Pesticide Use Adjacent to the Swan-Canning Estuary

Swan River Trust
Report No 11
May 1993

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Report to the Swan River Trust

LM Young, VV Klemm and DM Deeley

Swan River Trust
16th floor 'London House'
216 St Georges Tce
Perth

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Acknowledgements

The authors wish to acknowledge the assistance of the following;

Peter Rutherford,	W.A. Department of Agriculture.
Naomi Segal,	Householders for Safe Pesticide Use.
Geoff Ebell,	Chemistry Centre of W.A.
Peter Di Marco,	Health department of W.A.
Kevin McAlpine,	Environmental Protection Authority, W.A.

ISBN 0-7309-5540-0

ISSN 1033-9779

FOREWORD

In 1990 the Swan River Trust became concerned about possible contamination of the Swan-Canning estuary from pesticides used adjacent to the river system. Pesticides were known to be in use near the river to control insects, plants and fungi.

The Trust obtained information from State and Local Government instrumentalities detailing types and quantities of the various pesticides used. The results of the study have been tabled and discussed in this paper. Several recommendations have been made based on survey findings and pesticide profile research.

Pesticides in this report are defined as; insecticides, herbicides and fungicides.

CONTENTS

SUMMARY

State and Local Government instrumentalities were surveyed regarding their use of pesticides adjacent to the Swan-Canning Estuary. This information was used to gain an understanding of the potential for pesticide contamination to the Swan-Canning system.

The pesticides used in the region included insecticides, herbicides and fungicides. No organochlorine pesticides were in use. All persistent organochlorines have been banned for agricultural use and restricted for urban use in W.A.

Most of the pesticides in use in the study region would not pose a threat to the estuary environment if used at current quantity levels and in accordance with application recommendations.

The potential for some pesticides to be toxic in the short and long terms is of concern to the Swan River Trust. Contamination of waterways may occur in various ways including spraydrift, incorrect procedure during application, surface runoff, leaching or volatilization. Some of the pesticides that were in use carry restrictions regarding their application. Research also revealed a lack of conclusive information regarding the environmental fate and hazards of some pesticides in use in the region.

Eight insecticides were reported to be used in the study region. The most frequently used insecticides were temephos and chlorpyrifos. The current quantities of these insecticides in use adjacent to the river do not suggest a potential hazard. From the information gained in the study, the use of fenamiphos near waterways was of concern. One bacterial insecticide was used-Bacillus thuringiensis. It is considered to be the safest in use in the region. The small amounts of other insecticides in use in the area do not pose a threat to the river environment.

Sixteen herbicides were reported to be used. The most frequently used were glyphosate, bromoxynil, MCPA, dicamba, amitrole and atrazine. Of these, glyphosate is considered to pose the least threat when used adjacent to the river. From the information gained in the study, the use of amitrole, atrazine and simazine near waterways was of concern. For some herbicides used, information was unavailable regarding environmental fate and persistence in the environment. Current levels of use of other herbicides in the study region did not indicate a potential threat to the estuary environment.

Two registered fungicides were reported to be used. While neither of these are potentially hazardous to the estuary if used at current quantity levels, the use of thiram is preferred to mancozeb where possible.

Recommendations

The Swan River Trust recommends that;

1. **A public information programme be initiated to educate pest control operators about the environmental impacts of pesticide contamination of waterways and methods to minimize such impacts.**

2. **The Swan River Trust become computer-linked with the interdepartmental database currently being developed at the Department of Agriculture, W.A. with information on the available pesticide reports and research.**

3. **Alternative herbicides be used near waterways in preference to amitrole, atrazine and simazine until further studies are available regarding the safety of their use near waterways.**

4. **Further investigation be carried out regarding the environmental fate of the following pesticides, with particular consideration of mobility in soil and persistence in natural waters: DSMA and MSMA; bromoxynil; fluazifop, propyzamide and fenamiphos.**

5. **Use of the insecticide bacillus thuringiensis be encouraged as an alternative to chlorpyrifos and temephos in the control of mosquitoes, some fly larvae and beetles.**

1.0 Introduction

Pesticides can enter waterways in many ways. These include drift during application, atmospheric fallout on rain and dust, through soil erosion, industrial effluent, sewage and by spills into or adjacent to waterways. Most of the pesticides applied to terrestrial areas ends up in or on the soil. Most pesticides are degraded by microbial and/or chemical activity before they can reach a waterbody. However those pesticides soluble in water may be carried to nearby waters by surface runoff or through leaching, and both soluble and insoluble ones can be transported on soil particles in runoff waters. The rate of pesticide movement through soil depends on soil type, the pesticide's water solubility and physical and chemical structure. Since the soils in the study region are predominantly sandy, it would be reasonable to assume that most pesticides deemed to be highly mobile in soil could leach from these soils and may enter the river. Once pesticides have entered the stream or river, dispersal would be rapid compared with dispersal in standing waters such as lakes.

Most organochlorine pesticides are chemically stable and very persistent in soil and aquatic environments. All persistent organochlorines have been banned for agricultural use and restricted for urban use in W.A. It is expected that residue levels in the environment will decrease over time. However, residual amounts of pesticides such as aldrin, chlordane, heptachlor, DDT and dieldrin will continue to leach into rivers systems for many years due to their strong persistence in soil.

Most organochlorine pesticides are persistent in animal and plant tissue, highly soluble in animal and plant fats and weakly soluble in water. They are not readily broken down by micro-organisms, enzymes, heat or UV light (Ware , 1986). This means that once ingested an organism cannot eliminate or metabolise organochlorines. This may lead to bioaccumulation. Organochlorines vary widely in toxicity but are generally considered to be moderately toxic. Organochlorines affect the central nervous system by inhibiting transmission of nerve impulses in both insects and mammals, although the mode of action is unclear.

Organophosphate, carbamate and synthetic pyrethroid pesticides have gradually replaced organochlorine compounds in agriculture and horticulture. Organophosphate pesticides are chemically unstable and have relatively short residual lives (Health Dept. 1983). Organophosphate pesticides generally have equal or higher levels of toxicity but are less persistent in the environment than the organochlorine compounds. Organophosphates are cholinesterase inhibitors. Cholinesterase is an important enzyme at nerve synapses maintaining the flow of nerve impulses along nerve fibres (Ware, 1986). Most organophosphates are toxic to fish but do not accumulate in animal tissues. They are rapidly metabolized by soil micro-organisms and are subject to hydrolysis (American Chemical Society, 1966).

The study was undertaken in response to concern regarding pesticide use in the Swan/Canning Estuary region. In 1990 the Swan River Trust became concerned that some pesticide use may pose a threat to the estuarine environment if used where residues may enter the river through spraydrift, runoff or leaching.

The pesticides referred to in this report include various types of insecticides, herbicides and fungicides. In the study region, insecticides were used to control mosquitoes, midges, argentine ants, termites, aphids, scale, black beetle, cut worm and spiders. Herbicides were used against Arum lily, Kikuyu grass, Parramatta grass, Lovegrass, Nutgrass, Veldtgrass, Crabgrass, Couch, clovers, Blackberry, Reeds, Caltrop, Onehunga, flatweeds, Capeweed and other weeds and grasses. Fungicides were in use at tennis courts and a golf course, presumably to control pathogens in ornamentals.

1.1 Aim

The aim of this study was to find out which pesticides are in use in the Swan/Canning Estuary region and in what quantities they are used.

1.2 Methodology:

A written questionnaire was sent to local government authorities and relevant state government departments, seeking information regarding the range and quantities of pesticides used over a 12 month period (1990/91 financial year), the locations of application and the problems treated. This information was used to gain an understanding of the potential of pesticide contamination to the Swan-Canning system.

26 surveys were distributed; 24 responses were received. 20 local councils responded (see appendix 1); 14 indicated that planning and implementation pest management programmes were conducted by council, 3 contracted to licensed pest control operators and 3 used a combination of strategies. The remaining 4 replies were from state government authorities implementing their own pest control programmes.

Recently local authorities have begun reviewing the use of pesticides and their potential to cause environmental impact. Many have sought advice in planning workable solutions to pesticide problems. One council has requested advice on the use of atrazine and other spraying programmes. One council advised that since 1989, they had ceased using the herbicides which had previously been used routinely each year. These were DSMA, atrazine, propyzamide and dicamba. Only 500 ml of Roundup (glyphosate) had been used in that shire area last financial year (1990-1991). A policy has now been adopted in the council that pesticides only be used when the Council Health Surveyor deemed it necessary.

There has been some concern recently regarding the use of Roundup, and rumours that it had been banned for use near waterways in the USA. The rumours stemmed from an internal policy decision made by the USA Forest Service that none of their operatives use any pesticide in any forest without first seeking case by case approval. This did not change the overall use programme (Rutherford, *pers comm*).

Since glyphosate is the most widely used herbicide in U.S. forests the directive has been misconstrued as some kind of ban on glyphosate or Roundup (Rutherford,*pers comm*).

In the USA Roundup is not registered for use over/in water and carries the label statement "Do not apply directly to water or wetlands". Roundup is registered in Australia for terrestrial weed control and may be used on the margins of waterways, but not directly over water (Monsanto,1991).

1.2.1 Consideration of Limitations

In reading this report, its limitations must be taken into consideration.

- Information was reported in a variety of ways and may not be accurate in every case. Amounts of actual active ingredients used had to be calculated, based on listings of formulations registered in W.A. The particular formulation used was not always named so in some cases calculations were based on inferences from information provided (e.g. which pest was being controlled; whether the formulation was liquid, powder or granules; which formulation was most commonly chosen by other authorities).

- Exact proximity to the river of pesticide use was not always known (e.g.how much kerb spraying occurs near drains).

- Alternative pesticide users were not surveyed, such as other government organizations, agricultural land users, local industries, pesticide operators, local residents, drycleaners, tree nurseries, etc.

- Information regarding toxicity to various animals and aquatic life is usually studied under laboratory conditions, and usually only gives acute toxicity values, not long term chronic effects. Often laboratory studies do not give a true indication of actual or potential environmental impacts. An LC 50 for fish can be affected by temperature, hardness of water, pH, the size or stage of development of the fish and by the presence of other potentially toxic conditions (eg low dissolved oxygen concentration). Unfortunately toxicity values are rarely available for phytoplankton and other invertebrates and are not available for aquatic macrophytes. They are likely to be inherently more sensitive to most herbicides than fish or invertebrates, and submerged macrophytes and phytobenthos are important components of aquatic food chains. They provide shelter for invertebrates and fish and also control the physical condition of the aquatic environment, including flow patterns, oxygen, turbidity and light climate. They are important in protecting aquatic ecosystems against damage from nutrients, eroding

particles and other pollutants of terrestrial origin (Rutherglen Research Inst, 1986).

- Some information regarding pesticide persistence and mobility is unavailable.
- Some information regarding toxicology of inert ingredients such as solvents is unavailable, yet these may be more toxic than the known chemical ingredient in a formulation.
- Chemical metabolites formed during pesticide degradation may be more or differently toxic than the original pesticide ingredient, as can surfactants used in pesticide compounds, although information regarding these is mostly unavailable.

2.0 Results and Discussion

Table 1: Pesticides in Use in the Swan/Canning Estuary Region, July 1990-June 1991.

Insecticide	Herbicide	Fungicide
Bacillus thuringiensis	amitrole	mancozeb
bioresmethrin	atrazine	nabam (no longer registered)
chlorpyrifos	bromoxynil	thiram
diazinon	chlorsulfuron	
dimethoate	dalapon (2,2-DPA)	
fenamiphos	dicamba	
malathion	diquat	
temephos	DSMA & MSMA	
	ethofumesate	
	fluazifop	
	glyphosate	
	MCPA	
	metsulfuron-methyl	
	propyzamide	
	siduron	
	simazine	

2.1 Insecticide Use

The survey found that organophosphate insecticides were the most frequently used insecticides. One pyrethroid and one bacteriological insecticide were identified (see table 2).

The most commonly used insecticides used were temephos and chlorpyrifos, used for controlling mosquitoes, argentine ants, midges, black beetle and termites.

The largest quantity of insecticide used was temephos. This insecticide has low toxicity and is non-persistent in natural waters, and therefore it would

be reasonable to assume that it does not pose a long term threat to the river environment if used correctly. However, temephos is not target specific. That is it is toxic to other invertebrate species. This may result in a shift in the ecological balance. The long term impact is unknown at this stage.

The other concern with temephos is that it is moderately to highly toxic to birds. Granular temephos has been linked to waterbird deaths at Forrestdale Lake. It is likely that inappropriate use of the chemical was the cause. Temephos is not recommended for use in water less than 10cm deep. Waterbirds may have ingested the granules that were a lighter colour than the existing sediments.

Table 2 also shows that the insecticides malathion and bioresmethrin can both be highly toxic to some aquatic species. The very small amounts used in the study area, and the relative non-persistence of these insecticides in natural waters suggests that neither of them are a significant environmental threat to the Swan/Canning River ecology.

Fenamiphos is in use in the Swan/Canning estuary region as an insecticide against black beetle. It is also registered in W.A. as a nematicide. Although only limited information is available regarding this pesticide, it is known to have moderate to high toxicity to aquatic species. Only 2 kg of fenamiphos is known to be in use in the region and thus it is unlikely to threaten the aquatic environment. However since little is known about its mobility in soil and its persistence in water, the use of this pesticide near waterways should be discouraged.

Diazinon is in use by three authorities in small amounts. It is only slightly persistent in water, has a moderate potential to leach or runoff and has a high toxicity level to some aquatic species. However, the small amount used suggests it is unlikely to be a problem.

Chlorpyrifos, whilst considered to be highly toxic to fish and aquatic life, is tightly adsorbed to soil and is unlikely to leach or runoff into adjacent waterways but may be transported in soil particles (see Table 2). Chlorpyrifos has been reported to be transported by volatilization and in some cases to persist up to a year in soil. There are reports of contamination of waterbodies by chlorpyrifos, for example Davis and Garland (1986) detected it in Herdsman Lake after spraying. Chlorpyrifos has also been detected at low levels in a range of fish from Wilson Inlet. (Rutherford, 1989)

Table 2 shows that 130.35 kg of chlorpyrifos are being used by 5 authorities in the region. If used carelessly or under inappropriate weather conditions (e.g. warm humid days with wind present), or in close proximity to waterways, contamination and some localized persistence could occur. The small amounts in use do not suggest any potential problems.

It is of interest to note that one authority is using a bacteriological insecticide (Bacillus thuringiensis, or Bti) which is registered to control some of the same pests as chlorpyrifos (see Table 2). Because of the potential for

chlorpyrifos to bioconcentrate and bioaccumulate in some fish and aquatic organisms, its moderate to high toxicity level to fish and aquatic life, its moderate persistence in both water and soil and the fact that its long term human health effects are still being studied, Bti may be a safer alternative to recommend to pesticide operators in the region for some purposes. Bti may also be an alternative to temephos for control of mosquitoes and beetles, without threatening bird species or the long term ecological balance of wetlands. Bti is non-toxic to man and to natural enemies of many pests. It is virtually non-toxic to fish, shellfish and aquatic invertebrates. It is specific to certain species of pests and the bacteria do not spread. Bti is insoluble in water, and is non-persistent in soil or water. The authority using Bti in the Swan/Canning estuary region has reported highly satisfactory results for control of mosquitoes.

Dimethoate may be moderately mobile and moderately persistent under some conditions. It has low toxicity to aquatic species. The amount of dimethoate in use in the estuary region was negligible and as such does not pose any threat to the river environment.

Table 2: Insecticides in Use Adjacent to the Swan/Canning Estuary July 1990 - June 1991

Characteristics	Chemical	Chemical
	Bacillus thuringiensis (b)	bioresmethrin (Py)
Trade Names	Teknar; (also see "Pesticides Registered in Western Australia", 1991, p36)	Reslin; (also see "Pesticides Registered in Western Australia", 1991, p37)
Registered Uses in W.A.	Stomach action; control of flies, butterfly & moth larvae, mosquitoes; beetles.	Contact action; controls cockroaches, mosquitoes, houseflies, plant & grain pests.
Restrictions on Use, Safety Warnings		
Use in Swan/Canning	1 authority 0.32 kg	4 authorities 0.35 kg
Acute Toxicity Ratings & Health effects		
Mammals	Non-toxic	Low
Birds	Non-toxic	Low
Fish and Aquatic Life	Non-toxic. (Negligible effect on invertebrates & shellfish at 1000-2000 times normal use level; no effect on fish in seawater at > 400mg/L.)	Medium to high
Stability, Persistence	In soil: non-persistent. Non-phytotoxic. In water: non-persistent. Specific to pests. Bacteria do not spread.	On soil: strongly adsorbed. Readily decomposed by sunlight & UV. Readily hydrolyzed in alkaline media. In natural waters: degrades rapidly.
Solubility	Insoluble	(@25o C) 0.3mg/L
Sources	Anon(1991b) Anon (1991c)	Anon(1991b) Anon (1991c)

Characteristics	Chemical	Chemical
	chlorpyrifos (OP)	diazinon (OP)
Trade Names	Dursban(household);Lorsban (agricultural) (also see "Pesticides Registered in Western Australia", 1991, p44)	See "Pesticides Registered in Western Australia", 1991, p55.
Registered Uses in W.A.	Non-systemic. Works by contact, ingestion & respiratory action; controls flies, ants, cockroaches, mosquitoes (larvae & adults), various crop pests in soil & on foliage, & ectoparasites in animals.	Non-systemic, with contact, ingestion & respiratory action; controls sucking & leaf eating insects, flies & ixodid- ticks.
Restrictions on Use, Safety Warnings		
Use in Swan/Canning	6 authorities 130.35 kg	3 authorities 40.06 kg
Acute Toxicity Ratings & Health effects		
Mammals	Medium Long term effects of human & mammal exposure still being studied.	Medium
Birds	High	Very High Residue on grass & seed is hazardous to birds.
Fish and Aquatic Life	High Experimental values indicate potential bioconcentration and bioaccumulation in various fish and aquatic organisms.	Low to High Not expected to bioconcentrate in aquatic organisms but may be bioaccumulated by some aquatic species under continuous exposure.
Stability, Persistence	In soil: Persistence...1wk-1yr, depending on soil type, climate and conditions, but generally 60-120d. Volatile enough to form insecticidal deposits on nearby untreated surfaces; tightly adsorbed by soil; microbial degradation occurs in soil & some natural waters. Summer water surface photolysis: DT50: 3-4wks; hydrolysis: DT50(neut): 35-78d. In water,partitions significantly from water column to sediments. Desorption from sediments can contribute to long term residual concentrations in the water column.	In soil: Rapidly degraded (3-14 wks); moderately mobile; can enter the aquatic environment by runoff; biodegradation may be significant in soil & water; evaporation from soil insignificant; photolysis may be significant on the surface of soil & in water. In natural waters: Slightly persistent...2-6wks; stable in neutral & alkaline aquatic solution (12h-185d); if releasedto water, may sorb to sediments; hydrolysis may be significant; volatilization can be an important transport process.
Solubility	(@ 25o C) 2mg/L	(@ 20o C) 40mg/L
Sources	Anon (1991b) Howard (1990) Anon (1991c) Task Force on Water Quality Guidelines (1991)	Anon (1991b) Howard (1990) Task Force on Water Quality Guidelines (1991)

Characteristics	Chemical	Chemical
	dimethoate (OP)	fenamiphos
Trade Names	Rogor; (also see "Pesticides Registered in Western Australia", 1991, p61.)	Nemacur; Lawn Beetle Killer.
Registered Uses in W.A.	Contact & systemic; controls flies, aphids, mites, white -flies, scale insects, beetles, moths, mealy bugs & thrips.	Systemic Action; control of black beetle; active against various nematodes & homoptera as a nematicide.
Restrictions on Use, Safety Warnings		
Use in Swan/Canning	2 authorities 2.3 kg	1 authority 2 kg
Acute Toxicity Ratings & Health effects		
Mammals	Medium	Very high
Birds	High	High
Fish and Aquatic Life	Low Not expected to bioconcentrate in aquatic organisms.	Medium to high
Stability, Persistence	In soil: Persistence...usually 4 - 16 days but may be as long as 122days; biodegradation may be important; evaporation from dry soil & other surfaces may be important; should not adsorb to soil, may leach considerably; susceptible to hydrolysis in soils, (especially alk) & water. In natural waters: Persistence...6wks-6mths; relatively stable at pH2-7; not expected to sorb to sediment; direct photolysis & evaporation from water not expected to be important.	In soil: Persistence...ca. 4mths activity; no effect on soil bacteria; non-phytotoxic on soil. Oxidizes then hydrolyzes. Information unavailable regarding leachability or sorption.
Solubility	(@21o C) 25g/L	(@20o C) 400mg-700mg/L
Sources	Anon (1991b) Anon (1991c) Howard (1990)	Anon (1991b) Anon (1991c)

Characteristics	Chemical	Chemical
	malathion (maldison) (OP)	temephos (OP)
Trade Names	See "Pesticides Registered in Western Australia", 1991, p68-69.	Abate; Tempor; Atlas.
Registered Uses in W.A.	Non-systemic; controls flies, beetles, aphids, plant bugs, bed bugs, ants, bees, wasps, sawflies, moths, mosquitoes, mites, lice, grasshoppers, locusts.	Non-systemic. Controls mosquitoes,blackflies,sandflies & biting midges
Restrictions on Use, Safety Warnings		
Use in Swan/Canning	1 authority 2.5 kg	9 authorities 183.7 kg
Acute Toxicity Ratings & Health effects		
Mammals	Low	Low
Birds	Medium	Medium to High
Fish and Aquatic Life	Medium to High Not expected to bioconcentrate in aquatic organisms.	Low
Stability, Persistence	In soil: Subject to significant biodegradation & hydrolysis (DT50:4-6days); should moderately bind to the soil but may enter the aquatic environment through surface runoff & leaching. If released to the atmosphere, may be subject to direct photolysis (DT50:1.5d) In natural waters: relatively non-persistent...2wks (pH8) & 5mths (pH6); may moderately sorb to sediment; subject to biodegradation & photo - degradation at water surface; hydrolysis 0.2-21wks; volatilization from water insignificant.	In natural waters: Persistence-<2 wks. Stable in fresh & salt waters. Further information unavailable.
Solubility	(@25o C) 145mg/L	(@25o C) 0.03mg/L
Sources	Anon (1991c) Howard (1990) Taskforce on water Quality Guidelines (1991)	Anon (1991b) Anon (1991c)

2.2 Herbicide Use

The survey found that the most commonly used herbicide was glyphosate, an organophosphonate (Tradename Roundup; see table 3). Organophosphonates differ from organophosphates in that they are not cholinesterase inhibitors. 19 authorities were using glyphosate (as Roundup) in the Swan/Canning region as part of their weed control programmes, in quantities which totalled approximately 1634.76 kg. Its use extended right throughout the region.

Because of its strong tendency to sorb to soil, glyphosate is not expected to leach or runoff into waterways under normal use (see Table 3). If it entered a waterway, it would be expected to disperse rapidly, be taken up by vegetation and biodegrade readily. Glyphosate is not biocumulative.

Roundup also contains the surfactant POEA, which is moderately toxic to aquatic species. If used under label conditions, neither POEA or glyphosate should pose any threat to aquatic life.

As can be seen from Table 3, bromoxynil, MCPA and dicamba were also used quite commonly in the region, often in one formulation.

Bromoxynil is moderately to highly toxic to aquatic species. Information is unavailable regarding the likelihood of this chemical to leach in, or adsorb to soil. Its relatively short half life in soil suggests that persistence in soil is minimal and it would be unlikely to persist in or be a hazard to an aquatic environment.

MCPA is likely to be highly mobile in the soils of the study area and moderately soluble. It has low toxicity to aquatic life and is only slightly persistent.

Dicamba has low toxicity but is also likely to be very mobile in the types of soil found in the study region. It is moderately persistent in soil and slightly persistent in water.

The three previously named herbicides are not expected to present environmental problems at current levels of use.

DSMA and MSMA were being used by 5 authorities in the region (see Table 3) The combined amount of these pesticides in use was quite significant in relation to other pesticides in use in the region. Whilst these herbicides have low toxicity to aquatic species, very little data is available regarding their environmental fate and persistence in the environment.

Fluazifop was being used by 5 authorities at quantities totalling 29.04 kg (see Table 3). This herbicide is moderately toxic to aquatic life. Information is unavailable regarding its potential to leach into waterways or its persistence in natural waters, but the total amount in use does not pose a threat to the estuary environment.

Propyzamide has low toxicity to aquatic life. Data is unavailable regarding its persistence in natural waters or its mobility in soil. However, amounts in use do not suggest a threat to the aquatic environment.

Several triazine herbicides were in use in the Swan/Canning Estuary region including atrazine and simazine. Triazines may be of some concern in that they tend to be moderately persistent in the environment. 1263.88 kg of atrazine were in use in the Swan/Canning Estuary region (see Table 3). This amount is quite significant when compared to amounts of other pesticides in use in the region. Atrazine has been banned or severely restricted in several countries, because of concerns regarding its persistence in the environment. Atrazine's toxicity to aquatic species varies, but it is not expected to bioconcentrate so should not be a threat to the food chain. Atrazine is considered to be highly mobile in many soils and it may persist in some cases up to 12 months. As it degrades, atrazine produces metabolites which may be more toxic than the original chemical. There is some evidence that atrazine may be carcinogenic in test animals. Evidence of its carcinogenicity to humans is considered to be inadequate (IARC, 1991).

Simazine may be slightly biocumulative in some aquatic species. It may leach, particularly if heavy rain is present after application. Simazine has low to moderate toxicity to aquatic species and is moderately persistent in the environment. 757.5 kg of simazine are in use in the Swan/Canning region. Simazine has a "non-classifiable" rating from IARC, as available evidence concerning its carcinogenicity to humans or test animals is considered inadequate.

From available information about these two herbicides, particularly regarding soil mobility and moderate persistence in soil and water (see Table 3), it would seem preferable that atrazine and simazine not be used adjacent to waterways.

Amitrole is a triazole pesticide. It is only slightly toxic to aquatic life and is slightly to moderately persistent in natural waters. The total amount being used in the region was 1091.9 kg per year. This pesticide has the potential to leach and is very soluble in water. Amitrole carries a "possible human carcinogen" classification from IARC. This is due to a study which found it caused thyroid tumours in rats after chronic exposure. However this does not indicate that the same effects can be expected in humans exposed to amitrole as human thyroid metabolism is quite different to that of rodents. In the USA, all use patterns and application techniques for amitrole are classified as restricted (except homeowner use). Due to its moderate persistence in waterways, soil mobility and solubility, it would seem preferable that amitrole not be used adjacent to waterways.

Of the other 6 herbicides reported, only negligible amounts were in use. At current use levels, they do not pose a threat to the Swan/Canning estuary environment.

Table 3: Herbicides in Use Adjacent to the Swan/Canning Estuary

Characteristics	Chemical	Chemical
	amitrole	atrazine (t)
Trade Names	Vorox. (also see "Pesticides Registered in Western Australia", 1991, p4)	Vorox. (also see "Pesticides Registered in Western Australia", 1991, p5)
Registered Uses in W.A.	Non-selective herbicide; controls annual & perennial grasses & broad leaf weeds; aquatic weed control in drains, etc.	Selective herbicide; controls annual weeds in forest, grass, etc. Non-selective in non-crop areas. Throughout Europe, USA and Canada, over 24 species of weed have developed resistence to atrazine, & to other herbicides after exposure to atrazine.
Restrictions on Use, Safety Warnings	Classified by IARC as a possible human carcinogen - inadequate evidence in human data and sufficient evidence in animal data. Banned in Sweden due to concerns regarding persistence and carcinogenicity. USA: banned on food crops. No longer used on forestry sites-damages conifers. Livestock not allowed in treated areas during season of use. Label must state: "Do not discharge into lakes, ponds, streams or public waters...do not contaminate water by cleaning equipment or disposal of wastes."	Classified by IARC as a possible human carcinogen - inadequate evidence in human data and limited evidence in animal data; under review. Banned in Germany (1991) & Sweden (1966) due to its high mobility in soil and potential for contamination of water. USA EPA: Restricted to use by licenced operators.
Use in Swan/Canning	7 authorities 1091.9 kg	7 authorities 1263.88 kg
Acute Toxicity Ratings & Health effects		
Mammals	Low Chronic exposure caused thyroid tumours in test rats. Carries a 2b rating from IARC-possible human carcinogen.	Low Severe eye & mild skin irritant. Carries a 2b rating from IARC-possible human carcinogen.
Birds	Low	Low
Fish and Aquatic Life	Low No significant bioconcentration expected.	Low-High Not expected to bioconcentrate. Studies have shown that very low concentrations of atrazine affected the photosynthesis of submerged plantlife after chronic exposure.

Stability, Persistence	In soil:Persistence....1-56 days. Minor loss by volatilization or photodegradation. Studies indicate that amitrole becomes tightly adsorbed to soil particles, but may leach, depending on chemical & organic composition of soil. In natural waters: Persistence.... c.40-68 days.(20% residue after 200 d in outdoor pond study)Not expected to hydrolyze, directly photolyze or volatilize. Adsorbs to hydrosoil.	In soil: Persistence...60-150 days Atrazine's degradation products may persist for years following cessation of long term treatment. Not expected to volatilize or microbially degrade; high potential to migrate in soil ("probably the most common pesticide contaminant of US groundwater"EPA 1986) but may be temporarily & reversibly sorbed to soil particles; resists hydrolysis under neutral conditions. In natural waters: Persistence-6wks-2yrs in neutral or basic water; in sunlit estuarine water: 3-12 days.
Solubility	(@ 25o C) 280 g/L	(@20o C) 30 mg/L
Sources	Anon (1988b) Anon (1991b) Anon (1991c) Carter (1975) Ekstrom (1991) Howard (1990) IARC (1987)	Anon (1986b) Anon (1986c) Anon (1991b) Anon (1991c) Ekstrom (1991) Howard (1990) IARC (1991) O'Brien (1986) Uhler (1991)

Characteristics	Chemical	Chemical
	bromoxynil	chlorsulfuron
Trade Names	Barrel; Buctril MA; (also see "Pesticides Registered in Western Australia", 1991)	Glean (also see "Pesticides Registered in Western Australia", 1991)
Registered Uses in W.A.	Contact herbicide; some systemic activity; controls seedling broad leaf weeds	Controls broad leaf weeds in cereals.
Restrictions on Use, Safety Warnings		
Use in Swan/Canning	8 authorities 270.12 kg	1 authority 0.045 kg
Acute Toxicity Ratings & Health effects		
Mammals	Medium Mild eye irritant.	Low
Birds	High	Low
Fish and Aquatic Life	Medium to high	Low
Stability, Persistence	In soil: Persistence-10 days; degraded by hydrolysis; stable in UV light. Other info.not available.	Persistent in soil. Loss from soil by microbial action & by hydrolysis (28-56 days)
Solubility	(@25o C) 130 mg/L	(@25o C) 100-125 mg/L (PH4.1); 0.3 g/L (PH5);27.9 g/L(PH7)

Sources	Anon (1991b) Anon (1991c)	Anon (1991b) Anon (1991c)

Characteristics	Chemical	Chemical
	dalapon (2,2-DPA)	dicamba
Trade Names	See "Pesticides Registered in Western Australia", 1991, p1.	Banvel; Barrel (also see "Pesticides Registered in Western Australia", 1991, p10)
Registered Uses in W.A.	Controls annual & perennial grasses on non-crop land in orchards, olive groves, forestry, etc. Controls reeds, rushes, semi-aquatic grass weeds in water courses.	Foliar or soil applied; readily absorbed by leaves & roots; controls many annual & perennial broad leaf weeds in grass & turf.
Restrictions on Use, Safety Warnings		Toxic to conifers.
Use in Swan/Canning	1 authority 29.6 kg	7 authorities 73.26 kg
Acute Toxicity Ratings & Health effects		Chronic exposure studies unavailable.
Mammals	Low	Low Severe eye irritant; eye damage may be irreversible.
Birds	Low	Low to medium
Fish and Aquatic Life	Low Bioconcentration not expected to be significant.	Low Not expected to bioconcentrate or bioaccumulate. May be slightly mutagenic.
Stability, Persistence	In soil: Persistence...2wks-6mths, depending on amount of microbial action. Does not undergo significant degradation in plants. Leaches readily in soil. In water, hydrolysis half life is several months at <25o C. Degrades microbially in water (1 month in suitable conditions) & photolysis occurs. Aquatic volatilization & adsorption to sediments not expected to be significant.	In soil: Persistence....4 - 555 days (generally 1-4 wks) Microbial degradation significant in soil and in water. Very mobile in most soil; significant leaching may occur. In natural waters: Persistence... 2-6 wks; resists photodegradation. Aquatic hydrolysis, volatilization, adsorption to sediment not expected to be significant.
Solubility	(@ 25o C) 900g/kg	(@ 25o C) 6.5 g/L

Sources	Anon (1991b) Anon (1991c) Howard (1990)	Anon (1991b) Anon (1991c) Howard (1990) O'Brien (1988) Task Force on Water Quality Guidelines (1991)

Characteristics	Chemical	Chemical
	diquat (p)	DSMA & MSMA
Trade Names	Reglone (also see "Pesticides Registered in Western Australia", 1991, p12-13)	Daconate; Passtox; (also see "Pesticides Registered in Western Australia", 1991, pp 14 & 23)
Registered Uses in W.A.	Non-selective contact herbicide-dessicant; controls aquatic weed, grasses & seed crop.	Selective contact herbicide; some systemic properties; for weed control in grass, turf & on uncropped land.
Restrictions on Use, Safety Warnings	USA EPA: Due to high dermal toxicity, formulations of 2.5% or greater will now be classified "restricted use"& workers must wear protective clothing, since industry studies show that toxicity intensifies with repeated exposure. EPA has established a re-entry interval of 24hrs at crop sites, golf courses, etc, prohibiting access unless wearing protective clothing; also re-established a 14 day swimming re-entry interval.	
Use in Swan/Canning	1 authority 50 kg	5 authorities MSMA: 15.8 kg DSMA: 1576.29 kg
Acute Toxicity Ratings & Health effects	Bioaccumulation should be insignificant.	
Mammals	Medium Irritant to skin & eyes. Damages nails. Cancer & mutagenicity studies considered inadequate. Chronic exposure studies on rats showed lung damage, cataracts, damage to kidneys & lymph nodes.	Low Mild skin & eye irritant
Birds	High	Data unavailable

Fish and Aquatic Life	Low Not expected to bioconcentrate.	Low
Stability, Persistence	In soil: Persistence...74 days at pH7. Rapidly & strongly adsorbed to soil, then resistant to biodegradation & photodegradation. Rapidly deactivated on contact with soil. Low mobility in soil, air & water. Strongly absorbed by humic substances. Non volatile. In natural waters: non - persistent. (< 2 wks)	DSMA hydrolyzes to MSMA at pH6-7; MSMA is stable to hydrolysis. No further data available.
Solubility	(@20o C) 700 g/L	(@20o C) DSMA 279g/kg (anhydrous salt/kg water) MSMA 1.4kg/kg (anhydrous salt/kg water)
Sources	Anon (1986a) Anon (1991b) Anon (1991c) Howard (1990) Taskforce on Water Quality Guidelines (1991)	Anon (1991b) Anon (1991c)

Characteristics	Chemical	Chemical
	ethofumesate	fluazifop
Trade Names	Tramat	Fusilade
Registered Uses in W.A.	Growth inhibitor; controls grasses & broad leaf weeds.	Selective. Controls grass weeds in broad leaf crops
Restrictions on Use, Safety Warnings		
Use in Swan/Canning	1 authority 2 kg	5 authorities 29.04 kg
Acute Toxicity Ratings & Health effects		
Mammals	Low	Low
Birds	Low to High	Low
Fish and Aquatic Life	Low	Medium
Stability, Persistence	In soil: Persistence...<35 days (warm & moist), >98 days (dry & cold). Decomposed by light on soil surfaces (8-13days). Stable to hydrolysis in water at pH7.	In soil: Persistence...3-20 wks. Rapidly absorbed by vegetation. Further data unavailable.

Solubility	(@ 25o C) 0.05 g/L	(@ 20o C) 1mg/L
Sources	Anon (1991b) Anon (1991c)	Anon (1991b) Anon (1991c)

Characteristics	Chemical	Chemical
	glyphosate	MCPA
Trade Names	Roundup (also see "Pesticides Registered in Western Australia", 1991.)	Buctril MA; Barrel; (also see "Pesticides Registered in Western Australia", 1991, p18)
Registered Uses in W.A.	Controls a wide variety of annual, biennial and perennial grasses, sedges, broad leaf weeds & woody shrubs; controls aquatic weed.	Systemic; controls annual & perennial weeds in cereals, grasslands & turf.
Restrictions on Use, Safety Warnings		In Sweden, powder formulations were withdrawn because of dust formation & risk of inhalation when used.
Use in Swan/Canning	19 authorities 1634.76 kg	8 authorities 430.16 kg
Acute Toxicity Ratings & Health effects	In the commercial herbicide "Roundup", the surfactant POEA has moderate toxicity to mammals and aquatic life (more toxic than the active ingredient, glyphosate).	
Mammals	Low	Low USA EPA currently seeking data on reproductive & teratogenic effects; could be a weak mutagen.
Birds	Low to Medium	High

Fish and Aquatic Life	Low (as glyphosate); Medium (as Roundup) A 1980 watershed study found that runoff from fields treated with recommended rates of Roundup would not constitute a serious environmental hazard. (Edwards,Triplett & Kramer,1980) Other studies report that overspraying can potentially adversely affect salmon survival,behaviour, & migration, & that surfactants in Roundup can bioaccumulate & have harmful effects. (D.Monroe,90)	Low to medium
Stability, Persistence	In soil: Persistence varies from days to years; (Persistence of surfactant: 10-14wks in forest soil.) Strongly adsorbed to clay particles in soil, but can enter the aquatic environment through runoff and leaching,or direct use nearby. Should disperse rapidly in waterways. Rapidly taken up by vegetation. Degradation is mostly microbial. In pond water: Persistence...12 d -10wks; in bog/swamp...7-9wks. (Persistence of surfactant in natural waters3-4wks.) Because glyphosate adsorbs to soil & sediments, it may be transported several kms downstream.	In soil: Persistence...<7days after initial lag phase; has been found to persist in leaf litter. Seems to break down mostly microbially. Leaches readily through several different soil types and may persist in sediments. More specific information unavailable. In natural waters: Persistence... generally up to 22d.
Solubility	(@25o C) 12g/L	(@25o C) 825 mg/L
Sources	Anon (1987 & 1991) Anon (1991b) Anon (1991c) Edwards, Triplett & Kramer (1980) Monroe (1990) Taskforce on Water Quality Guidelines (1991)	Anon (1988a) Anon (1991b) Anon (1991c)

Characteristics	Chemical	Chemical
	metsulfuron-methyl (t)	propyzamide
Trade Names	Brushoff; Ally.	Kerb; Kerb-WP.
Registered Uses in W.A.	Controls a wide range of annual & perennial broad leaf weeds.	Controls many grass & broad leaf weeds.

Restrictions on Use, Safety Warnings	Label must read "Do not apply directly to lakes, streams or ponds and do not contaminate water by cleaning equipment or disposal of wastes. Do not apply on or near desirable trees or other plants, or areas where their roots may extend, or on lawns, walks, driveways, tennis courts, etc."	
Use in Swan/Canning	1 authority 1.2 kg	4 authorities 77.75 kg
Acute Toxicity Ratings & Health effects		
Mammals	Low Moderate eye irritant; mild skin irritant.	Low Mild eye & skin irritant.
Birds	Low	Low to high
Fish and Aquatic Life	Low	Low
Stability, Persistence	In soil: Persistence...1-4 wks. Broken down by chemical hydrolysis (2hrs at pH2 & >41days at pH7 & 9) & microbial degradation. More rapidly broken down with more soil moisture, lower pH & higher temps. Low mobility in soil & air; medium mobility in water. In plants, undergoes complete degradation in a few days. Stable in neutral & acidic solutions @ 25o C.	In soil: Persistence (residual activity) 2-6mths. Degraded photolytically on soil thin film; 13 -57 days in artificial sunlight. Further data unavailable.
Solubility	(@ 25o C) 1.1mg/L (pH 5) & 9.5g/L (pH 7)	(@ 25o C) 15mg/L
Sources	Anon (1991b) Anon (1991c)	Anon (1991b) Anon (1991c)

Characteristics	Chemical	Chemical
	siduron	simazine (t)
Trade Names	Tupersan	Gesatop; (also see "Pesticides Registered in Western Australia", 1991, p27)

Registered Uses in W.A.	Controls digitaria spp & annual weed grasses.	Controls broad leaf & grass weeds, & vegetation & algae in farm ponds, fish hatcheries, etc.
Restrictions on Use, Safety Warnings		In Sweden, its use is severely restricted in order to minimize risk of water contamination. Conifers are sensitive to simazine.
Use in Swan/Canning	1 authority 4 kg	2 authorities 757.5 kg
Acute Toxicity Ratings & Health effects		
Mammals	Low	Low Carries a non-classifiable rating from IARC due to inadequate human and animal carcinogenicity data. In soil, may form other carcinogenic compounds (nitrosamines).
Birds	Low	Low
Fish and Aquatic Life	Low	Low to medium Slightly bio-cumulative.
Stability, Persistence	In soil: Persistence...120-150 days,degradation mainly microbial; resists leaching in soil; not decomposed by sunlight. Further data unavailable.	In soil: Readily adsorbed and can persist 1 yr. Long residual action. Usually stays in topsoil, except in heavy rain. Medium potential to migrate in soil and large amounts may leach in heavy rain. Loss mostly by microbial action. In natural waters: Persistence... 6wks - 6mths.
Solubility	(@25o C) 18mg/L	(@20o C) 3.5-5mg/L
Sources	Anon (1991b) Anon (1991c)	Anon (1991b) Anon (1991c) IARC (1991)

2.3 Fungicide Use

Table 4 shows 3 fungicides in use in the region, all of which are highly toxic to some aquatic species.

Mancozeb and nabam both contain ETU as a trace contaminant (known to cause birth defects, thyroid effects and tumours in test animals) and both have the potential to leach in soil.

Mancozeb may persist up to 3 months in water.

The registration of nabam has recently allowed to lapse in Western Australia.

Thiram may persist in soil longer than 6 months, but is not expected to leach in soil.

Because fungicides are in use in such small quantities in the region, they do not pose significant potential for environmental contamination at this time. However in consideration of future use of fungicides adjacent to waterways it is recommended that thiram be used in preference to mancozeb, because of mancozeb's trace contaminant and its potential mobility in soil.

Table 4: Fungicides in Use Adjacent to the Swan/Canning Estuary

Characteristics	Chemical	Chemical
	mancozeb (TC)	nabam (TC)
Trade Names	See "Pesticides Registered in Western Australia", 1991, pp127-128.	A-103
Registered Uses in W.A.	Foliar or seed treatment to control wide range of pathogens in field crops, fruits, vegetables, ornamentals.	Control of algae in paddy fields; applied to soil may act on phytoplathora fragariae. Too phytotoxic for general use on foliage.
Restrictions on Use, Safety Warnings		Deregistered in W.A. since 1990. Use on food crops in USA currently suspended; chemical under evaluation (probable human carcinogen-EPA USA) Manufacturers Use: Product label must read "This pesticide is toxic to fish. Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans, public water or sewage systems. End use products: "Drift & runoff from treated areas may be hazardous to aquatic organisms in neighbouring areas. Do not discharge effluent into lakes, etc."

Use in Swan/Canning	1 authoriy 4 kg	1 authority 1.5 kg
Acute Toxicity Ratings & Health effects		
Mammals	Low May cause skin irritation on repeated exposure. At very high levels, caused birth defects in test animals. ETU (a trace contaminant & breakdown product) caused birth defects, thyroid effects & tumours in test animals.	Medium ETU is threat to thyroid gland.
Birds	Low	Information unavailable
Fish and Aquatic Life	Low to High Highly toxic to warm water fish.	Medium to High
Stability, Persistence	Rapidly degraded in the environment by hydrolysis, oxidation, photolysis & metabolism. In soil: Persistence...6-15 days. Available studies indicate potential to leach(thus allowing ETU to possibly threaten groundwater supplies) In water: Anaerobic aquatic metabolism...92 days.	High phytotoxicity. Available studies indicate a potential to leach (thus allowing ETU to possibly threaten groundwater supplies). Further information unavailable.
Solubility	(@ 25o C) 6-20mg/L	(@ 25o C) 200g/L
Sources	Anon (1991b) Anon (1991c)	Anon (1991c)

Characteristics	Chemical
	thiram
Trade Names	See "Pesticides Registered in Western Australia", 1991, p135.
Registered Uses in W.A.	Applied to foliage to control botrytis, uredinales, venturia pirina. Seed treatment to control "damping off" diseases. Used at high doses in fields & orchards as repellant to birds, rodents & deer.
Restrictions on Use, Safety Warnings	
Use in Swan/Canning	1 authority 16 kg
Acute Toxicity Ratings & Health effects	
Mammals	Low
Birds	Medium to high
Fish and Aquatic Life	Medium to very high Not expected to bioconcentrate significantly.
Stability, Persistence	In soil:Persistence...2days to 32wks, depending on pH, humus content & concentration of thiram. Should strongly adsorb to soil & not volatilize from wet or dry soil surfaces. Some deterioration occurs on prolonged exposure to air, heat or moisture. Photolysis may occur. In acidic soil, will decompose & microbially degrade. May enter plant tissue. If released to water:should chemically decompose in acidic conditions; hydrolysis may be significant; may adsorb significantly onto suspended solids & sediments.
Solubility	(@ 25o C) 30mg/L
Sources	Anon (1991b) Anon (1991c) Howard (1990)

3.0 Conclusion

No organochlorine pesticides were in use in the Swan/Canning estuary region. Organophosphate, carbamate and synthetic pyrethroid pesticides have gradually replaced organochlorine compounds in agriculture and horticulture.

Most pesticides being used in the region were herbicides, and these were used to control unwanted grasses and weed species. The most frequently used pesticide in the region was glyphosate, used as Roundup. Of all the herbicides used in the region, glyphosate is probably the least hazardous (about which there is a reasonable amount of environmental fate data) for use adjacent to waterways. Glyphosate, used as Roundup, has moderate toxicity to aquatic life, is strongly adsorbed to soil and is expected to disperse rapidly should leaching or runoff occur.

Data gaps exist for many of the herbicides used in the region. More research is needed into the soil mobility and persistence in water of herbicides such as DSMA and MSMA, fluazifop and propyzamide so that informed, appropriate decisions can be made regarding their use near waterways.

The use of triazine herbicides adjacent to waterways should not be encouraged. Atrazine and simazine are of concern because they may be moderately persistent in some situations and they have the potential to leach into waterways. Also atrazine is currently classified by the EPA and IARC as a possible human carcinogen.

Amitrole, a triazole herbicide, is currently classified by IARC as a possible human carcinogen, due to a study which found it caused thyroid tumours in rats after chronic exposure. However this cannot be realistically correlated with expected effects in humans due to differences between human and rodent thyroid metabolism. Amitrole is very water-soluble, has the potential to leach and can be moderately persistent in natural waters so its use near waterways should not be encouraged.

The most frequently used insecticides were temephos and chlorpyrifos. While neither of these pesticides is expected to pose a long term threat to the river environment if used correctly, the bacteriological insecticide bacillus thuringiensis (Bti) is considered to be a safer alternative for control of some insect species.

Also in use as an insecticide was fenamiphos. While the amount used (2kg) was insignificant, more research is needed into the soil mobility of this pesticide and its persistence in natural waters.

Of the two registered fungicides in use in the region, thiram is recommended in preference to mancozeb near waterways. Mancozeb has higher mobility in soil, and contains a carcinogenic contaminant that thiram does not contain.

An interdepartmental database of existing reports and information regarding pesticides is currently being developed through the Department of Agriculture, W.A. It is important that the Swan River Trust be linked into this database for more efficient exchange of information.

There is a need for appropriate education of pesticide operators. This may take the form of an information booklet which provides; a listing of pesticides in use in the region, including statements regarding which are considered to be least (and/or most) potentially hazardous for use near waterways; the environmental impact of pesticide contamination of waterways and information detailing ways to minimize that impact. It should include a statement encouraging operators to contact an appropriate authority for advice, if in doubt regarding the use of a particular pesticide.

3.1 Recommendations

1. The use of bacillus thuringiensis be encouraged as an alternative to chlorpyrifos and temephos in the control of mosquitoes, some fly larvae and beetles.

2. The use of atrazine, amitrole and simazine near waterways should not be encouraged.

3. More research should be carried out regarding the environmental fate of the following pesticides; DSMA & MSMA, bromoxynil, fluazifop, propyzamide and fenamiphos.

4. The Swan River Trust should be computer-linked to the pesticide information database currently being developed by the Department of Agriculture, W.A.

5. A public education programme should be developed to educate pest control operators about the environmental impact of pesticide contamination of waterways and ways to minimize that impact.

4.0 References

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Appendix 1: Pesticide Use Table

Organisation	Types of Pesticides	Quantities Used July '90-June '91	Locations Used	Control Purpose
Water Authority of W.A.	Glyphosate	338.4 kg	Drainage reserves	Grass control along fences, structures, drain side slopes, berm too narrow to be mowed
	Amitrole	192 kg	As above	As above
	Atrazine	192 kg	As above	As above
	Diquat	50 kg	As above	As above
Bayswater City Council	Temephos 1.25%	0.048 kg	Stormwater Sumps	Mosquito Larvae
	Temephos 10g	0.8 kg	Claughton Reserve/ Stone St	Mosquito Larvae
	Bioresmethrin	0.05 kg	Stone Street	Mosquito Adults
	Chlorpyrifos	0.35 kg	Crimea & Holden Reserve	Argentine Ants
	Amitrole	444 kg	Kerblines & verges; total 650km	Weed control
	Atrazine	444 kg	Kerblines & verges; total 650km	Weed control
	Simazine	630 kg	Kerblines & verges	Weed Control
	Glyphosate (as Roundup)	165.6 kg	Verges, open drains,sumps	Weed Control
CALM	Temephos	26 kg	Lake Forrestdale area	Mosquito Larvae
	Glyphosate(as Roundup)	7.2 kg	Avon National Park	Park and firebreaks
	Glyphosate(as Roundup)	7.2 kg	Metro area	
	Glyphosate (as Roundup)	18 kg	Jane Brook	
	Amitrole	9.6 kg	Avon Valley	
	Atrazine	9.6 kg	Avon Valley	
	Chlorsulfuron	0.045 kg	Metro area	Errum lily
City of Belmont	Temephos 100E	6 kg	6KY Tower, Garvey Park/Kanowna Ave; Ivy St	Mosquito Larvae
	Temephos 100SG	0.134 kg	As Above	Mosquito LArvae
	Bioresmethrin	0.1 kg	As above	Mosquito Adults

City of Melville	Propyzamide	0.75 kg	Pt Walter Tennis Courts and Golf Course	Weed control
	Ethofumesate	2 kg	As above	As above
	Fenamiphos	2 kg	As above	As above
	Thiram 80	16 kg	As above	As above
	Bromoxynil	7.5 kg	As above	As above
	Dicamba	1 kg	As above	As above
	Mancozeb	4 kg	As above	As above
	Siduron	4 kg	As above	As above
	Glyphosate	7.2 kg	As above	As above
	Diazinon	16 kg	As above	As above
	MCPA	7 kg	As above	As above
	Bromoxynil	4 kg	Tompkins Park	Weed Control/ wicket squares
	MCPA	4 kg	As above	As above
	Atrazine	1 kg	As above	As above
	Amitrole	1 kg	As above	As above
	Nabam	1.5 kg	As above	As above
	MSMA	0.8 kg	As above	As above
	Propyzamide	0.5 kg	As above	As above
	DSMA	15.75 kg	As above	As above
	Fluazifop	6.36 kg	Blackwall Reach Reserve/Pt Walter	Weed control
	Fluazifop	2.12 kg	Bull Creek Park	As above
	Glyphosate	7.2 kg	Dual Use Paths	Kikuyu control
City of Armadale	Glyphosate	216 kg	Footpaths, public access ways, playing fields	Weed control
	Bromoxynil	30 kg	As above	Weed control in turf
	Chlorpyrifos	10 kg	As above	Termite/Ant control
Shire of Swan	Glyphosate	information unavailable	information unavailable	information unavailable
City of Nedlands	Glyphosate	0.18 kg	Post and rail fence lines,dual use paths,building & play equipment; along foreshore, Gallop House, Birdwood Parade	Weed control
	Atrazine	87.5 kg	As above	Parramatta grass
	Propyzamide	10.5 kg	As above	Winter grass
	Dicamba	16.8 kg	As above	Broadleaf weeds
City of Perth	Glyphosate	237.6 kg	Road reserve, dual use paths	Vegetation control
	Temephos 50SG	3.75 kg	Lake Monger	Chrinominid midges

City of Subiaco	Glyphosate	57.6 kg	Footpaths,median strips,Rosalie & Hickey Ave Tennis courts,mini parks,main reserves,croquet greens	clover,jojo,weed control
	Bromoxynil	8.4 kg	As above	As above
	Dicamba	2.4 kg	As above	As above
	MCPA	16.8 kg	As above	As above
	Fluazifop	4.24 kg	As above	As above
	DSMA	9.45 kg	As above	As above
	Diazinon	8 kg	As above	As above
	Malathion	2.5 kg	As above	
	Dimethoate	1.5 kg	As above	
	Bacillus thuringiensis (Bti)	0.32 kg	Shenton Park Lake, Mabel Talbot reserve,Pelican Point	Mosquito and midge control
	Bioresmethrin	0.1 kg	As above	As above
	Temephos	1 kg	As above	As above
Town of East Fremantle	Glyphosate	5.4 kg	Kerbs	Vegetation control
	Chlorpyrifos	2.5 kg	Croquet greens, tennis courts	
Shire of Kalamunda	Glyphosate	187.2 kg	Roadside verges, islands,kerbs, paths, drains,park fencelines,structures,around trees,creeklines	Lovegrass, kikuyu
	Simazine	112.5 kg	As above	Winter grass
	Simazine	15 kg	Creeklines	Blackberry,reeds, nutgrass
	Fluazifop	0.212 kg	Parks, natural bushland	Veldt grass, love-grass
	Bromoxynil	25.34 kg	Parks, Sports turf	Onehunga, broad leaf weed,calthrop
	MCPA	50.68 kg	As above	As above
	Dicamba	7.24 kg	As above	As above
	MSMA	15 kg	Parks, Sports Turf	Crab grass
	Dimethoate	0.8 kg	Ornamentals	Aphids, scale
	Chlorpyrifos	10 kg	Sport turf, other	Black beetle, ants, other pests,termites
City of Fremantle	Glyphosate	1.44 kg	Beech Reserve & North Fremantle foreshore	Edge lawn areas

City of Stirling	Amitrole	4 kg	Fencelines & fixtures on reserves	
	Atrazine	4 kg	as above	
	Dalapon	29.6 kg	as above	
	Glyphosate(as Roundup)	3.6 kg	Maylands Foreshore Reserve	Specific noxious weed & plant infestations
	Fluazifop	2.12 kg	as above	as above
	Metsulfuron	1.2 kg	as above	as above
	Bromoxynil	7 kg	Bardon Park & De Lacey Park	Onehunga, Flatweed
	MCPA	14 kg	as above	as above
	Dicamba	2 kg	as above	as above
	Temephos	8 kg	Clarkson Reserve	Mosquito Larvae
Town of Mosman Park	Glyphosate(as Roundup)	36 kg	Footpath, road kerbs,islands	Weed control
City of Gosnells	Propyzamide	56 kg	Parks and reserves	Wintergrass
	DSMA	1476.09 kg	as above	Crabgrass
	Dicamba	42.8 kg	as above	Capeweed,flatweed, onehunga
	Bromoxynil	149.8 kg	as above	as above
	MCPA	299.6 kg	as above	as above
	Fluazifop	13.99 kg	Parks and reserves:handspraying-garden beds and natural bush areas	Perennial grasses,annual weeds
	Glyphosate(as Roundup)	39.6 kg	Parks & reserves	Total grass control
	Glyphosate (as Roundup)	3.6 kg	as above	Couch grass,kikuyu, annual weeds
	Glyphosate (as Roundup)	26.28 kg	Kerbs,paths,cycle ways,public accessways, laneways	Weed control
	Glyphosate (as Roundup)	68.04 kg	Main & road drains	as above
	Amitrole	268.8 kg	as above	as above
	Atrazine	329.28 kg	as above	as above
	Amitrole	160 kg	Kerbs,paths,etc	as above
	Atrazine	196.5 kg	Kerbs,paths,etc	as above
Shire of Peppermint Grove	Bromoxynil	4.08 kg	Manners Hill Park,Keane's Point,Foreshore reserve	Weed control
	MCPA	4.08 kg	as above	as above
	Dicamba	1.02 kg	as above	as above

Town of Claremont	Temephos	0 1 kg	Lake Claremont	Midge/mosquito control
	Glyphosate(as roundup)	1.62 kg	Narla Rd,Barnfield Rd,Victoria Ave,Dean & Walter Sts	Weed control
Shire of Mundaring	Glyphosate(as roundup)	117 kg	Throughout shire	Kerb spraying,general use
	Chlorpyrifos	100 kg	All ovals,lawned areas	Black beetle
	Bromoxynil	30 kg	All ovals	Broad leaf weeds
	MCPA	30 kg	as above	as above
	Amitrole	12.5 kg	Throughout shire	Specific weed control
	DSMA	75 kg	All ovals	Summer grasses
City of Canning	Glyphosate(as roundup)	3.6 kg	Canning Regional Park-Banks of Canning River,edge of mosquito drain channels	Typha control,weed control
	Glyphosate(as roundup)	7.2 kg	Shelley/Rossmone foreshore-Along cycleways and along Canning River	Kikuyu grass
	Temephos	1 kg	Within flood plain of Canning Regional Park	Mosquito larvacide
	Chlorpyrifos	2.5 kg	Within flood plain of Canning Regional Park	Mosquito control
Town of Bassendean	Glyphosate (as Roundup)	72 kg	Footpaths,kerbs, reserve fencing, structures	Weed control
	Propyzamide	10 kg	Reserves	As above
	Bromoxynil	4 kg	Reserves	As above
	MCPA	4 kg	Reserves	Broad leaf weeds
	Temephos	3 kg	2 reserves;road gully holes	Mosquito control
	Bioresmethrin	0.1 kg	as above	Mosquito misting control
	Chlorpyrifos	5 kg	Tennis & croquet courts,James St	Beetles
	Diazinon	16 kg	Tennis courts & various reserves	Cut worm & beetle
	Diazinon	0.06 kg	Buildings	Ants & spiders

Appendix 2: Table of Classification for Toxicity Ratings

Toxicity Rating	LD50 for Mammals (oral) (mg/kg) Solids.....Liquids	LD50 for Birds (mg/kg)	LD50 for Fish & Aquatic Life (mg/L)
High	5-50 20-200	<500	<0.5
Medium	50-500 200-2000	500-5000	0.5-5
Low	Over 500 Over 2000	>5000	>5

WHO (1988-89)