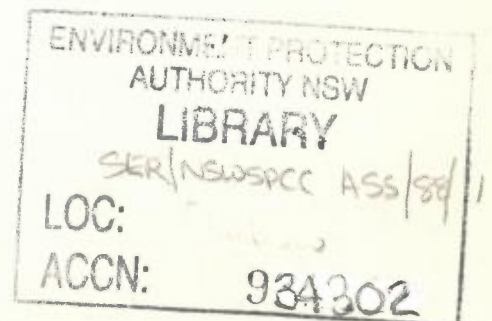


TABLE OF CONTENTS

	Page
1 INTRODUCTION	1
2 PROPERTIES OF POLYCHLORINATED BIPHENYLS (PCBs)	1
2.1 Chemical and Physical Properties of PCBs	1
2.2 Toxicity of PCBs	5
2.3 Environmental Effects of PCBs	9
2.3.1 Environmental concentrations and bioaccumulation	9
2.3.2 Behaviour and fate of PCBs in the environment	12
2.4 Brand Names and coding of PCBs	13
2.5 Uses of Polychlorinated Biphenyls	14
3 PCB WASTE MATERIALS	14
3.1 Types of Wastes Containing PCBs	14
3.2 Storage of PCB Wastes	15
3.3 Transportation of PCBs	15
3.4 Spillages Involving PCBs	15
3.5 Disposal Methods for PCB Wastes	15
3.5.1 Incineration methods	17
3.5.2 Chemical methods	18
3.5.3 Radiant energy processes	19
3.5.4 Biological methods	19
3.5.5 Burial of wastes containing PCBs	21
4 LEGISLATION, REGULATIONS AND STANDARDS FOR PCB WASTES	22
4.1 O.E.C.D.	22
4.2 Canada	23
4.3 US EPA	23
4.4 Australia	24
5 SUBMISSIONS TO THE ASSESSMENT	25
5.1 Submission from the Metropolitan Waste Disposal Authority	25
5.2 Submission from the Electricity Commission of NSW	27
5.3 Submission from the Prospect County Council	28
6 DISCUSSION	29
7 CONCLUSION	31
8 REFERENCES	33
TABLES	
1. Physical Properties of the Chlorobiphenyls	
2. General Properties of some Aroclors	
3. Composition of Different Liquid Chlorinated Biphenyls	
4. Accumulation of PCBs by Various Aquatic organisms	

5. PCB Residues in Fish in N.S.W. Fresh Water and Marine and Estuarine Waters
6. The World's Major Producers of PCB
7. Use of PCB Classified to Grade of Aroclor
8. Acceptable Methods of Disposals

APPENDICES

- A Special Conditions Applicable to the Storage of Polychlorinated Biphenyl (PCB) Waste.
- B Special Conditions applicable to Transport of Polychlorinated Biphenyl (PCB) Waste and Equipment Containing Liquid PCB.
- C Outline Spill Response Guide For Polychlorinated Biphenyls (PCB).

CHEMICAL CONTROL ORDER

[5W-MKD, C3, R-AF2, 8]

The purpose of this assessment report is to assess polychlorinated biphenyl (PCB) wastes under the Environmentally Hazardous Chemicals Act, (EHC Act) with a view to introducing any desirable statutory controls on PCB wastes.

Since 1930, PCBs have been extensively used in the manufacture of electrical capacitors (45-50 per cent of the total production), as insulating material in electrical transformers (15 per cent), for heating media (10-15 per cent), for plasticizers (5-10 per cent) and for a multitude of minor uses (the remainder) (Tatsukawa et al, 1971).

PCBs are virtually insoluble in water, are chemically inert, are not flammable and are unaffected by acids, alkalis or other corrosive chemicals (Peakall et al 1970). These properties often contributed to its importance in industrial use, but conversely make disposal of PCBs very difficult.

Because of the significant potential for environmental contamination the use of PCBs was restricted and banned in countries overseas including USA, Japan and Sweden. The importation of PCBs into Australia was prohibited in the mid 1970s. Since then the generation of PCB wastes has decreased. Most PCB wastes are generated when capacitors and transformers break down during use or are taken out of service.

There are a number of guidelines available within New South Wales and Australia for the handling, transportation and disposal of PCB wastes. Commission policy for environmental control is based on this information and on other information and standards from overseas, including those from the United States Environmental Protection Agency (USEPA). Conclusions and recommendations of this assessment report would be generally in accord with these guidelines and standards.

2. PROPERTIES OF POLYCHLORINATED BIPHENYLS (PCBs)

The chemical and physical properties, health effects, environmental effects, brand names and uses of polychlorinated biphenyls (PCBs) are examined in this section.

2.1 Chemical and Physical Properties of PCBs

The base structure of PCBs together with the numbering system for substitution is shown in Fig 1.

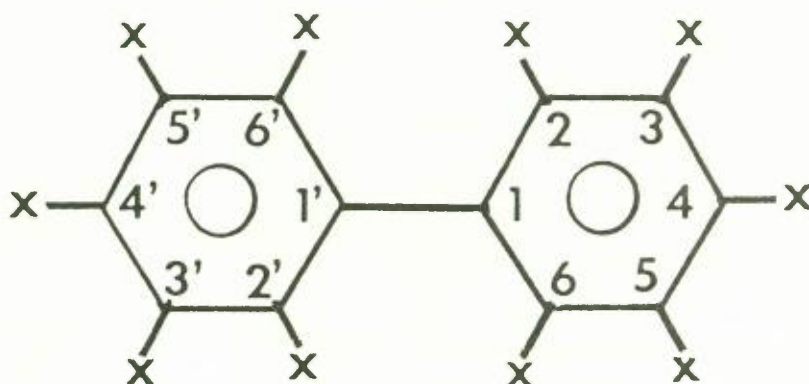


FIGURE 1. Base Structure of Biphenyl Showing the Numbering System for Positions of Substitution. (Hammond et al 1972).

PCBs are made by substituting chlorine atoms for one or more of the hydrogen atoms, shown as numbered positions in Fig. 1. There are 209 different chlorine-substituted biphenyls possible, of which 102 are probable (Hammond et al, 1972).

The outstanding physical and chemical characteristics of PCB are their thermal stability, resistance to oxidation or reaction with acids or bases and most other chemical compounds as well as their excellent dielectric (electrically insulating) properties (Hutzinger et al, 1974).

PCBs are very resistant to biodegradability (biological decomposition). It is believed that in the biosphere PCBs are more stable than DDT and its metabolites. This is because PCBs lack the ethane component between the aromatic rings which is the site of action of most of the transformations of DDT (Peakall et al 1970). The persistence of DDT on the soil surface is about one year (Kearney et al 1969) and about 10.5 years when incorporated in the soil (Nash and Woolson 1967), whilst for PCB, Metcalf et al. (1975) studied the fate, of 2,5,2'-trichlorobiphenyl, 2,5,2',5'-tetrachlorobiphenyl and 2,4,5,2',5'-pentachlorobiphenyl in a model ecosystem. After 33 days, the concentrations of the parent materials and metabolites were measured. The trichlorinated form was degraded considerably but the tetra- and pentachlorinated forms were, for the most part, unchanged. Moein et al (1976) detected no reduction in the concentration of Arochlor 1254 (basically a mixture of tetra- penta- and hexa-PCB) over a two year period in soil that had been contaminated by a spill of transformer fluid. Minimal losses of commercial formulations of PCBs in soil illustrate their chemical stability, nonvolatilization, and lack of biodegradation.

Most of the common metals and alloys have excellent resistance to PCBs, even at elevated temperatures. However, plastics, and to some extent copper, are attacked by PCBs even at room temperature (Kirk et al, 1964).

The physical properties of the chlorobiphenyls are shown in

Table 1 (Kirk et al, 1964; Rapaport et al, 1984 and Hutzinger et al, 1974). These show considerable variability and are generally quite different from the physical properties of commercial PCB mixtures as can be seen in Table 2 (Kirk et al, 1964 Hutzinger et al, 1974 and Versar Inc. 1979).

The compositions of some of the liquid PCBs, the Monsanto Aroclors, are shown in Table 3. Each of these commercial PCBs contains a mixture of the chlorinated biphenyl isomers with the lower numbered Aroclors containing higher percentages of the mono, di- or tri- chlorobiphenyls and conversely the higher numbered ones contain higher percentages of the tetra-, penta- etc. chlorobiphenyls. For example Aroclor 1221 contains 56.5% of the mono- and 27% of the di- with smaller percentages of the tri- and tetra isomers whilst at the other end of the scale, Aroclor 1260 contains 70% of the hexa- with lesser amounts of the penta- and tetra- isomers.

Boiling Points

Whereas the boiling points of the isomeric chlorobiphenyls can be specified to within one degree, those of the Mixtures (Aroclors) can only be quoted as a distillation range. For example, 2-monochlorobiphenyl has a boiling point of 267 - 268°C, whilst Aroclor 1221, which consists of about 56% of the monochlorinated biphenyl, has a distillation range of 275 - 320°C. The higher the percentage of chlorine, the higher is the distillation range; Aroclor 1260, has a range of 385 - 420°C (Tables 1 and 2).

Water Solubility

Water solubility of PCBs depends on the number of chlorine atoms, for example the solubility ranges from about 6000 ppb for the monochlorinated biphenyls to less than 10 ppb for the hexachlorinated isomers. The Aroclors behave similarly, with Aroclor 1221 having a solubility of 15,000 ppb and Aroclor 1260, about 3 ppb.

Octanol/Water Partition Coefficient (Kow and log Kow)

Another parameter widely used in correlations concerning pollutant partitioning between water and oils/fatty tissues is the octanol-water partition coefficient (Kow). Kow is used to estimate bioconcentration factors, the equilibrium distribution of those compounds in various compartments of the environment, and their toxicity (Rapaport et al 1984).

With an increase in water solubility ranging from 3 ppb for Aroclor 1260 to 15,000 ppb for Aroclor 1221 the octanol/water partition coefficient (Kow) of PCBs decreases from 2.2×10^4 to 6.5×10^2 (Table 2). Low water solubility of PCBs coupled with high Kows indicate that PCBs have a high affinity for hydrophobic materials, including activated carbon, organic

and inorganic sediments, soil particles and oily or lipophilic substances (Pal et al 1980). A material with log Kow of 3 or higher is found to bioconcentrate in the fatty tissue of aquatic organisms. Values of log Kow range from 4.4 for monochlorinated biphenyls to 7.8 for hexachlorinated isomers.

The common occurrence of PCBs in fatty tissue of biota results from their properties of low water solubilities and high log Kows.

Vapour Pressure

Vapour pressures of different Aroclors indicate a decrease with increasing chlorination, ranging from 9.3×10^{-4} kPa Hg for Aroclor 1221 to 5.3×10^{-6} kPa Hg for Aroclor 1260 at the ambient temperature of 25°C (Hutzinger et al. 1974) Table 2. The low molecular weight PCBs (Table 2) tend to volatilize much more readily than the high molecular weight species. Vaporization rates of commercial Aroclors from liquid surfaces range from 1.74 mg/cm²/hr for Aroclor 1221 at 100°C to 0.009 mg/cm²/hr for Aroclor 1260 (Hutzinger et al 1974). Volatilization and aerosol dispersion of PCBs have been considered responsible for their widespread distribution. Atmospheric transport by winds followed by fallout with dust settling and rain wash-out of particulate matter may have contributed to the presence of PCBs at places far from the major centres of production and use of these compounds.

Volatilization ranges in activated sludge under aerobic conditions were 12 days for Aroclor 1221 and 15 days for Aroclor 1016. At the surface of loamy soils one isomer, 2, 2'-dichlorobiphenyl, had a half-life of 350 days and presumably much higher figures for the higher molecular weight compounds would be expected.

Bioconcentration

Aquatic organisms bioconcentrate (biomagnify) PCBs. Fish, for instance, living in waters containing PCBs of the order of a few ppb biomagnify PCB in their fatty tissue to levels of well over 100 ppm (Pal et al 1980). Some reported levels of residues of PCBs found in fish and other aquatic organisms in New South Wales fresh waters and marine and estuarine waters are shown in Table 5 (from Scribner et al 1987 (a) + (b)). Concentrations of PCBs in the fresh water Mosquito Fish (Gambusia affinis) ranged from 0 to 1.1 ppm in Sydney rivers. Other results for fish caught near the Sydney Sewer Outlets (1977-79) had concentrations ranging from 0 to 3.9 ppm PCBs; whilst in Botany Bay (1978-79) the highest concentration recorded for Black Bream Acanthopagrus australis and for sand Mullet (Myxus elongatus) was 0.9 ppm.

2.2 Toxicity of PCBs

Whilst it is not the intention of this assessment report to fully discuss the health human effects of PCBs, it is appropriate to at least consider some of the major health problems associated with PCBs.

There is considerable information on the toxic effects of PCBs in both man and animals. Some information originates from the over exposure of workers in industry, and some from the Yusho incident in Japan. The ingestion of cooking oil, accidentally contaminated with 2000 to 3000 ppm PCBs, by several thousand people in Yusho, Japan caused nausea, lethargy, skin rashes, brown pigmentation of the skin and nails, eye discharges, jaundice and other effects. The maximum dose of PCB thought to have been ingested was about 2g, but there were no direct deaths attributable to this poisoning. About 1200 people were examined although several thousand were thought to have been affected and the symptoms persisted for several years. It was subsequently found that the PCBs involved were contaminated with polychlorinated dibenzofurans (PCDFs) (Maunsell et al, 1986) and this was suggested as a major contributor to the illnesses.

In the US, many workers in the electrical industry have been exposed to PCBs by direct contact and in the air in their work environments for long periods. This group has attracted considerable medical attention.

According to the report by Maunsell, some writers such as Miller (1983) conclude that apart from infrequent skin conditions no significant adverse health effects have been reported. This is attributed to the absence of PCDF contaminants. He reports a study of 12,500 electrical equipment workers exposed to PCBs, 50 per cent of whom had been exposed for at least 20 years. The results showed no increase in deaths due to cancer, cardiovascular disease, neurological or any other cause when compared to general population standards. Miller does not conclude that PCBs are definitely not carcinogenic but rather that if they are, then they must be weak agents.

Similarly Deichmann (1981) reports occasional skin effects but suggests that industrial exposure to PCBs in the US has not been a specific problem. A detailed study of workers in the capacitor manufacturing industry also found no health effects other than skin conditions despite high levels of PCBs in blood samples (Fishchbein et al, 1979).

A review of three studies of workers exposed to PCBs in the US was made by Kimbrough (1985). In one study she found that there was no increased incidence of cancer while in the other two, effects were found which could have been due to PCB exposure.

Wassermann et al (1983) have reported that both animal experiments and medical records of humans exposed by occupation or accident to PCBs, lead to the conclusion that PCBs have to be considered as representing a risk of cancer to humans. Whether or not the causative agent of such effects is the PCBs themselves or contaminants such as PCDFs or Polychlorinated dibenzodioxins (PCDDs) is of little relevance as most commercial PCBs are contaminated.

IARC (1978) has also concluded that there is experimental evidence that some PCBs can induce cancer in rodents and there are studies suggesting a link with cancer in humans (Bahn et al, (1977); Hattula et al (1976) and Fishbein (1979)).

In accordance with such conclusions, current US guidelines also treat PCBs as carcinogens (Rogan et al, 1985). It is likely that effects of occupational exposure to PCBs include cancer, lung damage and chloracne.

Animal Toxicity

Early studies of acute oral and dermal exposure of PCBs have involved in many cases, mixtures or compounds of undefined specifications leading to some ambiguous interpretations (NTIS 1972)

Acute toxicity

Work by the Monsanto Company indicated a low acute oral toxicity for the Aroclors, the LD₅₀ to rats ranges from 4.0 g/kg for Aroclor 1221 to 11.3 g/kg for Aroclor 1262. (WHO, 1976).

Work by Bruckner et al 1973 and others, has demonstrated a slightly higher toxicity. With a single intravenous dose, the LD₅₀ for Aroclor 1254 was 358 mg/kg body weight in adult female Stermen Rats (Linder et al 1975). The acute LC₅₀ oral for Aroclor 1254 in the same strain and sex was between 4 and 10 g/kg (Kimbrough 1972). According to Bruckner et al (1973), severely poisoned animals showed several symptoms, including weight loss, and diarrhoea and they considered progressive dehydration and central nervous depression were the causes of death. In rats, vacuolation in the liver and kidneys was observed (Bruckner et al 1973) and also stomach ulcers formed (Kimbrough et al 1972). It is generally agreed that the acute toxicity of PCBs is low and of the same order as that of other chlorinated aromatic compounds. PCBs are not quite as poisonous as DDT, although they possess a similar ability to alter important biological functions. The toxicity of pure PCBs is low compared with other organochlorine compounds in widespread use, such as the insecticides DDT, dieldrin, benzene hexachloride, aldrin, and endrin. The minimum dose necessary to produce positive clinical effects in humans is indicated to be 0.5 g.

As with the chlorinated hydrocarbon pesticides, the most important effects of PCBs are long-range sub-lethal effects (McMahon, 1975).

Like DDT, PCBs are suspected of affecting oestrogens which play a key part in the regulation of calcium metabolism in birds. This can lead to egg shell thinning and hence reduced breeding success (McMahon, 1975).

Based on this data PCBs would generally be classed as non toxic for single doses. (Toxic if LD₅₀ oral > 500 mg/kg).

Subacute oral toxicity

After repeated administration, the PCBs have a cumulative toxic action. In a group of rats receiving Aroclor 1254 at a dose of 1 g/kg of diet, deaths occurred between 28th and 53rd days of feeding (Tucker & Crabtree, 1970).

Repeated weekly oral administration of 150 mg of Aroclors 1221, 1242 and 1254 to rabbits for 14 weeks produced liver enlargement. Aroclor 1248 fed to female rhesus monkeys at a rate of 25 mg/kg of diet produced facial oedema, loss of hair and acne; one of six animals died after removal from the experimental diet (Koller and Zinkl, 1973).

Mink appear to be particularly sensitive to PCBs with a 100% mortality after 6 months after feeding them 10 mg/kg each of Aroclors 1242, 1248 and 1254 (Ringer et al 1972).

Chronic oral toxicity

Aroclors 1242, 1254 and 1260 have been administered for 18 months to rats at 1, 10 and 100 mg/kg in the diet (Keplinger et al., 1971). No adverse effects were recorded with the three Aroclors at 10 mg/kg but with Aroclors 1242 and 1254 at 100 mg/kg there was an increase in liver weight and a reduced survival of litters. In similar experiments on dogs, there was a reduced weight gain with Aroclors 1254 and 1260 in the diet at a level of 100 mg/kg (Keplinger et al., 1971). In the experiments reported by Kimbrough et al. (1972), male rats survived Aroclor 1260 in the diet at 1 mg/kg (71.4 mg/kg body weight) for 8 months but 8 out of 10 females died at this dose, 2 out of 10 died at 500 mg/kg, and 1 out of 10 at 100 mg/kg (7.2 mg/kg body weight). With Aroclors 1254 and 1260, a dose-dependent increase in liver weight in male rats was significant down to 20 mg/kg (1.4 mg/kg body weight) in the diet; with females the liver enlargement occurred only at diet levels of 500 mg/kg and higher.

The rhesus monkey is the only species reported to show signs of poisoning similar to those in human Yusho patients. The administration of Aroclor 1248 at 2.5 and 5.0 mg/kg of diet for 1 year produced dropsy, loss of hair, red patches on the skin and acne lesions involving the face and neck within 1-2

months. The effects were less marked in male monkeys. At 25 mg/kg of diet, one out of a group of six died, and at 100 and 300 mg/kg the mortality approached 100% within 2-3 months. Animals more severely affected showed hypertrophic hyperplastic gastritis with ulceration, anaemia, hyperproteinaemia and bone marrow hypoplasia. The survivors still showed signs of poisoning 8 months after exposure (Allen & Norback, 1973).

Dermal toxicity

Vos & Beems (1971) have confirmed earlier reports that PCBs damage the follicular epithelium in experimental animals. They applied three commercial 60% chlorinated mixtures, Clophen A60, Phenochlor DP6, and Aroclor 1260 to rabbit skin at a daily dose of 118 mg/50 cm² (5 times per week) for 38 days PCBs can cause adema, the accumulation of fluids in the tissues surrounding the heart; porphyria, an abnormality of blood pigment metabolism; thickening of the skin; and reduced resistance to certain kinds of pathogenic organisms (McMahon, 1975). These effects were more marked with Clophen and Phenochlor than with the Aroclor.

During these experiments, deaths occurred in the Clophen- and Phenochlor-treated groups but not in the Aroclor group. Kidney lesions were seen in all groups; liver damage was least in the Aroclor group. Vos & Beems attributed the greater severity of the effects observed with Clophen and Phenochlor to the presence of toxic impurities. In another comparative dermal toxicity study in rabbits (Vos & Notenboom-Ram, 1972) skin lesions in Aroclor 1260-treated animals were more severe than in animals treated with 2,4,5,2,4,5 - hexachlorobiphenyl. In a Japanese study, no difference in skin lesions were observed in rabbits after dermal applications of Kanechlor 400, Kanechlor 500, or 3,4,3,4 - tetrachlorobiphenyl (Komatsu & Kikuchi, 1972).

Inhalation toxicity

Only one inhalation study has been reported using Aroclor 1242 and 1254 (Treon et al., 1956). Rats, mice, rabbits, and guinea pigs were exposed to Aroclor 1242 or 1254 vapours for five days a week for several weeks at concentrations ranging from 1.5 to 8.6 mg/m³. These values are close to the concentration in air saturated with these PCB mixtures. At these concentrations Aroclor 1254 produced liver enlargement in rats.

Aquatic Organisms

Fish

Young fish appear to be more sensitive to PCBs than adults: 96-hour LC₅₀ values for newly hatched fathead minnows were 15 and 8 ug/L, respectively for Aroclors 1242 and 1254. Growth

of young fathead minnows and flagfish was affected above 2.2 ug/L (Nebeker et al., 1974). There is no information on pathological changes in fish that might be related to the lethal action of PCBs. (Hansen et al., 1971) found that fish survived exposure to Aroclor 1254 at 5 ug/L, but died later, after being returned to clean water, with signs of a lowered resistance to infection. Pathological changes were observed in kidney, spleen, and liver of rainbow trout fed Aroclor 1254 at 10 or 100 mg/kg of diet for up to 330 days (Nestel & Budd, 1975).

Microorganisms (WHO, 1976)

The growth of certain marine diatoms is inhibited by Aroclor 1254 at 10-25 ug/L, but marine and freshwater algae are more resistant, being unaffected by 100 ug/L (Mosser et al. 1972). Fisher et al. (1972) found that phytoplankton from the Sargasso Sea did not grow in Aroclor 1254 at 10 ug/L, though phytoplankton from estuarine and coastal waters were not much affected by this concentration. Keil et al. (1971) report that the growth of a diatom was inhibited by Aroclor 1242 at 100 ug/L with a reduction of RNA synthesis, but that 10 ug/L had no effect.

The growth of cultures of lake bacteria was not inhibited by concentrations of Aroclors 1221, 1242 and 1254 in excess of solubility, and Aroclors 1221 and 1242 could be utilized as the sole source of carbon and energy (Wong & Kaiser, 1975).

2.3 ENVIRONMENTAL EFFECTS OF PCBs

2.3.1 Environmental concentrations and bioaccumulation

According to WHO (1976) speaking generally of the more industrialized Northern hemisphere, the presence of PCBs in the environment is extremely widespread; they have been found in the ambient air, water, soil and sediments, and in human and animal tissue in almost all parts of the world. Concentrations of up to 0.05 ug/m³ of air (0.05 ppm) have been observed. Unpolluted fresh water generally contains very low levels of PCBs (less than 0.0005 ug/L) compared with 0.05 ug/L in moderately polluted rivers and 0.5 ug/L in heavily polluted waters. Levels are usually higher in the sediments of polluted waters, since PCBs are only slightly soluble in water. Most soils contain PCB levels of less than 15 ug/kg, but soils around factories producing electrical components have been found to contain as much as 510 mg/kg. Unfortunately, the presence of PCBs in the Australian environment has not been widely documented (Richardson et al, 1979). However in a study by Richardson et al (1980), the concentration of PCBs sediments from Port Phillip Bay in Melbourne was found to be low, ranging from 20 to 930 ug/kg.

It has been estimated that man's average daily intake of PCBs from the air and from drinking water is less than 1 ug from

each of these sources.

The main exposure pathway of PCBs for the general population is through food. Vegetable and fruits generally have less than detectable levels, but some exceptions have been noted in crops irrigated with contaminated water, and in some foods packaged in contaminated material. PCBs in feed consumed by animals are readily absorbed by the organism and are mainly deposited in fatty tissues where they may be stored for long periods; high levels may accumulate, even when the daily intake is quite low. For this reason, fatty foods such as milk, butter, cheese, eggs, and meat are the main dietary sources of PCBs. Fish can also be a major source, particularly those taken from contaminated waters. Fish caught at 13 sites in Sydney waters had a concentration ranging from 0 to 1.6 ppm for Aroclor 1254 and 0 to 5.3 ppm for Aroclor 1242 (ECOS, 1978).

Overseas, concentrations averaging about 1 ppm have been reported for fish caught in European waters, off the North east coast of North America and in bays along the Gulf of Mexico, the coasts of California and Japan. Much higher levels (10-800 ppm) have been reported from highly contaminated inland waters, including the Great Lakes in North America and Lake Biwa in Japan (Ecos, 1978). In the industrialized countries, the average daily intake from food, including fish, is rarely less than 5.0 ug or greater than 100.0 ug (approximately 1 ug/kg body weight) per day. PCBs accumulate in human tissues just as they do in animal tissues. Measurements of human fatty tissue have shown that most samples contain levels of PCBs of the order of 1 mg/kg of fatty tissue (roughly one thousand times the average daily intake level). This marked increase illustrates the strong accumulation of these chemicals in fat deposits. There does not appear to be any data for Australian levels of PCB intake in human diets.

PCBs are readily transmitted to infants through breast-milk. The mean PCB level in human milk generally ranges from 20 ug/kg to 100 ug/kg but may be higher (WHO, 1976). Such levels may result in relatively high intake and accumulation of PCBs in breast-fed infants. Of particular note has been the occurrence of PCBs in mothers' milk in a number of studies, especially in Europe (Slorach et al, 1985). The WHO (1976) reports average levels of 30 ug/day in the milk of nursing mothers and in some locations up to 100 ug/day. In Australia PCB levels in mothers' milk appear to be very low or non-detectable (Fishbein 1979).

People may also be exposed to PCBs in the working environment, not only during the manufacture of PCBs or through their use in the electrical industry, but also by contact with PCB-containing lubricating oils and hydraulic fluids, varnishes and paints. National surveys have revealed PCB blood levels of 0.3-1.2 ug/100 mL in persons not

subjected to occupational exposure, compared with levels as high as 190 ug/100 mL in occupationally exposed workers. Similarly, PCB levels as high as 700 mg/kg have been found in the fatty tissue of occupationally exposed workers compared with a typical level of 1 mg/kg in the general population.

PCBs were first detected in wildlife samples in 1966 ITU (1986). This led to further studies and by 1972 it was established that PCBs were widely distributed in the biosphere (WHO, 1976).

The discovery that PCBs are widely distributed in the environment led to general regulations in Europe and the US in an attempt to restrict production and control disposal. Various studies have demonstrated a downward trend in environmental contamination as a result of these measures (Maunsell et al, 1986).

Maunsell et al, (1986) reports that although the dissemination of PCBs mostly occurs through the atmosphere, the compounds tend to accumulate in bodies of water such as oceans and lakes and especially in lakes with limited water exchange. In such environments, PCBs accumulate in the sediments and are absorbed or ingested by bottom-dwelling animals. They are then transferred to fish through the food chain of one animal eating another or through intake of contaminated water and may be ultimately transferred from fish to human. In fact, people with a high fish intake in the US have been suggested as a target group for researching into the health effects of PCBs (Kimbrough, 1985).

Experimental work reported by NTIS, 1972, on biological accumulation by individual species of vertebrates and invertebrates has been conducted by a number of laboratories in the United States and elsewhere. Table 4 presents selected data that demonstrate accumulation factors of up to 76,000 in whole organisms, and in the hepatopancreas of pink shrimp. The data demonstrate that pink shrimp are able to accumulate PCB residues from water at levels as low 0.5 parts per billion (Table 4).

There are two means of PCB movement into the biota. One is the familiar pattern of food chain accumulations. The other involves direct uptake from the environment by various organisms, e.g., soil to earthworms; water to phytoplankton, zooplankton, larger invertebrates, and fish. It seems reasonable that food chain transfers are the principal route of accumulation in warm blooded vertebrates, and possibly in the highest levels of carnivorous fish. Conversely, direct environmental uptake is probably the most important for aquatic invertebrates.

Bioaccumulation was also discovered in the transfer of PCBs through the food chain. This is the well known phenomenon in which contaminants in organisms are transferred and

accumulate at higher levels in predators. In general, the higher the position of a predator in the food chain the higher will be its level of contamination and that level will far exceed the background level in the environment. In the case of ocean and lake systems, humans may be at the highest level of the food chain due to consumption of fish and thus may be subject to the highest levels of PCB accumulation.

It appears that the human population has been generally exposed to low levels of PCBs through food intake and especially through consumption of fish. Vegetables do not usually have detectable levels of PCBs. Intake of PCBs by human populations naturally shows considerable variation.

2.3.2 Behaviour and fate of PCBs in the environment

The modes of transport of PCBs within the environment are complex (McMahon, 1975). Vaporised PCBs will be partially adsorbed on particulates, transported with the prevailing winds, and deposited on land or water by particle sedimentation or rain (Hammond et al, 1972). PCBs introduced into water streams may be adsorbed by the waterborne particulates or the benthos; the adsorbed PCBs will diffuse into the bottom sediment, redissolve into the water stream, or be entrained with sediment eroded from the bottom surface. The problem is further complicated by the assimilation, transport, and degradation of PCBs by biota (Hammond et al, 1972; Peakall 1972).

The principal cause of concern, amongst conservationists and ecologists, is that PCBs are very stable chemical compounds which are resistant to degradation by chemical or biological oxidation. However, recent research has shown that different PCBs behave differently in nature. Some are easily degraded, whereas others are as persistent as all PCBs were formerly thought to be (Emmelin, 1973). Nevertheless, if the rate of dispersal of these persistent PCBs into the environment is greater than the rate of degradation, there will be accumulation. The combination of persistence and accumulation in fat during transition through the food chain can result in considerable increases in concentration of these compounds.

McMahon (1975) continues that in natural sunlight, some of the more highly chlorinated PCBs are more easily broken down than the less chlorinated PCBs and hence photolysis could be expected to reduce the proportions of at least some isomers of the more highly chlorinated PCBs. Photolytic dechlorination can also be expected to give rise to less-chlorinated PCBs, including some isomers which may not be present in commercial mixtures.

Studies have also shown that the less chlorinated PCBs are generally taken up and/or retained by animals less efficiently than higher isomers. However, it is indicated

(Nisbet et al 1972) that it is not clear whether the deficiencies of the less chlorinated PCBs resulted from metabolism or differential excretion and that it is likely that both occur. Other sources (Peakall, 1972, Lidgett et al, 1970) indicate that there is evidence that the less-chlorinated compounds are fairly rapidly metabolised in warm-blooded animals.

After reviewing the available evidence for the processes described above, it has been concluded (Hammond et al, 1972, Nisbet et al, 1972) that most PCBs with four or fewer chlorine atoms have been degraded in the environment, possibly by microbial action. Further, decomposition of penta- and hexa-polychlorinated biphenyls appears to occur in birds and mammals, but this will have affected only a negligible fraction of the PCBs in the environment. Finally, differential metabolism appears to be the primary mechanism in the environmental differentiation of PCBs, outweighing the effects of differential photolysis and differential mobility.

Knowledge of the degradation of PCBs in the environment is confined to general comparison of less chlorinated and higher chlorinated compounds because of the scanty quantitative data published on relative proportions of individual isomers in environmental samples (Hammond et al, 1972, Nisbet et al, 1972, Lidgett et al, 1970). However, the physical and chemical properties and biodegradability of PCBs depend not only on the total number of chlorine atoms in the molecule, but also on the positions of substitution (Hammond et al, 1972).

2.4 Brand Names and Coding of PCBs

PCB have been manufactured industrially since 1929 and Table 6 shows the world's major producers of PCBs. Most information by far is available on Monsanto's PCB preparations (the Aroclors) and this particular brand will serve to discuss various aspects of PCB in general.

All Aroclor products are characterized by a four-digit number. The first two digits represent the chlorinated biphenyl molecule. The last two digits represent the weight percent of chlorine in the molecule. This is shown in Tables 2 and 3 (Hutzinger et al 1974), where for example Aroclor 1242 contains about 42 per cent chlorine and 1260, 60 percent.

These Monsanto Aroclors contain between 21% and 68% chlorine and some may also contain up to 40% chlorinated terphenyls. (Hammond et al, 1972, Peakall et al, 1970 and Gustafson, 1970). Typical compositions of some of the commercial PCB mixtures (Monsanto - Aroclors) are given in Table 3.

2.5 Uses of Polychlorinated Biphenyls

The excellent chemical and physical properties of PCBs have led to numerous uses of these chemical compounds, such as dielectric fluids in capacitors and transformers; industrial fluids in hydraulic systems, gas turbines and vacuum pumps; fire retardants; heat transfer applications and plasticizers in adhesives, textiles, surface coatings, sealants, printing and copy paper (Broadhurst, 1972, Hubbard, 1964 and Monsanto Tech. Bull PL-321).

Uses of PCB (Aroclors) are shown in Table 7 (Hutzinger et al, 1974).

All PCBs used in Australia were imported from overseas. Since 1975 all importation has been controlled by the Customs and the Police Department under Regulations of the Customs Act 1901-1974, administered by the Department of Police and Customs. Since 1975 and in line with OECD recommendation (OECD, 1973) the importation of PCBs and polychlorinated terphenyls (PCTs) has been prohibited, except with the consent of the Minister for Customs, and then only for specific purposes including their use in transformers or large power factor correction capacitors, as heat transfer fluid other than in installations for processing of food, drugs, feed and veterinary products, and as hydraulic fluids in mining equipment.

PCBs are found in various components and equipment used throughout the country (McMahon, 1975). Apart from the manufacture of transformers (which contain from 160 L to 6,000 L of PCBs and large power factor correcting capacitors, (containing around 10 L of PCBs), small capacitors (containing about 10-50 mL of PCBs) were also manufactured in large numbers, for use in fluorescent lights and small electric motors and compressors. Quantities of PCBs, PCB containing equipment and components and other wastes are discussed in Section 6 of this report.

3 PCB WASTE MATERIALS

The types of wastes generated and stored are examined in this Section, together with transportation and disposal methods available for PCB wastes.

3.1 Types of Wastes Containing PCBs

It is essential at the outset to differentiate between PCBs and non-PCB containing materials. The SPCC can set a criteria for disposal of wastes of zero PCB-concentration. However this is very difficult to achieve in practice because PCB is a widespread contaminant in the environment. With this limitation in mind a classification system which defines the maximum concentration of PCB in a waste for the purpose of disposal by landfill is considered in Section 4.

3.2 Storage of PCB Wastes

It is desirable to have satisfactory measures to prevent escape of PCBs to the environment, minimize contamination and to facilitate clean-up of spilled material.

In the Sydney Metropolitan Area the MWDA requirements are outlined in a document entitled: "Special Conditions Applicable to the Storage of Polychlorinated Biphenyl (PCB) Waste". These special conditions are included in licences for the storage of PCB wastes, by the MWDA and are attached at Appendix A.

3.3 Transportation of PCBs

In NSW, at present the transportation of PCB materials, wastes and equipment containing PCB must be carried out in accordance with the current edition of the "Australian Code for the Transport of Dangerous Goods by Road and Rail".

The MWDA requirements in the Sydney Metropolitan Area for the transportation of PCBs are specified in a document entitled "Special Conditions Applicable to Transport of Polychlorinated Biphenyl (PCB) Waste and Equipment Containing Liquid PCB" and are at Appendix B. This document clearly sets out the conditions under which PCB transport may be conducted; the requirements for an escort vehicle carrying equipment for use in the event of a spill, personnel requirements, protective and cleaning equipment requirements and other requirements pertaining to notification by the transporter.

3.4 Spillages Involving PCBs

Spills or leaks from electrical equipment whilst in use or in storage or during transport and handling of waste PCBs cause significant environmental problems particularly during clean-up, containment, storage and disposal.

In regard to the clean up of PCB spills, the MWDA have a procedure entitled "Outline Spill Response Guide for Polychlorinated Biphenyls (PCB)". This is used as the basis for the Guidelines for the Clean Up of PCB spills that is included in the proposed Chemical Control Order. The Guidelines detail the requirements for protective clothing, control of spills, final cleaning and the disposal of PCB-contaminated material and equipment and are at Appendix C.

3.5 Disposal Methods of PCB Wastes

PCBs are considered to be environmental pollutants of concern because of their persistence, their bioaccumulation, and the possibility of longterm harmful effects. Accordingly disposal of waste PCBs needs to ensure that they are either satisfactorily converted or destroyed, to safe end products -

this is the preferred option - or be put in a permanent and secure disposal site (landfill).

Five techniques are considered below:

- high temperature combustion in)
incinerators, high efficiency)
boilers and cement kilns;)
)
- radiant energy) destruction
- chemical dechlorination;)
)
- biological degradation, and)
- landfilling or subterranean deposition.

None of the above methods is commercially available within Australia at the present time although recent proposals by the Victorian, Western Australian and the Northern Territory Governments may change this. A trigovernment task force supported by the governments of NSW, Victoria and the Commonwealth, is considering the strategies for establishing a facility for the destruction of intractable wastes. Because of the bulk of stored wastes in NSW it would be desirable that the facility be established in NSW.

Previous proposals for a high temperature incinerator by the Metropolitan Waste Disposal Authority (MWDA), at Wetherill Park and by Rinex Environmental Services Pty Ltd, including one at Bringagee in the Riverina Region and at The Gorge near Broken Hill, met with local opposition resulting in either the withdrawal of the proposal (MWDA) or as in the latter two proposals the non-approval of the proposals by the Government on technical grounds.

There is still widespread agreement on the need for a suitable facility to be established in Australia for the safe disposal of stored intractable wastes, including PCBs. Moreover, it is believed that a high temperature incinerator, properly managed and controlled is a technically proven way to provide this service.

PCBs do not make up a large proportion of stored intractable wastes in New South Wales.

The estimated quantity stored here is less than 500 tonnes or about 7 per cent of the total stored waste. (DEP, 1985). However unknown quantities of PCBs are still in use around the State, particularly in power capacitors and transformers.

The safe domestic disposal of NSW's PCBs is therefore dependent upon the development of a facility for the relatively larger quantities of intractable wastes.

3.5.1 Incineration methods

The major commercially available and presently the most effective method of destroying PCBs is high temperature incineration. Suitable types of high temperature, land based, incinerators are rotary kiln incinerators, high efficiency boilers and cement kilns.

Such rotary-kiln type incinerators are reported to be operated safely with seemingly minimal environmental impact in populated areas of Europe, including the United Kingdom, France and the Federal Republic of Germany. Similar facilities are also established in the United States and a new incinerator is soon to be commissioned in Canada. It has however been very difficult in New South Wales to find a suitable site for the establishment of an incinerator because of the "NIMBY" (Not In My Back Yard) syndrome.

In recent years several hundred tonnes of PCBs, PCB wastes from capacitors and transformers and other wastes contaminated with PCBs, have been shipped overseas for high temperature incineration. Two transport companies, AACI and J and A J Roberts both operating from Victoria, have separate contracts with incinerator companies in Europe, respectively Rechem in England, and Tredi in France, to dispose of PCB wastes from Australia. Overseas disposal is continuing.

In 1982/83 the incinerator ship "Vulcanus" visited three Eastern Australian ports including Sydney, where some 3000 tonnes of intractable wastes including a small quantity of liquid PCB wastes were loaded and destroyed, off-shore.

To achieve a high level of destruction of PCBs, the prescribed conditions are above 1200°C with two seconds residence time. The wastes, often supplemented with fuel, burn with air to form carbon dioxide and water vapour (which can be discharged to the atmosphere), and the acid gases hydrogen chloride (hydrochloric acid) and sulphur dioxide (which are removed by gas cleaning). Most wastes also contain ash that may include heavy metals; therefore the ash also must be removed from incinerator flue gases (McKenzie - Low, 1986) for land disposal.

Bailey, 1985 published a very comprehensive report describing in detail, the many different types of incinerators available overseas for the destruction of PCBs. They include:

- Rotary kiln incinerators;
- Cement kilns;
- Multiple hearth incinerators;
- Fluidized bed incinerators;
- Liquid injection incinerators;
- High efficiency boilers;
- Shipboard incinerators and

- Mobile incinerators including a USEPA developed mobile incinerator.

3.5.2 Chemical methods

PCBs are very stable chemical compounds. They are not very chemically reactive. There are, however, a number of specialized chemical processes which can destroy PCBs. Sodium based dechlorination processes can be used to decontaminate liquids such as mineral oils or other wastes containing up to a few thousand parts per million PCBs; the upper concentration limit is set by the process costs in each case. In these processes, the sodium reagent reacts with the chlorine atoms on the PCB molecule to form sodium chloride, and the biphenyl part of the PCB molecule polymerizes to form a non-chlorinated polymer (polyphenylene); the mineral oil remains unchanged. Sodium chloride and polyphenylene are the wastes from these processes.

Rechlorination of PCBs by sodium reagents must be conducted in a nitrogen or other inert atmosphere to prevent the fire hazard created when hydrogen is generated by reaction of the sodium reagent with any moisture in the oil. Sodium-based dechlorination processes cannot be used to treat PCBs in oil or other medium containing significant amounts of water (Environment Canada, 1983).

a number of different types of chemical dechlorination methods are described by Bailey, 1985 including:

- Sunohio PCBX Process: This involves the use of organic sodium compounds in an amine solvent;
- Goodyear Sodium Naphthalide process: This process is based on sodium-naphthalide reagent and it is claimed, can handle pure PCBs or PCB-contaminated oils;
- Acurex Process: This is a modification of the Goodyear Process. USEPA has given approval to this process after tests showed that PCB concentrations of 1062 ppm were reduced to 2 ppm (Dillon, 1983);
- Franklin Institute Na PEG™ method: this process uses molten sodium dispersed in polyethylene glycols and operates at 150°C. In soil samples PCBs were reduced in concentration from 1000 ppm to 481 ppm in 53 days (Ord, 1985).

There are a number of processes being developed claim to destroy PCBs by oxidation. These are also described by Bailey, 1985 and include:

- "MODAR" Supercritical Water process;

- Wet Oxidation processes;
- Catalysed Wet Oxidation Process.

3.5.3 Radiant energy processes

A number of radiant energy processes utilizing electric arc (plasma), microwave, infra red radiation or ultraviolet radiation also claim to reduce the concentration of PCBs. These process, described by Bailey, 1985, include:

- Plasma Arc Pyrolysis Process: In this process, feedstock containing PCB waste is degraded by molecular fracture (Dillon, 1983). Efficiencies of destruction of 99.9999% have been claimed (Dillon, 1983);
- Microwave Plasma Processes: This process involves continuous radiation and activation of low pressure oxygen with microwave energy to form free radicals which then dissociate to react with oxygen to form simple products, such as CO₂, CO and Hydrochloric acid. 99% efficiencies are claimed (Dillon, 1983);

Other Processes include:

- Catalysed Microwave Process;
- High Temperature Fluid Wall Reactor;
- Light-Activated Reduction of Chemical Process;
- Ultraviolet-Ozone (Ultrox) Process.

Most of the above processes are still under development.

3.5.4 Biological methods

There are a number of biological methods claimed to be effective in degrading PCBs. In most instances the concentration of PCB in the waste is limited to, between about 50 and 5000 ppm, higher concentration tend to "poison" the system. One method discussed later in this section, the "Biotox method", claims to destroy PCB at full concentration and low temperatures and pressures in less than 24 hours.

Bailey, 1985 reported that PCB containing three or more chlorine atoms are extremely resistant to bacterial degradation, although mono- and dichlorobiphenyl can be degraded over a number of days (Dillon, 1983). For example Alcaligenes was used to decompose 500 ppm dichlorobiphenyl by 100 percent in three days and 100 ppm trichlorobiphenyl by 70 per cent in six days.

In another species of bacteria, Corynebacterium species and alcaligenes eutrophus degraded a number of PCBs including several pentachlorobiphenyls.

(Isbister et al, 1984) showed that the concentrations of tri- and tetrachlorobiphenyls were reduced by aerobic composting. The decrease was noticeable in about four weeks. A PCB solution dechlorinated by a chemical process using sodium, was diluted with water to 2350 ppm of biochemical oxygen demand (BOD) and treated with a mixture of six species of Enzobac bacteria. The BOD value decreased by about 90 percent after nine days. These results demonstrated that highly toxic by-products, such as chlorinated dibenzofurans, were not produced by the dechlorination (Fradkin et al, 1982).

Activated sludge processes have been used to degrade various Aroclors (Sworzyn et al, 1982). The degree of degradation decreased as chlorine atoms in the PCBs increased.

Mutant bacteria have been applied to soil contaminated by PCBs. After 18 days 99.8 percent of Aroclor 1254 (at 300 ppm) were destroyed (Dillon, 1983).

A process known as "Biotox Process" is a highly accelerated complete microbial destruction of PCBs. This claim has been made by an Australian company, EVCON International Pty Ltd of Milton in Brisbane, Queensland. When assessed in terms of the optimum criteria for commercially available PCB destruction, it is claimed, that it has the following properties:

- " (i) The temperature in the Biotox Process is controlled at 30°C to 50°C for most steps and 90°C for one step
- (ii) The Biotox Process has no inherent tendency to convert the PCBs into other toxic compounds, as some other biological degradation processes do
- (iii) The Biotox Process rapidly destroys all highly chlorinated PCB isomers (eg Aroclor 1260)
- (iv) The bacteria used in the Biotox Process are harmless soils micro-organisms which have not been subjected to genetic engineering of any sort
- (v) The Biotox Process plant can be transported to a contaminated site and then removed after the site is decontaminated
- (vi) Cheaper to run than a high-temperature incinerator."

Further claims are made by the company that the Process has been investigated by a reputable Government Laboratory who stated that the "Biotox Process has a sound scientific

basis".

The company indicated that verification of the Process, on a large pilot plant scale, is now proceeding.

Other processes described by Bailey, 1985 included:

- Extraction and Adsorption Processes;
These processes do not destroy PCBs, but change the location and concentration of the contamination. The solvent extraction process, developed by Union Carbide operates in three stages:

- (i) the solvent dimethylformamide extracts PCBs from the oil;
- (ii) water is used to free the PCBs from the solvent, resulting in a concentrated PCB fraction that can be removed from disposal;
- (iii) the solvent is purified by distillation and recycled.

Oil purified by this process is available for reuse.

In another process a filter material, known as "EPAC" filter, acts as a "chemical sponge" to selectively remove small quantities of PCBs from oil in a transformer whilst the unit is in operation (Fradkin et al, 1982).

3.5.5 Burial of wastes containing PCBs

Up until the middle to late 1960s and before information connecting the accumulation of PCBs in nature was available, disposal of wastes containing PCBs, including liquids, solids, capacitors etc was mainly by landfill (Jansen, 1972). Records of disposal sites in Sydney and quantities disposed of had not been kept. It is suspected however that a number of the garbage disposal sites around Sydney and particularly those surrounding the industries using PCBs, were used for the disposal of PCB contaminated wastes. Since the late 1970s, landfilling had been considered more as a controlled storage technique than as a destruction method. Nevertheless, landfilling has been used in a few countries for certain types of PCB wastes (OECD, 1984). Landfilling also generally occurs for materials with low PCB concentrations (50 ppm or less).

Small quantities of PCBs, such as those found in small fluorescent type capacitors, cannot be easily segregated from other domestic and industrial wastes and so usually become included with these in landfill sites. Encapsulation of the PCB waste (ie by solidification) can increase the security of the landfill site and its contents (OECD 1984).

The typical maximum concentration of PCB contamination acceptable in some countries including Canada, USA and OECD member countries, without further treatment at municipal landfills is 50 ppm (Section 4). It is also an accepted practice in some of these countries to permit the disposal of PCB contaminated wastes, containing for example up to 100 ppm PCBs (OECD,1987), and small capacitors containing up to 0.5 kg PCBs at approved landfills.

4 LEGISLATION, REGULATIONS AND STANDARDS FOR PCB WASTES

There are a number of standards worldwide, for the control and disposal of PCBs. Countries including Canada, USA and OECD member countries have set a limit for wastes which can be classed as non-PCB wastes. This limit is commonly set at 50 ppm PCBs and so wastes containing up to 50 ppm PCBs may be disposed of at municipal landfill. Any material, including liquids, which contains between 50 and 100 ppm PCBs is classed as PCB - contaminated and is commonly disposed of at secure landfills. Any waste containing more than 100 ppm PCBs should be stored for high temperature incineration or other approved methods. There are exceptions, however, including the disposal of small PCB capacitors containing less than 0.5 kg PCBs. These may be disposed of at municipal landfills.

The following sections summarize the standards as required by overseas countries as well as those guidelines that already exist and often adopted in New South Wales and other parts of Australia.

4.1 OECD member countries

The OECD recommends that Member Countries should ensure that for contaminated fluids and soils, the levels of contamination are not greater than 50 ppm (OECD, 1987). These wastes may be disposed of at municipal landfill. Further, Member countries shall ensure that disposal of waste fluids and solids containing PCBs at levels greater than 100 ppm and of equipment which has contained PCBs and has not been adequately cleaned, is carried out in adequate disposal facilities by means of high temperature incineration, or a comparably effective method, in a manner which does not endanger human health or the environment (OECD, 1987).

The OECD further recommends that, as far as practicable, Member countries should ensure that the disposal of wastes containing or contaminated by PCBs at levels of 100 ppm or less is carried out in adequate disposal facilities and in a manner that avoids the release of PCBs into the environment.

Member countries shall also prohibit the deliberate dilution of wastes containing PCBs where such activity is intended to contravene the foregoing disposal options (OECD, 1987).

4.2 Canada

A critical issue in the management of PCB waste is the PCB concentration or mass at which a material is defined as a PCB waste. Two criteria are applied:

- any material containing more than 50 ppm PCBs; and
- any capacitor containing more than 0.5 kg PCBs.

As a general guide, any PCB capacitor with a volume greater than 1250 cm³ will be considered to contain in excess of 0.5 kg PCBs.

The above does not mean that PCB wastes that do not meet these criteria should be disposed of indiscriminately or routinely go to municipal landfills. Low-concentration or small-quantity PCB wastes should be addressed individually and disposed of in accordance with provincial regulations or requirements.

The disposal of PCBs in concentrations lower than 50 ppm may also be subjected to certain restrictions. The maximum concentration of PCBs in oil applied to a road surface is limited to 5 ppm. This limit was imposed because of the potential for contamination of surface water and sediments from run-off from roads.

An exemption for capacitors containing less than 0.5 kg of PCBs is included to allow for the practical difficulties in attempting to channel small capacitors in home appliances, electronic equipment and fluorescent light ballasts to destruction facilities or approved landfills. This exemption is in keeping with the 0.5 kg exemption for PCB mixtures in the May 26, 1986, amendments to the Transportation of Dangerous Goods Act Regulations. As a general principle, however, where possible, small capacitors should be segregated and collected for handling and disposal as PCB waste (Environment Canada, 1987).

Wastes approved for municipal landfill (\leq 50 ppm PCBs), included major equipment, such as drained equipment and small capacitors containing less than 0.5 kg PCBs. Other wastes acceptable at approved (or secure landfill), include major equipment containing less than 500 ppm PCBs, soil demolition spoils and PCB destruction residues containing more than 50 ppm PCBs and dredging spoils (Environment Canada, 1987).

4.3 United States of America - US EPA

The US EPA (1985) in Part 761 et seq. of the US Code of Federal Regulations states that all PCBs in concentrations greater than 50 ppm, and all PCB items must be disposed of in an incinerator, a chemical waste landfill or in an approved

high efficiency boiler. The conditions are summarized below:

- Liquid PCBs (concentration > 500 ppm) must be incinerated in a high temperature incinerator.
- Liquid PCBs (concentration 50-500 ppm included mineral oil dielectric fluid from PCB - contaminated transformers, and other PCB - contaminated liquids) may be destroyed in a high temperature incinerator; they can be disposed of in a chemical waste landfill or alternatively can be destroyed in an approved high-efficiency boiler.
- Non-Liquid PCBs (contaminated soil, rags and other debris) may be destroyed in a high temperature incinerator or disposed of at a chemical waste landfill.
- Municipal Sewage Treatment Sludge and Dredged Materials same conditions as for "Non-Liquid PCBs" above, apply
- PCB Transformers can be destroyed by high temperature incineration or if drained, filled with solvent and allowed to stand for 18 hours before draining will be acceptable in a chemical waste landfill.
- PCB Large High or Low Voltage Capacitors, same conditions as for "Non-Liquid PCBs" above, apply.
- PCB Small Capacitors, owned by manufacturers of PCB capacitors or PCB equipment and acquired in the course of such manufacturing - same as for "Non-Liquid PCBs".
- PCB Small Capacitors, other than the above will be acceptable in municipal solid waste landfill.
- PCB Hydraulic Machines, if drained of free flowing fluid - same as for "PCB small capacitors - other...".
- Other PCB Articles as per "Non-Liquid PCBs"
- PCB Containers, not decontaminated - as per "Non-Liquid PCBs".
- PCB Containers, containing only PCBs at concentrations below 500 ppm - can be disposed at Municipal Solid Waste Landfill if liquid PCBs are drained.

4.4 Australia

There are a number of guidelines within Australia on the handling and disposal of PCBs. Nominal standards set by most Government authorities follow those set overseas but particularly those set by the US EPA.

Maunsell (1986) state in their report for the Western Australian Department of Conservation and Environment that the 50 ppm standard is used as a cut off in the classification of electrical and hydraulic equipment. If 50 ppm or more PCBs are involved, the article is PCB-contaminated; below this level it is classified as non-PCB. Further, the various regulations applying to PCB-contaminated items must not be avoided by dilution of the PCBs to levels less than 50 ppm.

Guidelines for the storage and transportation of PCBs have been produced in NSW by the MWDA (Appendices A and B respectively). These guidelines ensure that PCB wastes are properly handled during storage and transportation within the MWDA's area of jurisdiction.

In areas outside of the MWDA's Sydney jurisdiction, State Pollution Control Commission officers are often actively involved in advising on and authorising safe handling and disposal practices for a variety of industrial wastes. There have been a number of instances outside the Sydney area where advice has been sought on proper storage and transport procedures for PCB wastes. Commission officers have generally prescribed these MWDA guidelines.

The practising NSW standard, of 50 ppm PCBs as the lower limit for materials to be classified as PCB contaminated, is embodied in the Chemical Control Order (CCO) attached to this Assessment Report.

In summary, the commonly acceptable methods of disposal are shown in Table 8. Basically any waste containing less than 50 ppm PCBs can be disposed of at "controlled municipal landfills"; wastes containing between 50-100 ppm PCBs may be disposed of at "secure landfill". (eg Castlereagh or equivalent landfills); wastes containing greater than 100 ppm PCBs must be destroyed by high temperature incineration or securely stored.

5 SUBMISSIONS TO THE ASSESSMENT

Persons were invited by notice in the Government Gazette of 7th November 1986, to lodge submissions with the Commission in relation to the assessment of PCB wastes.

Submissions were received from:

- . Metropolitan Waste Disposal Authority
- . The Electricity Commission of NSW, and
- . The Prospect County Council.

5.1 Submission from the Metropolitan Waste Disposal Authority (MWDA)

The submission from the MWDA deals with the special conditions applicable to the transport and storage of PCB wastes and with procedures for disposal of PCB wastes.

The following is a summary:

- (1) The Authority recognised during the development of the conditions that occupational health and environmental safety were of paramount importance.
- (2) The conditions are attached to certificates of registration or licences issued by the Authority in accordance with the provisions of part V of the Waste Disposal Act.
- (3) The conditions have allowed the development of a sound storage and transport system within the areas for which the Authority is responsible.
- (4) The Authority is concerned that satisfactory health, safety and environmental standards are maintained while avoiding over regulation.
- (5) The Authority believes that further controls are required to adequately control PCB wastes.
- (6) Controls are necessary on the retrofilling of equipment which has contained PCB material.
- (7) Consideration to the development of an inventory of PCB material similar to the Canadian system would assist in notifying those holding PCB material of their responsibilities.
- (8) The Authority is no longer accepting even small quantities of PCB wastes for disposal. Guidelines for those holding small quantities (eg small capacitors) are required.
- (9) The concentration level of PCB at which waste is classified as a PCB waste needs quantifying.

The MWDA enclosed the following special conditions and Procedures for dealing with PCB wastes.

- (i) "Special Conditions Applicable to Transport of Polychlorinated Biphenyl (PCB) Waste and Equipment Containing Liquid PCB."
- (ii) "Special Conditions Applicable to the Storage of Polychlorinated Biphenyl (PCB) Wastes."
- (iii) "Procedure for the Disposal of Polychlorinated Biphenyl Waste."

These are attached as Appendices (A), (B) and (C) respectively.

5.2 Submission from the Electricity Commission of NSW

The submission from the Electricity Commission of NSW details the practices which have been evolved within the Commission. The following is a summary:

- (1) Due to environmental hazards of PCBs the Electricity Commission has adopted a policy of selective retirement of PCB capacitor banks and has also decided not to purchase new PCB equipment.
- (2) The practices (summarized below), that have evolved in the keeping, conveyance and disposal of this chemical have proved successful in preventing any leakage into the environment.
- (3) The following is a summary of the practices evolved by the Electricity Commission of NSW:
 - (i) Identification of PCB Equipment - the equipment containing PCBs are located, identified and the site labelled. The PCB items are also labelled.
 - (ii) Safety Procedures with PCB Spills - Staff working on the Spill are to be advised of clean-up procedures. A kit containing the necessary clothing and clean-up equipment should be accessible. Respirators and goggles should be worn in case of fire and to prevent splashing into eyes from open drums. Thorough washing of hands should precede any smoking, eating or drinking.
 - (iii) Clean-up Procedures for PCB Spills - Requires that leaking capacitor cans or other small-size equipment, clothing, soil, sawdust and other absorbent material contaminated with PCBs should be double sealed in heavy duty plastic bags and subsequently sealed in strong leak-proof containers and labelled. Clean-up solvents should be stored in 200 L drums. To prevent ignition, no flames or cigarettes should be permitted. Leaking capacitor cans should be removed from the capacitor bank and the spill cleaned up.
 - (iv) Transport of PCB - Vehicles carrying PCB wastes are required to be licensed by the MWDA and subject to certain labelling conditions as prescribed under the Dangerous Goods Act.
 - (v) Health Tests for Staff - staff working with PCBs should be entitled to have a prompt health test if they have reason to believe that they have been adversely affected. Results should be made available

to the employees.

- (vi) Storage of PCB - this section deals with labelling of PCB waste-storage containers. Records of containers to be kept. Drums to be stored in a bunded leak proof structure. Storage site needs to be above the 100 year flood level.
- (vii) PCB Spillage Associated with Fire - although rare, heat from a fire can vapourize PCB. Water hoses should not be used if foam extinguishers are available. Spillages should be contained. Any equipment used should be cleaned using a suitable solvent which must then be stored in drums. Co-operation between PCB users and the Fire Brigade is of paramount importance in the event of a fire at a PCB site. Commercial trade names, generic terms such as "Askarel" and other names meaning PCB should all be listed in the hazard file and held by the Fire Brigade.

5.3 Submission from the Prospect County Council

The submission from the Prospect County Council deals with Instructions, issued by the County Council, on the handling, storage and transportation of PCBs. The following is a summary of the submission.

- (1) The instructions were issued when concern was being raised by unions and other authorities regarding the handling, storage and transportation of PCBs.
- (2) Council has now disposed of all cannisters, capacitors, drums, etc, that were being stored. No equipment containing PCBs is stored.
- (3) The Council has 162 capacitors, containing 1.5 to 2.0 litres of PCB per capacitor, still in service at approximately 37 zone substations as well as approximately 22,000 small capacitors containing 10-15 millilitres of PCB per capacitor in service in street lighting installation.
- (4) Zone substation capacitors are being replaced at about 21 per year and the street lighting capacitors are being replaced when the street light column is either damaged or requires maintenance.
- (5) Disposal of equipment containing PCBs is arranged through AACI, a Melbourne based transport company, which organises transport to collect the sealed containers and subsequent disposal by incineration in the UK.

The Council also submitted copies of the following two documents which are used by its employees when handling

equipment containing PCBs.

- . Substation Maintenance Instruction No. 853 - Polychlorinated Biphenyls (PCBs). Handling, Transporting, Storage and Disposal
- . Mains Branch Instruction No. 35 - Handling, Transporting, Storage and Disposal of Street Lighting Equipment Containing Damaged PCB (Polychlorinated Bi-Phenyl) Paper Capacitors.

The instructions cover handling, transport, storage and disposal and also safety procedures at spills, clean-up procedures, labelling of stored wastes, type of clean-up equipment, clean-up crew and procedures to be followed in the event of leakages of PCBs and general assessment and recording of incidents.

6 DISCUSSION

The Commission, as a matter of policy, prefers that hazardous wastes not be disposed of in landfill if there is a potential for environmental harm or if the site would require monitoring or careful management into the indefinite future. Environmental impacts to be avoided include any direct toxic effects if the site is disturbed and the effects of atmospheric emissions or the contamination of groundwater or adjoining sites. Once generated, environmentally hazardous wastes should be destroyed, or otherwise rendered non hazardous, rather than being buried as is.

There are several options available for the safe disposal of PCB wastes including high temperature incineration, chemical and to a lesser extent biological methods, however none of these are presently available or practiced in Australia. High temperature incineration has been the most effective method of destroying PCB wastes, practised by a number of nations including the USA, UK, several countries in Europe and Japan.

Disposal of PCB wastes by landfill with or without encapsulation in concrete has in the past been practised by most countries who have either manufactured components, such as capacitors or transformers, or used equipment or products which contained PCBs. In Australia wastes generated during the manufacturing of components and products, especially during the 1950s-1960s, were also disposed of by landfill without encapsulation. Encapsulation in concrete of smaller capacitors and drained but larger capacitors with small volume (less than 100 millilitres) of PCBs from capacitor manufacturers were also disposed of by landfill under the MWDA's supervision at depots specified by the Authority. This practice has recently been discontinued by the MWDA.

In-ground disposal of PCB wastes can pose environmental risk

especially if the site is disturbed. The Commission considers that landfill is no longer a generally acceptable method for disposal of wastes which contain more than 100 ppm PCBs. The most acceptable alternative is to store wastes containing more than 100 ppm PCBs under conditions specified by the MWDA and the SPCC.

Enforcement by the MWDA of the Authority's Special Conditions is sufficient to ensure that PCB wastes are properly and safely stored within the MWDA's area of jurisdiction pending an acceptable means of disposal. An acceptable method of destruction of PCB wastes, encouraged by both the MWDA and the Commission, is high temperature incineration at an acceptable overseas facility, such as exists in the United Kingdom.

In areas outside of the MWDA's Sydney jurisdiction, Commission officers are often actively involved in advising on and authorising safe storage or disposal practices for a variety of industrial wastes. There have been instances in non-Sydney areas where advice has been sought on storage and transportation procedures for PCB wastes. Commission officers have generally prescribed the "Special Conditions" as required within Sydney by the MWDA (Appendices A and B).

Notwithstanding the above advice, there has been disquiet from some employees, particularly those handling PCB wastes. There have also been union black bans on the handling of equipment containing PCB and on PCB wastes at some sites, even though the practice has been in accord with that advised by the Commission. These handling difficulties meant that often equipment and wastes had to be transported long distances for storage. Sometimes they were sent to Sydney where controlled areas were available for storage prior to disposal overseas.

The special conditions prepared by the MWDA provide a generally satisfactory basis for the environmentally sound methods of transportation, storage and disposal of PCB wastes in areas outside the MWDA jurisdiction. There is need, however, for consistent and structured application of the conditions. Accordingly, these can be taken as the basis for conditions to be applied to the storage, transportation and disposal of PCB wastes in non Metropolitan NSW, and incorporated in a chemical control order issued under the Environmentally Hazardous Chemicals Act, 1985.

The most difficult problem has been the lack of information available to accurately establish the quantities of PCB and PCB wastes:

- . still in service; and
- . being stored.

A very rough estimate of the number of transformers, large

power factor correcting capacitors and small fluorescent type capacitors still in service has been determined from information received from such bodies as the MWDA, Department of Local Government and Administrative Services, the Prospect County Council, the Electricity Commission of NSW, the Australian Environment Council and others. The number of transformers in NSW can be estimated to range from about 150 to 250 containing volumes ranging from 160 to 6000 litres (240 to 9000 kg) of PCBs each, with an average of about 950 litres (1430 kg) each.

The number of larger capacitors (power factor correcting capacitors) in service is very difficult to estimate, but a rough figure could be between 10,000 and 15,000 with the volume of PCB averaging perhaps 10 litres (15 kg) each.

The number of small capacitors used in fluorescent lighting, motors etc still in service in NSW and containing between say 10 mL and 50 mL (15 to 75 g) of PCBs, is in the vicinity of one to two million. It is very difficult to establish their whereabouts as they are spread throughout the state.

It is equally as difficult to police their disposal as they would normally be disposed of in the garbage and end up at local garbage depots.

The quantity of PCB wastes being stored, either as liquid or as a contaminant of solid materials such as rags, gloves, aprons, dirt, gravel, drums, etc or still contained in capacitors or transformers, is also difficult to establish. The quantity of waste PCBs is continually being depleted as quantities are exported overseas for high temperature incineration. The quantity of PCB waste currently in storage in NSW is judged to be not large and in total may only range from about 200 - 450 tonnes. Contaminated solid wastes containing low concentrations of PCBs between 50 and 100 ppm PCB) could be in the region of 500 to 1000 tonnes.

The MWDA proposed that consideration be given to the development of an inventory of PCB materials. This would be particularly beneficial in establishing the need for the type, size and siting of facilities for centralized storage areas around the state and would assist in making a decision of the type and size of a high temperature incinerator or similar disposal facility in NSW.

7 CONCLUSION

The Metropolitan Waste Disposal Authority has issued Special Conditions which provide for environmentally suitable procedures for transport and storage of PCB wastes. There are however, no formal requirements especially outside the MWDA's area of jurisdiction, for the transport, storage and disposal of PCB wastes.

The purpose of any chemical control order should be to minimise environmental dispersion during storage, transport or disposal of PCB wastes.

Accordingly, the attached chemical control order embodies conditions to meet these requirements and also covers most of the MWDA's special conditions prevailing at the time of writing. (Following the making of this control order, the MWDA could withdraw its special conditions and use the conditions of the control order for the regulation of PCB wastes in the Sydney region.)

PCB Disposal Sites

There remains a hazard, though greatly reduced, associated with sites in which PCB wastes have been interred.

Sites highly contaminated with PCBs may require detoxification or removal of contaminated materials or permanent controls (e.g. non disturbance). Any soils removed would need to be stored pending an environmentally acceptable method of disposal.

The SPCC should ensure environmentally appropriate management and clean up of such sites by the issue of notices to the occupiers under Section 35 of the Act or through provision of Section 55 of the Health Act. The notices under the EHC Act would include conditions generally requiring:

- any proposed disturbance of land, which has buried on it, encapsulated materials, including small capacitors or other PCB contaminated wastes, shall only be conducted with the prior notification and approval of the Commission
- any PCB materials excavated during the clean-up of a contaminated site shall be stored in a manner approved by the Commission.
- that in the event of any wastes containing PCBs becoming exposed at such sites the Commission shall be notified immediately by the occupier.

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[5W-MKD, C3, R-AF2, 4]

TABLE 1

PHYSICAL PROPERTIES OF THE CHLOROBIPHENYLS

Compound	log Kow(1) (range)	Literature log Kow (range)	Water Solubility ppb	Melting Point o C (range)	Boiling Point o C (range)
Biphenyl	3.79	3.89(1)	-	70	254-255
Monochlorobiphenyls	4.4-4.6	4.4(1)-4.7(2)	1190-5900	34-89	125-285
Dichlorobiphenyls	4.8-5.1	4.9(1)-5.4(2)	80-1880	23-168	171-326
Trichlorobiphenyls	4.2-6.3	5.6(1)-5.9(2)	78-85	55-79	-
Tetrachlorobiphenyls	5.6-6.7	5.7(3)-6.4(2)	34-175	83-198	230
Pentachlorobiphenyls	5.7-7.2	6.2(4)-6.9(2)	22-31	179	195-220
Hexachlorobiphenyls	6.5-7.8	6.7(4)-7.4(2)	8.8	111-198	-
Heptachlorobiphenyls	8.1	-	-	-	240-280
Octachlorobiphenyls	-	7.1(1)	-	161	-
Decachlorobiphenyls	-	8.2(1)	15	310	-

NOTES: (1) Woodburn (1982)*
 (2) Bruggeman et al (1982)*
 (3) McDuffie (1981)*
 (4) Chiou et al (1977)*

* References not cited; Refer to
 Report by Rapaport et al (1984)

[5W-MKD,OA,TAF2]

TABLE 2 GENERAL PROPERTIES OF SOME AROCLORS ¹

Material	Type (Main Component)	Percent Chlorine	Specific Gravity	Distillation Range ² ° C	Flash Point ° C ³	Average Molecular Weight	Vapour ⁴ Pressure at 25 ° C (kPa)	Aqueous ⁵ Solubility ug/L (ppb)	Kow x1000 ⁵	Log Kow ⁵ (Log Pow)
Aroclor 1221	Mono-56%	21	1.182-1.192 (25/15.5 ° C)	275-320	141-150	192	9.3 x 10 ⁻⁴	1,500	0.65	2.81
Aroclor 1232	Di-55%	32	1.270-1.280 (25/15.5 ° C)	290-325	152-154	221	6.7 x 10 ⁻⁴	1,450	1.70	3.23
Aroclor 1242	Tri-54%	42	1.381-1.392 (25/15.5 ° C)	325-366	176-180	261	1.1 x 10 ⁻⁴	240 250 ⁶	3.5	3.54
Aroclor 1248	Tetra-55%	48	1.405-1.415 (65/15.5 ° C)	340-375	193-196	288	6.7 x 10 ⁻⁵	54 100 ⁶	6.4	3.81
Aroclor 1254	Penta-60%	54	1.495-1.505 (65/15.5 ° C)	365-390	none	327	1.1 x 10 ⁻⁵	12 50 ⁶	12	4.08
Aroclor 1260	Hexa-70%	60	1.555-1.566 (90/15.5 ° C)	385-420	none	372	5.3 x 10 ⁻⁶	2.7 25 ⁶	22	4.34

¹ Kirk et al, 1964; Hutzinger et al, 1974; Versar Inc. 1979

² ASTM D-20 (modified)

³ Cleveland open cup

⁴ Vapour Pressure Values extrapolated from a VP vs T diagram produced by Hutzinger et al (1974) and Versar Inc (1979) - (Values converted from mm Hg to kPa; where 1 mm Hg = 0.133 kPa)

⁵ Versar Inc. 1979

⁶ Monsanto Co (1972)

TABLE 3

Composition of Different Liquid Chlorinated Biphenyls

Components - given as %	Monsanto Aroclors					
	1221	1232	1242	1248	1254	1260
Chlorine	21	32	42	48	54	60
Biphenyl	14.8		.02			
Mono-chlorobiphenyl	56.5		.72			
Di-chlorobiphenyl	26.9	55 (approx)	15.6			
Tri-chlorobiphenyl	1.42		54.5			
Tetra-chlorobiphenyl	.06		22.5	55 (approx)		
Penta-chlorobiphenyl			6.7*		60	
Hexa-chlorobiphenyl						70

*Includes higher than penta-chlorinated isomers

NTIS (1972) (Appendix C p77)

[5W-MKD,OA,TAF4]

TABLE 4: ACCUMULATION OF PCBS BY VARIOUS AQUATIC ORGANISMS

Species	Aroclor Compound	Exp. Time	Environmental Concentration (ppb)	Residue (ppb)	Concentration Factor	Source
Catfish	1248	60 da.	13.3	958,000	72,000	Stalling and Mayer, (1972)
	1254	60	4.1	312,000	76,000	"
Bluegill	1248	60	4.9	312,000	63,700	"
	1254	60	6.8	87,000	12,800	"
Fiddler Crab	1254	30	3.5	80,000	22,900	"
			0.5	17,000	34,000	"
Pink Shrimp	1254	30	3.5	240,000	69,000	"
			0.5	6,000	12,000	"

[5W-MKD, C3, RT4-AF2]

TABLE 5:

PCB Residues in Fish in N.S.W. Fresh Water
and Marine and Estuarine Waters
(From Scribner et al 1987 a & b)

SPECIES	LOCALITY	No of SAMPLES	RANGE ppm (mg/kg) PCBs	MEAN ppm (mg/kg) PCBs
<i>Gambusia affinis</i>	Sydney Rivers	15	0 - 1.1	0.28 \pm 0.36
<i>Aseraggodes Maclaeyanus</i>	Sydney Sewer Outfalls	1	0.5	-
<i>Platycephalus Caeruleopunctatus</i>	"	9	0 - 0.7	0.06 \pm 0.14
<i>Pseudorhombus Arsius</i>	"	18	0 - 3.9	0.19 \pm 0.69
<i>Girella Tricuspidata</i>	Botany Bay	3	0 - 0.2	0.06 \pm 0.08
<i>Acanthopagrus Australis</i>	"	6	0 - 0.9	0.41 \pm 0.27
<i>Mugil Cephalus</i>	"	1	0.2	-
<i>Mixus Elongatus</i>	"	37	0 - 0.9	0.27 \pm 0.17
<i>Pseudorhombus Arsius</i>	"	1	0.2	-
Misc. Fish	"	10	0 - 0.3	0.05 \pm 0.11

[5W-MKD,OA,TAF5]

TABLE 6: The World's Major Producers of PCB
(Hutzinger et al 1974)

Producer	Country	Tradename of PCB
Monsanto	U.S.A. and Great Britain	Aroclor(R)
Bayer	Germany	Clophen(R)
Prodelec	France	Phenoclor and Pyralene(R)
Kanegafuchi	Japan	Kanechlor(R)
Mitsubishi- Monsanto	Japan	Santotherm(R)
Caffaro	Italy	Fenclor(R)
Sovol	U.S.S.R.	
Chemko	Czechoslovakia	

[5W-MKD, OA, TAF6]

TABLE 7: Use of PCB Classified to Grade of Aroclor
(Hutzinger et al 1974)

Current use of PCB	Grade of Aroclor used
Electrical capacitors	1016 (1221, 1254)
Electrical transformers	1242, 1254, 1260
Vacuum pumps	1248, 1254
Gas-transmission turbines	1221, 1242
Former use of PCB	
Hydraulic fluids	1232, 1242, 1248, 1254, 1260
Plasticizer in synthetic resins	1248, 1254, 1260, 1262, 1268
Ashesives	1221, 1232, 1242, 1248, 1254
Plasticizer in rubbers	1221, 1232, 1242, 1248, 1254, 1268
Heat transfer systems	1242
Wax extenders	1242, 1254, 1268
Dedusting agents	1254, 1260
Pesticide extenders, inks, lubricants, cutting oils	1254
Carbonless reproducing paper	1242

[5W-MKD, C3, RT7-AF2].

TABLE 8: Acceptable Methods of Disposal

Applicable Item	Secure Storage or High Temperature Incineration	Secure Landfill (eg Castlereagh Liquid Depot)	Controlled Landfill (some Municipal)
Liquid PCBs (>100ppm)	x	-	-
Liquid PCBs (50-100ppm)	x	x	-
Contaminated soil, rags, and other debris (50-100ppm)	x	x	-
PCB Transformers	x	-	-
PCB <u>Large</u> , High or low Voltage Capacitors (>75g PCB)	x	-	-
PCB <u>Small</u> Capacitors (eg Fluorescent Types (<75g PCB)	x	x	x
Contaminated PCB Containers (>100ppm)	x	-	-
Contaminated PCB Containers (<100ppm)	x	x	-
Decontaminated PCB Containers (<50ppm)	x	x	x
Any Waste Containing (<50ppmPCB)	x	x	x

(x) acceptable
 (-) not acceptable

[5W-MKD,C3,RT8-AF2].

Metropolitan Waste Disposal Authority



Special Conditions Applicable to the Storage of Polychlorinated Biphenyl (P.C.B.) Waste

1. The storage area shall be isolated from the active area of the site.
2. The storage area shall be bunded such, that the volume of the largest container or twenty five per cent of the maximum contents of the store, whichever is the greater, will be contained in the event of spillage.
3. The floor of the storage area shall
 - a. have no drain valves, floor drains, expansion joints or sewer lines that would allow liquid to flow from the bunded area
 - b. be painted with P.C.B. resistant paint.
4. The walls and roof of the store shall be so constructed to adequately protect the contents.
5. The packages shall be clearly and permanently marked with details of the contents.
6. The packages holding P.C.B. waste shall be maintained in good order. Corroded or leaking packages shall be immediately emptied and the wastes placed in sound packages.
7. The store should be adequately ventilated.
8. Protective clothing, clean-up material and equipment shall be kept in the store.
9. The occupier shall ensure that all persons who handle P.C.B. wastes wear adequate protective clothing.
10. The occupier of a depot upon receiving P.C.B. waste shall advise the Authority the quantity of P.C.B. waste in store, the quantity received in each consignment and the origin of the waste received.
- * 11. The company shall seek approval from the Authority for transportation of P.C.B. wastes to or from the storage area.
12. The store shall be securely locked to prevent unauthorised entry.
- * 13. The company shall inspect the store at monthly intervals to ensure that no unauthorised entry has occurred. A log of the inspections shall be maintained at the store.



Metropolitan Waste Disposal Authority



Special Conditions Applicable to Transport of Polychlorinated Biphenyl (P.C.B.) Waste and Equipment Containing Liquid P.C.B.

1. The vehicle transporting the P.C.B.'s must at all times be followed by a second vehicle carrying equipment for use in the event of a spill, excepting that the maximum quantity of liquid P.C.B. which may be carried in a single vehicle convoy is 20 litres.
2. The second vehicle shall carry two persons both of whom are trained in methods of containing spilled P.C.B.
3. The second vehicle shall carry suitable protective clothing, spades, brooms, cleaning fluid, rags and at least 150 kg of oil absorbent.
4. Sufficient sealed containers shall be kept readily available for holding the clean-up material.
5. The transporter shall notify the Authority of any spill immediately.
6. P.C.B. liquid and equipment containing liquid P.C.B. shall only be transported between 9.00 am and 2.00 pm Monday to Friday, Public Holidays excepted.
7. A single vehicle convoy shall carry protective clothing and clean-up equipment and material for use in the event of a spill.
8. All other Acts and Regulations shall be complied with.



OUTLINE SPILL RESPONSE GUIDE FOR POLYCHLORINATED BIPHENYLS (PCB)

APPENDIX "C"

What are PCB's: PCB's are a nonflammable oil used as a coolant and electrical insulating fluid in some transformers, capacitors, and separator magnets and in electric motors on certain continuous miners and loaders.

Hazards: PCB's are a toxic environmental pollutant. Do not breathe vapors or get on skin. Do not allow spilled PCB's to get into drains, sewers, or other water.

First Aid:
Skin contact: Wash off with waterless hand cleaner using paper towels. Store contaminated towels for special disposal.
Eye exposure: Flush with water.
Vapor exposure: Get medical aid.

Spill Response

Spill from live electrical equipment: Disconnect power, call responsible officer (telephone)

Then try to plug leaks with rags or other materials.

All spills:

Call Responsible Officer (telephone)

Protective Clothing: Use PVA gloves to prevent contact with skin. Contaminated gloves, clothing, shoes, etc., should be put into a 200l drum for storage as PCB's. Tools may be decontaminated by washing with solvent; store solvent, rags, etc., as PCB's.

Control Spill: Dike major spills with dirt or other material. Soak up spilled PCB's with rags or other absorbent material. Do not let PCB's run into drains or water.

Final Cleaning: Check with Responsible Officer, at (telephone) for detailed instructions.

Disposal of PCB - Contaminated Material and Equipment:
Solids - load into steel containers; label PCB, poison, class 6; store.
Liquids - drain into 200l drums; flush equipment with solvent such as trichloroethylene to remove as much residual PCB as possible; drain solvent into drums; apply PCB label and store in secure roofed area meeting Metropolitan Waste Disposal Authority requirements until an approved incineration facility becomes available for the disposal of PCB's.

ENVIRONMENTALLY HAZARDOUS CHEMICALS ACT, 1985

CHEMICAL CONTROL ORDER IN RELATION TO

POLYCHLORINATED BIPHENYL WASTES

NOTICE is hereby given pursuant to Section 21 of the Environmentally Hazardous Chemicals Act, 1985, that the State Pollution Control Commission has made a chemical control order under sections 22 and 23 of that Act in relation to polychlorinated biphenyl wastes.

The terms of the chemical control order are as follows:

1. Citation:

This order may be cited as the "Polychlorinated Biphenyl Wastes Chemical Control Order 1988".

2. Commencement:

This order commences on
4 November 1988

3. Definitions:

In this Order -

- 3.1 "capacitor" means a device for accumulating and holding a charge of electricity consisting of conducting surfaces separated by a dielectric;
- 3.2 "fluorescent light ballast" means a device used to electrically control fluorescent light fixtures;
- 3.3 "licence", except insofar as a contrary intention may appear, means a licence issued by the Commission under the Act or the Authority under the Waste Disposal Act, 1970 (being a licence having force within the area of jurisdiction prescribed in that Act);
- 3.4 "PCBs" are polychlorinated biphenyls being chemical substances in which the biphenyl structure has chlorine substitutions (for hydrogen atoms) to varying degrees. They have the chemical formula $C_{12}H_{10-n}Cl_n$ where n ranges from 1 to 10;
- 3.5 "PCB waste" means polychlorinated biphenyl waste being any waste liquid, sludge or solid, including manufactured articles and containers which contain

fifty or more parts per million (50 ppm) of a PCB or PCBs, ie, 50 milligrams or more per kilogram of waste;

- 3.6 "secure landfill" means a waste disposal area which is an impermeable cell to prevent leaching into surface or groundwaters;
- 3.7 "the Act" means the Environmentally Hazardous Chemicals Act, 1985;
- 3.8 "the Authority" means the Metropolitan Waste Disposal Authority;
- 3.9 "the Commission" means the State Pollution Control Commission;

4. Prohibition of Prescribed Activities:

The following prescribed activities are prohibited:

- 4.1 The keeping, processing, conveying and disposing of PCB waste other than the keeping, processing, conveying and disposing of PCB waste in the manner described in this Order.

5. Description of Prescribed Activities Permitted to be Carried On:

5.1 Keeping of PCB Waste

- 5.1.1 Where less than one tonne of PCB waste is kept or proposed to be kept:

- .1 All packages containing PCB waste shall be clearly marked with details of the contents.
- .2 A PCB waste storage area shall be sited and constructed so as to minimise any discharge of PCB waste to the environment.
- .3 The occupier of any premises where PCB waste is kept shall ensure that an adequate supply of protective clothing is available and used by any person handling PCB waste.

- 5.1.2 Where more than one tonne of PCB waste is kept or proposed to be kept:

- .1 PCB waste shall be kept in accordance with the

- conditions of a licence issued by the Commission, or otherwise registered or licenced by the Authority;
- .2 All packages containing PCB waste shall be clearly marked with details of the contents.
 - .3 A PCB waste storage area shall be a roofed and walled enclosure with an impermeable floor such as concrete or steel with no drainage outlets. Concrete floors shall be coated with sealant material to prevent the absorption of any leak or spill. The floor shall be bunded so that it will contain the contents of the largest package or twenty five percent of the maximum contents of the store, whichever is the greater volume.
 - .4 The walls and roof of a PCB waste store shall be so constructed and sealed to adequately protect the contents from weather conditions and unlawful entry.
 - .5 All packages containing PCB waste shall be maintained in good order. The contents of corroded or leaking packages shall be immediately repacked into sound packages.
 - .6 A PCB waste storage area shall be adequately ventilated and secured to prevent unauthorised entry and shall be located no closer than ten metres from any flammable liquid store. The storage area shall be located at an elevation above the 100 year flood level for the locality and constructed so as to prevent the ingress of stormwater.
 - .7 An adequate supply of protective clothing, clean-up material and equipment shall be kept in a PCB waste store.
 - .8 The licensee shall ensure that any person handling PCB waste wears adequate protective clothing.
 - .9 Immediately upon receiving or despatching for conveyance any PCB waste the licensee of a PCB waste store shall notify details of such receipt or despatch in writing. Such notice shall be given to the Commission, or to the Authority (as the case may be) and to any other authority which may be prescribed in the licence.
 - .10 Conspicuous notices stating a warning that the packages containing PCBs are hazardous shall be placed in the vicinity of a PCB waste store.

- .11 The licensee of a PCB waste store shall inspect the store at monthly intervals to ensure that no unauthorised entry or leakage has occurred. A log, containing details of the personnel carrying out, and dates of inspections, shall be maintained at the store.
- .12 Without limiting the generality of 5.1.2.1, licences granted under 5.1.2.1 may attach conditions:
- (a) requiring remedial action to be taken by the licensee in the event of contamination occurring by reason of the keeping of PCB waste;
 - (b) requiring the lodging with the Commission, of a security, in such a form and amount as the Commission considers appropriate under Section 34 of the Act, for the performance of the conditions of the licence.

5.2 Processing of PCB waste

- .1 PCBs or PCB waste recovered from any manufactured item shall be kept, conveyed or disposed of in accordance with this order.
- .2 Contaminated containers containing up to 100 ppm PCBs shall be disposed of in accordance with this order.
- .3 Where more than one tonne of PCB waste is to be processed PCB waste shall be processed in accordance with the conditions of a licence granted by the Commission.
- .4 Without limiting the generality of 5.2.3, licences granted under 5.2.3 may attach conditions:
- (a) requiring remedial action to be taken by the licensee in the event of contamination occurring by reason of the processing of PCB waste;
 - (b) requiring the lodging with the Commission, of a security, in such form and amount as the Commission considers appropriate under Section 34 of the Act, for the performance of the conditions of the licence.

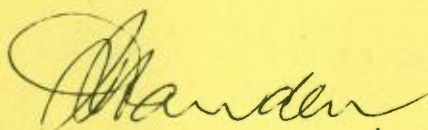
5.3 Conveying of PCB waste

PCB waste shall be conveyed in accordance with the requirements of the Dangerous Goods Act, 1975.

- 5.3.1 Where less than one tonne of PCB waste is to be conveyed, the vehicle conveying PCB waste shall carry two persons provided with adequate protective clothing, clean-up material and equipment to deal with any spill.
- 5.3.2 Where more than one tonne of PCB waste is to be conveyed
- .1 An escort vehicle shall accompany the vehicle(s) conveying PCB waste, and shall be capable of maintaining radio contact with the vehicle(s).
 - .2 The escort vehicle shall carry two persons both of whom are trained in methods of containing spilled PCB waste.
 - .3 The escort vehicle shall carry suitable protective clothing, spades, brooms, cleaning fluid, rags and at least 150 kilograms of oil absorbing material.
 - .4 The escort vehicle shall carry sufficient sealable containers for holding any clean-up material.
 - .5 The Commission and, if a spill takes place in an area over which the Authority has jurisdiction, the Authority, shall be notified immediately of any spill of PCB waste occurring during the conveyance.
 - .6 PCB waste shall be conveyed in accordance with the conditions of a licence.
 - .7 Without limiting the generality of 5.3.2.6 licences granted under 5.3.2.6 may attach conditions:
 - (a) requiring remedial action to be taken by the licensee in the event of contamination occurring by reason of the conveying of PCB waste;
 - (b) requiring the lodging with the Commission of a security, in such form and amount as the Commission considers appropriate under Section 34 of the Act, for the performance of the conditions of the licence.

5.4 Disposing of PCB waste

- 5.4.1 Where the total amount of PCB contained in separate packages or units does not exceed 75 grams per collection, small capacitors and fluorescent light ballasts, each containing less than 75 grams PCB, may be disposed of in the same manner as household garbage.
- 5.4.2 PCB containers containing up to 100 ppm PCBs may be disposed of at secure landfill in a manner approved by the Commission.
- 5.4.3 Where the PCB contamination of the materials does not exceed 100 ppm, materials, including soil, gravel, sand, clothing and rags, contaminated with PCBs may be disposed of in a secure landfill in a manner approved by the Commission.
- 5.4.4 Where it is intended that liquids containing between 50-100 ppm PCBs are to be disposed of at a secure landfill by absorption in solids, the maximum concentration is 15 per cent liquid by volume. The disposal shall be carried out in a manner approved by the Commission.
- 5.4.5 Disposal of any matter containing more than 100 ppm PCBs, shall be carried out in a manner approved by the Commission.



PETER STANDEN 31/10/88
Director
State Pollution Control Commission