SOLVING MAJOR POLLUTION PROBLEMS:

A NEW PROCESS MODEL

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OCTOBER 1997

SUBMISSION FOR THE AWARD OF
DOCTOR OF PHILOSOPHY
IN ENVIRONMENTAL STUDIES

ACKNOWLEDGMENT

I would like to acknowledge the support and direction provided during the preparation of this thesis from Professor Alistair Gilmour of the Graduate School of the Environment and David Lamond of the Graduate School of Management both at Macquarie University. I would also like to thank Dr John Pickard for developing and maintaining a forum that enabled research students to achieve high standards in reporting and communications of their research. This forum provided me with many opportunities to present and discuss my ideas with staff and other students before irrevocably committing them to paper.

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Existing process models describe the general social and institutional processes involved in the solution of environmental problems and in the solution of public policy problems. These existing models do not include many processes specific to pollution problems and in most cases they do not included a quantitative assessment of the likely duration and strength of the processes involved.

In this work I have proposed a process model with nine specific processes involved in the solution of major regional pollution problems. I have named the nine processes: affected party, harbinger, public concern, political action, inquiry, body of knowledge, legislation, allocation of funds, and organisational change. The processes were selected to be consistent with general processes of the literature models and to reflect actual processes that have been involved in the solution of pollution problems in Sydney since European settlement.

I have used five case studies of regional air and water pollution problems from the Australian cities of Melbourne and Sydney. The nine proposed processes were identified in each of the case study problems and were quantified by the use of indicators that measured the strength and duration of the individual process. This quantification was used to demonstrate empirically that the proposed process model provides a good approximation of the social and institutional processes involved in the solution of major regional pollution problems. It is argued that because the individual processes exist in each case study, have been quantified and are sufficiently similar, the model represents an acceptable approximation of reality.

The new model can provide a framework for a better understanding of the social and institutional process that are likely to be involved in the solution of emerging major regional pollution problems. This better understanding could lead to better planning and management of solutions to these problems.

Future research could assess the universality of the model by studying other regional pollution case studies e.g. other pollutants, other Australian cities, and overseas cities. Future research could also develop a process model for the solution of global pollution problems to provide a similar framework for understanding of the social and institutional processes involved in the solution of global pollution problems.

DECLARATION

This is to certify that this work has not been submitted for a higher degree to any other university or institution, that the work is original, and that where the work of others has been used it has been referenced in the text and to the section titled “References”.

Robert Staib

1 SUMMARY

(**Note**: This chapter in included in 01front.pdf but is included again for consistency of numbering)

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In this work I have proposed a process model with nine specific processes involved in the solution of major regional pollution problems. I have named the nine processes: affected party, harbinger, public concern, political action, inquiry, body of knowledge, legislation, allocation of funds, and organisational change. The processes were selected to be consistent with general processes of the literature models and to reflect actual processes that have been involved in the solution of pollution problems in Sydney since European settlement.

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The new model can provide a framework for a better understanding of the social and institutional process that are likely to be involved in the solution of emerging major regional pollution problems. This better understanding could lead to better planning and management of solutions to these problems.

Future research could assess the universality of the model by studying other regional pollution case studies e.g. other pollutants, other Australian cities, and overseas cities. Future research could also develop a process model for the solution of global pollution problems to provide a similar framework for understanding of the social and institutional processes involved in the solution of global pollution problems.

2 INTRODUCTION

2.1 The Thesis

The central thesis of this work is that major regional pollution problems require specific social and institutional processes for their solution and these processes can be determined and their strength and duration quantified.

Existing process models describe the general social and institutional processes involved in the solution of general environmental problems and in the solution of public policy problems. These existing models do not include many processes specific to pollution problems and in most cases they do not included a quantitative assessment of the likely duration and strength of the processes involved.

The aim of this work is to develop a new quantitative pollution process model and to empirically demonstrate that the model is an acceptable approximation of reality. The new model can provide a framework for a better understanding of the social and institutional process that are likely to be involved in the solution of major regional pollution problems. This better understanding could lead to better planning and management of solutions.

The new model could then be used to assist in the solution of major regional pollution problems. The information from the model could be used to assist in the identification of the processes likely to be needed for solutions to emerging major regional pollution problems and then to be used in forecasting the duration of individual processes and of the total solution. The model could also allow the identification of particular processes that might delay the solution and allow the pollution problem to become more severe if they were not completed expeditiously. The model could then be used to identify or suggest actions to shorten the time for a solution and to assist in progressive monitoring and management of the solution.

The model is developed by critically examining the main processes involved in the solution of major or regional environmental pollution problems; developing a model that incorporates the above processes; measuring the strength and duration of the process by the use of indicators using five case studies to empirically demonstrate the adequacy of the model.

The model proposed uses social and institutional processes and as such does not address specific management or organisational techniques needed or the specific scientific or technological knowledge required to solve a pollution problem. Typical processes include “generation of public concern”, “passing of legislation” and “development of a body of knowledge”.

Examination of the main processes involved reviewing the environmental literature for similar work and models, the public policy analysis literature for more general approaches to solving significant political problems, and the historical literature on pollution for case study information on the resolution of particular pollution problems. The model proposed was developed as a result of the literature review and refined as the pollution case studies were studied and quantified.

An important consideration in the development of the process model was to ensure that the individual processes were concrete enough to allow effective measurement. Five case studies of regional pollution problems were selected and the duration and strength of the processes were measured by the use of indicators and an assessment made of how interrelated the processes were. For the model to be effective management tool it needs to enable an early definition and acceptance of a pollution problem and an early solution before a problem becomes more severe.

2.2 What is Pollution?

To pollute is to make unclean or dirty (Macquarie University, 1981, p1319). While there are pollutants produced naturally (Ehrlich et al. 1977), this work examines only human created pollution in quantities that are potentially damaging to human welfare or to organisms other than people (Ehrlich et al. 1977).

The Victorian EPA Act 1970 defined pollution as an alteration to the existing environmental quality but this definition was limiting as it failed to recognise an existing polluted state (Russ and Tanner 1978, p3).

The perception of what constitutes pollution can also change with time e.g. solid particles like smoke were once synonymous with air pollution whereas air pollution now encompasses a greater range of substances like carbon dioxide, ozone etc. (Russ and Tanner 1978, p125).

It is recognised that the environment has capacity to absorb some wastes produced by humans, and a pollution problem can be said to exist if the flow of wastes exceeds the capacity of the environment to absorb these wastes. (Butlin 1977, p2)

Early concepts of pollution were that waste disposal caused pollution when the environmental absorptive capacity was exceeded and it impaired human use of air, land, and water. (Butlin 1976, p4). This anthropocentric view of pollution has now generally been expanded to include organisms other than humans (Ehrlich et al. 1977, SPCC 1977a). The acceptable level of pollution determined by regulating authorities is now generally established based on the effect on human health and amenity and on the effect of organisms other than humans.

Aside from this scientific definition of an acceptable level of pollution is the perception of pollution by people. The acceptance that there is a pollution problem by government is an essential part in the promulgation of solutions (Trudgill 1990). The model developed in this work identifies perception of pollution problems and acceptance that there is a pollution problem as an important component of the solution.

2.3 Local, Regional, and Global Pollution

Local pollution problems have been with mankind for centuries, e.g. in 1307 Fleet Brook (a tributary of the Thames in London) suffered severe water pollution (Clapp 1994), and have progressively increased with increasing industrialisation and population growth (Clapp 1994).

As industrialisation expanded e.g. in Britain pollution extended to whole cities and by the end of the 19th century air pollution from coal burning by industry and homes was considered quite extreme. This regional pollution has remained with Britain ever since. It culminated in the disastrous air pollution smogs in London in 1952 where over 4000 people died. After the problems of dust and smoke were solved in Britain, the problem of acid rain being deposited on countries remote from their source in Britain started an era where the global nature of pollution was recognised. (Clapp 1994)

Perhaps the most widespread and widely known global pollution problem is emissions of greenhouse gases, which have the potential to cause global warming. This particular type of global pollution became widely discussed after 1987 after an important United Nations study brought the issues to the attention of the world. (Brundtland 1987)

Local urban pollution has existed in Australia since white settlement (Coward 1988) but regional pollution has become more evident in Australian large cities since the second World War because of the significant growth in the industrial economy and the population (SPCC 1973 - 1990). Global pollution is now becoming the concern of regional authorities in Australia as they seek to implement international agreements to limit Australian emissions of global air pollutants (EPA 1995, ABS 1992)

The focus of this work is on major regional pollution problems that affect large urban areas. Global pollution problems may require different processes including some at international level and have not been analysed. The period from which the case studies have been drawn is the 1960s to the early 1990s - the period of accelerating industrial and population growth after the Second World War in which there were significant increases in wastes discharged to the environment. (SPCC 1973-1990)

2.4 Pollution in Australia

The following sections describe some of the salient aspects of the history of pollution of water and air in the two largest cities of Australia: Sydney and Melbourne. This information provides a background to pollution in Australia. Section 2.9 summarises some of the processes that have occurred in the solution of pollution problems in Australia and this information is used later in the development of a pollution process model.

2.5 Sydney Water Pollution Caused by Sewage Disposal

The history of Sydney's major water pollution caused by the disposal of sewage is summarised into several time periods in this section and is based on Coward (1988) unless otherwise noted.

2.5.1 Tank Stream Pollution and Solution (1848 to 1887)

One of the first features of Sydney to become polluted was the Tank Stream. This was a creek running through the colonial town of Sydney and had been the new colony's water supply. Up to the 1850s the Tank Stream had received a proportion of Sydney's waste and had become severely polluted. Sources of this pollution included cesspit overflows, effluent from slaughterhouses and other direct and indirect discharges. In 1848 the Legislative Council established a Select Committee to investigate slaughterhouses.

In response to these problems a number of Acts of Parliament were passed including the Sydney Slaughter House Act in 1849, the Sydney Abattoir Act in 1850, and the Sydney Sewerage Act in 1853. This problem of pollution of the Tank Stream was reduced when a sewerage collection system was constructed and the untreated sewage was diverted to Port Jackson in the vicinity of the present day Darling Harbour.

2.5.2 Port Jackson Pollution and Solution (1858 to 1883)

This solution of the Tank Stream pollution was effective in reducing discharges to the Tank Stream but it eventually created water pollution problems for Darling Harbour. In 1877 petitions from residents of Redfern and Waterloo complaining about sewage discharges into Port Jackson were presented to the government.

While the first sewer discharging to Port Jackson was constructed in 1858, the Sydney Council did not have powers to compel connection to the sewer until 1879. Moore Park was used from 1856 to 1885 for the dumping of excreta from toilet pans. Around the late 1875s and early 1880s a number of Acts were legislated to address the pollution problems associated with cesspit overflows and toilet pan emptying. They included Nuisances Prevention Act of 1880, City Improvement Act of 1880, the Public Health Act of 1885, and the Metropolitan Water and Sewerage Act of 1880. During the period 1885 and 1886 there were over 300 typhoid deaths per year and there was pressure to extend Sydney's sewerage network.

The problems of the disposal of sewage were reduced by the construction of a sewer to a sewage disposal farm on land south of the city at Botany Bay (1883 to 1885) and a ocean discharging sewer at Bondi (1883 to 1890).

2.5.3 Botany Bay Sewage Farm/Blackwattle Bay Pollution (1883 to 1916)

Over the period 1890 to 1915 the quantity of sewage being disposed at Botany Bay sewer farm increased five times. During this period there were public complaints including public meetings in 1894 over excreta loading at Blackwattle Bay and public pressure about smells from Botany Bay sewage farm in 1907. In 1907 plans were mooted for other sewage disposal options. The South Western Ocean Outfall Sewer (SWOOS) draining the southern suburbs of Sydney was opened in 1916 and the Northern Suburbs Ocean Outfall Sewer (NWOOS) draining the northern suburbs of Sydney commenced construction in 1916 and opened in 1928. These sewers discharged sewage with only a low level of treatment into the onshore water off Sydney's coastline.

2.5.4 Beach Pollution (1916 to 1965)

There were frequent complaints about sewage pollution on Coogee Beach in the period 1921 to 1930 and in 1930 there were public complaints about fat on the beaches. Up till then the sewage was discharged untreated from the ocean outfall sewers to cliff face outfalls and on days when the wind and tides were unfavourable the pollution could end up on beaches. In 1938 there was public debate over the options to solve the sewage problems and a Metropolitan Sewerage and Drainage Board report recommended that the sewage be treated prior to ocean discharge. This was not an insubstantial recommendation as treatment facilities were quite expensive and if the treatment could be done by the ocean it was significantly cheaper. In 1935 a decision was made to also proceed with a second South Western Ocean Outfall Sewer.

The war stopped work on the sewer and the first phase of the Bondi sewage treatment works started in 1945 and was completed in 1954, with the second phase completed in 1965. Treatment works for the SWOOS at Malabar were built from 1959 to 1977, and for the NWOOS from 1968 to 1981. Treatment processes were basic with less than primary treatment.

2.5.5 Beach Pollution (1965 to 1992)

During the period from 1965 to 1992 the volume of sewage discharged and the pollution loads on beaches steadily increased (Water Board 1959 to 1988). Even with the sewage treatment plants there was considerable public complaint (Beder 1989). The measures to combat the pollution were put in place before the increased level of public complaint that occurred in 1988 and 1989 (Brown and Caldwell 1967) but because the sewage projects took so long to become approved and built, the pollution problems had become so large that a significant proportion of the public had become affected (Beder 1989). Severe beach pollution occurred during the 1988 -1989 summer continuing until the three deep ocean outfalls (discharging deep under water at 3 to 5 km off shore) were completed. A consultants report (Brown and Caldwell 1967) in the mid 1960s had recommended that deep ocean outfalls be constructed but a decision to proceed was not made until 1984. Construction was completed on the three deep ocean outfalls at Bondi, Malabar, and Manly in 1992 (WB 1989 to 1992). The commissioning of the outfalls considerably reduced beach pollution by increasing the treatment levels and disposing of the sewage further out to sea. (Refer to Figure 8.1).

2.6 Sydney River Water Pollution Caused by Factory Effluent - 1960 to present

The history of pollution of Sydney's rivers and waterways caused by discharge of factory effluent is described in this section.

Coward (1988) categorised the major sources of waste flows as households, industry, and transport. For the period from the end of the second world war to the early 1960s there were significant increases in the numbers of people, factories and vehicles in Sydney (Refer to Figure 9.4) and consequently in waste generation and pollution loads to the environment (water, land, and air). A large part of this waste was in the form of industrial effluent, sewage overflow and septic tank waste etc. and some of it found its way into the Sydney's creeks and rivers (Coward 1988).

This affected all rivers in the populated areas of Sydney including one of the major Sydney rivers: the Parramatta River (See Figure 9.1). The water pollution problems experienced by the Parramatta River during this period were similar to those experienced by other rivers and creeks in the Sydney metropolitan area (SPCC circa 1985).

The most severe water pollution problems were associated with the upper reaches of the Parramatta River from Lake Parramatta to the Gladesville Bridge from late 1950s to the late 1970s. One reason was because that part of the river had insufficient tidal flushing to enable dilution of the effluents (SPCC circa 1985, Barton 1970).

A Senate Select Committee (1970) identified that similar factors were responsible for causing increasing pollution in Australian cities: increasing population; increasing urbanisation (density of population); and increasing industrialisation (use of energy and production of waste).

From the 1930s onwards articles on the polluted state of the Parramatta River regularly appeared in the press (Powell 1987). Residents complained to councils but very little was done. In 1951 the condition of the river was so bad that netting of fish above Gladesville Bridge was prohibited. Powell (1987) notes that a newspaper article complained that " a thick black sludge blankets 10 miles of foreshore area."

Whitington (1968) expressed concern at the problem of water pollution drawing on evidence presented at the Australian Senate Select Committee enquiry into pollution (SSC 1970). Whitington (1968) says, "little has been done to remedy air and water pollution. Governments have been notoriously slow to act and when public demands for action are lacking governments are less likely to move on their own imitative".

The control and monitoring of water pollution or quality was not vested in any single authority in NSW with the Department of Health, Maritime Services Board, and the Sydney Water Board (then the Metropolitan Water Sewerage and Drainage Board - MWSDB) having major roles (DGPH 1953-1971).

Monitoring data from the Maritime Services Board over the period June 1963 to January 1966 showed very low levels of dissolved oxygen in the Parramatta River (Brown and Caldwell 1967). The major problem perceived at the time in the Parramatta River was the death of aquatic life in the river because of low dissolved oxygen. The dissolved oxygen level in the river was used as a measure of the state of oxygenisation of the water and consequently its ability to support aquatic life. A level of 60% to 70% was considered the minimum level necessary to maintain a healthy ecosystem. Other contaminants like heavy metals, pesticides etc. were not the prime concern of the initial clean up. (SPCC circa 1985)

In the early 1950s to the late 1960s the percent saturation was around 50% on average though in many cases it was as low as 10% in the upper reaches. By 1976/77 the effect of licensing and control of industry discharges brought the dissolved oxygen levels up to around 100% on average. There were still trouble spots that took many years to solve. (SPCC circa 1985)

The growing public concern and governmental inquiries (SSC 1970, Barton 1970) influenced the development and the passing of both the Clean Waters Act in 1970 and the SPCC Act in 1970. (SPCC 1973 to 1990)

The SPCC/CWA legislation enabled the State Pollution Control Commission (SPCC) to act to identify sources of industry pollution to waterways and to require the licensing of these discharges. This eventually reduced the quantity and improved the quality of these types of discharges. (SPCC 1973 to 1990)

The approach adopted to reduce the problem of pollution caused by industry was to provided a single authority with increased power and funds and to introduce penalties for non compliance as recommended by the inquiries (SCC 1970, Barton 1970).

2.7 Sydney Air Pollution 1960 to Present

2.7.1 Introduction

This section presents a short history of air pollution in the Sydney region from the year in which the Clean Air Act was passed 1961 (DGPH 1960-1971) to 1991. It identifies the major air pollutants, how their concentrations in the atmosphere have changed over the time period as a result of increased anthropogenic emissions, and actions were taken in an attempt to reduce the quantity of these emissions.

Air pollution has been a problem in cities around the world for a long time and in 1952 thousands of people died of illness caused by air pollution in London (SPCC 1977a). This episode and severe pollution in other cities around the world brought the problem to the attention of the world (Clapp 1994).

The Clean Air Act of NSW 1961 was enacted in an attempt to control air pollution in NSW particularly in Sydney and the industrial cities of Wollongong and Newcastle. The industrial and population growth after World War II greatly contributed to the problems of air pollution (Coward 1988).

In the thirty years since the Clean Air Act was passed significant steps have been implemented to reduce air pollution but it was still perceived to be a major problem in NSW in 1991 (NSW Government 1991).

2.7.2 Pollutants

In 1977 the SPCC (1977a) described the main air pollutants in Sydney as: primary pollutants (sulphur dioxide, suspended matter (0.1µm to 10µm), total suspended solids (0.1µm to 50µm), grit and dust fallout (generally > 50µm), carbon monoxide, lead, nitrogen oxides (NO, NO_2, N_2O), non methane hydrocarbons, and odours) and secondary pollutants (ozone and aerosols).

2.7.3 History

From 1961 when the Clean Air was passed to the mid 1970s gains were made in reduction of air pollution concentrations caused by deposited matter (grit and dust), and suspended matter, and sulphur dioxide. The sources of these pollutants were mainly point sources associated with industry and power stations.

The State Pollution Control Commission of NSW (SPCC) commenced operation in 1971 primarily as an environmental watchdog. It wasn't until 1974 that the SPCC was given the task of administering the Clean Air Act (and the Clean Waters Act) from the Director General of Public Health. They were allocated more resources with staff numbers being increased from a handful to over 250 to undertake this added responsibility. (SPCC 1973 to 1990)

In 1977 the SPCC (1977a) warned of the dangers of current levels of air pollution and the expected increase if control measures were not taken. They stated that: "particulates and sulphur dioxide concentrations are approaching and in some cases exceeding the World Health Organisation (WHO) long term goals; ozone and carbon monoxide levels up to four and five times their respective goals are being measured; nitrogen dioxide concentrations are below air quality standards established in the United States but above those of Japan; lead emissions are such that the National Health and Medical Research Council (NHMRC) has recommended that they should not be permitted to increase; aerosols restrict the visibility on more that 150 days each year."

In addition to their concern over the levels, SPCC also predicted higher ozone levels in Sydney (15 to 30 pphm) if the Sydney Outline Plan were implemented (i.e. 4.3 million people in Sydney by 2000). Projections in 1991 (NSW Government 1991) were that the 4.3 million would be reached after 2006.

2.7.4 Motor Vehicles

It has long been recognised that the car is the dominant cause of pollution in Sydney and since 1972 the Australian Design Rules for new motor vehicles have required progressively lowered emissions from vehicles (NSW Government 1991). The application of these rules brought about 90% reduction in carbon monoxide and hydrocarbon emissions and 70% reduction in the oxides of nitrogen. (SPCC 1973 to 1990)

SPCC in 1980 stated that vehicles were responsible for the following anthropogenic air pollutants in Sydney's atmosphere: virtually all of the lead, 52% of the Hydrocarbons, 85% of the nitrogen oxides, and 90% of the carbon monoxide. (SPCC 1980)

2.7.5 Strategies

A number of significant studies were completed in the 1970s that increased the body of knowledge on air pollution and enabled the formulation of strategies for air pollution control. (SPCC 1977a)

The strategy adopted by the SPCC to reduce pollution and in particularly ozone (a secondary pollutant from the photochemical reaction of NO_X and Non Methane Hydrocarbons (NMHC) was to reduce emissions of NMHC.

Other control measures adopted (or mitigating events that occurred) during the 1980s included (SPCC 1973 - 1990): vapour controls on vehicles and industrial processes; banning backyard burning (through bans by Municipal Councils - finally implemented Sydney in 1990); less use of solvent based paints and more use of water based solvents; better dry cleaning processes; gas/electricity replacing coal and fuel oil burning (natural gas available in Sydney from 1977); closure of old city power stations at White Bay and Bunnerong (This effectively exported some of the pollution to the rural areas of Hunter Valley and Lithgow where large coal fired power stations now supplied Sydney with electricity.); industries moving from the inner part of Sydney to Western and South Western areas; better urban planning.

2.7.6 Trends in the 1980s

During the 1980s many air quality indicators showed a progressive improvement in air quality (SPCC 1974-1990, NSW Government 1991): ozone maximum levels and days exceeding the NHMRC goal dropped from 1983 to 1988 but have appeared to stabilise since then (NSW Government 1991); nitrogen dioxide levels and days exceeding the NHMRC goal after an initial rise dropped and stabilised; lead levels dropped mainly in response to the introduction of unleaded petrol - the chief cause of lead in the atmosphere.

Johnson (NSW Government 1991) argues that a significant part of the improvement in Sydney haze can be accounted for by more felicitous meteorological conditions. Any gains made during this period appear to have been partially eroded by the increasing number of cars and length of journeys as Sydney has grown. These increases are linked to Sydney's growth.

Ozone levels are predicted to increase significantly in the next 20 years (to 2011) and the highest levels are projected to occur in the proposed new growth areas on the western outskirts of Sydney: MacArthur South, South Creek Valley, and Rouse Hill (Hyde and Johnson 1990).

The analysis of trends (Hyde and Johnson 1990) over the past 15 years suggest that there has been a downward trend (of maximum and second maximum one hour average readings) of ozone concentrations from 20 to 25 pphm to just below the NHMRC guideline of 12 pphm in mid city locations but that trend has been less definite in western areas. They also suggest that the lack of comprehensive monitoring in western/south western areas may have hidden the real situation.

A number of observations have been made about air pollution in Sydney and these should considered when solution processes are considered: There has been a decrease in pollution over the last 30 years but not to the extent often believed by many people (Johnson in NSW Government 1991); The pollution by virtue of typical (and maybe atypical) weather patterns has been exported to western and south western parts of Sydney basin (Hyde and Johnson 1990); It is not until a significant number of people are about to settle in these areas that pollution becomes a political problem as distinct from a problem recognised by the technical experts and the environmentalists (NSW Government 1991); While the NSW Environment Protection Authority (EPA) has the potential to be a more effective organisation than the former State Pollution Control Commission (SPCC), it has limited power over vehicle emissions because the Commonwealth Government has taken over control of emissions on new vehicle for the state of NSW. Most experts agree that the motor vehicle is the single greatest cause or future cause of air pollution (SPCC 1973-1990); Countering this is the feeling (NSW Government 1991) that most of the gains in new vehicle emission controls have been made and future gains will have to be in non-petroleum vehicles, reductions in total fleet size and length of journeys, and in existing vehicle emission controls; Controls often take 10 - 20 years to become fully effective (SPCC 1973-1990).

2.8 Air Pollution in Melbourne 1960 to Present

This section provides a short history of air pollution in Melbourne from the period of the 1950s to the present.

In the early 1950s control of air pollution was possible under the nuisance provisions of the Health Act. The Clean Air Act of 1957 enabled the Victorian government to make regulations to control pollution from industrial sources and in particular to control the combustion processes. The first regulations were made in June 1958. The Victorian legislation is considered an enabling legislation that provides the framework for the promulgation of regulations. (Cock 1965)

Air pollution problems were quantified when the Victorian EPA began monitoring air pollution in Melbourne. In 1974 EPA monitoring was performed at 2 sites and by 1983 this had increased to 11 sites. (EPAV 1990b)

The Victorian EPA Act of 1970 brought the Clean Air Act under its umbrella and included the ability for the Environmental Protection Authority to licence waste discharges and impose fines for non compliance (EPAV 1971 to 1993). The Victorian government set air quality objectives in a State Environment Protection Policy for the air environment in 1981. Objectives were set for carbon monoxide, nitrogen oxide, oxidants, sulphur dioxide, particles and lead. (EPAV 1971 to 1993)

Over the two decades 1970 to 1990 (the first twenty years of the Victorian EPA) the problems of visible air pollution were tackled and significant reductions made. Visible pollution included soot and smoke from cars and stacks. (EPAV 1990a)

Ozone levels identified by intermittent monitoring showed an increase from 1965 to the early 1970s (Galabally 1972). When EPA commenced regular monitoring in the early 1970s ozone levels were often in excess of the EPA one hour goal of 12 pphm. By the mid 1980s they were down close to or below the goal. (EPAV 1971 to 1993). EPA believed that there was some reduction over the period 1982/83 to 1986/87 but this fall was not substantial probably because of unfavourable meteorological conditions and slower than anticipated uptake of the use of unleaded fuel which in 1987 only fuelled 30% of the State's motor vehicle fleet (EPAV 1971 to 1993).

Ozone in 1991 was still seen as a major source of air pollution problem in Melbourne though average levels were close to the then one hour goal of 12pphm. Streeton (1990) recommended that the goal be reduced to 8pphm. The breaches of a goal of 8pphm would be 25 per annum compared with 5 per annum with the goal at 12pphm.

The car has been one of the major sources of pollution in Melbourne and the introduction of Australian design rules (ADR) for motor vehicle design have been used to limit emissions. Two rules have been critical: ADR27A introduced in 1976 and ADR37 introduced in 1986. ADR37 required the use of unleaded petrol and catalytic converters and this enabled considerable reductions in emissions from individual new cars though it required the replacement of the old fleet with new cars over time to be totally effective. (EPAV 1971 to 1993)

2.9 Summary

The history of pollution caused by sewage (Section 2.5) displays a recurring nature that seems common to pollution problems, e.g. it shows that disposing of sewage with various levels of treatment into the environment away from population centres can be only a temporary solution and that the problem often recurs. This recurring nature of problems suggests that similar processes are occurring.

The descriptions of the history of Sydney's sewage pollution problems (Section 2.5) and the other regional pollution problems (Sections 2.6, 2.7, 2.8) suggest that long time frames are necessary to solve regional pollution problems. From the description of the history of pollution a number of social and institutional processes appear to be required for the solutions including: people initially affected by pollution; public complaints as people become affected; consultants' or experts' reports to define the extent of the problem and the likely solutions; public inquiries into the nature of the pollution; passing of general legislation to solve particular problems; developing of a body of knowledge about a pollution problem by research and monitoring; specific legislation in the form of regulations and licensing to regulate a problem.

These types of processes are taken into account in Section 4 when a proposed pollution process model is developed.

2.10 Background and Trends

Prior to reviewing current process models (Section 3) it is useful to review trends in public concern for the environment and for the levels of pollution that have occurred during the time period of the selected case studies. It is also an opportunity to review some of the indicators that have been used to measure trends.

2.10.1 Increasing Pollution

Many authors over the last 20-30 years have described how increasing world population and increasing use of energy with waste producing technology (especially in the period of rapid economic growth since the Second World War) have contributed to the production of a greater quantity of pollutants discharged into the environment. (Meadows et al. 1972, Ehrlich et al. 1977, Brundtland 1987, Pearce et al. 1989). These pollution problems have been significant for industrialised countries and many have been described in the literature e.g. United States of America (Milbraith 1985), Japan (Miyamoto 1991), Great Britain (Clapp 1994).

Australian authors have also documented the rise in the level of pollutants discharged into the Australian environment since World War II: (Coward (1988), SPCC (1973-1990), EPA Victoria (1971 to 1993), ABS (1992), SSC (1969), and SSC (1970).

The factors that contribute to the rise in pollution (population, industrialisation and energy use) have been increasing steeply since World War II and in some periods this rise has been exponential (Meadows et al 1992). Tables 2.1 to 2.3 illustrate the rise in these factors worldwide.

Table 2.1: World Population Growth - Approximate

Year	Billions (10^9)	Growth Average %/year for period
1930	2	
1960	3	1.7
1970	3.6	2.0
1975	4.0	2.2

Source: Erhlich et al. (1977), p.183, and p. 199

Table 2.2: World Industrial Production - Approximate

Year	Index (100 in 1963)	Growth % increase over period
1930-1950	24 to 44	80
1950-1970	44 to 164	270
1970-1990	164 to 310	90

Source: Meadows et al. (1992), p.5 Figure 1.2

Table 2.3: World Energy Use – Approximate

Years	Terajoules $x10^6$/year	Growth % increase over period

1930	60	8
1940	65	8
1950	70	8
1960	130	86
1970	220	69
1980	280	27
1990	350	25

Source: Meadows et al. (1992), p67 Figure 3.9

2.10.2 Trends in Concern for Environmental Issues

There is evidence showing a worldwide increase in the concern for the environment including concern about the effects of pollution since the late 1950s. The following sections discuss the evidence of this increase in concern and illustrate it with data from opinion polls and other indicators of public concern both in Australia and overseas.

2.10.2.1Trend Data from the United Nations

Soroos (1981) studied trends in the debates on environmental topics in the United Nations in the years 1968, 1972, and 1976 and showed an increase from 1968 to 1972 and a decrease to 1976 but not to the level of 1968.

2.10.2.2Trends in Public Opinion Surveys of Environmental Concern in USA

Dunlap (1991a) analysed 23 separate public opinion surveys in the USA on attitudes towards the environment that were undertaken during the period 1965 to 1990. No one survey extended continuously over the full period so there is no continuous consistent measure over the full period. Table 2.4 summarises these 23 surveys.

Table 2.4: American Public Opinion Polls on Concern for the Environment

(Percentage of respondents showing concern)

POLL NO.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
year	AVERAGE	GALLOP	ORC	L.HARRIS/1	L.HARRIS/2	L.HARRIS/3	MICHIGAN/NAT.SUR	L.HARRIS/NAT.SUR	WISCONSIN/TREND	WASHINGTON/PANEL	WASHINGTON/TREND	ROPER/1	ROPER/2	NORC	CAMBRIDGE	ROPER/3	NYT/CBS	CAMBRIDGE/3	CAMBRIDGE/4	CAMBRIDGE/5	CAMBRIDGE/6	CAMBRIDGE/7	CAMBRIDGE/8	ROPER/4
1965	24	17	32																					
1966	49		49																					
1967	51		53	56	44																			
1968	25		57				2		17															
1969	38					38																		
1970	50	53	72	70	54	55	17	41	40	61	34													
1971																								
1972	13						10	13	15															
1973	36							11				37	34	61										
1974	35							9	10	35		39	25	59		69								
1975	32							6				39	31	53										
1976	37										17	44	32	55	38									
1977	37											35	27	48	39									
1978	45													52	37									
1979	35											38	29		37									
1980	46											36	33	48		69								
1981	37											40	31		41		45			28				
1982	38											46	37	50	41		52	35				43	2	
1983	44												48	54	42		58	44	34	29				
1984	49													58	42	71		56	33	37				44
1985	47													58	53			54		40	31			
1986	51													58	58		66	59	32	39	31	63		
1987	41													61	57			49	32	50	34		5	
1988	55													65	52	82	65	53	46	54	45	71	8	62
1989	55												55	70	52		74	58	49		45	75	16	
1990	56												54	71	64		74	62	55		46		21	

Source: Dunlap (1991a)

Each poll extended over a number of years allowing the assessment of trends. The questions asked by each poll were different but each attempted to measure the level of concern for environmental issues or the state of the environment.

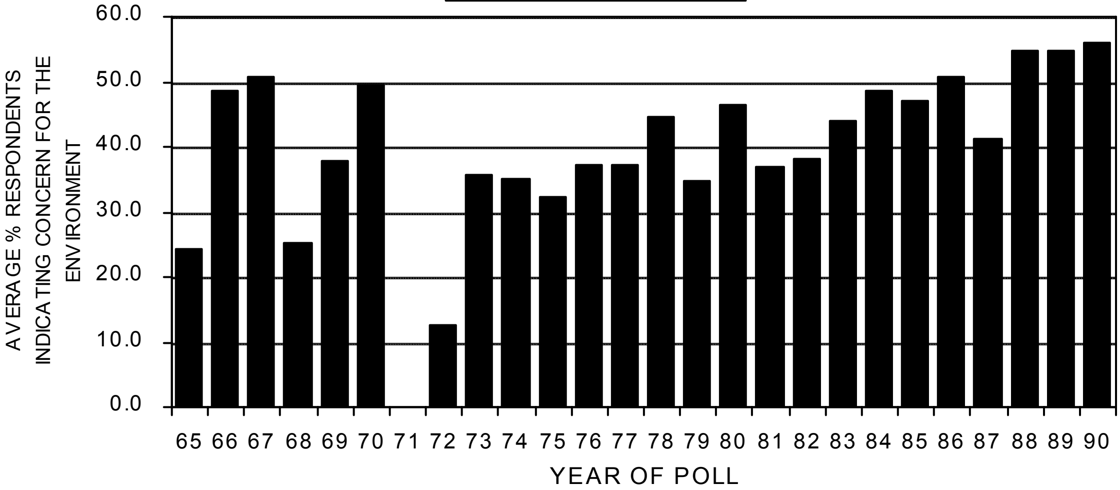
Figure 2.1 plots the average values of the 23 surveys described by Dunlap (1991a) and shown in Table 2.4. The vertical axis of Figure 2.1 shows the percentage of respondents who expressed concern for the environment. The average of the polls shows a rise (up to 50%) in the late 1960s, a lower concern during the 1970s (around 30%). During the 1980s the average of the polls rose gradually to a high of about 55% in 1990. These averages should be interpreted with caution especially in the early years when there were only a small number of polls.

Dunlap (1991a) refers to the "issue attention cycle" model (Downs 1972) in assessing the trends in public opinion surveys shown in Figure 2.1. The issue attention cycle is discussed further in Section 3.2.2. During the late 1960s and the 1970s there was a widespread emergence of public concern for the environment. This declined during the 1980s only to re-imerge in the mid 1980s and 1990s. She says that the decline in interest in the environment predicted by the Downs (1972) model was not strongly evident in the surveys and that support for the environment remained high. She shows that public support for the environment was not high in the early 1960s and calls this the Downs pre-problem stage. Though she says that environmental organisations were building up in numbers and size and activity and this was a sign of the pre-problem phase. Dunlap (1991a) says that although there was strong public concern for the environment this does not automatically translate into the basic social changes needed for solving major environmental problems.

FIGURE 2.1 TRENDS OF USA OPINION POLLS:

AVERAGE OF 23 POLLS

Source: Dunlap (1991)

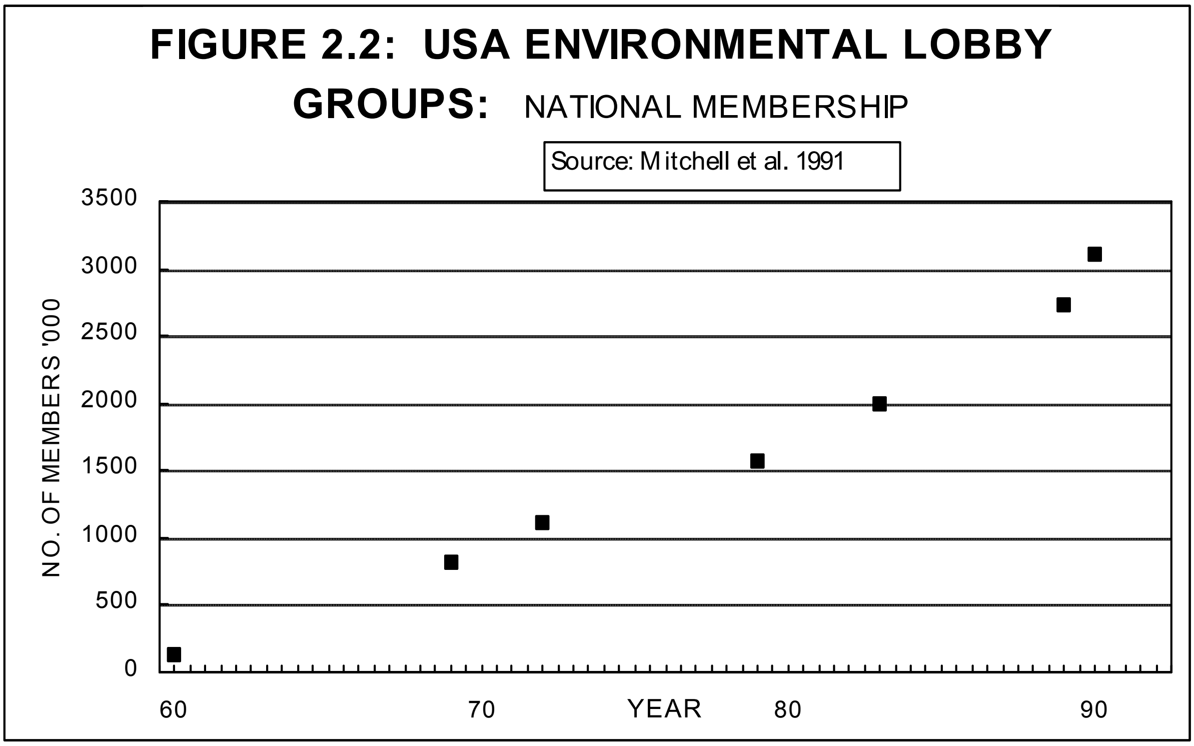


2.10.2.3Other USA Trend Indicators

Other data, which supports these USA trends, is described in this paragraph. McGeachy (1989) studied trends in magazine coverage in the USA over the period 1961 to 1986 and showed a sharp build up in number of articles on environmental issues to 1970 and a decline after the early 1970s though not to the level that existed before 1970. Holdgate et al. (1982) used the number of articles in the New York Times on environmental topics in the years 1960, 1970, and 1979 to show and report a similar pattern. Dunlap (1991b) in studying tends in views on environmental issues showed the significant increase in concern for the environmental from the early 1982 to 1990.

2.10.2.4USA Environmental Lobby Groups

Another indicator of changing public concern for the environment in the USA is rise in the number of members of environment interest and lobby groups. Figure 2.2 shows the steady build up of national environmental lobbying organisations in the USA (Mitchell et al. 1991) over the period in question. This data shows a steady rise which is different to the up and down trends of the public opinion polls displayed in Table 2.4 and Figure 2.1 though there is probably not sufficient data in the period 1970 to 1980 to be sure that membership was continuously rising in this period.

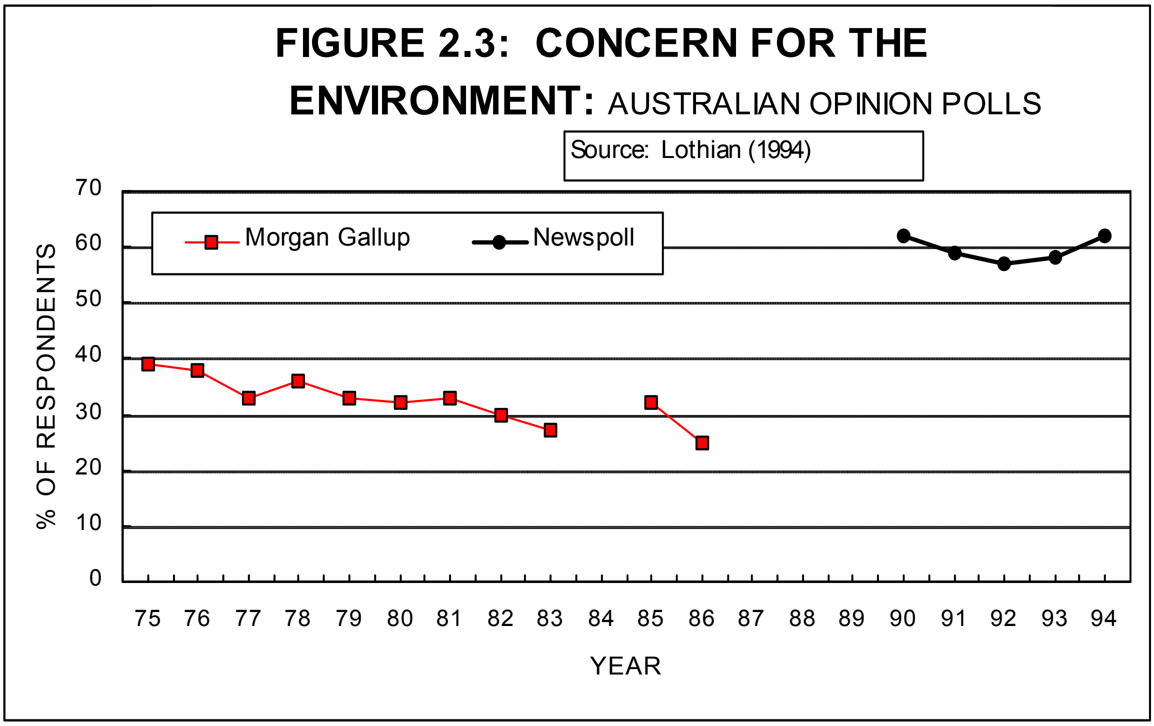


2.10.2.5Trend Data from Canada

Parlour and Schatzow (1978) documented a significant build up in newspaper coverage of environmental issues from 1960 to 1970 in Canada of environmental pollution issues.

2.10.2.6Trends in Public Opinion Surveys of Environmental Concern in Australia

Lothian (1994) reviewed Australian opinion polls that measured environmental concern over the period from 1975 to 1994. There was no continuous poll over the period so there was no consistent measure over the full period. Figure 2.3 shows a downward trend (Morgan Gallop poll) in concern for the environment from 1975 to the mid 1980s and a high level in the Newspoll in the early 1990s. Notwithstanding the fact that these polls are different he believes that the level of public concern during the 1980s was relatively stable between the two higher periods of higher concern in 1975 and 1990. He also believes that although these opinion polls support a case that there is no lack of concern for the environment, governments seem to be held back because of a perception that there is insufficient. The data of Figure 2.3 by itself does not appear to totally justify his assertions: firstly because the polls used different questions and secondly there is no data from the period from 1986 to 1990.



2.10.2.7NSW Environmental Interest Groups

Like the USA example of Section 2.10.2.4 Table 2.5 shows a steady build up of membership in three of the largest environmental interest groups in NSW over the period from 1960 to 1978 (Craney 1980). The Australian Conservation Foundation (NSW branch) peaked in 1975 before falling to a lower figure in 1978 while the other two groups were still rising at the end of the study data in 1978.

Table 2.5: NSW Environmental Group Membership

Group	Approx. Membership			Peak (year)
	1960	1967	1978	
National Trust of NSW	1900	8500	23,000	23,000(1978)
Australian Conservation Foundation (NSW branch)	-	100	1200	1700(1975)
National Parks Association of NSW	500	1100	3200	3200(1978)

Source: Craney (1980)

2.10.2.8Trends in Australian Indicators of Concern for Pollution

This section discusses other indicators that can be used to measure the level of concern for pollution in Australia. These are more specific to pollution than the general indicators of environmental concern discussed in previous sections.

A useful indicator of Australian public concern for pollution is level of newspaper coverage. Indicators of this type have been used by other authors as described in a previous section (See Sections 2.10, 2.3).

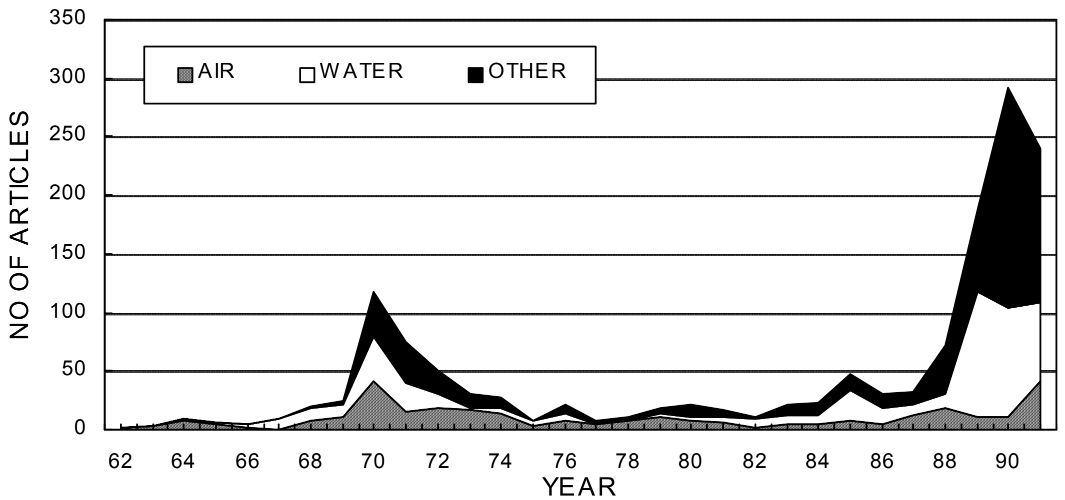
Figure 2.4 shows the number of articles on pollution (air, water, other) in the Sydney Morning Herald from 1963 to 1991 (SMH 1963-1992). The number of articles on a particular topic is assumed to reflect the level of public concern as perceived by the newspaper journalists and editors. Figure 2.4 shows a build up of the number of articles in the late 1960s peaking around 1970. During the 1980s there was a reduction in the number of articles though not down to the pre 1970 level. Towards the close of the 1980s there was a sharp build up of the number of articles to a peak in the early 1990s which is the extent of the data on the graph. The graph also shows how the concern for water pollution, air pollution, and general pollution varied over the time frame. This graph has important implications for the case studies of this work. The peak around 1970 is relevant to the solution of the major pollution problems for the case studies of this work.

The peak in the early 1990s corresponds to the high level of concern for the environment shown in Figure 2.3 but as there were no relevant public opinion polls reported by Lothian (1994) prior to 1975 the peak in 1970 can not be compared with the data from Lothian (1994) in Figure 2.3.

FIGURE 2.4: SMH ARTICLES ON POLLUTION

BY TYPE BY YEAR

Source: SMH 1963 - 1992



2.10.3 Summary

The data discussed in Section 2.10 suggest that the trends in the perception or concern about the environment and about environmental pollution in Australia are similar to those in other parts of the world. The broad picture that emerges is that the late 1960s and early 1970s were characterised by rising concern for the state of the environment and through the 1970s and 1980s there was a falling and then levelling of concern. During the late 1980s and early 1990s there was a significant rise in concern for the environment. If anything the rise and fall of concern in Australia occurred a few years later than in the USA.

Other sections of this work (See the case studies in Sections 6.1 and 9.1) suggest that the rise in concern in the early 1970s was, at least in Australia, concern for regional pollution brought about by a large rise in industrial activity, use of energy, population and cars after World War II. A large part of the rise in concern in the late 1980s and early 1990s seems to have been caused by greater impact of global pollution as the regional pollution escaped the local boundaries and cumulated over large areas. (SMH 1963 to 1992)

Because the World War II involved many countries and certainly affected the world economy it is a reasonable assumption that the recovery after the war in many countries would proceed along similar lines and produce similar pollution problems across similar time scales. The Australian situation is similar to the USA situation. The Australian public concern for the environment (especially as it relates to regional pollution) while probably arising from a similar cause (recovery after World War II) would have been affected directly by pollution in Australia as the data of Sections 2.10.2.6 to 2.10.2.8 illustrate.

The case studies analysed in this work all originate in the period of increased concern for the environment in the late 1960s and early 1970s and end prior to the rise in concern of the early 1990s. The analysis of this section suggests that a rise in public concern may be a significant aspect in the solution of pollution problems.

3.0 CURRENT PROCESS MODELS

3.1 Introduction

Several authors have proposed and discussed models that describe the processes and cycles involved in the solution of general environmental problems. Other authors have proposed models that describe processes and cycles involved in the solution of general public policy problems. This section discusses the main features of these models and how they may be relevant to the development of a specific model for the solution of major pollution problems.

3.2 Environmental Process Models

3.2.1 Introduction

The general environmental process models are discussed under two headings "Issue Attention Cycle" (Downs 1972) and "Other Cycles".

3.2.2 Issue Attention Cycle

3.2.2.1 Downs (1972)

Downs (1972) was one of the first authors to identify a cycle involved in the solution of large scale public problems and in particular environmental problems. His article, though not referenced or quantitative, suggests (rather than proves) that key domestic problems in the USA often suddenly leap into prominence, remain for a short time and then generally fade from the public attention largely unresolved.

His "issue-attention" cycle includes five stages: **the preproblem stage** where some social problem exists but although identified by experts or interest groups has not captured the public attention; the stage of **alarmed discovery and euphoric enthusiasm** where the public suddenly becomes aware of the problem; the **high cost of solution** stage where it is realised that there is a problem but the cost of solution may be high both in money and life style; the **gradual decline of intense public interest** stage where interest in the problem declines; the **post-problem** stage where public attention has shifted to another area of concern.

During the time interest was high new institutions, programs, and policies may have been created to solve the problem. The problem is often portrayed as being capable of being solved. Downs (1972) suggests that some older cultures do not have the belief that problems can be solved in any complete sense. The corollary of this statement is that the concept of discrete problems with solutions may be a modern way of thinking.

Downs (1972) believes that for a problem to follow this cycle it will: directly affect a majority of people; require a solution that would involve fundamental changes in society and vested interests could be threatened ; and have some exciting or entertaining qualities as determined by the media.

Downs (1972) suggests that environmental problems could follow the issue-attention cycle but the decline in his forth and fifth phases may be slower than for other USA domestic problems. He cautions that maybe the environment is too board an issue on which to apply the issue-attention cycle.

3.2.2.2 Parlour and Schatzow (1978)

Parlour and Schatzow (1978) studied the rise and fall of the environment as an issue reported by the media over the period of 1960 to 1972. Their graphs show a slow rise in the 1960s with a dramatic rise in the late 1960s and early 1970s with an equally rapid decline in the next few years. This quantified rise and decline of media attention is similar to the issue-attention cycle of Downs (1972). Parlour and Schatzow (1978) believe the decline is caused by displacement of the environment by other issues, the superficial nature of the media coverage, and the feeling that problems were solved after the institutionalisation of concern.

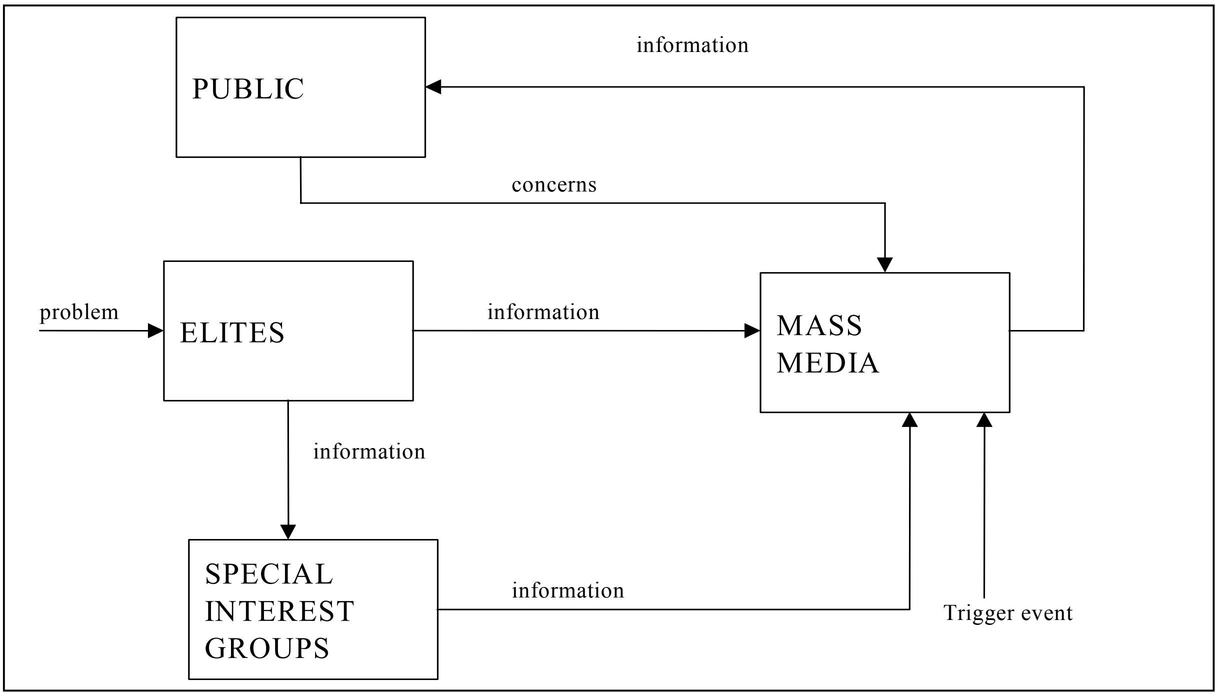
This feature of rise and decline of concern can be seen in the average trend in public opinion polls in the USA shown in Figure 2.1. It can also be seen in the level of newspaper articles on pollution issues in Sydney as shown in Figure 2.4.

The underlying assumption of the above analysis is that a measurement of the level of media attention is an indication of public concern. Parlour and Schatzow (1978) describe a model of mass media and public interaction (Refer Figure 3.1) that suggests that an environmental problem is first perceived by opinion leaders (or elites) who communicate their concern to the media and/or interest groups (or form interest groups). This concern (and/or trigger events) produces a media response. The increased media coverage increases public concern which in turn reinforces media perceptions .

They also makes the point that research has shown that a high level of concern is not accompanied by significant changes in public behaviour. The inference is that a high level of public concern for the environment does not necessarily mean that a high level of public or political action to solve environmental problems will follow. Dunlap (1991a) with a similar observation says that a high level of public concern for the environment does not automatically translate into the basic social changes necessary to solve environmental problems.

The issue attention cycle (Downs 1972, Parlour and Schatzow 1978) is likely to be an important part of a process model for the solution of major pollution problems in Australia but may be only one of the processes important at the commencement of the solution.

Figure 3.1: Media Model from Parlour and Schatzow (1978)



3.2.2.3 Anthony (1982)

Anthony (1982) says Downs' (1972) issue attention cycle illustrates the fickleness of public opinion. He says that the issue attention cycle is only weakly evident in environmental issues. The high level of public concern for the environment during the early 1970s (as measured by opinion polls in America) diminished during the 1980s but contrary to the issue-attention cycle hypothesis the environmental movement has been able to maintain public support and make the environmental concern become one of the lasting issues. This is a valid observation (See Figures 2.1 and 2.4) but even though public opinion may remain higher than before the peak, the issue attention cycle is still a discernible

3.2.2.4 Conrad (1987)

Conrad (1987) uses a case study on energy conservation to assess whether increased public concern (as related to the issue attention cycle) can cause policy change. He says in theory broad public debate can influence both the passing of significant legislation and the provision of substantial funding, and more stringent implementation and application of existing legislation. Events like the energy crises can also influence environmental protection. Conrad (1987) believes if there is significant concern and debate some issues (environmental problems) can be resolved in a relatively short time. Conrad (1987) says the time lag in implementing policy makes it is difficult to assess the impact the energy debate had on the implementation process or its outcome. Some of the data he uses appears to be inconclusive.

3.2.2.5 Summary of Issue Attention Cycle Literature

An important feature of the "issue attention cycle" is the concept of a build up of public concern about a problem followed by a diminution of this concern. Enough political action may have been commenced or been reinforced as a result of this heightened public concern to set a solution in train. Against this is the view that the transient nature of the increased concern may not be enough to sustain a solution to the problem. Either way it is important to consider this feature as a part of any proposed model of the solution to major pollution problems and to measure the strength and duration of this feature in the form of the level of public concern when assessing each of the case studies of this work.

Rosenbaum (1991) also stresses the importance of public opinion and believes that the strength of public opinion will determine political agendas and the pace of policy implementation.

This section has discussed the issue attention cycle as a measurable phenomenon in environmental problems. It may be only one of the processes necessary for the solution of pollution problems, though as the data presented suggests, it is probably an important one. The discussion of the history of pollution in Sydney (See section 2.5 to 2.7) also supports this idea by showing that early in the solution of pollution problems in Sydney there was an increasing concern displayed by the public.

3.2.3 Other Process Cycles

Other authors have proposed different types of cycles (e.g. policy cycle, research cycle, and science policy cycle) to describe the processes necessary to solve or resolve environmental problems. This section discusses the main features of these cycles and models and how they may be relevant to the solution of pollution problems.

3.2.3.1 Zoeteman and Langeweg (1988)

Zoeteman and Langeweg (1988) describe a policy cycle that consists of the following phases: identifying a problem, regulating the problem by laws or other measures, solving the problem by constructing facilities, and controlling through regulatory control. A characteristic policy would be developed for each phase.

They also describe a research cycle which includes the following steps: identification, process analysis, system simulation, and system control. During identification scientists look for substances or effects harmful to the environment; during analysis the process of emission, transport, and transformation are studied; during simulation mathematical models are developed to assist in policy formulation; during control science is used for control and reinforcing policies.

Many of the concepts in their paper (Zoeteman and Langeweg 1988) were developed at the National Institute of Public Health and Environmental Protection at Bilthoven, The Netherlands though no quantitative justification of cycles is presented.

3.2.3.2 De Groot (1989)

De Groot (1989) refers to the environmental policy cycle described by Zoeteman and Langeweg (1988) with its sequence of processes: environmental problem identification; regulation; solution; and control. De Groot (1989) says that the environmental policy cycle is a deceptively naive picture especially where it purports to support a picture of physical scientific research backing the problem identification phase. De Groot (1989) believes that normative sciences should also be used to define environmental problems. He believes that policy making goes on outside physical science, and often outside forces drive policy sometimes cultural trends sometimes major events like an oil crises.

3.2.3.3 Adriaanse and Jeltes (1989)

Adriaanse and Jeltes (1989) identified four phases in environmental policy cycle: the recognising phase where there is emergence of the problem and rising awareness; formulating/regulating phase where there is development of policy; problem solving phase where there is development of measures to solve the problems; control phase where there is enforcement and maintenance of control. Adriaanse and Jeltes (1989) also describe the information requirements and information types required during each of the policy phases.

3.2.3.4 Löwgren and Segrell (1991)

Löwgren and Segrell (1991) believe that environmental problems are rarely solved once and for all and they have a recurring nature. They identify two cycles: a research cycle where environmental problems are formulated and a policy cycle where action is taken. Each cycle has several phases. The **research cycle** (from Zoeteman and Langeweg (1988) comprises: identification of substances or harmful effects not earlier identified; analysis of cause and effect; modelling and simulation; development of system control scenarios for decision making. The **policy cycle** comprises: recognition - where there is the emergence of a new problem because of rising anxiousness; formulation/regulation - where there is a search for a policy to deal with problem; solution - where there are measures to solve problem; and control where there is enforcement and control of problem. Löwgren and Segrell (1991) say the distinction between the phases and the cycles is not clear.

3.2.3.5 Trudgill (1990)

Trudgill (1990) adopts a different approach to formulating a model for the solution of environmental problems by identifying the barriers to their solution and then identifies processes to overcome these barriers. He describes an environmental problem and its solution going through several phases or categories: **problem** comprising categories of agreement, knowledge, technology, economic, social, political; and **solution.**

Some of the significant barriers to solution of environmental problems are obtaining agreement: that an environmental situation exists; that the situation is a problem; that the problem is significant and to whom; to the causes of the problem; and to an appropriate solution.

Trudgill's processes (1990) are not quantified but they do provide an inventory categories that he believes important for the solution of environmental problems. In describing a particular case study on lead pollution Trudgill says, "What we learn about the lead issue is the publication of scientific evidence alone is not enough for action to be taken quickly. Lobbying by pressure groups, the communication of information to the public, and the force of public opinion seem to be a pre-requisite for changes to be made by industrialists committed in terms of investment and plant and for action by cautious politicians."

3.2.3.6 Summary of Other Process Cycle Literature

The processes of an environmental policy cycle concept originally proposed by Zoeteman and Langeweg (1988) have been extended and refined by other authors (De Groot 1989, Adriaanse and Jeltes 1989, Löwgren and Segrell 1991). Table 3.1 shows a comparison between the cited authors aligning similar processes along rows.

Table 3.1: Environmental Policy Cycle Comparison

Zoeteman and Langeweg (1988)	De Groot (1989)	Adriaanse and Jeltes (1989)	Löwgren and Segrell (1991)	Trudgill (1990)
Phases, processes	Phases, processes	Phases, processes	Phases, processes	barriers to solutions
problem identification	problem identification	recognising, emergence of problem, rising awareness	recognition, emergence of problem, rising anxiousness	agreement: that situation exists, that situation is a problem, that problem is significant,
regulation by laws etc.	regulation by laws etc.	formulating, regulating, policy development	formulation, regulation, search for a policy	
solving by constructing facilities	solving by constructing facilities	problem solving, development of measures to solve	solution, measures to solve problem	agreement to causes, and solution
controlling through regulatory control	controlling through regulatory control	control, enforcement, maintenance	Control, enforcement	

The authors have identified functions or processes e.g. regulation by laws, control etc. that they believe are evident in the solution of environmental problems. The processes are described qualitatively but could be quantified in the same way as the issue attention cycle was quantified (See Sections 3.2.2.2 to 3.2.2.5).

The comparison of the columns from the Table 3.1 suggests a generic cycle with the following processes: a) problem identification and acceptance; b) problem regulation framework established, e.g. legislation, policies, regulations; c) constructing facilities, implementing measures, implementing planned solution; and d) controlling and enforcing solution.

The description of the history of air and water pollution in Sydney (See section 2.5 to 2.7) identified and discussed similar processes to these generic processes.

These elements (or processes) of the environmental policy cycle have not been quantified by the authors and are probably at a too generic or summary level to enable this to be done. The specific processes of the issue attention cycle provide a good example of how e.g. public opinion can be measured or quantified by the use of an indicator of the extent of media coverage (See section 3.2.2.2)

3.3 Public Policy Processes

3.3.1 Introduction

This section discusses public policy process models. The "solution of environmental problems" could be considered a sub-set of the "solution of public policy problems". With a similar argument the "solution of pollution problems" could be considered a sub-set of the "solution of environmental problems" and this aspect is discussed in a later section. For this reason a pollution process model would need to be consistent with this more generic model.

A discussion of public policy formulation and implementation is relevant because, as the early sections have discussed, the solution of environmental problems involves the political system in the making legislation and regulations.

3.3.2 Jones (1970)

Jones (1970) proposed a framework that identified the policy processes involved in resolving specific political problems in the USA. The framework is reproduced in Table 3.2. His policy process has three components: systems, activities within systems, and an output from each system.

He avoids giving his framework prescriptive powers but views it as an aid to policy analysis. It is built around the concept of problem identification and political resolution of the identified problem. He concedes that the whole progression from identification to resolution can itself change the nature and extent of the problem. Jones (1970 p.120) introduces the concept of policy cycles. Problems may not be resolved fully until several iterations of the policy process occur. (See Figure 3.2.

Table 3.2: The Policy Process

System	Activities	Output
Problem identification system	**Problem to Government Phase** perception - to receive and register an event definition - bringing into sharp relief the effect of an event aggregation - grouping organisation - to develop structure and organise for action representation - means of access to government	Problem to demand
Formulation system	**Action in Government Phase** formulation - to develop a plan for solving a problem legitimacy - to conform to recognised principles, accepted standards	Course of action
Legitimation system	legitimation - process to legitimate, importance of majority building in parliament	Policy - legitimate course of action
Application system	**Government to Problem to Phase** Application - administering policy to problem, to associated activities, new agencies if required	Action to apply
Evaluation system	**Policy to Government phase** Reaction - response to application of policy Evaluation - judging the effects of policy on public problems	Support or demand to adjustment
Policy cycle of change, adjustment	**Problem resolution or Change Phase** Resolution - relief from needs Termination - ending policy application	Solution

Source: Jones (1970) p149.

Figure 3.2: Public Policy Cycles

Identification
Formulation
Legitimation
Application Evaluation

Support or Adjustment
or Termination

Identification
Formulation
Legitimation
Application Evaluation

Support or Adjustment
or Termination etc.

Source :Jones (1970, p123)

3.3.3 Hogwood and Gunn (1983)

Hogwood and Gunn (1983) describe a model for the solution of political problems in the British context that involves a process of policy analysis. Their process model has similar features to Jones (1970) including: issue search, issue definition, forecasting of consequences, setting objectives and priorities, analysis of options, policy implementation, monitoring and control, evaluation and review, policy maintenance, and succession or termination.

An important part of the policy process as described by Hogwood and Gunn (1983) is the setting of the agenda (or raising the issue or problem). They describe a number of typical agenda setters including organised interests, protest groups, senior officials and advisers, informed opinion, and mass media.

The process of policy analysis is an important component of the solution to pollution problems but to provide a full framework it would need to address the whole implementation process. The policy analysis process (Hogwood and Gunn 1983) though similar to the policy process of Jones (1970) (Table 3.2) is more concerned with the processes within government. The policy process (Jones 1970) extends its ambit to the community and as such provides a more comprehensive model to address environmental and pollution problems.

The model proposed by Jones (1970) has been enduring and is replicated in the third edition of his book (Jones 1984). Rushefsky (1995) uses an integrated policy model based on the model of Jones (1970). It has similar processes: problem perception and definition; agenda building; problem formation; adoption; evaluation; and succession.

Lester (1995, page 69) also uses Jones (1978) as a base for his cycle of policy development.

3.3.4 Summary of Public Policy Process Models

The generic policy cycle developed from Table 3.1 for the solution of environmental problems is similar to the generic policy processes for the solution of public policy problems described in Table 3.2. These are compared in Table 3.3. This shows that there is not a strict one-for-one relationship but that each cover similar ground with broad overlaps between the individual processes.

Table 3.3: Approximate Comparison of Processes

<table>
<tr><th>Generic processes for the solution of environmental problems from Table 3.1</th><th>Processes for public policy implementation (Jones 1970), Figure 3.2</th></tr>
<tr><td>Problem identification and acceptance</td><td rowspan="2">Problem identification and formulation</td></tr>
<tr><td rowspan="2">Problem regulation framework</td></tr>
<tr><td rowspan="2">Process of Legitimation</td></tr>
<tr><td rowspan="2">Problem solution and implementation</td></tr>
<tr><td rowspan="2">Application: administering policy to problem, new agencies if required</td></tr>
<tr><td>Controlling and enforcing the solution</td></tr>
<tr><td></td><td>Evaluation, support or adjustment</td></tr>
<tr><td></td><td>Resolution of problem and termination of policy</td></tr>
</table>

Both process models display a progression from problem identification to problem solution (or resolution) though the public policy process takes the policy through to completion and termination whereas the process model for environmental problems envisages an ongoing process of control and enforcement.

3.4 Summary of Environmental and Public Policy Models

This above comparison shows that while the "environmental process models" and the "public process models" are similar they are both generic. Their generic nature makes them difficult to quantify. As one of the aims of this work was to develop a quantified model it was necessary to propose a model with processes that were capable of quantification.

As has been previously suggested (Section 3.3.1) a process model for the solution of "pollution problems" can be considered a sub-set of both the process models for "environmental problems" and public policy problems." If this is the case then any specific "pollution process model" proposed should be consistent with the generic process models.

The generic process models discussed in this section are used in Section 4 as a basis for proposing a pollution process model for the solution of major pollution problems that overcomes some of the shortcomings with the existing models i.e. the processes proposed are in general not specific enough to allow measurement and the processes have not in general been quantified.

To allow measurement specific indicators of the processes are required. Before these are proposed some of the other factors that might influence a proposed "pollution process model" are discussed.

3.5 Attitudes and Behaviour

3.5.1 Introduction

Firstly some of the behavioural aspects involved in converting public opinion into public policy are discussed. An important point is how people's behaviour (e.g. implementing solutions) changes in response to changes in their attitudes (e.g. level of concern for the environment or pollution). Section 3.2 discussed the "issue attention" cycle (Downs 1972) where problems are often highlighted by increased public concern and in Section 3.2.2.5 it was suggested that the strength of public opinion can determine political agendas and the pace of policy implementation (Rosenbaum 1991).

3.5.2 Converting public opinion into public policy

For the public to display concern when there previously was little concern would requires a change in attitude. For the public to act to solve a problem where there was previously little action would requires a change in behaviour What causes behavioural change? There is a common belief that behavioural change is preceded by attitude change. What causes attitude change? Rajecki (1990) suggests that attitude change can be brought about: by direct experience; by a persuasive message in the media (TV, radio, newspaper or magazine, film); by communications with acquaintances; or by various forms of education. It may be thought of as self evident that if attitudes change behavioural change will follow but the following discussions suggest that this is not always so.

Luttbeg (1968) reviewed models that attempted to explain (if at all) how public opinion (attitude) is converted into public policy (behaviour) in the American context. While the models that Luttbeg (1968) reviewed describe useful ways of viewing the process they tended to be prescriptive rather than descriptive i.e. they described what should be rather that what is. The models though alluded to a number of factors that can influence the process of converting public opinion into public policy including: individual attitudes, opinions, actions; public attitudes, opinions, actions; method of determining or perceiving public opinion; leaders perception of public opinion; individuals perception of leaders performance in reflecting or acting upon public opinion; role of the political party as a reflection of individual or public opinion; role of pressure groups and their relation to the individual and to the leaders; role of powerful individuals; role of other society groups; role of politicians as trustees of their constituents or as their representative.

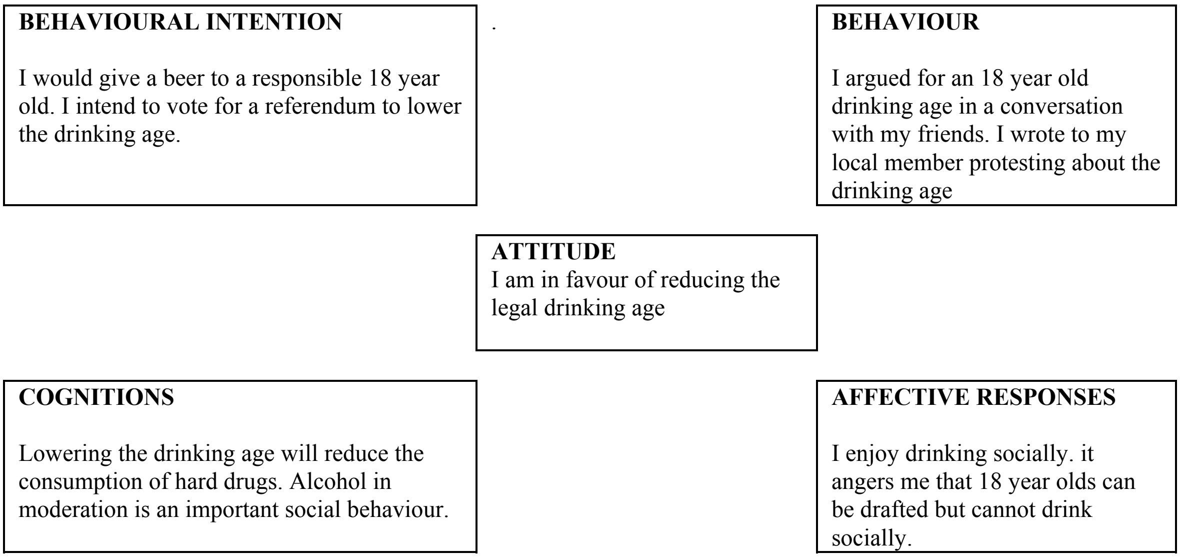
Without trying to determine how much each of these factors contribute to the level to which public policy is able to reflect public opinion they do suggest that the sequence of events might be: individual attitude > opinion > behaviour, group attitude > opinion > behaviour, political attitude > opinion > behaviour.

In a complex system like the political process there would be feedback from one process to the next and within individual processes and the chain described in the preceding sentence could be viewed as salient points in the total political process. The attitude behaviour nexus looms large in all these discussions.

The solution to a major pollution problem could require a change in political behaviour which would (if there is a nexus with attitude) be proceeded by a change in individual and group attitude. This statement rests on the assumption that a major pollution problem is sufficiently different from other problems such that no adequate political process exists for its solution. The process models (Section 3.2 and 3.3) all suggest that legislative change is a strong element in the solutions of public policy problems. The case studies described in Sections 5,6,7,8, and 9 each show that legislative change was required to implement solutions. Questions that might be asked are: How are individual attitudes changed or formed? How are these changed attitudes converted into changed behaviour? Does the literature show that significant correlation exists between changes in attitude and changes in behaviour? Is it effective for individuals, pressure groups, or governments to try to change individual attitudes in an effort to change behaviour? This question could be asked of people's behaviour towards pollution or the behaviour of governments towards pollution.

Zimbardo and Leippe (1991) propose a model to help describe the attitude behaviour nexus by introducing further concepts like behavioural intention, cognitions and affective responses. The system describes the reactions of people to social objects. This is illustrated below in Figure 3.3.

Figure 3.3: Attitude Behaviour Model*



* Zimbardo and Leippe (1991)

Zimbardo and Leippe (1991) believe that attitudes can guide behaviour and measurement of attitudes can be used to predict behaviour, but a careful attention to what attitude is being measured and what specific behaviour is being predicted is required.

Rajecki (1990) discusses an approach of social psychology that seeks to understand people's behaviour by developing an understanding of people's attitudes. He suggests that by measuring attitudes it should be possible to predict something about subsequent behaviour.

Applied to this study of pollution problems this approach would enable a behaviour to be changed by changing attitudes, for example by changing people's attitude to the environment it should be possible to change people's environmental behaviour. This could mean that by persuading people that it is wrong to contribute to the pollution of Sydney's beaches they would change their behaviour and they would for example, cease to, pour oils, fats, and milk down kitchen sinks.

Organisations often rely on their ability to persuade people through advertising to buy their products. In reviewing the literature on the effect of the media and its ability to affect people's attitudes and subsequently their behaviour, Rajecki (1990) says that there is considerable research on the relationship between attitude change and behavioural change in this area. He says that change is measurable but the changes in behaviour are minor shifts not quantum shifts. Notwithstanding this Rajecki (1990) says the minor shifts can be significant for a person or community.

By the late sixties research findings were not fulfilling earlier prophesies of a strong nexus between attitudes and behaviour. Indeed Rajecki (1990) says that some research was indicating no significant link. La Piere (1934) in a study looked for correlations between restaurant personnel's actual behaviour in serving Chinese people and their expressed attitude to Chinese people (measured later) and found little. Kutner et al (1952) in a further study of racial attitudes searched for correlations between restaurant personnel's actual behaviour in serving black Americans and their expressed attitude towards black Americans (measured later) and also found little.
In 1970s researchers started to look more closely at what was actually being measured in these studies. Ajzen (1982) measured behavioural intention and found that this correlated better with measured behaviour and this was particularly true for a single behaviour.

Weigel and Newman (1976) carried out a study on environmental attitudes. They initially measured people's attitudes to environmental and pollution issues. Using a number of field situations they then measured the same people's behaviour through approaches such as different types of petitioning (whether people would sign a petition demanding action of legislators), litter pick up at different times (whether people would participate in a litter pick up themselves), and recycling actions over a number of weeks (whether people would recycle their own waste). The average correlation between a global index of measured attitudes and individual behaviours was 0.32, with categories of behaviour (petitioning, litter pick up, and recycling) the correlation was 0.42, and with a general index of behaviour was 0.62. This illustrated that the global measures (or multi act measures) of attitudes and global measures of behaviour were more likely to show a positive correlation.

As well as applying the appropriate measures to the attitude behaviour nexus Ajzen and Fishbien (1977) (reported in Rajecki (1990)) showed that there needs to be a correspondence between the behaviour and the attitude for a significant correlation to exist. Ajzen and Fishbien (1977) defined four entities that make up both an attitude and a behaviour: TARGET - the attitudinal object, ACTION - what one would like to do with the object; TIME - in which both exist; CONTEXT - the situational reference. They postulated that for maximum correlation between the measurement of attitude and the measurement of behaviour the correspondence between each of the entities needs to be close.

In a study of 109 published investigations within which a total of 142 attitude behaviour relations were reported they found support for the correspondence theory. Table 3.4 shows a strong relationship between correspondence level and attitude behaviour consistency.

Table 3.4: Attitude Behaviour Correspondence[1]

Correspondence level	**Attitude behaviour consistency**		
	not significant	**low or inconsistent[2]**	**high[3]**
low	26	1	0
partial	20	47	4
high	0	9	35

1. From Table X in Ajzen and Fishbien (1977), Table 1 in Rajecki (1990).

2. Low or inconsistent relations were defined as r less than .4 or were from reports of inconsistent correlations across measures or studies.

3. High consistent relations were defined as r equal to or greater than .4

Rajecki (1990) reported two other studies by Weigel and Newman (1976) and Heberlein and Black (1976) that supported the correspondence proposition in the environmental area. Table 3.5 shows that high correlation coefficients exist when the correspondence between the attitude and the target is close.

Table 3.5: Correspondence in Environmental Studies[1]

Research report	Target of action entity	Scale type attitude type	Correlation coefficient
Weigel and Newman (1976)	Sierra Club	pure environment	.06
		pollution	.32
		conservation	.24
		Sierra Club	.68
Heberlein and Black (1976)	Lead free gasoline purchases	environmentalism	.14
		pollution	.26
		benefits of lead free petrol	.45
		personal norm to use lead free petrol	.54

1. Data from Table XI of Rajecki (1990).

These approaches and results give support to the idea that there does exist a nexus between attitudes and behaviour but that careful consideration needs to be given to the way measurements of both attitudes and behaviour are measured. Rajecki (1990) used this correspondence approach to show that earlier studies of La Piere (1934) and Wrightsman in 1969 which showed little correlation between attitude and behaviour didn't have a strong correspondence between attitudinal and behavioural measures and this would explain the poor correlation.

Fazio and Zanna (1981) state that direct experience is more likely to develop stronger attitudes than indirect experience and they cite the literature and their research to illustrate this. Their rationale for the fact is: "direct experience may simply make more information available and hence result in a more accurate and stable attitude; direct experience may cause the person to focus on his or her very behaviour during that experience and thus this behaviour may become an element on which to base an attitude (e.g. 'Did I act as if I liked or disliked it.'); direct experience of a voluntary sort may involve repetition or rehearsal and may lead to an attitude that is more easily retrieved from memory."

3.5.3 Application to environmental and pollution problems

Zimbardo and Lieppe (1991) says that concern for the environment is a matter of "out of sight, out of mind." People are concerned about pollution when they can see it or it effects them. When the symptoms or outward appearances of the problem disappear the concern lessens. Two problems contribute to pro-environmental behaviour: low salience as described above and low motivation i.e. these pro-environmental motives must compete with stronger needs and desires e.g. Can I afford organic vegetables grown without pesticides. Zimbardo and Lieppe (1991) believe that this is symptomatic of a weak attitude behaviour relationship. People can not connect their behaviour easily or directly to environmental problems. He says the factors that would contribute to a stronger relationship include knowledge, clarity, direct experience with an attitude object. While we may have the pro-environmental attitude it may not lead to meaningful actions. He believes the effective application of social science to the attitude behaviour relationship can bring about change in behaviour when applied to initially changing attitude.

3.5.4 Attitude Behaviour Nexus Summary

In summary the literature cited above suggests that: single measures of attitudes should be used to measure single behaviours; multiple act measures (global) of attitudes should be used to measure multiple act behaviours; there should be a direct correspondence between measures of attitude; behaviour for each of the entities - action, target, time, and context; and direct experience of an object is more likely to develop stronger attitudes towards that object and as a consequence lead to stronger behaviour towards that object.

3.5.5 Attitude/behaviour and Methodology of This Work

Table 3.6 shows how the social psychology principles described above can be used to assist in the development of a process model for the solution of pollution problems.

Table 3.6 : Social Psychological Principles

Principle	Methodology of this work
Single measures of attitudes should be used to measure single behaviours;	The pollution process model should use global measures of attitudes and behaviour.
Multiple act measures (global) of attitudes should be used to measure multiple act behaviours;	The pollution process model should use a global measure of public opinion e.g. newspaper articles and a global measure of public behaviour e.g. parliamentary debates. The proposed model of Section 4 does not seek a correlation between attitude/opinion and behaviour but suggests that a change in public opinion necessarily precedes a change in political behaviour.
There should be a direct correspondence between measures of attitude and behaviour for each of the entities - action, target, time, and context;	Each pollution case study can be assessed for the level of correspondence achieved in the indexes
Direct experience of an object is more likely to develop stronger attitudes towards that object and as a consequence lead to stronger behaviour towards that object.	This can be translated to the process model in that people are more likely to demand or seek political action to solve a pollution problem if they are personally effected.

The general process models described in Sections 3.2 and 3.3 were generic not specific and have not been quantified and a quantitative link between attitudes and behaviour was not contemplated. Therefore it is important when developing a specific pollution model (Section 4) that the proposed pollution model includes process for public attitudes and public behaviour and indicators to measure them.

3.6 Quantitative Indicators of Process

Previous process models (Sections 3.2 and 3.3) did not in general quantify processes though one component of previous models, the issue attention cycle (Section 3.2.2) was partly quantified.

One of the aims of this work is to not only identify the processes involved in the solution of major pollution problems but to quantify each of the processes.

Rajecki (1990) used indicators that show trends over time as a measure of public attitudes and behaviour. Rajecki (1990) reviewed perceived rises and falls in patriotism in America. The indicators he used for patriotism were magazine articles, Presidential speeches, and interview surveys. He also looked at measures of behaviour that reflected attitude towards patriotism.

Two indicators were used. Program Covers from the World Series baseball over the period from 1900 to 1980 were analysed for patriotic content of the covers and were scored based on a scale of 0 to 3. The number of war movies produced per year over the period 1940 to 1985 were listed and plotted on a time graph. These were reviewed and peaks and troughs were accepted as indicators of social behaviour change and these were related to historical events e.g. the Vietnam war. Rajecki (1990) believes from this research that trend analysis of indicators is an appropriate method to study and measure attitude and behaviour trends or changes over time.

This work uses similar types of indicators. Indicators are developed as a measure of the processes involved in the solution of major pollution problems in Sections 5 to 9 which describe five pollution case studies.

3.7 The Time Dimension

A key factor that influences the development of a proposed model is the dimension time. This section reviews some of the literature on the subject.

3.7.1 Closeness in Space and Time

People are more likely to be concerned with events that are close to them in space and time (Meadows et al 1972). Figure 3.4 (Meadows et al 1972) uses density of dots to diagrammatically portray this. For example the box at the intersection of "family" and "next week" is more densely packed than that at the intersection of 'family" and "children's lifetime" indicating that for most of the time people are concerned with current family issues rather than the issues of the world.

A similar concept is that people are more likely to react to pollution when it has affected (or is about to) affect them personally. Coward (1988) in describing the history of the treatment and disposal of sewage in Sydney illustrates this when he describes the effect of public opinion and public concern in initiating political actions. From the 1880s to the 1980s, the disposal of sewage has frequently been a major contributor to water pollution. In general terms the sewage has been disposed of at locations that were away from population centres and with treatment methods that were considered adequate or affordable at the time.

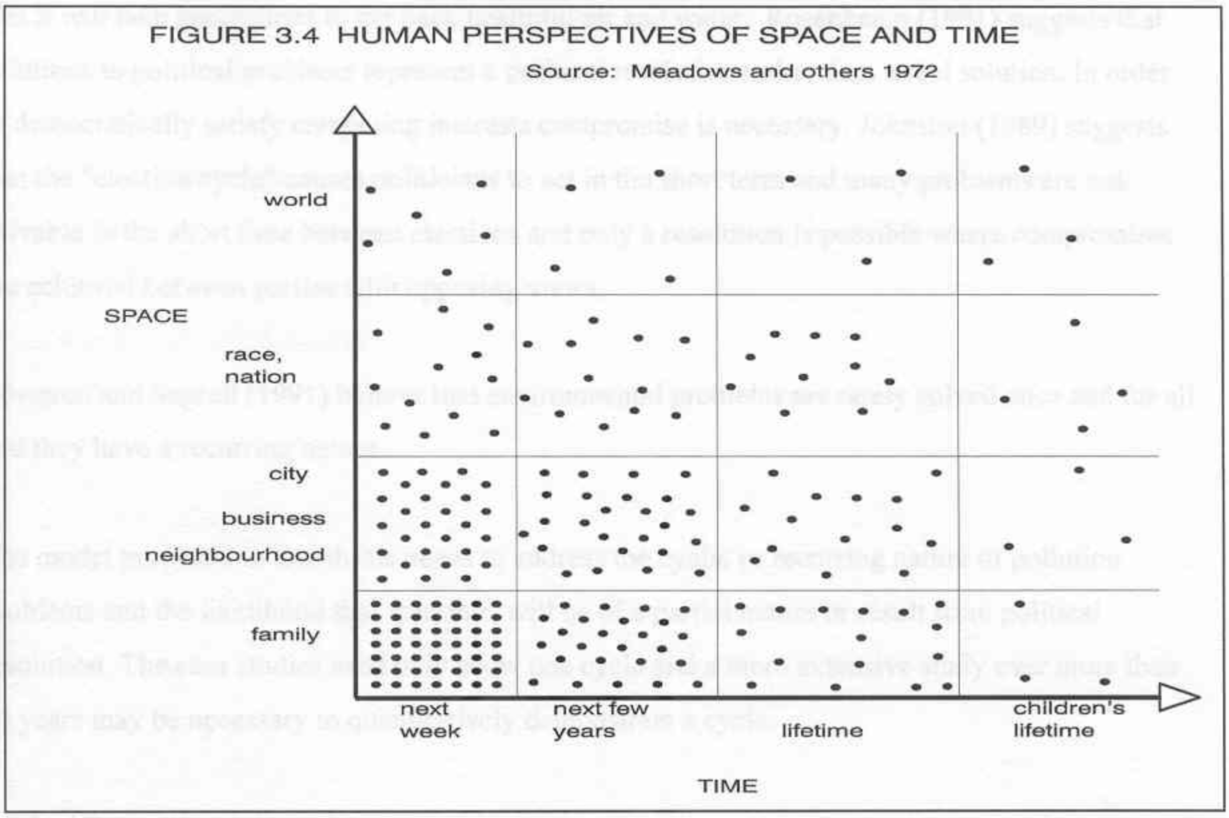


FIGURE 3.4 HUMAN PERSPECTIVES OF SPACE AND TIME
Source: Meadows and others 1972

As the population of Sydney has expanded from approximately 300,000 in the 1880s to over 3,500,000 in the late 1980s people were also more likely to come into contact with the location and effects of sewage disposal either through the location of their dwellings or their places of recreation or work. As the pollution affected people personally (temporally and spatially) the more likely they were to demand political action. This is a recurring theme described by Coward (1988).

3.7.2 Cyclical and Partial Nature of Solutions to Pollution Problems

Coward (1988) illustrates a recurring pattern in the identification and the solution of water and air pollution problems that extends from the time of first identification of a pollution problem to its solution. This pattern has occurred frequently over the 150 years of white settlement in Sydney.

The data gathered for this thesis (Section 5 to 9) also illustrates this recurring nature of pollution problems. Similar pollution problems to those that have occurred in the two cities of Sydney and Melbourne over the period from 1960 to 1990 are now observed to be recurring. e.g. the atmospheric ozone pollution said to have been solved years ago is now recurring in Sydney. (NSW Government 1991). It may be that the recurrence is a reimurgence because the problems were never fully solved.

Rosenbaum (1991 p169) laments that after 20 years of sustained effort in America and an estimated expenditure of $700 billion the nation's air and water remain dangerously degraded and that it will take generations to get back healthful air and water. Rosenbaum (1991) suggests that solutions to political problems represent a political resolution rather than a real solution. In order to democratically satisfy competing interests compromise is necessary. Johnston (1989) suggests that the "election cycle" causes politicians to act in the short term and many problems are not solvable in the short time between elections and only a resolution is possible where compromises are achieved between parties with opposing views.

Löwgren and Segrell (1991) believe that environmental problems are rarely solved once and for all and they have a recurring nature.

The model proposed in this thesis needs to address the cyclic or recurring nature of pollution problems and the likelihood that solutions will be of a partial nature or result from political resolution. The case studies used only show one cycle and a more extensive study over more than 40 years may be necessary to quantitatively demonstrate a cycle.

3.7.3 Generational Aspects

Costain and Lester (1995) in describing American government policy changes over time refer to a 30 year generational cycle first described by Schlesinger (1986). Quoting Costain and Lester (1995): "Thirty years is the span of a generation. People tend to be formed politically by the ideals that are dominant in the years during which they attain political consciousness: roughly between their seventeenth and twenty-fifth years. When their own generation's turn in power comes thirty years later they tend to carry forward the ideals they imbibed when young. Over time each phase tends to run its natural course...."

Major pollution problems because of their size and the number of people and organisations involved in their solution may take a long time to solve - 20 to 25 years (Refer Section 12.). This time period is similar to the difference between successive generations. In assessing a process model for pollution this time period may need to be considered to determine if its relation to a generation is relevant.

3.8 Summary of Section 3.0

The review of the literature of process models for solving environmental problems and public policy problems discussed a number of features that a proposed pollution process model should contain. These were summarised in Tables 3.1, 3.2, 3.3 and in Section 3.3.4. The importance of recognising the attitude/behaviour nexus was discussed and social psychological principles that would need to be applied to a proposed model were summarised in Table 3.6. Finally some aspects of the nature of the time dimension of problem solution were reviewed.

In section 4 a process model for the solution of pollution problems is proposed. This proposed model seeks to overcome some of the shortcomings of the existing models by proposing specific processes as distinct from generic processes and proposing specific indicators to enable the specific processes to be quantified.

4 PROPOSED POLLUTION PROCESS MODEL

4.1 Introduction

Existing process models for the solution of "environmental problems" and "public policy" problems (Section 3.2 and 3.3) use generic processes and in most cases the processes were not quantified (Section 3.4). The review of the history of pollution problems in the Australian cities of Melbourne and Sydney identified a number of specific processes (Section 2.9) that had occurred in the solution of major regional air and water pollution problems.

This section proposes a specific "pollution process model" and describes a methodology to quantify the pollution processes. The quantification of processes through the use of appropriate indicators enables an empirical demonstration of the postulates upon which the proposed model to be done. Five pollution case studies selected for quantification are described as well as the basis for selecting them.

4.2 Formulation of a Specific Pollution Process Model

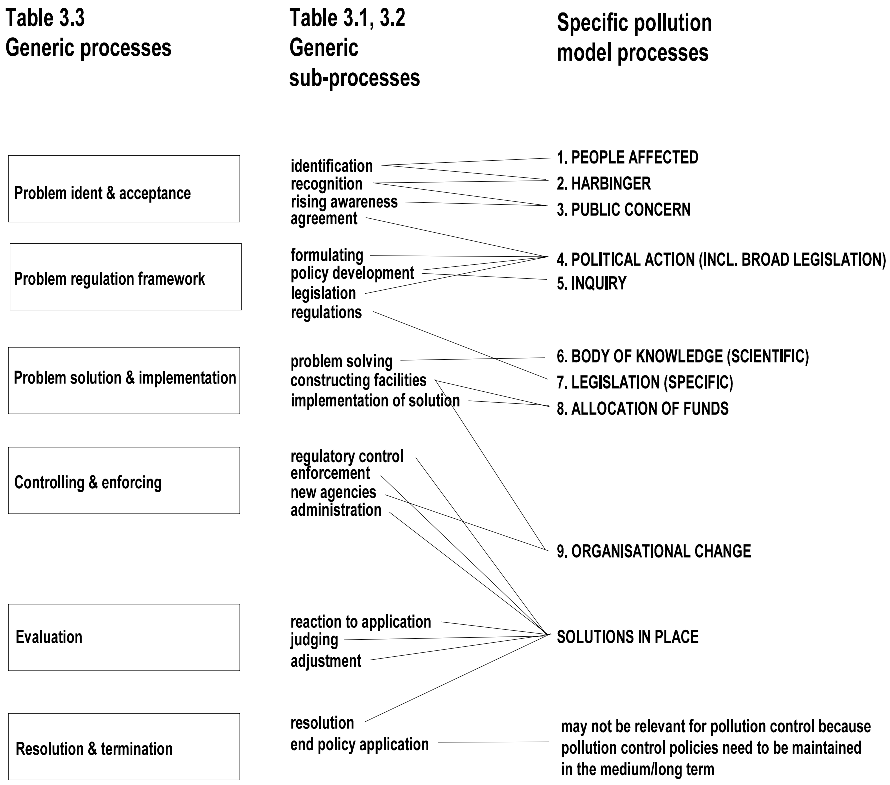
A proposed pollution process model for the solution of major regional pollution problems is derived from the previous review of general environmental models (discussed in Section 3.2 and summarised in Tables 3.1 and 3.3), the review of public policy models (discussed in Section 3.3 and summarised in Tables 3.2 and 3.3), the discussion of the time dimension (discussed in Section 3.6), and the history of pollution in Sydney and Melbourne, Australia (discussed in Section 2.4 to 2.9).

Figure 4.1 is used to illustrate the steps in the derivation of the proposed model. It displays the approximate links from the generic processes identified in the references noted in the preceding paragraph to the proposed pollution process model. Column one displays the generic processes (derived form Table 3.3) and column 2 displays the sub processes (derived from Tables 3.1 and 3.2.

As discussed previously the shortcomings of these models need to be recognised. Firstly these models are generic for public policy problem solution and general environmental problem solution. The solution of pollution problems can be thought of as a subset of both of these more generic or general models and the model proposed in Figure 4.1 illustrates this feature. Secondly the literature models are generally qualitative and one of the main aims of this thesis (Section 2.1) is to quantify the processes involved.
The third column of Figure 4.1 "Specific Pollution Model" shows the names suggested for the specific processes proposed for the model. The processes themselves are discussed further in

Section 4.3. The proposed processes are similar to the specific processes suggested by the review of pollution problems in Australia (Section 2.9). In some cases there is a direct link from the proposed processes to the generic processes of column 2 while in others cases there is a many-to-one or a one-to-many relationship. The proposed processes of the pollution process model in Figure 4.1 are to be quantified by the use of suitable indicators.

Figure 4.1: Proposed Pollution Process Model



While this derivation of a pollution process model was initially based on the steps outlined above, it was refined with feedback from the empirical pollution case studies (Sections 5, 6, 7, 8, 9). The case study feedback also helped in assessing how easily the proposed processes were capable of being measured with appropriate indicators.

It might be argued that this feedback might have tempted me to distort the processes simply to achieve ease of measurement. The fact that most of the processes proposed for the model have occurred in the historical examples (Section 2.9) and were in general measured in all of the case studied provided evidence that a significant distortion did not occur.

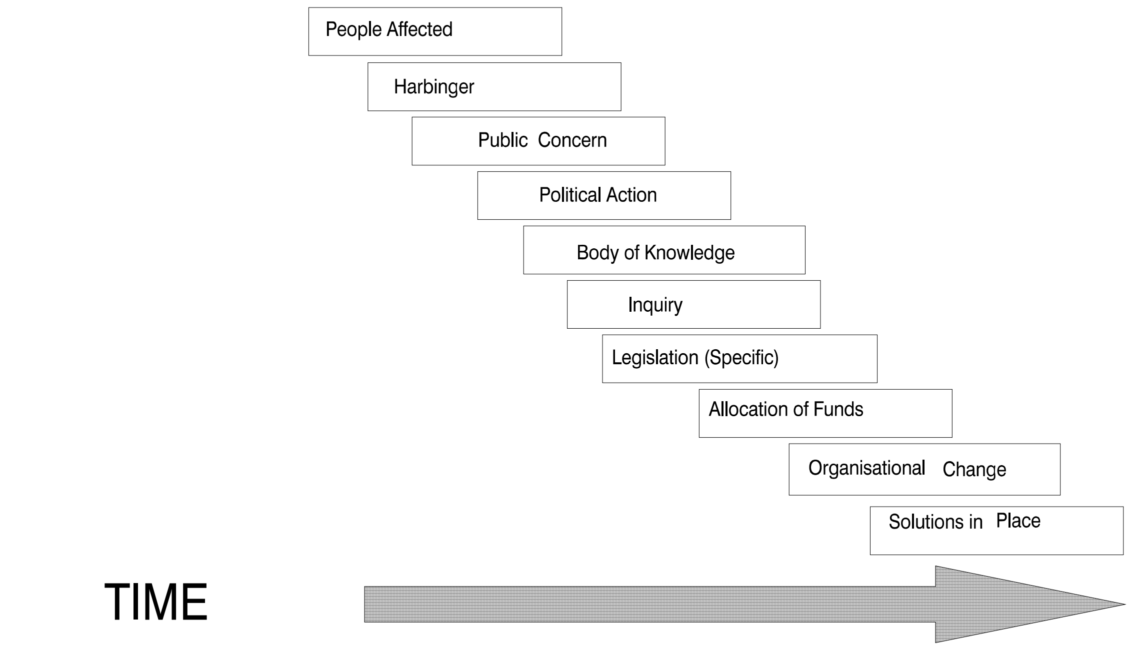
The proposed pollution process model has a focus on the processes (or means) to achieve ends rather than the ends themselves. The proposed processes, as seen from Figure 4.1, can be described as social and institutional processes. The ends of the pollution problem solution are pollution reduction objectives which could be e.g. the reduction of sewage pollution of Sydney's beaches or the reduction in the level of brown haze in Sydney's atmosphere.

4.3 Description of the Proposed Pollution Process Model

The pollution process model as proposed enables quantification of the processes that occur from the time of identification of a pollution problem (or potential problem) to the eventual solution (or resolution) of the problem. It suggests that each major pollution problem has unique starting and completion points and that the events that affect the process are discrete and can be isolated from other processes events. This implies a cause and effect or apriority. In reality the processes (described here as discrete) may be often continuous and the cause and effect not clear cut and the links with other processes of the model broad.

Figure 4.2 suggest how the proposed model might be represented in time bar chart form. The length of the bars would typically represents the time over which each process was active. The form is diagrammatic only as the real durations may not be as discrete or the overlap in time as neat.

Figure 4.2: Diagramatic Representation of Pollution Process Model



In the following sections each proposed specific process of the model is discussed and related to the general processes of column 2 of Figure 4.1.

4.3.1 Problem and People Affected

Note: For the purposes of distinguishing the names used for the proposed processes of the pollution process model, they are typed in italics.

The first process of the proposed model (*people affected*) is the response of parties (a person or group of people) who are initially affected by the pollution problem. This corresponds to the process of "identification" of column 2 Table 4.1.

The early identification of a problem by people could be the observation of: the impact of the fouling of a beach by pollution; fish kills in a river; a decline in bird numbers; a decline in frog species or numbers; an increase in smoggy days; or an increase in breathing complaints.

This process describes the situation where people are first affected by a particular type of pollution. Initially a few people may be affected and this might be dismissed as the price of progress or as insignificant. What is a problem to some people may not necessarily become a problem for other people, the population at large, the bureaucracies, or the politicians. This proposed process marks the starting point of the perception or observation of a potential pollution problem.

4.3.2 Harbinger

The second process of the proposed model is where a group or person predicts that the pollution could become a major problem if no action is taken to reduce it. This corresponds to the processes of "identification" and "recognition" from column 2 Figure 4.1.

The word *harbinger* is used to describe the person (or group) who is able to identify a potential pollution problem, look ahead in time, and recognise or predict that it could become a significant problem if no action is taken. The *affected party* (Section 4.3.1) could be the *harbinger* but it is more likely that the *harbinger* would be somebody with a special knowledge or interest e.g. an environmental interest group, an Environmental Protection Authority, other public Authority, or an academic institution. This is a similar concept to that of "agenda setter" (Hogwood and Gunn (1983) in Section 3.3.3).

It is suggested that the *harbingers* do not cause an immediate initiation of a solution through political or governmental means but assist in putting the problem onto the public and political agenda. The early signs of a pollution problem are acknowledged by the *harbingers*. Interest groups whether motivated by wider philosophical or altruistic concerns may turn their attention to the problem. Academics may see it as a new field of study to exercise the mind or benefit society.

The media may assist in raising the public profile of a pollution problem. (Refer section 3.2.2.2) The interest groups, academics and others may generate data and information about the problem. They may even suggest a solution in terms of desirable outcomes but without much attention to the processes involved or assessment of time frames involved. The bureaucracies and politicians may acknowledge the problem but action may not be a priority in the absence of strong public pressure to act. Mainstream concern that might be needed to support political action may be slow in coming.

In discussing the public perception of pollution (Section 3.5) it was described how for people to react strongly to pollution, the pollution needed to effect them personally. In the early stages of identification of a pollution problem these conditions may not exist.

4.3.3 Public concern

The third process of the proposed model is an increase in *public concern*. This corresponds to "recognition" and "rising awareness” from column 2 Figure 4.1.

Increase in public awareness may be preceded by the actions of *affected people* and *harbingers*. Public concern for a pollution problem may be increased as more people become personally affected by the problem (Refer to Figure 2.4 for an example). A significant increase in the level of *public concern* (or perception of public concern) is often necessary to cause politicians to accept that there is a problem, bring it to the top of the political agenda, and then act. (Rosenbaum 1991).

4.3.4 Political Action

The fourth process of the proposed model is an increase in the level of *political action*. This is a process that brings together several of the categories of column 2 in Figure 4.1: "agreement" that a pollution problem exists, "formulation" of the problem scope, "policy development", and "legislation".

With increasing *public concern*, pressure on bureaucratic organisations charged with the responsibility of identifying, solving, regulating a pollution problem may be mounting. They may first attempt to solve the problem through existing organisational, administrative and legal avenues. For major pollution problems this approach may not be successful because if a problem is archetypical existing organisations, procedures, laws, and policies may not be adequate.

Political action when it comes may take a number of forms. Its form may depend on whether an election is in the offing. Commitments (political promises) may be given before an election and may be implemented in the early part of the political term. Environmental interest (or other special interest) groups make use of this fact in extracting political commitment in exchange for concrete or tacit support before an election. Pressure may be also applied after elections for political parties to honour election promises. Small gains may be achieved this way but in the broader time frame of ten to twenty years or so needed to solve major problems (See Table 10.11) the political election process may be of less significance.

Responsibility for a new pollution problem may be spread over several existing government organisations. Each by themselves may not have the authority or responsibility to solve the major pollution and the political process needs to assist or intervene. Paterson (1986) believes problems that do not fall clearly within the responsibility of a particular government agency should be resolved at the political level not in a less than adequate way by compromise between several agencies. Sagoff (1988) believes that where problems involve value judgements (and the solution of major pollution problems would involve value judgements) the political process is a necessity.

Reform of the public sector in Australia in the last 10 years has focused on strengthening the political process and giving politicians greater responsibility for direction and policy (Kouzmin and Scott 1990).

For the purposes of the proposed model the process *political action* includes perception of public concerns, advice from government departments, receipt of petitions, parliamentary debate, general legislation. The later process *legislation* (Section 4.3.7) is in addition to *political action* and includes the formulation of specific regulations and policies to assist in implementing a solution as distinct from general legislation of the process - *political action*. New or amended legislation by itself may not solve the pollution problems and they may require regulations and other bureaucratic policies to ensure a solution.

4.3.5 Inquiry

The fifth process of the proposed model is an *inquiry*. This corresponds with the "policy development” activity of column 2 of Figure 4.1.

Often an early political action is to initiate a process to gather the facts about a pollution problem. This may take the form of a public inquiry, a commission of inquiry, a conference of experts, a consultant's study, or a combination e.g. a Royal Commission, Senate Inquiry, or use of outside experts often from overseas - commonly from America. Coward (1988) lists 41 officially commissioned inquiries concerning pollution and other environmental issues from 1852 to 1978 in NSW. Examples of recent Senate inquiries on air and water pollution include SSC (1969) and SSC (1970). An example of use of overseas experts to advise on major pollution matters is Brown and Caldwell (1967).

The *inquiry* or experts' report often establishes a framework that acknowledges or confirms that a problem exists and makes recommendations for its solution.

The government (through its political processes) may then act on the recommendations. A major change in the way society and its organisations work may be necessary to solve a major pollution problem. This may involve the passing of new legislation and building new or substantially modified bureaucracies with regulations to administer. The roles of existing organisations may be often changed and new and revised responsibilities allocated.

An *inquiry* may result in the need for the generation of more information (more research etc.) or it may require the passing of specific legislation to provide the basis for the solution of the problem.

4.3.6 Body of Knowledge

The sixth process of the proposed model is the generation of a *body of knowledge* about the problem. This corresponds to and is a part of the "problem solving" activity of column 2 in Figure 4.1.

Generation of scientific knowledge is often a necessary precursor to action by governments or institutions to solve major environmental problems (Trudgill 1990, Löwgren and Segrell 1991). The body of knowledge about a particular pollution problem may be accumulated by general research or it may be generated by more directed research funded specifically to solve the problem. While there is often an ongoing generation of knowledge about pollution, this work has focused on the identification of the generation of knowledge about a specific pollution problem that helps form the basis for developing solutions.

A *body of knowledge* may be developed by academics, interest groups, government departments, consultants, the mass media, and others.

4.3.7 Legislation

The seventh process of the proposed model is the *legislation* of new or amended laws and or regulations. This corresponds with the activity "regulation" of column 2 of Figure 4.1.

Legislation may be in several phases: the original legislation directed at the problem; revisions to legislation to correct unworkable or unsuitable legislation; regulations to provide for practical implementation; some exposure to the courts and the regulated to obtain sufficient feedback throughout the community to achieve a practical working process.

This process focuses on the later phases of specific legislation and regulations. The process *political action* would include generic legislation e.g. a clean waters act, whereas this process would include regulations necessary to properly administer a previous act, or administrative regulations to make the previous legislation practicable.

4.3.8 Allocation of Funds

The eighth process of the proposed model is the *allocation of funds* to implement solutions. This corresponds with the activity "implementation of a solution" of column 2 of Figure 4.1.

Major pollution problems are not solved without extra expenditure (Coward 1988). Changed legislation and regulations may require government funding or may impose financial requirements on private organisations or the public. The process *allocation of funds* includes expenditure of funds.

4.3.9 Organisational Change

The ninth process of the proposed model, *organisational change*, is the development of new or substantially changed organisations. This corresponds with the activities "new agencies" and “constructing facilities” of column 2 of Figure 4.1.

New organisations or substantially changed organisations may be required to administer changed legislation. Changed organisations require a process of organisational development where staff are recruited and trained, policies and procedures are developed, management systems are implemented, and working arrangements with government, industry, and the public are established. Examples of the establishment of new organisations and the development of organisational branches dealing with pollution are described in the annual reports of the relevant government agencies (DGPH 1953 to 1971, SPCC 1973, and WB 1992).

Management techniques may have to be developed or adapted to enable the legislation to be effectively and efficiently implemented. The changed organisation may be charged with different types of solution: structural e.g. engineering and legal, and non-structural e.g. behaviour modification through persuasion (WB 1992).

Some structural solutions will require considerable capital works and the time frame for major infrastructure projects may cover many years from the inception of the planning to the completion of engineering, manufacturing, installation and commissioning. Financing and increasingly the assessment of environmental impact of the solution (or justification of the environmental benefits) add to the time scale. (WB 1992, WB 1993)

Behaviour modification may involve persuasion through advertising, face to face communication, and long term change through the education of adults and children. The education of children will often involve curriculum change - itself a slow process (SPCC 1973-1990).

4.3.10 Solutions in Place and Pollution Problem Being Solved

For the purposes of the proposed model it is assumed that solutions are in place when pollution problems are solved routinely by the existing laws and organisations without the need for significant public or political input and the level of pollution has been reduced to a target or desired level.

This final feature of the model incorporates the following activities from column 2 of Figure 4.1: "regulatory control", "enforcement", "administration", "adjustment", and "resolution" of the problem. No separate process is proposed for the model. The indication of solutions being in place is given by the change over time of an indicator showing the actual level of pollution e.g. average ozone concentration reducing over time to an acceptable target level would show the resolution of the problem of atmospheric ozone pollution in Sydney. This indicator is referred to as the "extent of solution".

4.3.11 Summary of Proposed Model

The third column of Figure 4.1 summarises the processes of the proposed model. As shown by the links between column 2 and 3, a strong one-to-one correspondence is not proposed though all the processes of column 2 are linked to processes in column 3.

4.4 Methodology for Quantification

4.4.1 Methodology

This section describes the methodology used to empirically demonstrate that the pollution model proposed in the previous section is an acceptable approximation of reality. The methodology consisted of: using five case studies of major regional pollution problems (See Section 4.5): selecting and quantifying appropriate indicators for each of the individual processes of each case study (Sections 5, 6, 7, 8, 9); plotting process diagrams (of the indicators) to visually illustrate the quantified processes for each case study; comparing the same processes for each case study to assess their similarity and whether a consistent similarity confirmed that the particular process was a valid and measurable process (See Section 10); assessing whether the number and type of processes of the empirically demonstrated model are sufficient to explain the main social and institutional processes involved and sufficient to enable the model to be useful as a planning tool (Appendix A); and calculating the average time taken to achieve solutions by measurement taken from the process diagrams (Appendix B).

4.4.2 General Approach to Quantification

The method of quantification of the pollution process model was to use indicators that provided a measure the strength and duration of each of the proposed processes. There was a need to select indicators that were representative of each of the processes, extended over the period that the pollution problem process was active, and were measured in a consistent manner over this period. It was considered that the absolute value of the indicator (if it satisfied the above criteria) was less important than its trend over time and its ability to identify when a process had substantially commenced and when it was substantially complete.

Where possible the most direct indicator needs was chosen. A secondary though important consideration was the availability of adequate data from a reliable source. The actual indicators used are described in later sections where the case studies are described (Sections 5, 6, 7, 8, and 9).

The indicators are used to measure how the processes vary over time. Peaks in the value of an indicator suggest a more intense part of the process. Overlaps in time of the indicators from one to the next suggest a general time order for the processes. If the indicators and their overlaps supported the logical sequence of the model then the assumption was made that the model was adequate. If the indicators and their overlapping in time were at variance with the model then the model logical was reviewed.

Once the indicators were selected, they were quantified and plotted on process diagrams. (See figure 5.10 for an example) for each of the five case studies. The process diagrams show the strength and duration of each process and when they occurred on a time line.

Once the five case studies were quantified a comparison was made (Section 10) of similar processes across the five case studies (e.g. legislation) to assess how consistent the quantified processes of the five case studies were with the proposed pollution process model (Section 4.2) and how similar they were across the case studies. In other words did the quantified case studies demonstrate the postulates proposed for the model. Finally an assessment was made of the adequacy and logical consistency of the model processes to explain the overall process of achieving a solution to a pollution problem. This assessed whether the processes proposed and quantified were necessary and sufficient.

A rigorous proof of apriority was not performed for the case studies but the historical description of the pollution problems and the timing of the indicators of the processes were used to check for logical consistency. This procedure identified if logical inconsistencies or lack of apriority existed but could not be considered to be an absolute proof that apriority existed. Notwithstanding this lack of an absolute proof of apriority, if the case studies stood the test of logical sufficiency then it was assumed that they were an adequate approximation of reality.

The following questions were used to test this sufficiency. Are the processes proposed sufficient for a solution? Are the processes proposed and measured the only processes involved, and if they are not, are they the most important or significant ones? Are the processes proposed necessary for a solution? Are the processes linked by causal relationships or are they influenced by the underlying independent variables not proposed or measured?

4.4.3 Indicators

As discussed previously indicators needed to be representative of the process to be measured, extend over the period that the pollution problem process was active, and be measured in a consistent manner over this period. As the examples below illustrate, indicators of the type used in this work are commonly used to measure organisational and social processes.

Although the technique of content analysis to produce an index may have some limitations in terms of interpretation of the significance of the index value, Löwgren and Segrell (1991) and Andersson et al. (1992) have used similar techniques effectively. The limitation is not as relevant for this study as this study relies more on trends over time and relative changes of magnitude rather than absolute values. Löwgren and Segrell (1991) used numbers of articles on environmental topics in the Swedish Environmental Protection Agency journal Miljö-Aktuellt to identify and measure the community concern for environmental problems. Andersson et al. (1992) used numbers of references on environmental topics in the database ENVIROLINE to identify and measure environmental problems in 18 different countries.

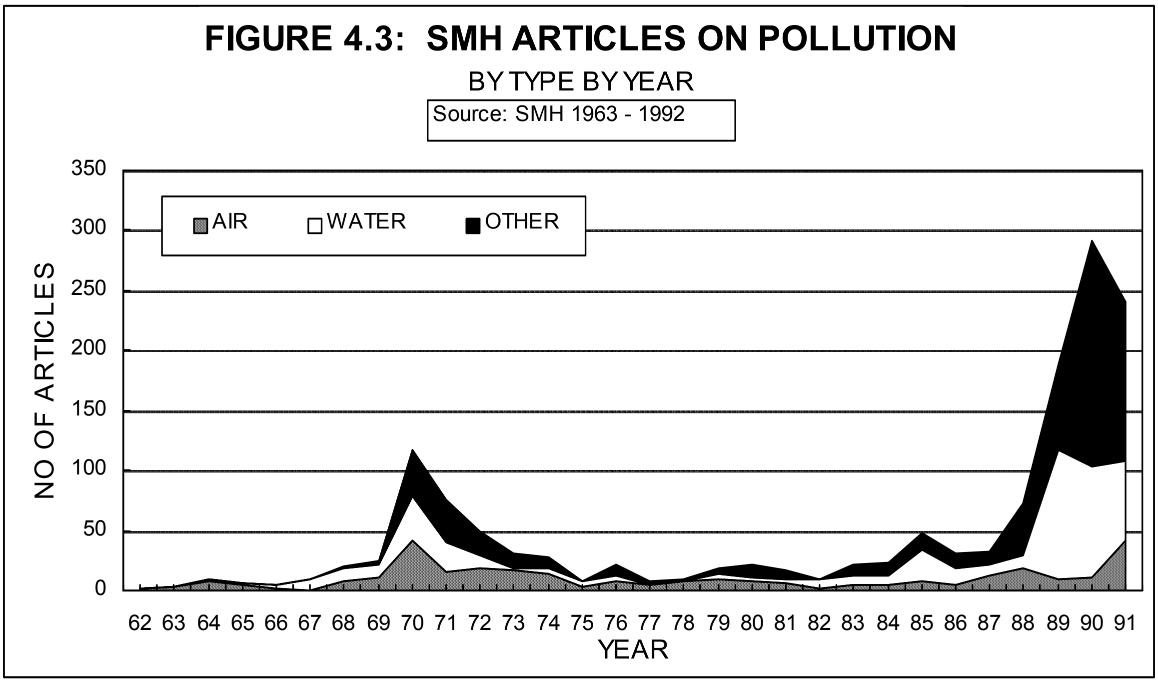
Section 2.10 illustrated the use of indicators in the form of public opinion surveys to measure level and trends in public concern for the environment and pollution, and the use of indicators to measure public behaviour in terms of membership of environmental interest or lobby groups.

Indicators are being increasingly used by government organisations in Australia to measure organisational outputs in response to management trends that have seen the incorporation of private sector models into governmental organisations e.g. "results oriented" management approaches such as Management By Objectives (Coombes 1976, Kouzmin et al 1990).

Some issues in the selection of indicators are discussed below. More discussions on specific indicators used included in later sections where the case studies are discussed (Sections 5, 6, 7, 8, and 9).

4.4.4 Indicators of Public Concern

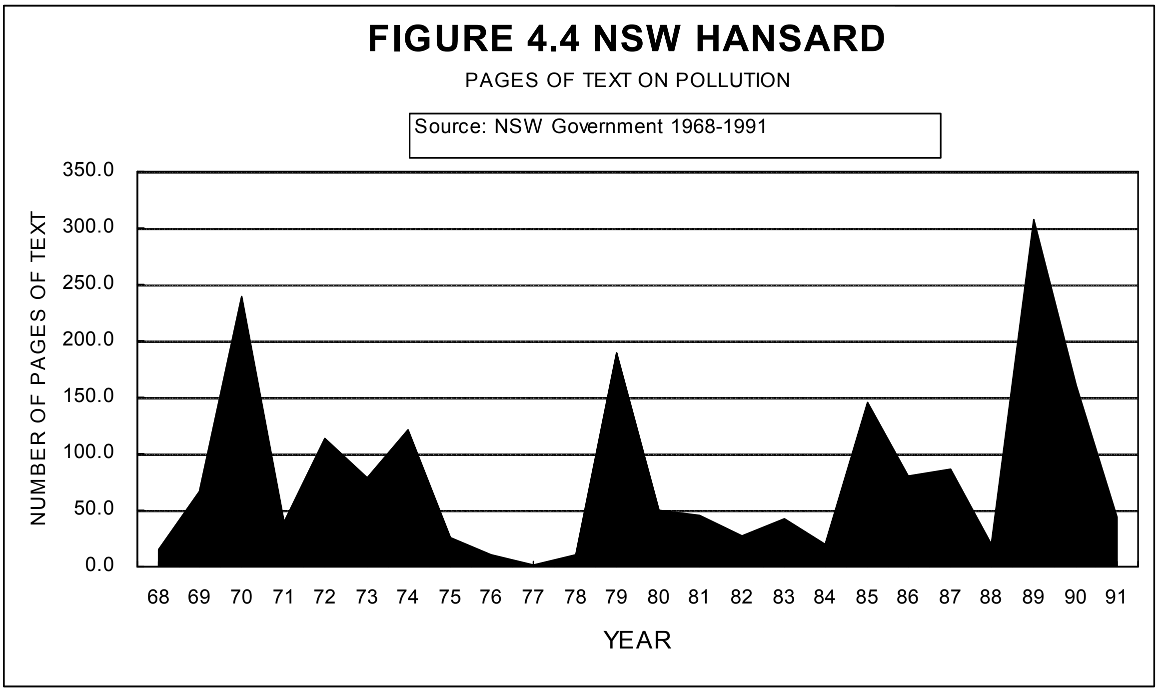
The numbers of newspaper articles appearing in major daily newspapers have been used in this work as a measure of the level of public concern in society for pollution (Refer Figure 4.3.). The Sydney Morning Herald (SMH) was used for Sydney. Although the technique of content analysis to produce an index may have some limitations in terms of interpretation of the significance of the index value, the limitation is not as relevant for this study as this study relies more on trends over time and relative changes of magnitude rather than absolute values. The indexes used in this work were developed by adding up the number of references to a particular topic in the newspaper from indexes of articles from the newspaper. These indexes rely on the interpretation and classification of the articles by the original newspaper indexes not the author.

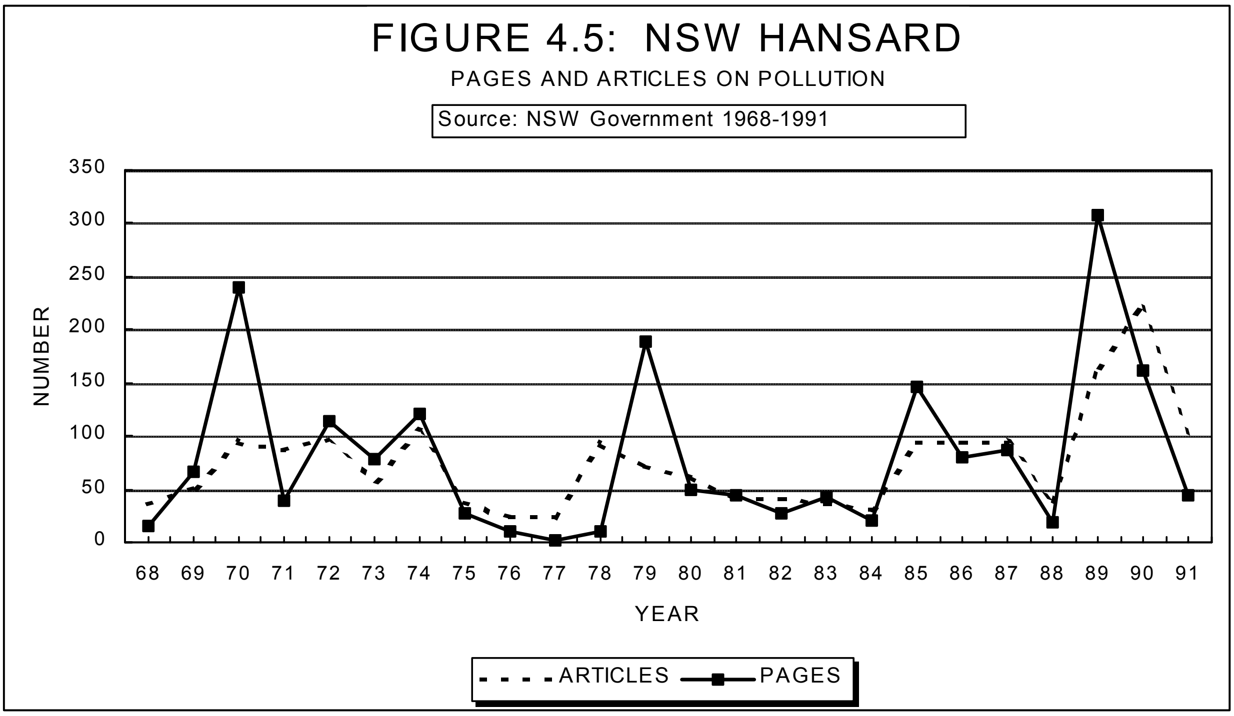


4.4.5 Indicators of Political Action

The level of political action in Parliament was measured by using the number of pages of text on a particular pollution topic (or the number of references in the Hansard index) to a particular pollution topic as an indicator. The number of pages of text from NSW Hansard (the record of parliamentary proceedings of the Australian state of New South Wales of which Sydney is the capital) devoted to parliamentary action on pollution was used for Sydney (See Figure 4.4.). These parliamentary proceedings include question time, statements from members of parliament, etc. though a significant part of the measured pages of text refers to debates in both houses of Parliament (House of Representatives and the Senate) on the introduction of new or amended legislation.

The number of pages could be considered the more accurate measure of the level of political debate though collection of the data on number of references requires less effort. The data for NSW was collected for both the number of references and the number of pages of text devoted to a particular pollution topic. At the scale used there was a close relationship between the number of pages and number of articles as shown in Figure 4.5.





The Hansard record of the Victorian parliament was used to measure political action in Melbourne. Here the number of articles (or entries) as shown in Figure 4.6 was used rather than the number of pages on the basis that the corresponding NSW figures showed a close relationship between number of pages and number of references.

4.4.6 Indicators of Organisational Action

A number of different types of indicators were used to measure organisational action or organisational processes. These included changes in expenditure of funds e.g. capital expenditure on sewer outfalls or expenditure on relevant research, changes in the number of people devoted to a particular operation e.g. the Air Pollution Control Branch of the State Pollution Control Commission.

In some cases where processes extended over a period of less than a year, the indicator was not effective in showing a longer term trend or peaks and troughs rather it showed a point in time (a particular year) in which the process occurred.

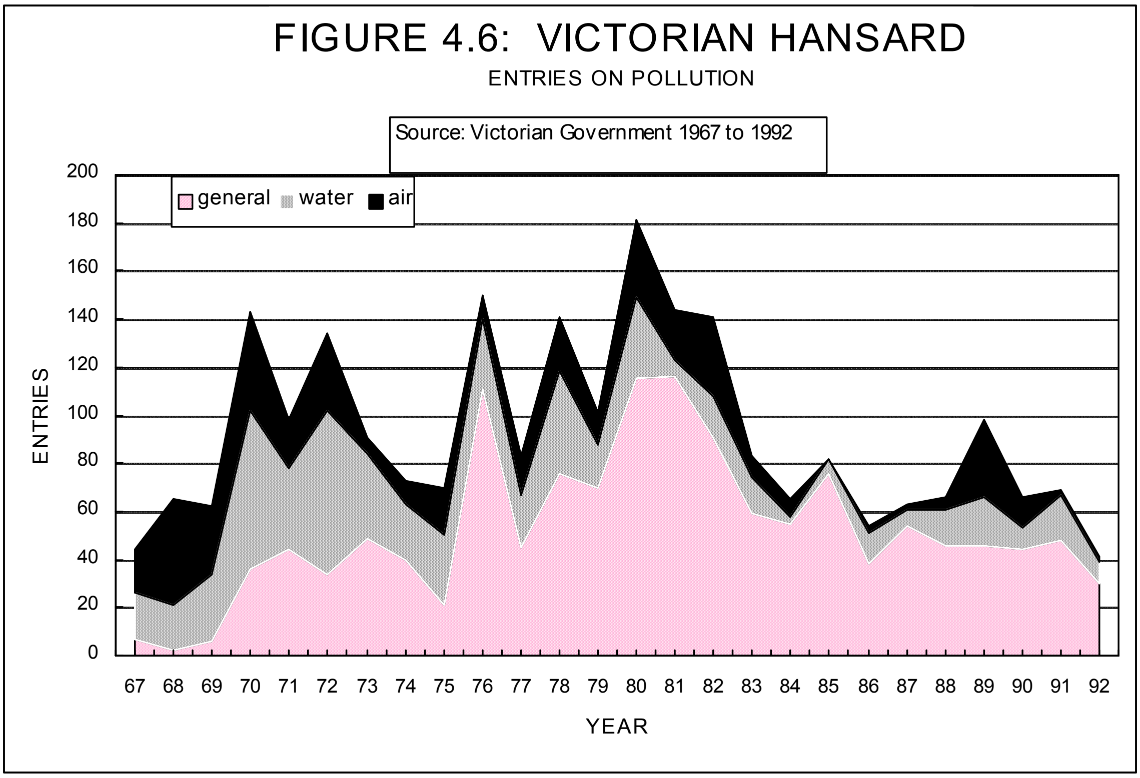


FIGURE 4.6: VICTORIAN HANSARD

4.5 Case Studies

There were a considerable number of major regional pollution problems in Australia that could have been used for the case studies, some of which were described in Sections 2.4 to 2.8. The case studies chosen were:

Air pollution

Sydney's brown haze problem caused by back yard burning;

Sydney's ozone pollution caused by motor vehicles and industry;

Melbourne's ozone pollution caused by motor vehicles and industry;

Water pollution

Sydney's beach pollution caused by cliff face discharge of sewage;

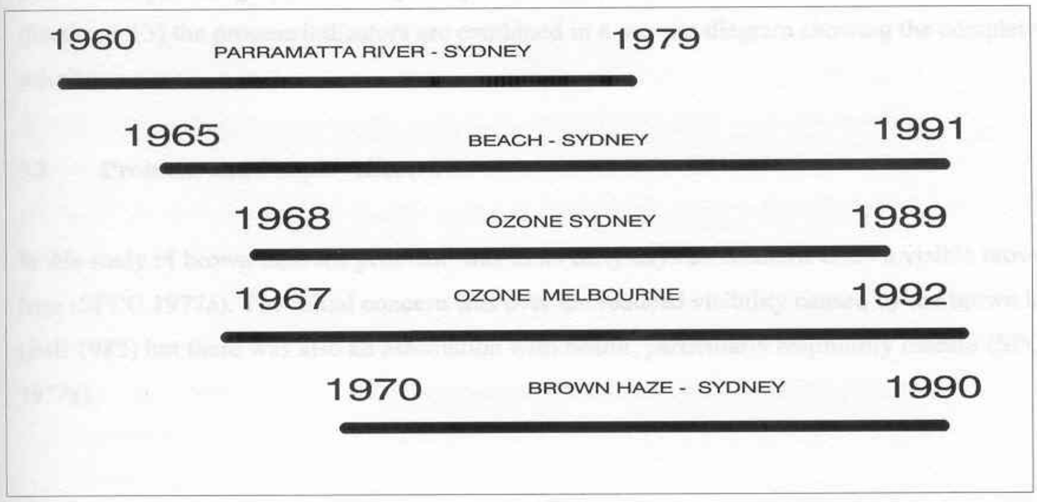
Parramatta River pollution in Sydney caused by industry discharges;

The case studies selected are representative of the regional air and water pollution problems that have occurred in Sydney and Melbourne since the Second World War in the period from approximately 1960 to 1990. Figure 4.7 shows the time over which the case studies occurred.

There were several reasons for selecting these particular case studies. They were and still are major pollution problems that are regional in nature i.e. they extend across a large part of a large city. They are representative of other air and water pollution problems of this period. By also selecting the same pollution topic in a different city and state a comparison across states operating under different legislation was possible (e.g. ozone pollution in Sydney and Melbourne). Finally the pollution sources are from distributed sources rather than from one large source and so involve large sections of the community contributing to pollution and suffering from pollution.

Sections 5, 6, 7, 8, and 9 describe each of the case studies and develop quantitative indicators to measure each of the pollution processes proposed in this section. The results of each case study are summarised in process diagrams (See Figures 5.10, 6.11, 7.16, 8.15, 9.15). These figures are normalised by presenting the data in the same format making direct comparison possible. The time scale (x axis) is the same length for each of the figures though the span of years is different. The Indicator axis (y axis) is the same height for each of the figures though the measured indicators and their absolute values are different.   Section 10 compares the five case studies and Section 11 provides a summary of the research.

FIGURE 4.7: DURATION OF POLLUTION CASE STUDIES



5 BROWN HAZE AIR POLLUTION IN SYDNEY

5.1 Historical Context

The chapter describes the winter air pollution problem of brown haze in Sydney, Australia caused in part by the backyard burning of household waste at suburban homes.

Attention was focused on air pollution in 1952 when thousands of people died of illness caused by air pollution in London (SPCC 1977a). The Clean Air Act of New South Wales (NSW), Australia was enacted in 1961 in an attempt to control air pollution in Sydney and the nearby industrial cities of Wollongong and Newcastle. By the mid 1970s gains had been made in the reduction of air pollution caused by deposited matter (dust, grit), suspended matter, and sulphur dioxide (SPCC 1973 to 1990). The problems associated with these pollutants had not been completely solved but they had been greatly reduced.

In the early 1970s the air over Sydney was often hazy with considerably reduced visibility (SPCC 1973 to 1990). Two types of haze manifest themselves: a white haze (mainly photochemical smog) predominant in the summer months and a brown haze predominant in the winter months.

Brown haze is caused by the scattering of light from microscopic particles suspended in the air. The particles are 2 microns and less and are similar in size to the wavelengths of visible light. (SPCC 1977a, Streeton 1990)

Each of the following sections describe the solution of the brown haze pollution problem in terms of the processes of the proposed pollution process model, describe the indicators chosen for each process and provide graphs showing the quantification of these chosen indicators. In a later section (Section 5.13) the process indicators are combined in a process diagram showing the complete solution.

5.2 Problem and People Affected

In this study of brown haze the problem was in its early days an aesthetic one - a visible brown haze (SPCC 1977a). The initial concern was over the reduced visibility caused by the brown haze (Bell 1982) but there was also an association with health, particularly respiratory disease (SPCC 1977a).

Concern was being expressed in the newspaper, the Sydney Morning Herald, in the late 1960s for Sydney's level of air pollution in general (SMH 1963 to 1991). It wasn't until the mid 1970s that brown haze was scientifically proven to be a different type of air pollution to white haze (Williams et al 1981).

The indicator chosen to measure the process *people affected* is the year of the first recorded identification of the problem in 1969. This is shown as a single bar in Figure 5.10.

5.3 Harbinger

The State Pollution Control Commission of NSW (SPCC) was formed in June 1971 to bring control of water and air pollution under a single authority and to administer new laws on pollution. It is now called the Environmental Protection Authority of NSW. The SPCC appears to be one of the earliest harbingers of the brown haze problem. The first SPCC annual report (SPCC 1973) documented that open burning was one cause of Sydney's brown haze air pollution problem with the other major contributors being industrial combustion processes, and motor vehicle emissions.

The indicator chosen to measure the process *people affected* is the first recorded forecast by SPCC in 1973 of the likely consequences of the pollution problem. This is shown as a single histogram bar in Figure 5.10.

5.4 Public Concern

Figure 5.1 shows the chosen measure of the level of *public concern* in Sydney for air pollution over 28 years. The indicator is the number of indexed articles on air pollution in Sydney from the major Sydney daily newspaper the Sydney Morning Herald (SMH 1963 to 1992).

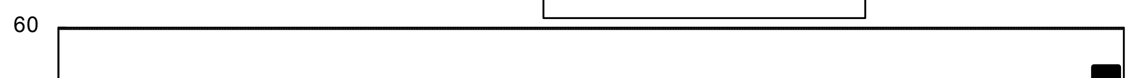
It could be argued that the number of articles on brown haze would be a more accurate measure. Several factors mitigate against this argument: firstly at this time there was insufficient scientific knowledge to distinguish between the different causes of visible air pollution (Refer Section 5.6) and secondly there is probably insufficient data (articles per year) to divide the data into different subtopics without diminishing its accuracy.

On the assumption that numbers of articles in the SMH are a reasonable measure of public concern for visible air pollution (of which brown haze was the winter manifestation), the graph shows a quite significant increase in public concern from 1968 to 1974 with a peak during 1970. The data also shows a significant peak in the early 1990s but this is outside the time frame of the brown haze problem.

FIGURE 5.1 : SYDNEY MORNING HERALD

ARTICLES ON AIR POLLUTION

Source: SMH 1963 - 1992



5.5 Political Action

Figure 5.2 shows the chosen indicator of the level of *political action* as the number of articles from NSW Hansard (the record of parliamentary proceedings of the Australian state of New South Wales of which Sydney is the capital (NSW Government 1968 to1991) devoted to parliamentary actions and proceedings on air pollution. These parliamentary proceedings include question time, statements from members of parliament, etc. though a significant part of the measured pages of text refers to debates in both houses of Parliament on the introduction of new or amended legislation under the Clean Air Act. The Clean Air Act put in place legislation to enable the control of air pollution. This included control of brown haze, photochemical smog, and other forms of air pollution. Other authors (e.g. Löwgren and Segrell 1991) use parliamentary motions as an indicator of the level of political action.

This indicator shows a build up of *political action* from 1968 to a peak in 1972. This indicator in some way also measures *public concern* particular when considering the level of public petitions and some questions from parliamentary question time. The peaks in the late 1980s are outside the time frame for the brown haze problem.

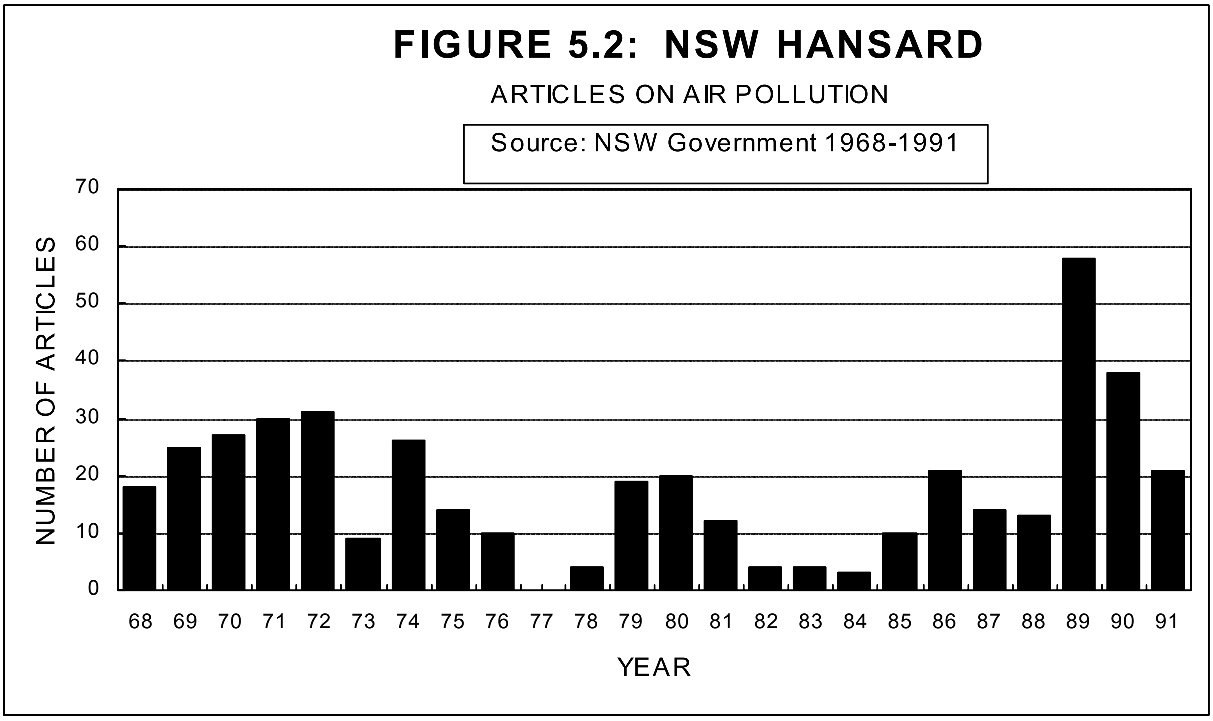
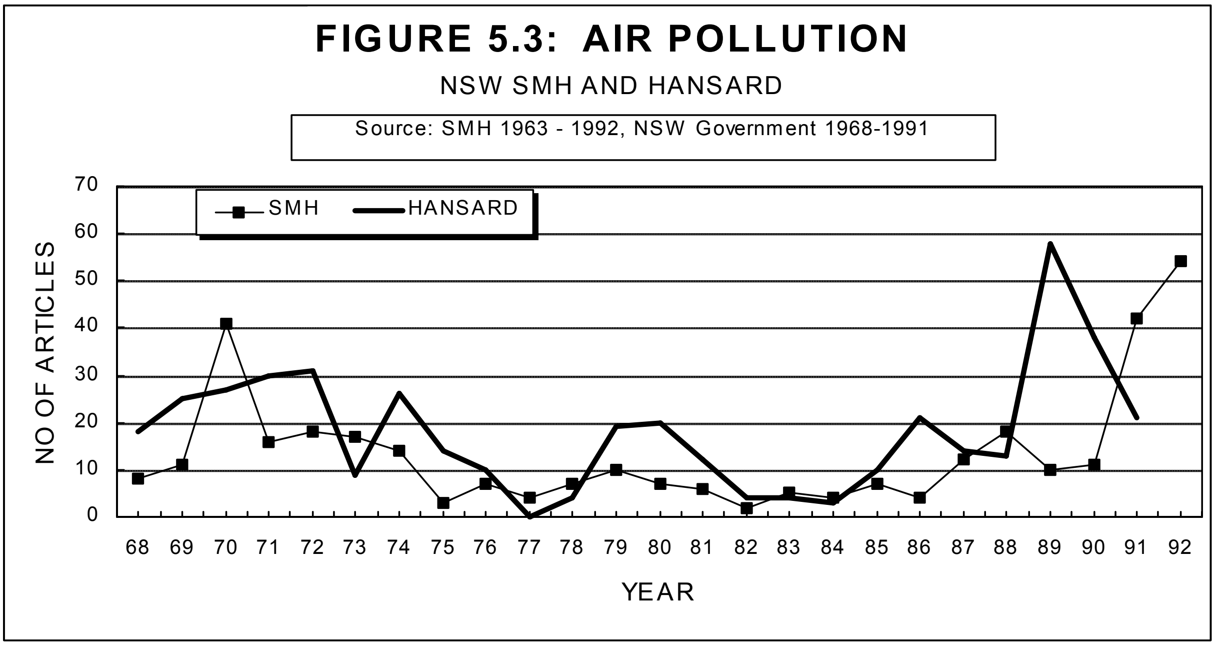


Figure 5.3 combines Figures 5.1 and 5.2 and shows that increases and decreases in the indicator of public concern (the number of articles in the SMH on air pollution) often preceded the rise or fall in the indicator of political action (the number of articles in NSW Hansard devoted to air pollution). An increase in public concern preceded an increase in political action in the 1970s and through the 1980s though the situation was reversed in the late 1980s.



It is interesting to note that the value of the indicator of *public concern* (SMH articles) reduced greatly after the passing of significant air pollution control legislation. This could indicate that the public was less concerned once it was perceived that solutions were in progress e.g. research started, State Pollution Control Commission formed, and relevant legislation enacted. This phenomenon (Parlour and Schatzow 1978) is discussed in Section 3.2.2.2.

5.6 Body of Knowledge

Generation of scientific knowledge is often a necessary precursor to action by governments or institutions (Trudgill 1990, Löwgren and Segrell 1991) The body of knowledge about a particular pollution problem can be accumulated by general research or it may be generated by more directed research funded specifically to solve the problem. While there was an ongoing generation of knowledge during the 1970s about air pollution (SPCC 1973 to 1990), this process seeks to measure the generation of a specific body of knowledge about brown haze that formed the basis for developing solutions.

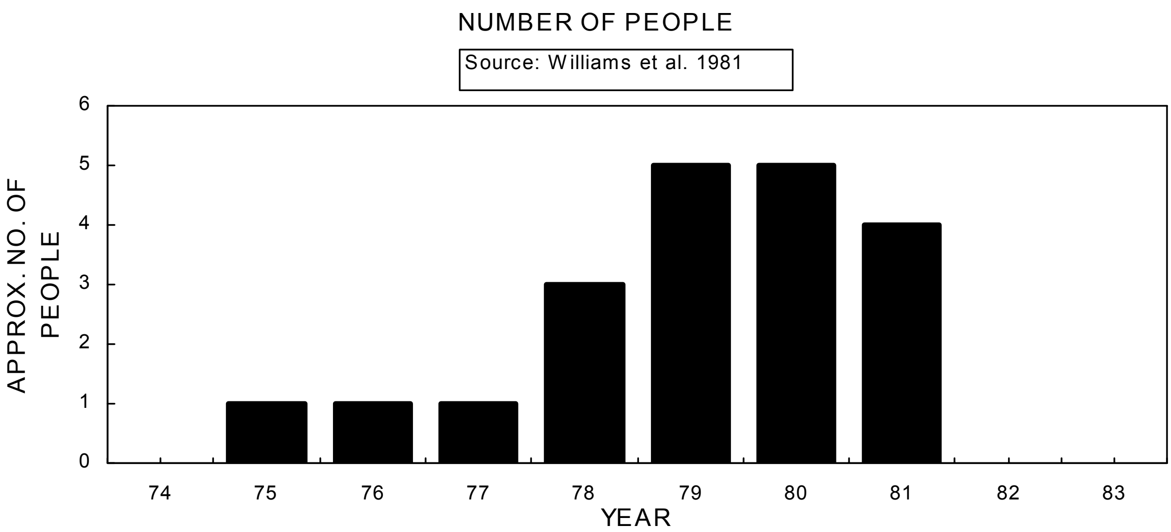
The Sydney Oxidant Study (SPCC 1977a) commenced in 1974. The objective of this study was to develop an understanding of oxidants present in Sydney's atmosphere, including their source, their formulation, and their distribution in order to gain an understanding of the source of photochemical smog.

This involved research into the physics and chemistry of the oxidants and their precursors as well as research into the meteorology of the Sydney basin. Some of this information especially an understanding of the dynamics of the meteorology, was an important precursor to the Brown Haze study which commenced in 1976 (Williams et al 1981).

The Brown Haze research continued until 1981. Figure 5.4 indicates the approximate level of effort in numbers of people engaged on the research (data from Williams and others 1981) and personal communications with Dr. Robert Hyde of Macquarie University, Sydney and Jim Duguid of the NSW Environmental Protection Authority). The results of this research are documented in a number of reports. (Williams et al 1981 and Bell 1982).

A significant finding from this research was that at times backyard burning of garden and paper waste could contribute up to 40% of the brown haze. The research also indicated other causes, the major one being motor vehicle emissions. This case study has considered only the solution to that component of the brown haze problem caused by backyard burning. A parallel study could look at the component caused by motor vehicles.

FIGURE 5.4: BROWN HAZE RESEARCH



5.7 Inquiry

A conference on Sydney's air pollution (Carras and Johnson 1982) in 1982 promulgated the knowledge accumulated on the major air pollution problems of Sydney especially over the 9 years prior to the conference. This conference included papers on Brown Haze and its causes: backyard burning, industrial combustion processes, and motor vehicle emissions. This major conference produced a result similar to a public inquiry: an accumulation of current knowledge and the production of recommendations on measures to reduce particulate emissions e.g. restrictions on motor vehicle emissions, industrial incineration and domestic burning.

The measurement of the process *inquiry* is by the use of a single histogram bar showing the year in which the process (or event) occurred. (Refer to Figure 5.10).

5.8 Legislation

The political action described previously in Section 5.5 resulted in broad legislation to facilitate the solution of air pollution problems but not specific legislation required to facilitate a solution of the brown haze problem.

The SPCC had been addressing the problem of emissions of fine particles from combustion: industrial, commercial, and domestic. A Ministerial Order was proclaimed in 1973 prohibiting open burning though this did not apply to domestic burning. Throughout the 1970s SPCC (SPCC 1973 to 1990) explored various options to control the emissions from combustion. These included design of better incinerators for the burning of domestic waste, limiting burning (both voluntary and compulsory) on days where meteorological conditions were likely to exacerbate the problems of haze formation, and prohibition by the NSW State Government and Municipal Councils.

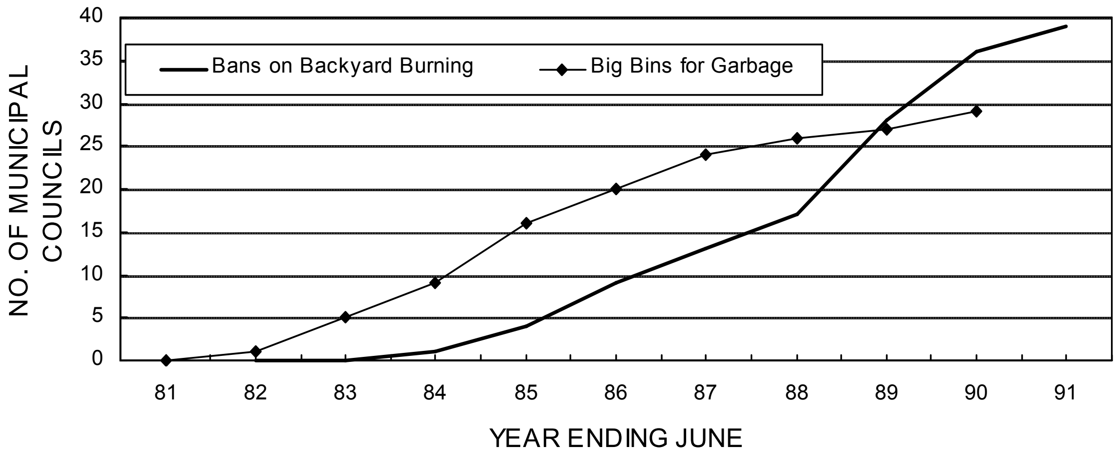
The SPCC had been trying to engender voluntary restraint on backyard burning with limited success. It had also been encouraging Municipal Councils to introduce orders banning backyard burning. Many councils were loath to do this because of the problems with disposing of the material previously burnt by householders. (SPCC 1973 to 1990)

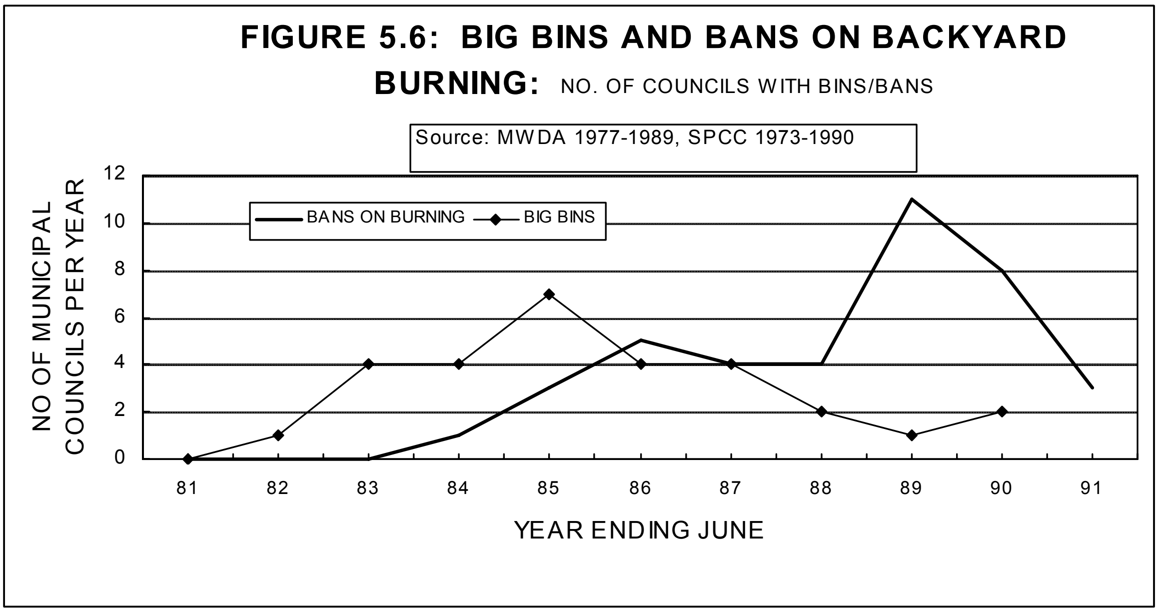
The solution to the problem of disposal of unburnt waste was the "big bin". The big bins were not introduced solely to solve the problem of disposal of waste previously burnt in backyards (Australian Environment Council 1987). They were also introduced as a means to reduce the cost of garbage collection. Previously household garbage was collected in 55 litre bins often twice a week. Big bins of 240 litre capacity with weekly collection were introduced to reduce the cost of garbage collection. (Some 120 and 330 litre bins were also used). Supported by the introduction of the "big bins" Municipal Councils put in place regulations to ban back yard burning (Australian Environment Council 1987).

Figure 5.5 uses the index of the cumulative number of councils with bans on backyard burning as an indicator of legislative action to solve the problem of backyard burning. Figure 5.6 showing the data on a per year basis illustrates the nexus between the introduction of big bins and the progressive introduction of bans on backyard burning by Municipal Councils (Metropolitan Waste Disposal Authority 1977 to 1989).

FIGURE 5.5: BIG BINS AND BANS ON BACKYARD BURNING: CUMULATIVE COUNCIL NUMBERS

Source: MWDA 1977-1989, SPCC 1973-1990





5.9 Allocation of Funds

Major pollution problems are not solved without extra expenditure (Coward 1988). Changed legislation and regulations may require government funding or may impose financial requirements on private organisations or the public.

The introduction of backyard burning bans required Municipal Councils to allocate extra finance to establish the new collection system. While the big bins saved in collection costs over time they added immediate extra costs (Australian Environment Council 1987) in the form of automatic bin loading trucks, big bins, extra garbage handling at depots. Figure 5.5 shows the number of Municipal Councils with "big bins". The indicator used for the allocation of funds is an estimate by the author of the extra costs of introducing big bins and is shown diagramatically in Figure 5.10.

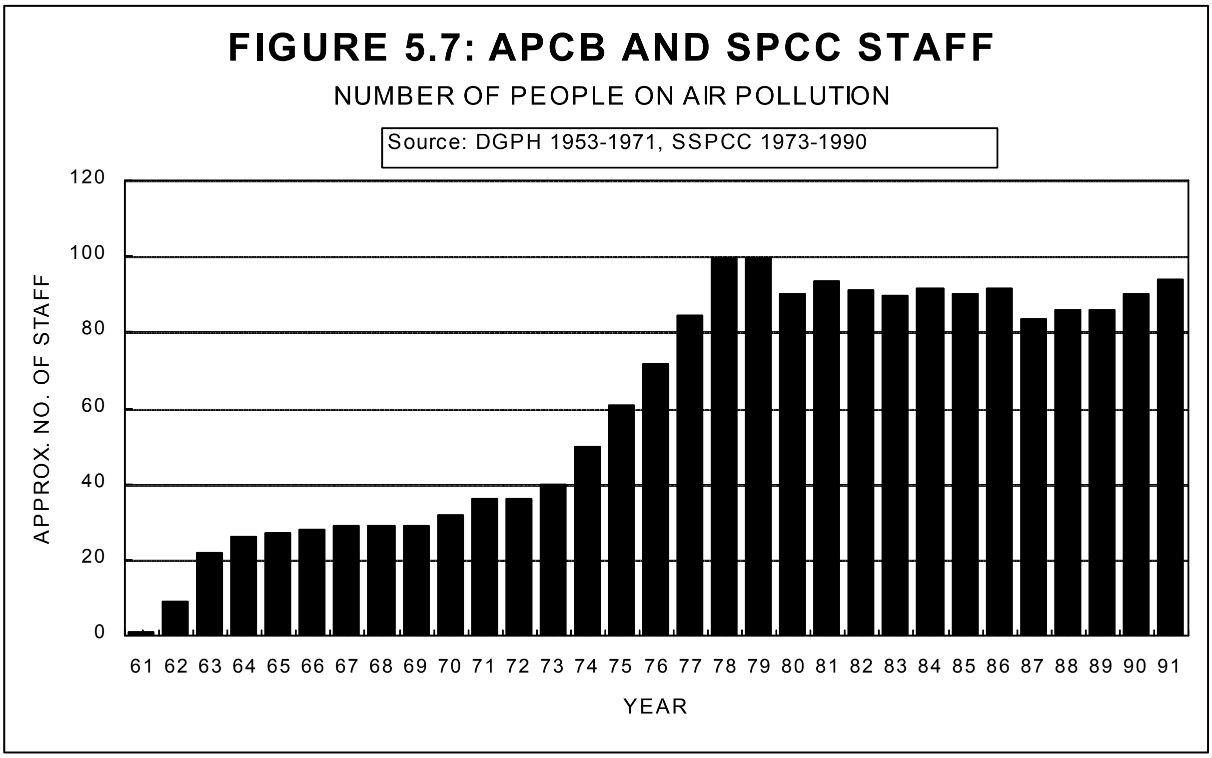
5.10 Organisational Change

New organisations undergo a process of organisational development where staff are recruited and trained, policies and procedures are developed, management systems are implemented, and working arrangements with government, industry, and the public are established. The State Pollution Control Commission (SPCC) Annual reports (SPCC 1973 to 1990) illustrates this process in describing how the SPCC took about 2 years from 1971 to 1973 to become fully effective in their role as a pollution control commission.

New organisational arrangements were required to manage the new method of garbage collection both within Municipal Councils' and in their arrangements with existing or new garbage contractors

(Metropolitan Waste Disposal Authority 1977 to 1989). This process follows very closely the indicators of Figure 5.5 and 5.6.

Figure 5.7 shows the how the number of people in the SPCC and the Air Pollution Control Branch of the DGPH increased in response to the need to monitor and control air pollution of which brown haze was one significant component. The indicator chosen to represent *organisational change* is Figure 5.6 the number of Councils with big bins.



5.11 Solutions in Place and Institutionalised

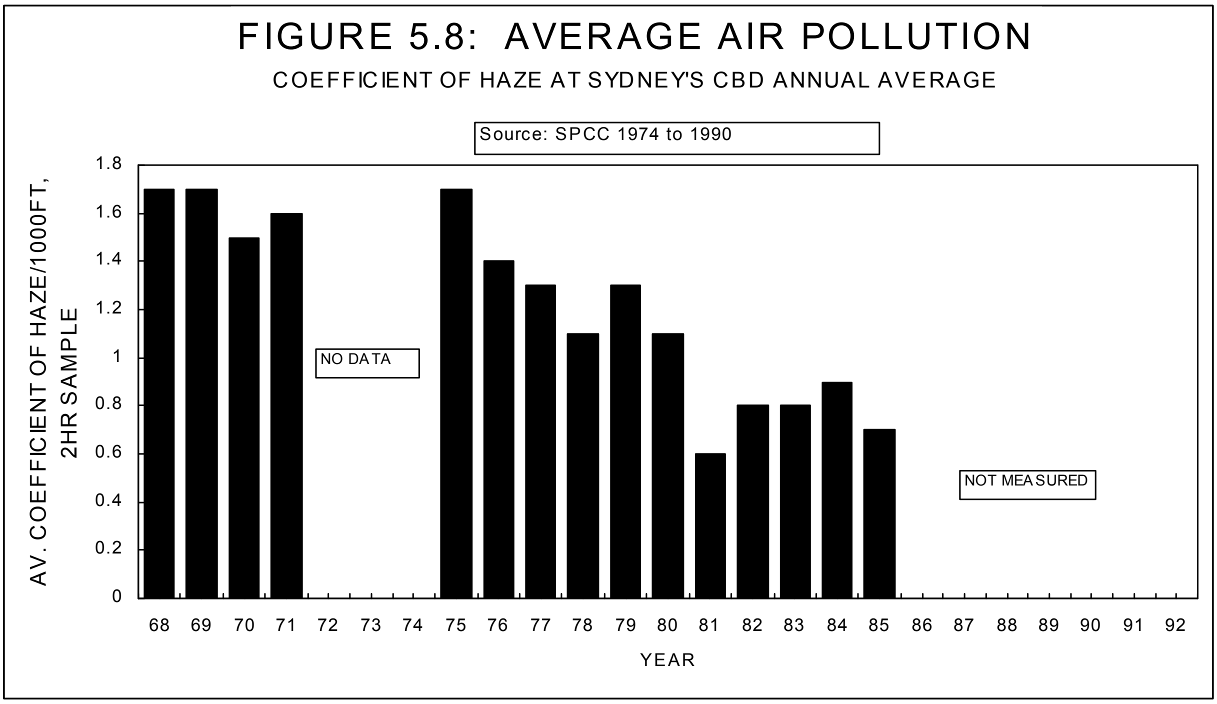
The process of introducing big bins and bans on backyard burning took a number of years in individual Municipal Councils (See Figure 5.6). The process for metropolitan Sydney took from 1982 to 1992 for big bins and from 1984 to 1991 for bans on backyard burning for all 39 councils. 29 out of 39 metropolitan councils had introduced big bins by 1990. (SPCC 1973 to 1990).

By 1990 the solution to the air pollution problem of brown haze (fine particulate matter) caused by backyard burning was in place and institutionalised: big bins were used by the majority of councils; bans on backyard burning were in place in all metropolitan councils and enforced by bylaws and fines; various recycling schemes were implemented by councils or on a voluntary basis by householders and these helped to reduce the increased volume of waste (SPCC 1973 to 1990).

5.12 Extent of Solution

Figures 5.8 and 5.9 illustrate the extent to which the suspended matter that causes the brown haze has been reduced. Over the period of the case study, 1968 to 1990, there was no continuous record using the same indicator of the measurement of brown haze or the visual effect of brown haze. Two different indicators were used as described below.

SPCC measured Coefficient of Haze (COH) per 1000 linear feet for the period 1959 to 1985 (SPCC 1974 to 1990). The COH measures particles in the range of 0.1 to 10 μm. Figure 5.8 shows the trend from 1959 to 1985 in Sydney's central business district.



Since 1981 at Rozelle (an inner Sydney suburb) and later at other sites SPCC have measured particles in the range of 0.1 to 2.0μm using an integrating nephelometer. This measures a Coefficient of Light Scattering per 10km (COLS). During the late 1970s SPCC also took a photographic record of Sydney's brown haze (J. Duguid EPA, personal communication). COLS is a better indicator of the level of haze than COH and Figure 5.9 shows the trend from 1981 to 1990 at Rozelle an inner suburb (SPCC 1973 to 1990).

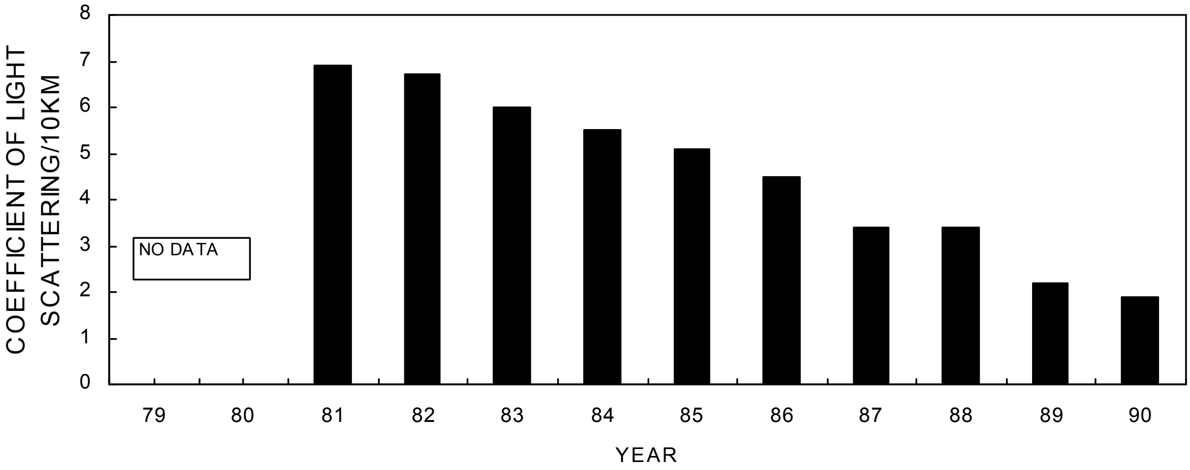
The data for COH shows a reduction of the index from 1.4 to 1.6 during the 1960s to a value of 0.6 to 0.8 during the mid 1980s and the COLS shows a reduction from 6 to 7 in the early 1980s to 1 to 2 in the late 1980s. The reduction in haze corresponds to the implementation of: bans on backyard burning; motor vehicle emission controls; and other industry emission controls.

It would require a study of the chemical composition of the Sydney air (as was done in the initial studies that determined the cause) to confirm how much bans on backyard burning contributed to this reduction.

FIGURE 5.9: AVERAGE AIR POLLUTION

COEFFICIENT OF LIGHT SCATTERING, AV. WINTER & AUTUMN INNER CITY

Source: SPCC 1974 to 1990



While the reduction is significant, brown haze still occurs in Sydney on a number of days per year and appears to be increasing (personal observation). Forest (1991) indicates that while there has been a significant decline in the level of fine particles that contribute to the brown haze in Sydney's air there are signs that the levels could rise again in the future with increasing use of domestic solid fuel heaters (using mainly wood), industry growth, and growth in the numbers of motor vehicles.

This indicates that the solution to the Brown Haze problem may only have been a partial or temporary solution. Section 3.7.2 discussed the idea that partial solutions are a feature of the resolution of major pollution problems.

A recent increase in the rise in concern for air pollution is highlighted in figures 5.1 and 5.2 where the indexes rise sharply in the late 1980s and early 1990s. Most of this is concern for the problem of photochemical smog (Sydney Morning Herald 1968 to 1992).

The indicator chosen for this process is the coefficient of light scattering as shown in Figure 5.9.

5.13 Processes

Figures 5.1 to 5.9 presented in this section represent indicators of the strength of processes and the time over which they were active. In order to visualise the chronology and the overlapping of the processes involved in the solution to the brown haze problem, Figures 5.1, 5.2, 5.4, 5.6, 5.7, 5.9

together with other data from this section have been placed on a common time scale as shown in Figure 5.10. This diagram is a key to the understanding the interconnected nature and time frames of the processes.

The main processes are listed on the vertical axes of the diagram. For each process the horizontal axis is a measure of the time over which the process was active in the solution of the pollution problem and the vertical dimension is a measure of the intensity of the process.

The process *people affected, harbinger,* and *inquiry* are shown as single histogram bars as they are events that do not extend over one year in duration. The other process histograms show the trends over time. *Public opinion* and *political action* are shown over the whole period of the case study to contrast the early peaks with the later trough. The latter peaks in the early 1990s are not related to the solution of the brown haze problem.

It has been suggested that the reduction in the number of high pollution days could be explained by fortuitous meteorological conditions though Dean and Ferrari (1990) believe that the majority of improvement is a result of the control programme on backyard burning and to some extent the reduction in motor vehicle emission limits.

5.14 Discussion

Figure 5.10 shows that the processes overlap in time by varying degrees without a simple progression from one process to the next. As the processes represent a multitude of activities by a variety of groups and people a simple progression could not be expected.

Figure 5.10 shows that the identification and recognition of the problem of visual air pollution both photochemical smog (summer haze) and brown haze (winter haze) took place in the late 1960s and early 1970s (*people affected, harbinger*). *Public concern* about this air pollution was being increasingly expressed in the newspaper (Sydney Morning Herald) during this period. Increased *political action* in response to this general public and public authority concern took place in parliament in the early 1970s through parliamentary debates, private members questions, and the passing of legislation to among other things revise the Clean Air Act which had previously been passed in 1961.

A need to undertake further research was identified because at the time there was a lack of scientific knowledge about the causes of and the solutions to the brown haze problem (Williams and others or et al 1981). *Body of knowledge* shows the development of this scientific knowledge about brown haze and process *inquiry* shows the scientific conference that promulgated this and other knowledge about air pollution in Sydney. *Organisational change, allocation of funds,* and *legislatio*n represent the phases where there was general recognition that the problem was significant and where the solutions were implemented. The solutions required allocation of funds for an alternative garbage disposal method and Municipal Council regulations to ban the practice of backyard burning.

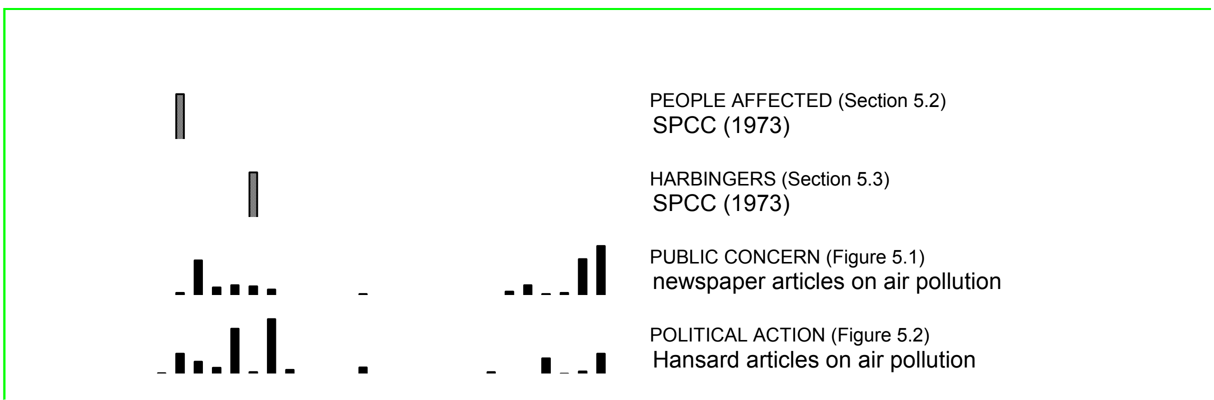
The period of time from when the problem was first identified until a decision was made to actually implement a solution was about 15 years (1969 to 1984) while the time taken to implement a solution was about 6 years (1984 to 1990).

While the indicators chosen represent the magnitude change and duration of the processes it could be suggested that a better proof of the model might be achieved if the indicators of *public concern* and *political action* measured brown haze pollution rather than air pollution in general. The author does not believe this would be possible because sufficient knowledge to scientifically distinguish between the causes of the two types of haze (brown and white) was not available at the time. (Sydney Morning Herald 1963 to 1992, NSW Government 1968 to 1991).

As shown by the Coefficient of Haze indicator (Figure 5.8) haziness had started to reduce before Municipal Council bans on backyard burning were in place due to reductions in emissions in other areas e.g. emissions from motor vehicles and commercial incineration (SPCC 1973 to 1990). As shown by the Coefficient of Light Scattering indicator haziness was further reduced as the Municipal Council bans were enforced.

The pollution process diagram Figure 5.10 provides a succinct summary of the processes involved in solving the brown haze pollution problem. It illustrates many aspects of the processes: the long time frames involved (over 20 years); the processes (e.g. social and institutional); the methods appropriate to measure the outputs from these processes; the identification of the role of *public concern;* and the partial nature of the solution. It could be called the political resolution rather than the solution. The first case study also illustrates that the model and the methodology for quantifying the processes are valid and practical.

FIGURE 5.10: PROCESSES INVOLVED IN THE SOLUTION OF BROWN HAZE POLLUTION



6 OZONE AIR POLLUTION IN SYDNEY

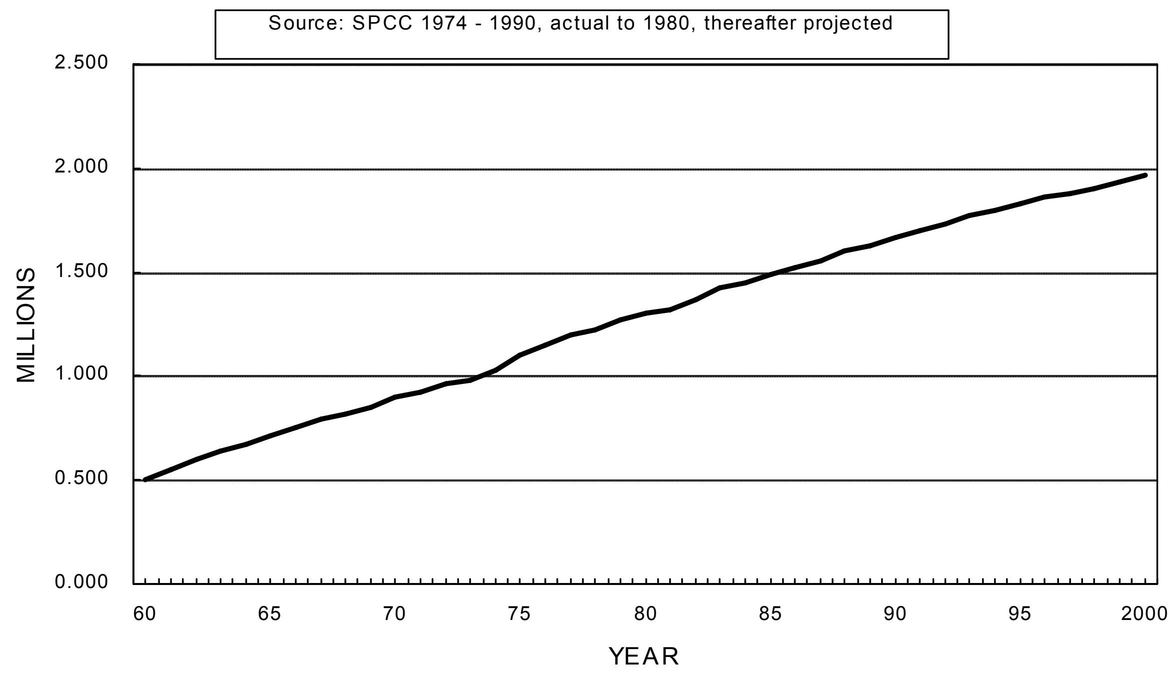
6.1 Historical context

The chapter describes the summer air pollution problem of atmospheric ozone in Sydney, Australia caused primarily by the motor vehicle emissions.

Sullivan (1962) in reviewing atmospheric ozone measurements taken during 1959 to 1961 concluded that Sydney had the potential for an ozone problem similar to that of Los Angeles but at the time there was no evidence to support the existence of a current problem. In the early 1970s the air over Sydney was often hazy with considerably reduced visibility (SPCC 1973 to 1990). Two types of haze manifest themselves: a white haze predominant in the summer months and a brown haze predominant in the winter months as described in Section 5.1.

In 1972 DGPH (1972) stated that there was an urgent need to control motor vehicle emissions (the prime source of ozone producing gases) to reduce the precursor chemicals (hydrocarbons and nitrogen oxides) that cause the formulation of atmospheric ozone. Motor vehicles numbers had increased dramatically since the end of World War 2 and in the early 1970s were still increasing at a steady rate as shown on Figure 6.1.

FIGURE 6.1: SYDNEY CAR POPULATION



Each of the following sections describe the solution of the ozone pollution problem in terms of the processes of the proposed model, describe the indicators chosen for each process and provide graphs showing the quantification of these chosen indicators. In a later section (Section 6.13) the process indicators are combined in a process diagram showing the complete solution.

6.2 Problem and People Affected

In the early 1970s the air over Sydney was often hazy with considerably reduced visibility. Two types of haze manifest themselves: a white haze predominant in the summer months and a brown haze predominant in the winter months. A major part of the white haze was caused by oxidants with the primary oxidant being ozone. The ozone was formed by the reaction of hydrocarbons and nitrogen oxides in the atmosphere under favourable meteorological conditions. On 11 November 1972 ozone levels peaked at 21pphm for 5 minutes causing some vegetation damage. The observable problem with ozone was one that affected the visual amenity of Sydney people. It also caused possible health effects and intermittent vegetation damage. (SPCC 1973 to 1990, Mitchell in Carras and Johnson 1982).

The indicator chosen to measure this process is the first recorded affect of the problem in the period 1970 to 1972. This is shown as a single histogram bar in Figure 6.11.

6.3 Harbinger

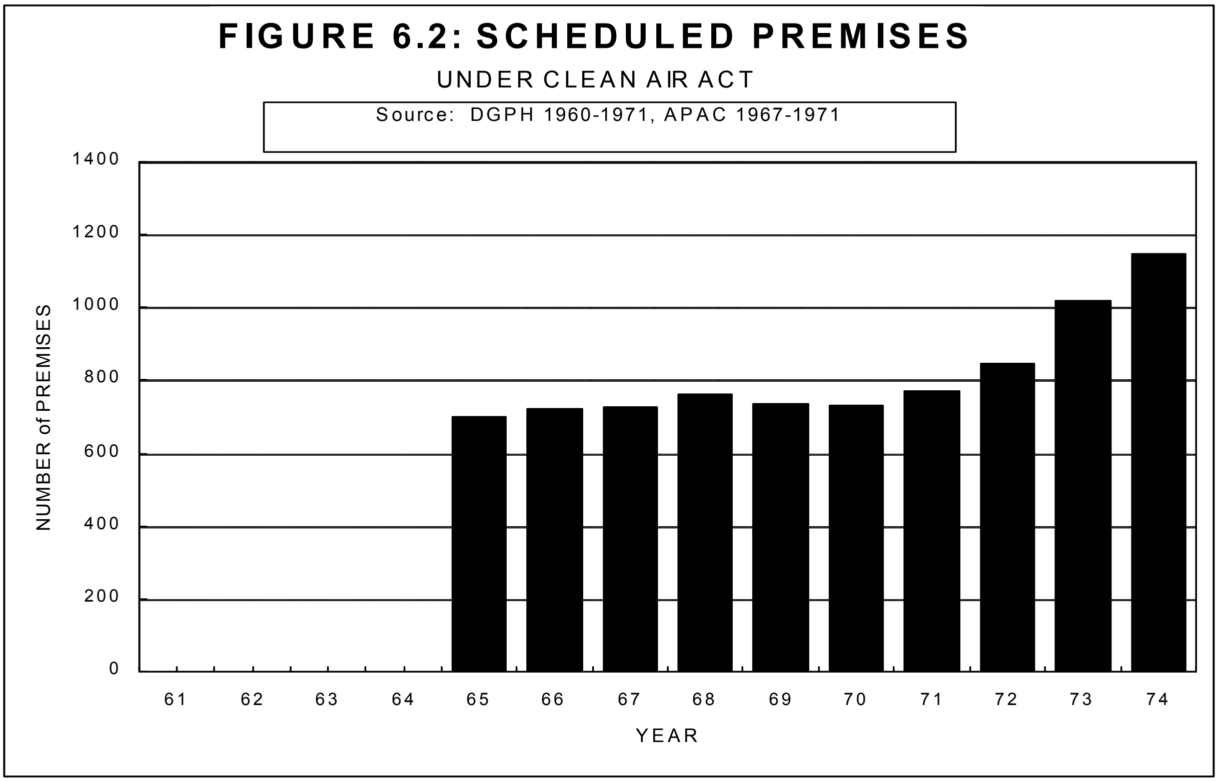
As described in Section 6.1 Sullivan (1962) believed that Sydney had the potential to experience an ozone problem in the future but at the time (in 1962) he wrote that there was insufficient evidence to say a problem currently existed.

In 1960 measurements of atmospheric ozone were first undertaken by the staff of the Director General of Public Health. The Director General of Public Health stated in its annual reports throughout the 1960s that there was no ozone problem in Sydney especially when compared with USA cities though in 1968 the Director General of Public Health stated that there could be a problem by 1992 unless controlled and that time was needed to be allowed for manufacturers to develop new engines and controls. (DGPH 1960 to 1971).

By 1970 intermittent monitoring reported by the Director General of Public Health was showing higher levels of ozone and it was predicted that there may be a problem developing and suggested a need to relate air pollution to meteorology and to investigate the role of the motor vehicles in causing air pollution. (DGPH 1970)

Previously air pollution control had been focused on point sources such as factories, power stations, and manufacturing facilities. During the early 1960s the Air Pollution Control Branch

(DGPH 1960 to 1971) through licensing was attempting to bring fixed point source pollution under control. Figure 6.2 shows the cumulative number of scheduled premises.



Motor vehicle emissions were not covered by the Clean Air Act but carbon monoxide was the biggest concern of motor vehicle pollution at the time with high levels occurring in the Sydney business district.

The Director General of Public Health in its report of 1971 stated that the ozone 1 hour average was 17pphm and ozone levels were approaching USA levels. On 11 November 1972 ozone peaked at 21pphm for 5 minutes causing some vegetation damage. Sydney was blanked in a visible haze caused by particulates. The DGPH in its report perceived an urgent need to control atmospheric ozone and carbon monoxide levels.

This report also stated that motor vehicles were causing 60% of all air pollution. The Air Pollution Advisory Committee of the DGPH in 1971 said that petrol consumption was up 6.9% on the previous year. It was conceded that Australian Design Rules (ADR) 26 and 27 (regulation to control vehicle emissions on new vehicles) would not reduce ozone and carbon monoxide significantly especially in light of increasing number of motor vehicles on the roads. More stringent controls were planned for 1 January 1975 and 1 January 1976.

A Senate inquiry (SSC 1969) concluded that ozone was not a current problem but could be by 1992.

It is interesting to note that the ozone problem as perceived by the Director General of Public Health had gone in the space of 4 years from a problem that could possibly occur in 1992 to one that was in urgent need of control in 1972. A number of things could have contributed to this apparent error in foresight: the intermittent monitoring that was being done in 1968, the increasing number of motor vehicles - though this could have been predicted, and meteorological conditions.

It could be argued that the first harbinger was DGPH (1970) rather than Sullivan (1962), because Sullivan (1962) did not believe that an ozone problem existed. The counter argument is that DGPH was not a real *harbinger* because it was actually measuring a problem that had arrived not forecasting a problem that might arise unless something was done about it. The basis for the indicator used for this process is Sullivan (1962) because in terms of the definition adopted for a *harbinger* he was the first to identify a potential problem and forecast that it could get worse if something was not done about it. Refer to Figure 6.11.

6.4 Public Concern about Air Pollution

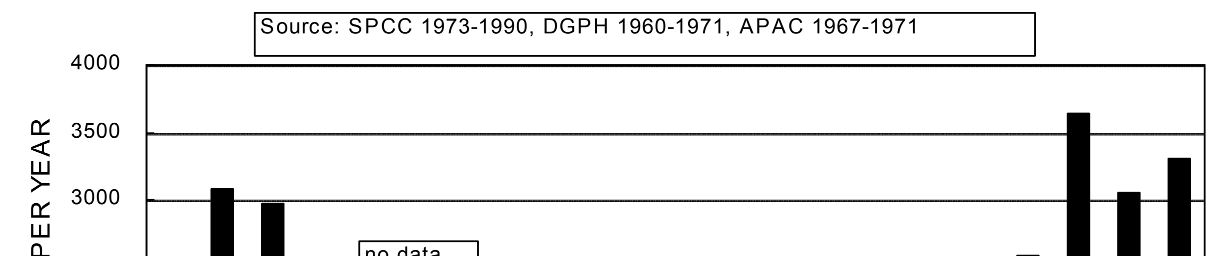
In response to perceived public concern over air pollution the Air Pollution Control Branch (APCB) of the Director General of Public Health (DGPH 1960 to 1971) established a telephone service in 1970 to receive and investigate public complaints. This service was continued by the SPCC (SPCC 1973-1990) when it was established. Figure 6.3 shows this build up in numbers of complaints about air pollution to over 3000 per year. By 1975 the number had dropped to about 2000 per year. These graphs indicate a build up of public concern as the air pollution problem became more visible and as public debate and public information increased.

It is important to note that these graphs relate to all complaints. About 60% relate to DGPH matters (on pollution) but they are still a good indication of increasing concern. Often the public (and the scientists) are not aware of what causes the particular problems until research is undertaken (Carras and Johnson 1982). Figure 5.1 from Section 5.4 shows the general concern for air pollution as measured by articles in the SMH.

The indicator used for this process is the number of telephone complaints to the APCB of the DGPH and the SPCC about air pollution as shown in Figure 6.3.

FIGURE 6.3: PUBLIC TELEPHONE COMPLAINTS

AIR POLUTION

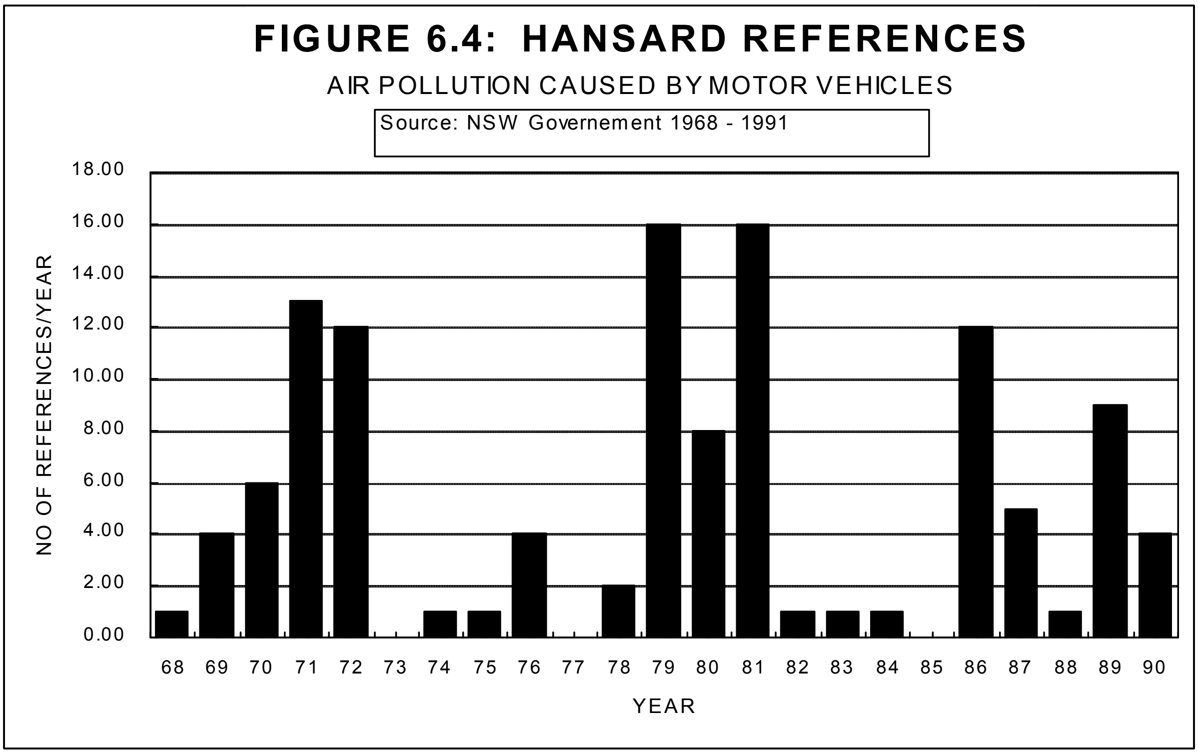


6.5 Political Action

Political action took a number of forms. The NSW parliament entered into the debate on air pollution from motor vehicles and the Air Pollution Control Branch (APCB) of the Director General of Public Health (DGPH 1960 to 1971) increased its monitoring of air pollution in response to indications of a growing problem.

Public concern for pollution was increasing in the early 1970s and the State Pollution Control Commission (SPCC 1973 to 1990) was formed to address concern for increasing pollution problems. Previously the Director General of Public Health was responsible for air pollution latterly through the APCB and the Air Pollution Advisory Committee (APAC). (DGPH 1960 to 1971). The SPCC was formed in 1971 to provide more focus and action in an attempt to control pollution including air pollution thought it was not until 1974 that the SPCC finally took over all the functions of the APCB of the Director General of Public Health including administration of the Clean Air Act.

The indicator used for measuring *political action* is the number of references in NSW Parliamentary debates (NSW Government 1968 to 1991) to air pollution caused by motor vehicles as shown in Figure 6.4. Figure 6.4 shows a peak in 1971 and 1972 coinciding with the time that the problems of ozone were coming to the fore. The indicator is shown for the period from 1968 to 1990 for reference. It is interesting to note that the indicator reduced significantly during the 1970s after its initial peaks in 1970 and 1971 implying a lessening of political action. The peaks around 1980 and 1986-1989 were not considered to have a direct influence on this case study because solutions were in train prior to these dates though these increases in concern may have had some reinforcing effect on the promulgation of the solution.



6.6 Body of Knowledge

There was an ongoing generation of knowledge during the 1970s about pollution and air pollution in general. The Sydney Oxidant Study (SPCC 1977a) commenced in 1974. The objective of this study was to develop an understanding of oxidants present in Sydney's atmosphere, including their source, their formulation, and their distribution.

This involved research into the physics and chemistry of the oxidants and their precursors as well as research into the meteorology of the Sydney basin. Figure 6.5 shows that over $1 million was spent on the research over the years 1975 to 1977 (Mitchell in Carras and Johnson 1982).

The Sydney Oxidant Study was conducted over summers of 1975/76 and 1976/77. (SPCC 1975, Mitchell in Carras and Johnson 1982). The aims were to monitor the precursors of photochemical smog (nitrogen oxides (NOx) and non-methane hydrocarbons (NMHC)) and the ozone levels, to determine the meteorological conditions conducive to formation of photochemical smog, and to identify significant sources of NMHC and NOx. The final aim was to establish a relationship between the precursors and the photochemical smog so that a control strategy could be developed.

Four parties were involved: **SPCC -** management, monitoring network, mobile laboratories; **Macquarie University** - meteorology**; Commonwealth Scientific and Industrial Research Organisation** (CSIRO) - type and source of NMHCs, smog chamber; and **Sydney University -** mobile laboratory, relationships between precursors and ozone concentrations

The Sydney Oxidant Study produced data showing how the meteorological conditions facilitated the production of ozone, and identified the conditions necessary for its formation. Motor vehicle emissions were confirmed as a major source of the precursor gases and the consensus appeared to be that the preferable control approach was to reduce the amount of NMHC emitted so as to limit the ozone formation. This route was chosen in preference to reducing NOx emissions because it was less expensive and easier to implement.

Figure 6.5 shows the approximate change of the process indicator over time and this is the indicator for the generation of the *body of knowledge.*

6.7 Inquiry

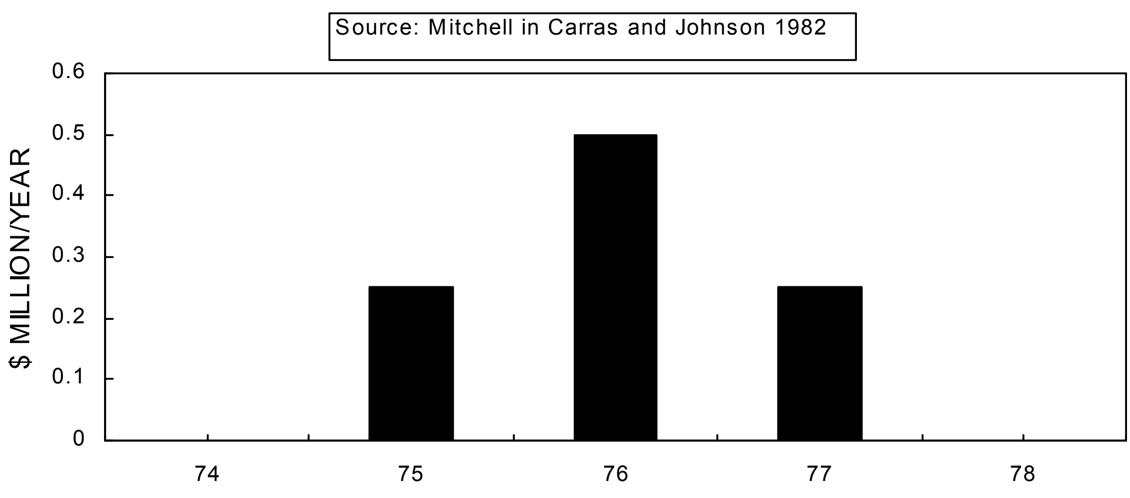
Over the period May 1968 to August 1969 the Commonwealth Senate (SSC 1969) held an inquiry into air pollution but concluded that ozone pollution in Australia (including reference to Sydney) was not a current problem but could be in the future.

A conference on Sydney's air pollution (Carras and Johnson 1982) held in 1982 promulgated the knowledge accumulated on the major air pollution problems of Sydney especially over the 9 years prior to the conference. A major conference produces a similar result to an inquiry: a accumulation of current knowledge and the making of recommendations on solutions albeit not political or organisational solutions. Some of the knowledge from the conference had already been acted upon by the SPCC in the development of Australian Design Rules for controlling motor vehicle emissions.

The Senate inquiry is shown in Figure 6.11 as single histogram bars but it is very early in the proposed model. This suggests that the *inquiry* process may not have had a direct impact on the solution.

FIGURE 6.5: SYDNEY OXIDANT STUDY

APPROX. EXPENDITURE ON RESEARCH



6.8 Legislation

The problem of motor vehicle emissions was addressed by developing and promulgating Australian Design Rules (ADR) for new motor vehicles. In November 1972 the Clean Air Act was changed to provide for the control of emissions from motor vehicles by enabling the application of the ADRs (DGPH 1973). These required manufacturers to develop vehicles that emitted less pollutants. Figure 6.6 shows how the rules have required the progressive reduction in the amounts of carbon monoxide, hydrocarbons (HC), and nitrogen oxides (NOx) over the period 1973 to 1986.

ADR 26 required the reduction of 4.5% in carbon monoxide emissions from the idling engine by 1/1/72. ADR 27 involved reductions in carbon monoxide and HC by 1/1/74. ADR 37 in 1986 was predominantly concerned with the introduction of unleaded petrol but because it enabled catalytic converters (which do not work effectively with leaded petrol) to be installed in motor vehicles the carbon monoxide and HC could be significantly reduced.

Forest (1991) shows that the carbon monoxide emissions have potentially been reduced by 70% from pre 1972 levels and NOx emissions have potentially been reduced by 75% from pre 1972 levels. Both ADR 26 and 27 had been promulgated prior to the Director General of Public Health indicating that there was an ozone problem. (DGPH 1960 to 1971)

In understanding the process involved in the solution it is important to be aware of some of the time frames involved from the time a problem is first identified until it is possible to implement a complete solution.

Data presented by Voumard and Molitorisz (1994) suggests that it will take 15 to 20 years for the Sydney motor vehicle fleet to be converted to unleaded petrol. The twenty year period would be made up approximately as follows:

Planning period	2 years
Lead time to change car design	3 years
Replace older vehicles	15 years
TOTAL	**20 years.**

That is 20 years from 1986 when unleaded petrol was introduced.

APAC (1972) said that motor vehicle numbers would double in 12 years. This means that by the time a solution is put in place the current problem could have doubled so the solution has to solve twice the problem that currently exists. In 1973 there were 1.2 million vehicles. See Figure 6.1 for projections.

The Air Pollution Advisory Committee also looked other actions to combat smog. In early 1978 draft regulations to limit HC emissions form transfer points and storage vessels. Control of evaporation was instigated including evaporation form tanks, cars, and service stations.

The indicator used for this process is the cumulative reduction in hydrocarbons in exhaust emissions as shown in Figure 6.6.

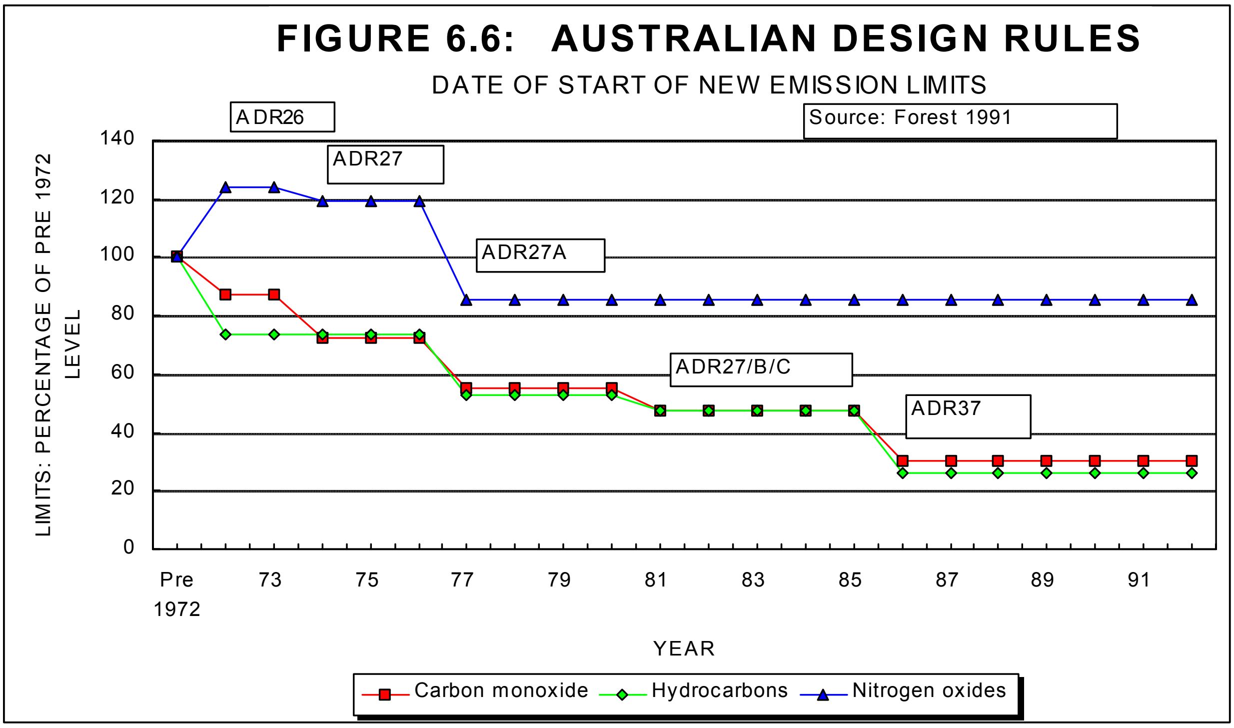


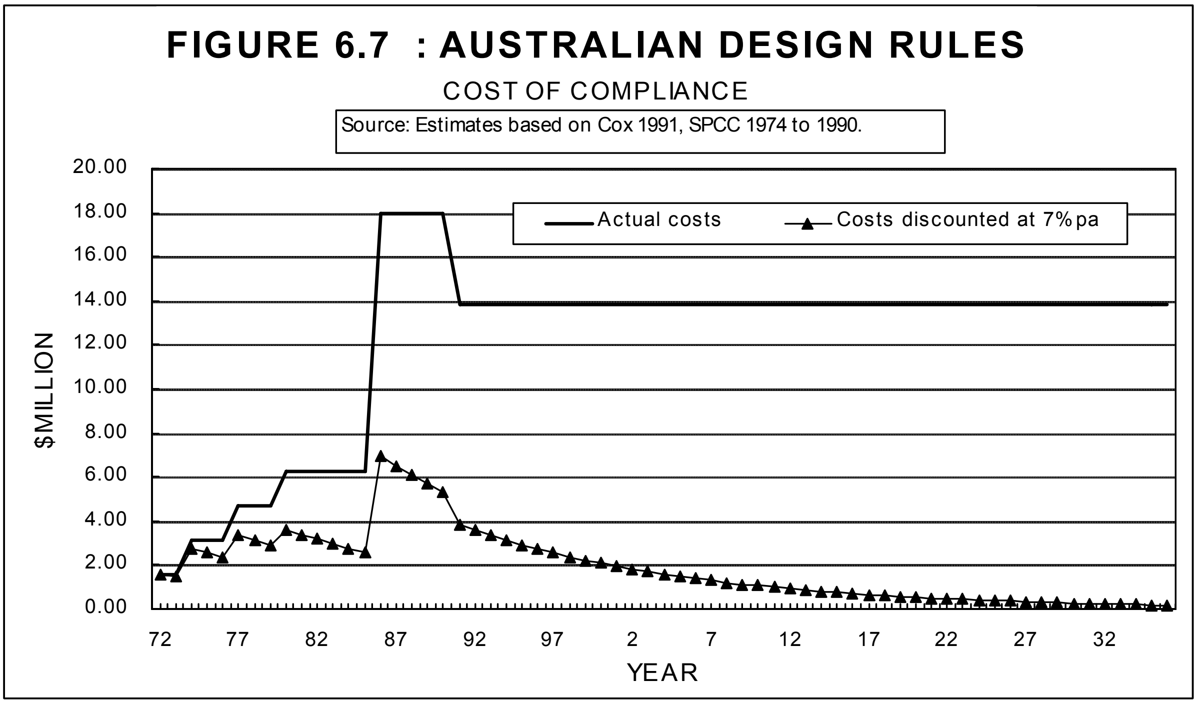
FIGURE 6.6: AUSTRALIAN DESIGN RULES

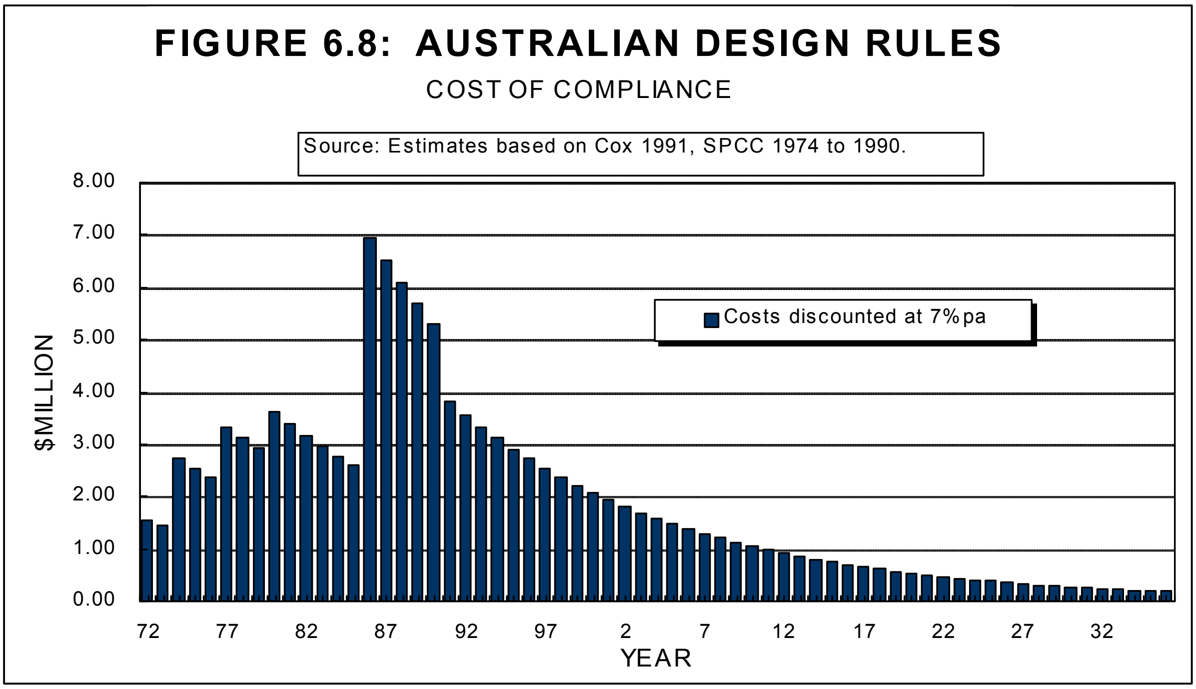
6.9 Allocation of Funds

Because cars can contribute up to 60% of the ozone problem (SPCC 1977a) a major part of the solution involved reducing motor vehicle emissions. This involved considerable cost and use of technology. Considerable effort was placed on determining the best control strategy, regulating it by design rules and manufacturing cars to suit. The SPCC 1977 annual report did not find a clear recommendation for either a HC or NOx reduction strategy but chose the HC because the technology was cheaper and more advanced and it also resulted in reduction in fuel usage. This was the path chosen.

Figures 6.7 and 6.8 show the approximate initial cost of complying with the ADRs to reduce hydrocarbon emissions. The ADRs required changes in car design that also helped reduce other pollutants like lead, carbon monoxide. The costs are based on data from Cox (1991) and an estimate by the author of other costs. The data is presented in 1972 dollars with future costs discounted at 7% per annum. (7% discount factor (real discount excluding inflation) is used by NSW Government Treasury to assess expenditure on government capital works.)

The indicator for this process used is the discounted cost of compliance as shown in Figure 6.8.





6.10 Organisational Change

A number of organisational changes occurred in relation to the control of air pollution over the time of this study. The Clean Air Act was enacted in 1961 and was fully effective when regulations were promulgated in 1964. The act was administered by the Air Pollution Control Branch of the Department of Public Health (DGPH 1960 to 1971).

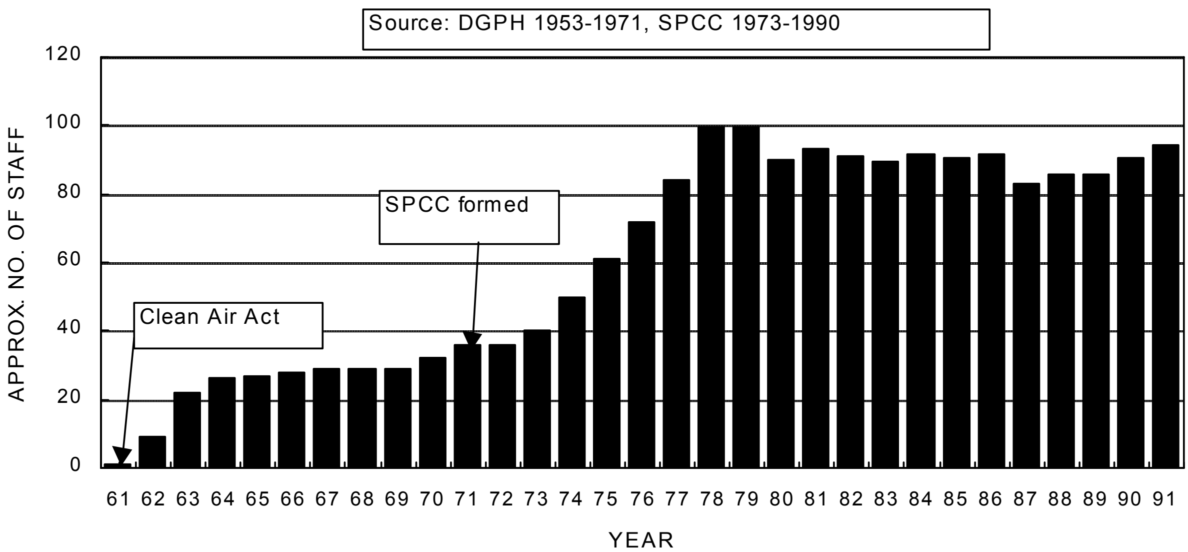
The increasing problems of water and air pollution resulted in the State Pollution Control Commission (SPCC) being formed in June 1971 to bring control of pollution under a single authority and to administer new laws on pollution though it wasn't until May 1974 that the SPCC had taken over full responsibility for administering the Clean Air Act (CAA) and Clean Waters Act (CWA) from the Director General of Public Health.

Figure 6.9 shows the build up of staff to 26 of the Air Pollution Control Branch of the Director General of Public Health (APCB) from 1961 to 1964. This is the indicator chosen to measure this process. It shows the combined staff numbers (estimated numbers associated with air pollution control) after the establishment of the SPCC to approximately 80 staff by 1977. This increased staff were responsible among other air pollution duties for administering the new controls required on motor vehicle through the Australian Design Rules, testing motor vehicle emissions, and monitoring ozone levels in the atmosphere. The major part of the increase in staff was required to control motor vehicle air pollution and the problem of ozone caused by motor vehicle emissions was a large part of the problem. (DGPH 1953 to 1971, SPCC 1973 to 1990)

In addition to SPCC/DGPH staff vehicle manufacturers would have required extra staff to design and manufacture components to reduce emissions in compliance with the ADRs but these are not included as a part of the indicator.

FIGURE 6.9: APCB AND SPCC STAFF

NUMBER OF PEOPLE ON AIR POLLUTION



6.11 Solutions in Place and Institutionalised

Once established the process of compliance with ADRs was essentially automatic both during manufacture and policed by periodic testing by the SPCC.

6.12 Extent of the Solution

The diagram (Figure 6.10) in the next section illustrates the solution to the ozone problem and the partial nature of that solution achieved in major ozone pollution episodes.

In 1960 measurements of atmospheric ozone were first undertaken by the Director General of Public Health (DGPH 1960 to 1971). The Director General of Public Health stated in its annual reports throughout the 1960s that there was no ozone problem in Sydney especially when compared with USA cities though in 1968 the Director General of Public Health stated that there could be a problem by 1992 unless controlled and time needed to be allowed for manufacturers to develop new engines and controls.

By 1970 intermittent Director General of Public Health monitoring was showing higher levels of ozone and it was now predicting that there may be a problem developing. In 1970 the Director General of Public Health was reporting on the need to relate air pollution to meteorology and looking to investigations into the role of the motor vehicles in air pollution. Motor vehicle emissions were not covered by the Clean Air Act (CAA). Carbon monoxide was the biggest concern of motor vehicle pollution with high levels especially in the Sydney business district.

In the Director General of Public Health annual report of 1971 (DGPH 1960 to 1971) the Director General of Public Health was measuring the ozone 1 hour average at 17pphm and indicating that ozone was approaching USA levels. This report also said that the motor vehicle was causing 60% of all air pollution.

On 11 November 1972 ozone peaked at 21pphm for 5 minutes causing some vegetation damage. Sydney was blanked in a visible haze caused by particulates.

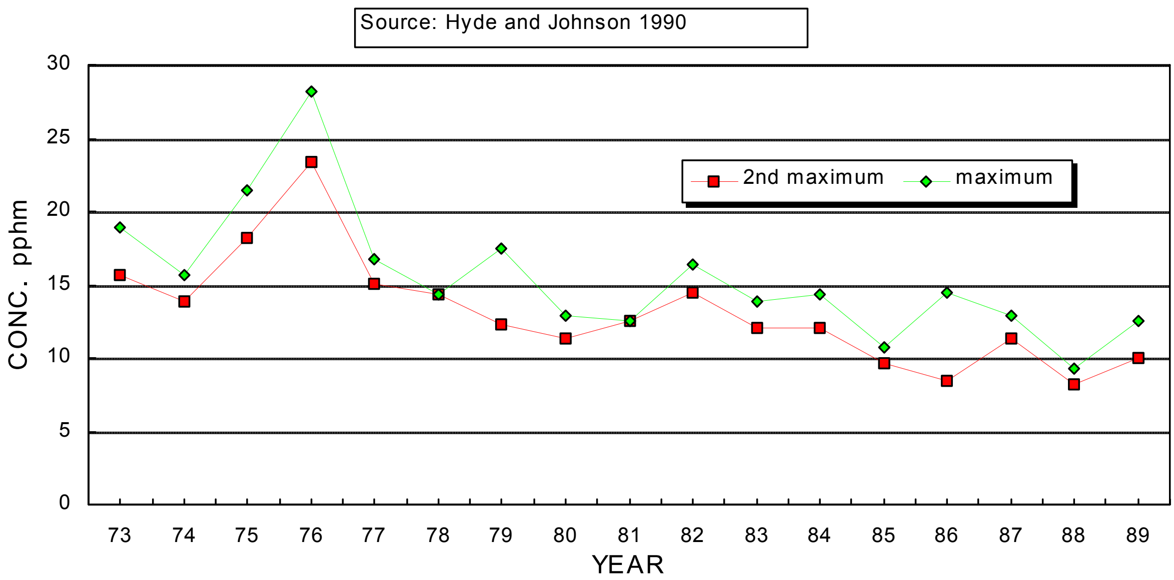
Figure 6.10 uses ozone measurements taken by the SPCC in Sydney from 1973 to 1989. SPCC measured among other items the 1 hour average at a number of sites. Figure 6.10 is the average of the maximum 1 hour readings for each summer from the sites at Wentworthville, Lidcombe, Marrickville, Liverpool, and Campbelltown as described by Hyde and Johnson (1990). Figure 6.10 shows a build up of high values from the early 1970s to peaks in 1974, a sharp decline in 1975 and a gradual decline from 1975 to 1983 and a flattening out during the mid and late 1980s.

Meteorology was being recognised as an important component in increasing the likelihood of exacerbating pollution. Also during the 1970s and 1980s meteorology had an important effect on ozone pollution formulation and some observers suggest that the reduction from the high levels experienced in the mid 1970s was caused more by propitious meteorological conditions than by legislated controls. (Johnson 1991 in NSW Government 1991)

Nevertheless the legislation in the form of ADRs did reduce the amount of one of the precursors of ozone, hydrocarbons, being emitted into the atmosphere. Hyde and Johnson (1990) say that the ozone problem is likely to increase again as the number of cars increase, population of Sydney expands into western locations where ozone is showing an increase, and because of the slower than expected replacement of older vehicles with newer vehicles which are fitted with more effective pollution control devices.

FIGURE 6.10: OZONE READINGS IN SYDNEY

AVERAGE OF FIVE SYDNEY MONITORING SITES



6.13 Processes

Figure 6.11 combines the indicators described in this chapter to measure each of the proposed model processes to show the sequence, size, and timing of the processes involved in the solution of Sydney's ozone problem have over the period 1961 to 1989 that contributed to a solution. Figures 6.3 to 6.10 (less Figure 6.7) presented in this section represent indicators of the strength of processes and the time over which they were active. In order to visualise the chronology and the overlapping of the processes involved in the solution to the atmospheric ozone pollution problem, these figures have been placed on a common time scale as shown in Figure 6.11. This diagram is a key to the understanding the interconnected nature and time frames of the processes.

The main processes are listed on the vertical axes of the diagram. For each process the horizontal axis is a measure of the time over which the process was active in the solution of the pollution problem and the vertical dimension is a measure of the intensity of the process.

The processes *harbinger* and *inquiry* are shown as single histogram bars as they are events that do not extend over one year in duration. The other process histograms show the trends over time. *Public opinion* and *political action* are shown over the whole period of the case study to contrast the early peaks with the late trough. The latter peaks in the early 1990s are not related to the solution of the brown haze problem.

6.14 Discussion

Figure 6.11 shows that the identification and recognition of the problem of visual air pollution both photochemical smog (summer haze) and brown haze (winter haze) took place in the 1960s and early 1970s (processes *people affected, harbinger*s). *Public concern* about this air pollution was being increasingly expressed through increasing numbers of public telephone complaints during this period. Increased political action in response to this general public and public authority concern took place in parliament in the early 1970s through parliamentary debates, private members questions, and the passing of legislation to among other things revise the Clean Air Act which had previously been passed in 1961. The SPCC was formed during this period in 1971 and powers over air pollution were transferred from the DGPH to the SPCC in 1974.

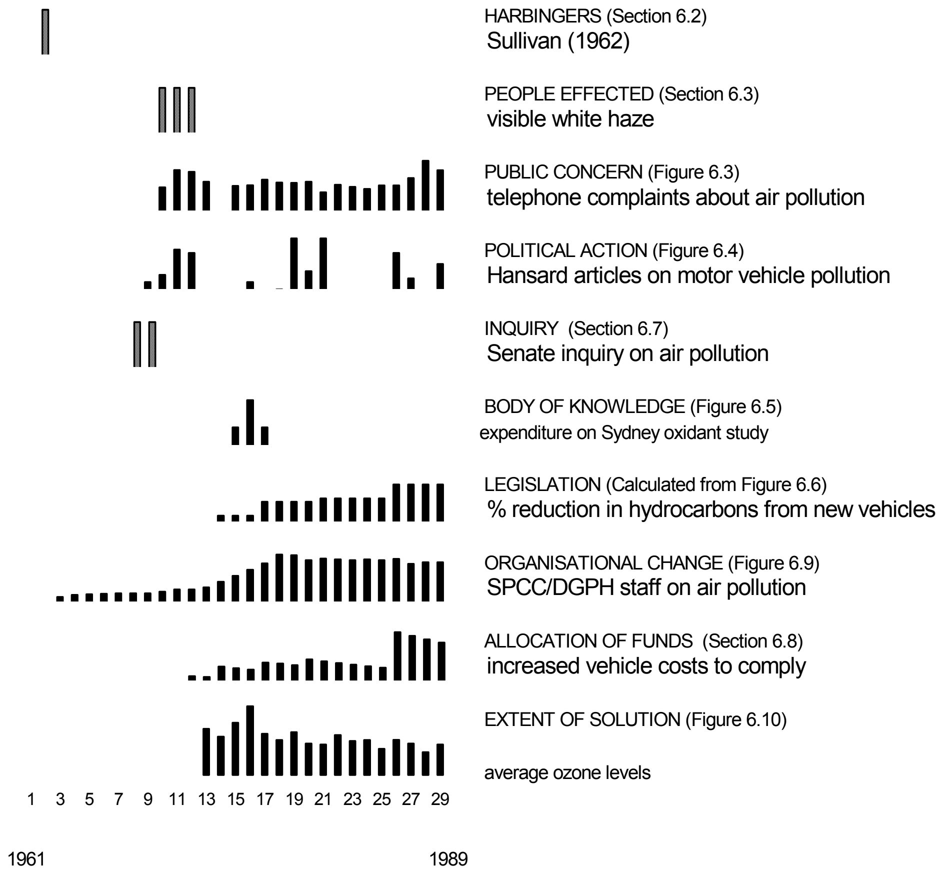
A need to undertake further research was identified because at the time there was a lack of scientific knowledge about the causes of and the solutions to the ozone problem . A scientific *body of knowledge* was generated about the problem of atmospheric ozone pollution through the Sydney Oxidant Study. A scientific conference promulgated this and other knowledge about air pollution in Sydney. During this latter process there was general recognition that the problem was significant. The solutions required *allocation of funds* by motor vehicle manufacturers to design and build better exhaust emission control devices and eventually the motoring public paying higher prices for cars.

The period of time from when the problem was first identified until a decision was made to actually implement a solution was about 15 years (1962 to 1977) while the time taken to implement a solution was about 11 years (1977 to 1988). By 1988 the solution had resulted in a significant reduction in average ozone levels (See Figure 6.10) to below the target level of 12pphm. The time taken to fully implement the solution would be even longer if the time taken to replace the motor vehicle fleet with motor vehicles using unleaded petrol was considered.

While the indicators chosen represent the magnitude change and duration of the processes it could be suggested that a better proof of the model might be achieved if the indicators of public concern and political action measured ozone pollution rather than air pollution in general. The author does not believe this would be possible because sufficient knowledge to scientifically distinguish between the causes of the two types of haze (brown and white) was not available at the time. (Sydney Morning Herald 1968 to 1992, NSW Government 1968 to 1991).

The process diagram Figure 6.11 provides a succinct summary of the processes involved in solving the brown haze pollution problem. It illustrates many aspects of the processes: the long time frames involved (over 25 years); the processes (e.g. social and institutional); the methods appropriate to measure the outputs from these processes; the identification of the role of public concern; and the partial nature of the solution. It could be called the political resolution rather than the solution. The case study also illustrates that the model and the methodology for quantifying the processes are valid and practical.

FIGURE 6.11: PROCESSES INVOLVED IN THE SOLUTION OF SYDNEY'S OZONE POLLUTION



Notes:

1. Vertical scales are % of largest y value. The first peaks of PUBLIC CONCERN AND POLITICAL ACTION are relevant for the solution but other peaks are shown to illustrate the change that occurs in these indicators.
2. Figure numbers in brackets are references to the detailed figures in this section containing the graph scales.
3. The data after the right hand end of the histograms e.g. after 1989 was not collected or shown as it was not relevant to the time period of the case study

7 OZONE AIR POLLUTION IN MELBOURNE

7.1 Historical context

The chapter describes the air pollution problem of atmospheric ozone in Melbourne, Australia caused by the motor vehicle emissions.

Galbally (1972) described the measurement of ozone at Aspendale on the eastern side of Port Phillip Bay (on which Melbourne is situated) and showed over the period from 1965 to 1971 a steadily increasing trend as shown in Figure 7.1. The increase was from 2pphm ozone concentration to 4pphm at 1300 hours (monthly mean at surface with up to 15 observations per month) and an increase from 2pphm to 4pphm at 1100 hours. Galbally (1972) observed by comparing Aspendale measurements with rural sites that the ozone increase was probably of urban origin.

By 1974 the EPA (EPAV 1974) was predicting that Melbourne would if no action was taken have a health problem induced by high ozone levels.

Each of the following sections describe the solution of the ozone pollution problem in terms of the processes of the proposed model, describe the indicators chosen for each process and provide graphs showing the quantification of these chosen indicators. In a later section (Section 7.14) the process indicators are combined in a process diagram showing the complete solution.

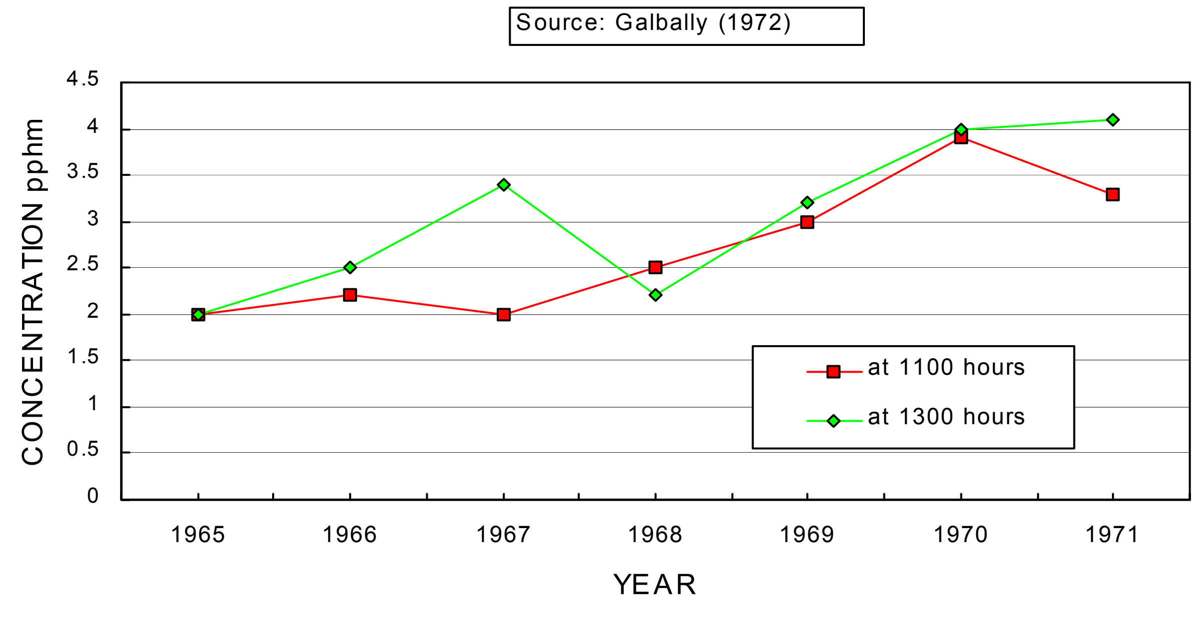
7.2 Problem and People Affected

A Senate inquiry (SSC 1969) concluded that ozone was not a current problem in Australia but could be by 1992.

Galbally (1972) as shown in Figure 7.1 had been taking measurements and writing papers describing steadily increasing atmospheric ozone concentrations though as Figure 7.1 shows it was probably not until 1970 that a trend emerged. The levels of ozone measured by Galbally (1972) though were below the EPA's subsequent objective of 12pphm 1 hour reading. (Refer Section 7.13.)

FIGURE 7.1: MELBOURNE OZONE TREND

YEARLY AVERAGE READINGS AT ASPENDALE



EPAV (1971) reported public concern about pollution including air pollution and the next year raised concern about the atmospheric haze and the contribution to pollution from motor vehicles.

The indicator chosen to measure this process is the early identification of the problem in the EPA annual report of 1971 as shown in Figure 7.16.

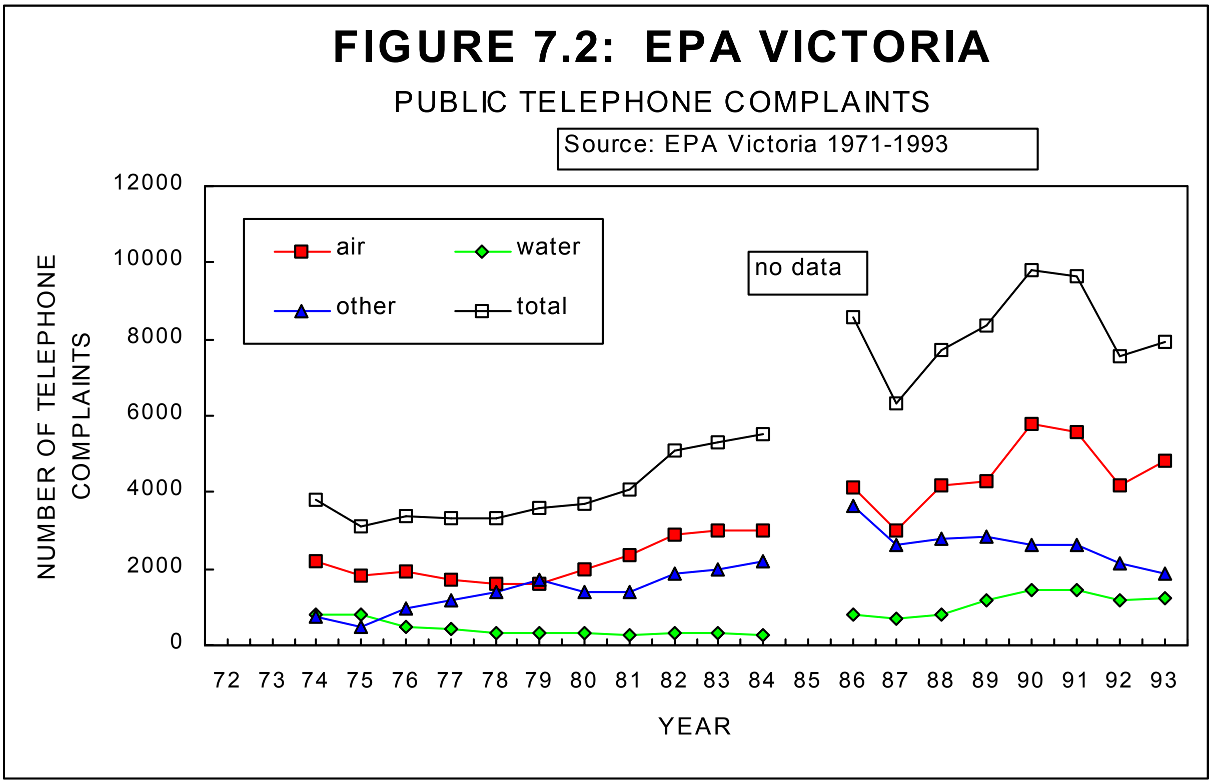
7.3 Harbinger

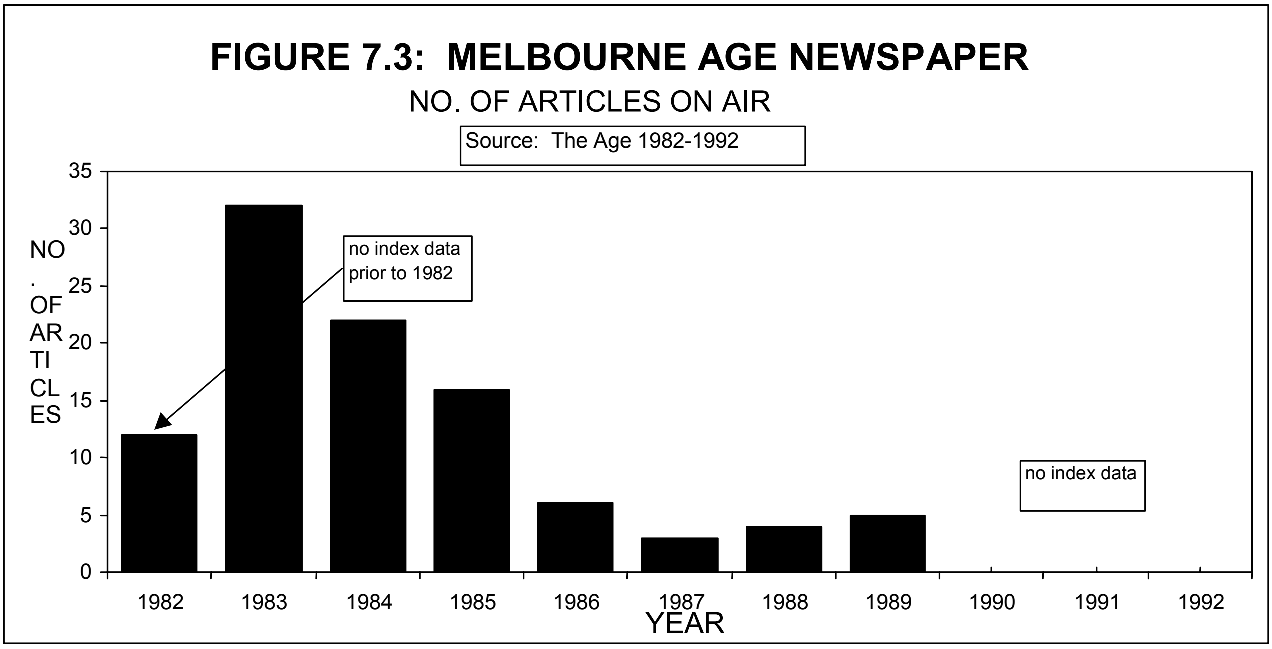
By 1974 (EPAV 1974) the EPA were confirming that Melbourne had an ozone pollution problem and that the pollution would cause health and visual amenity problems unless action were taken to solve the problem. They also confirmed the motor vehicle as a significant cause of the problem.

The indicator chosen to measure this process is the EPA annual report of 1974 as shown in Figure 7.16.

7.4 Public Concern about Air Pollution

Figure 7.2 shows the increasing level of public complaint about air pollution though the EPA annual reports state only a proportion of this is motor vehicle pollution. No data was published about the source or type of pollution on which the complaints were based. Another measure of public concern would be articles in a Melbourne newspaper on air pollution of pollution caused by motor vehicles. There is no index of articles for this period though it would be possible to peruse the newspapers for the period from 1968 to 1982 to extract this information though it would be a sizeable task. An index from the Melbourne Age newspaper is available for the period 1985 onwards but this is outside the period on interest as shown in Figure 7.3.





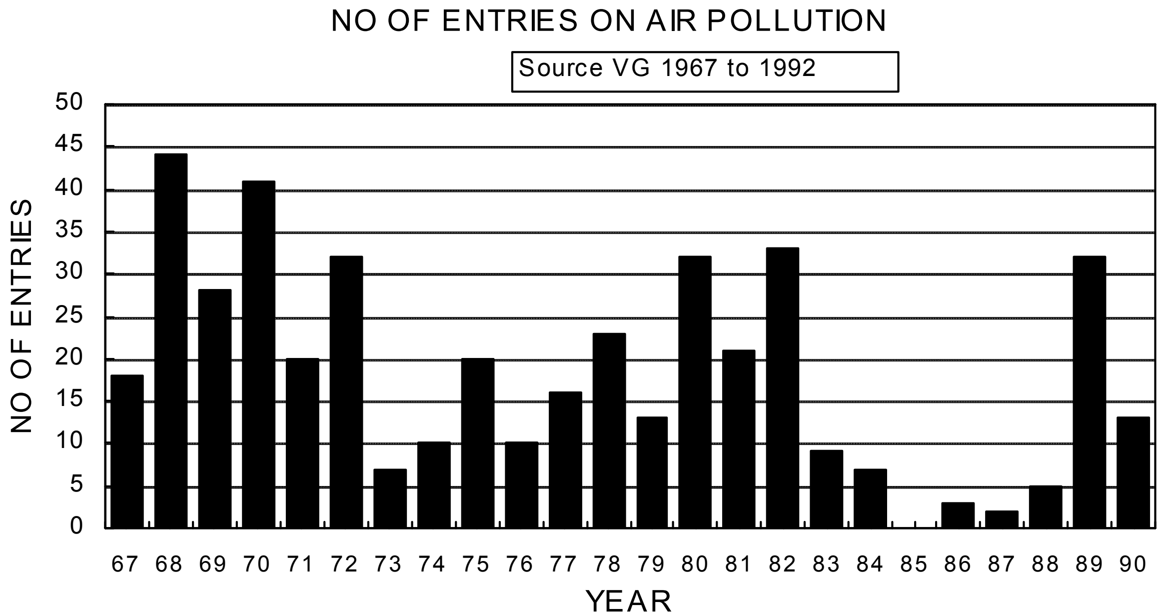
At the commencement of the EPA's complaint service complaints were about 2000 per year and this remained constant until a steady rise in 1979. The indicator used is the level of public complaints about air pollution as shown in Figure 7.2.

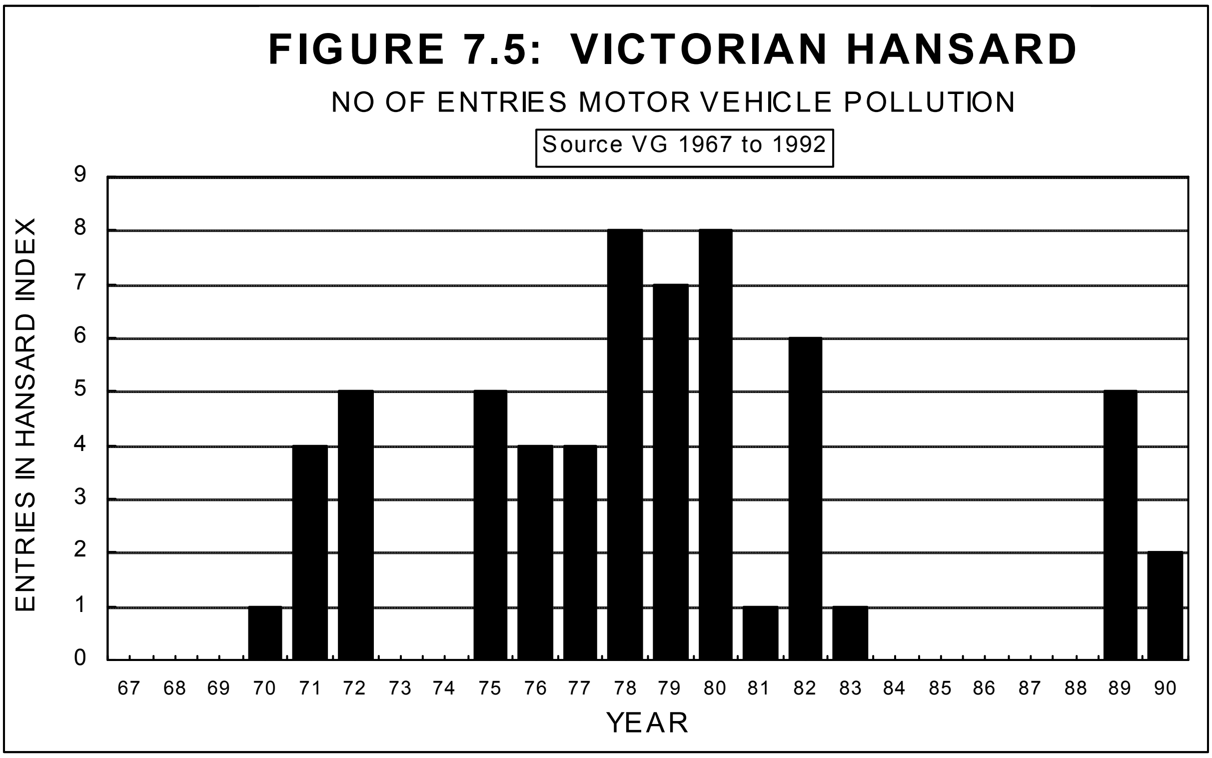
7.5 Political Action

The Victorian parliament engaged in the debate on air pollution of which air pollution from motor vehicles was a component. Figure 7.4 (VG 1967 to 1992) shows the number of indexed entries on air pollution from the record of debate in the Victorian parliament (Hansard) over the period 1967 to 1991. It shows a build up from 20 entries per year in 1967 to a level of 45 in 1968 and a fairly high level throughout the late 1960s and early 1970s with the level then dropping back during the 1970s with a rise in the early 1980s. The Victorian Environmental Protection Authority was formed in 1971 in response to increasing public concern with pollution (EPAV 1971).

Figure 7.5 (VG 1967 to 1992) shows the number of index entries on motor vehicle related pollution from Victorian parliamentary debate records over the period 1967 to 1991. It shows a build up of a peak in 1972, no entries in 1973 and 1974 and a level similar to 1972 from 1975 to 1977. There was a build up to a peak in the early 1980s which corresponds to the peaks in Figure 7.4. The indicator used for measuring *political action* is the number of references in Victorian Parliamentary debates (VG 1967 to 1992) to air pollution caused by motor vehicles as shown in Figure 7.5.

FIGURE 7.4: VICTORIAN HANSARD

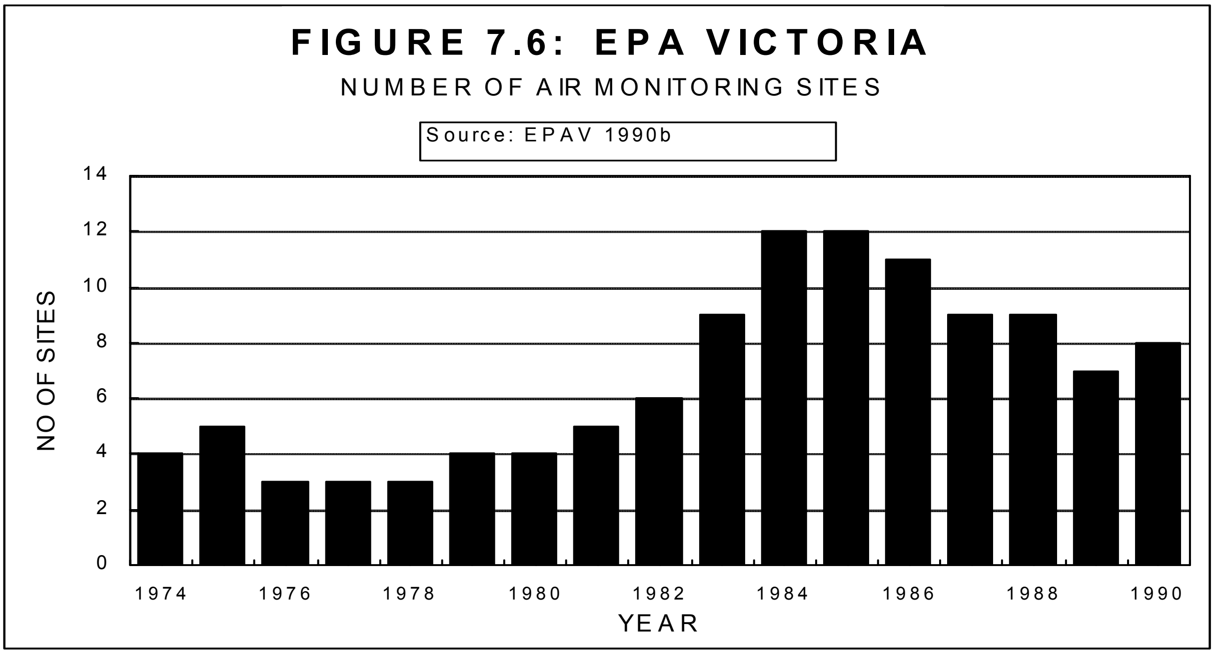




7.6 Body of Knowledge

There was an ongoing generation of knowledge during the 1970s about pollution and air pollution in general. Figure 7.6 shows the number of sites sampled for air pollution in Melbourne. It shows an initial number of 3 to 4 then a build up to 12 in 1984.

A study by the EPA in 1975 (EPAV 1975) concluded that the motor vehicle was the main cause of Melbourne's photochemical smog.



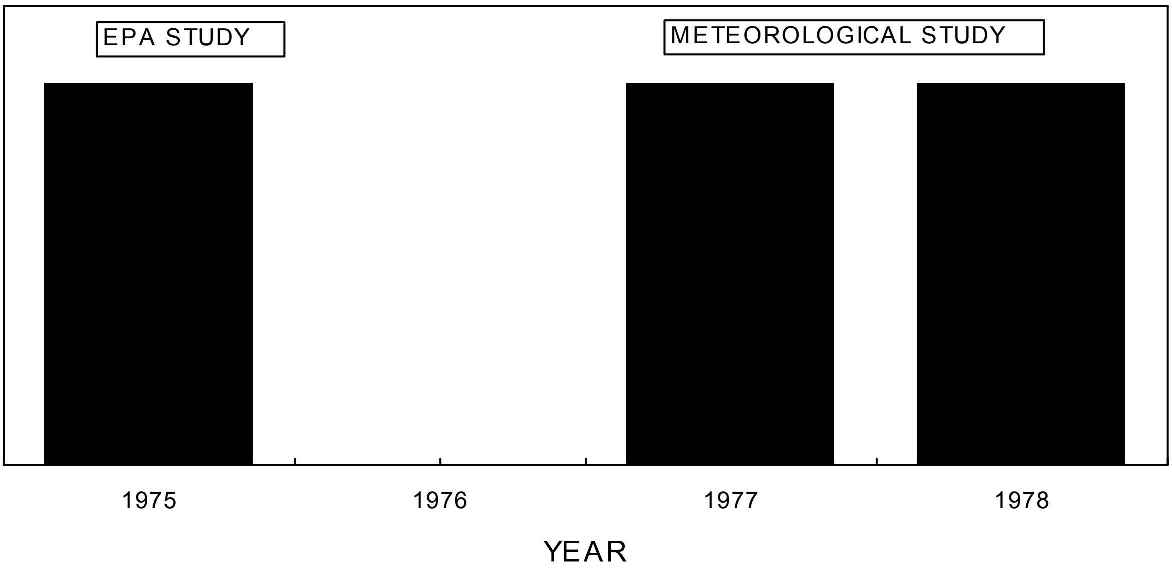
A 3 year meteorological study was undertaken by the University of Melbourne over the period 1977 to 1979 to obtain a better understanding of how meteorological factors would affect pollution. (EPAV 1979).

The indicator used for the *body of knowledge* in the form of a histogram (Figure 7.7) is the years over which the important research on motor vehicle related air pollution was undertaken i.e. 1975 and 1977 to 1978.

FIGURE 7.7: MELBOURNE OZONE

BODY OF KNOWLEDGE

Source: EPAV (1975, 1979)



7.7 Inquiry

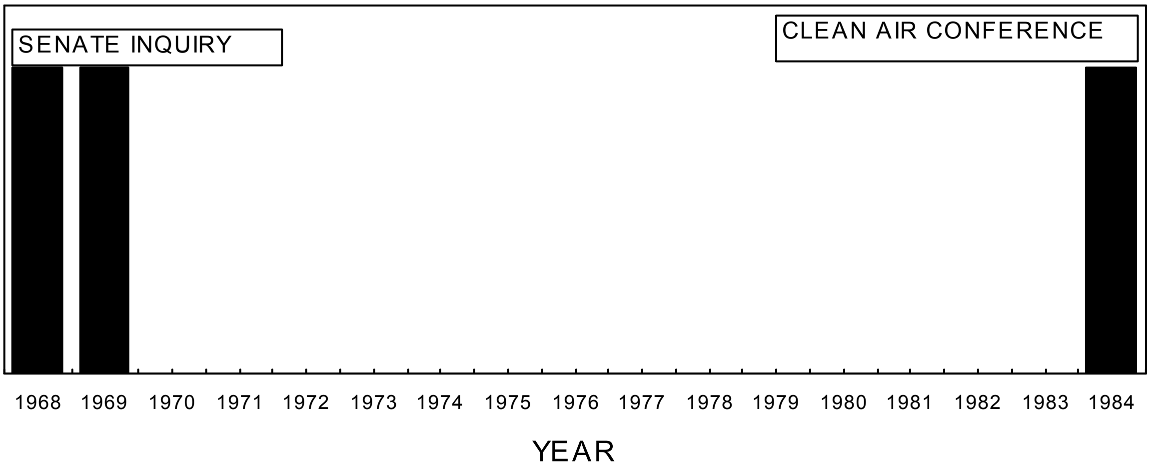
Over the period May 1968 to August 1969 the Commonwealth Senate (SSC 1969) held an inquiry into air pollution but concluded that ozone pollution in Australia (including reference to Melbourne) was not a current problem but could be in the future.

An international clean air conference was held in Melbourne in 1984 and this inter alia confirmed Melbourne's ozone pollution problem. A major conference produces a similar result to an inquiry: a gathering of current knowledge and the making of recommendations on solutions albeit not political or organisational solutions.

Some of the knowledge from the conference had already been acted upon by the EPA in the development of Australian Design Rules for controlling motor vehicle emissions.

Both these events (the Senate inquiry and the conference) are shown in Figure 7.8 as single histogram bars but neither fit neatly into the progression of processes for the proposed model. This suggests that the inquiry process may not have had a direct impact on the solution.

FIGURE 7.8: MELBOURNE AIR POLLUTION
INQUIRIES/CONFERENCES



7.8 Legislation

The problem of motor vehicle emissions was addressed by developing and promulgating Australian Design Rules (ADR) for new motor vehicles. In 1976 ADR 27A was proscribed for vehicles sold in Victoria. This required manufacturers to develop vehicles that emitted less hydrocarbons and nitrogen oxides. ADR 37 starting in 1986 was predominantly concerned with the introduction of unleaded petrol but because it enabled catalytic converters (which do not work effectively with leaded petrol) to be installed in motor vehicles which meant that the carbon monoxide and hydrocarbon (HC) emissions could be significantly reduced. (EPAV 1977)

Figure 7.9 shows how the rules have required the progressive reduction in the amounts of carbon monoxide, hydrocarbons (HC), and nitrogen oxides (NOx) over the period 1976 to 1986.

In understanding the process involved in the solution it is important to be aware of some of the time frames involved from the time a problem is first identified until it is possible to implement a complete solution.

Data presented by Voumard and Molitorisz (1994) suggests that it will take 15 to 20 years for the Sydney motor vehicle fleet to be converted to unleaded petrol. The twenty year period would be made up approximately as follows:

Planning period	2 years
Lead time to change car design	3 years
Replace older vehicles	15 years
TOTAL	**20 years.**

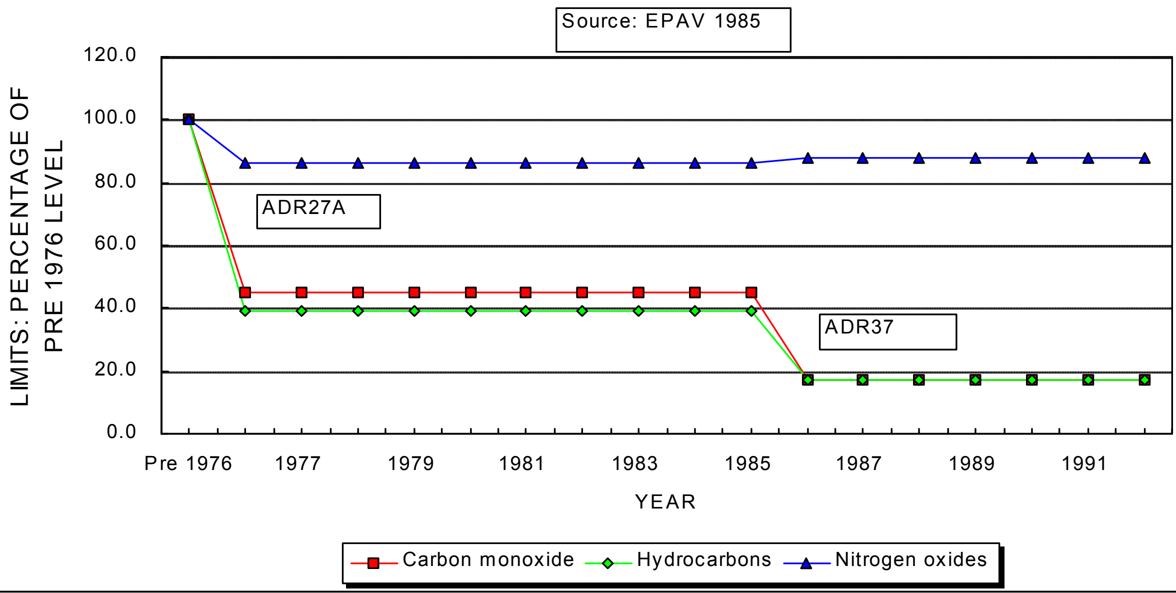
That is 20 years from 1986 when unleaded petrol was introduced.

APAC (1972) said that motor vehicle numbers would double in 12 years. This means that by the time a solution is put in place the current problem could have doubled so the solution has to solve twice the problem that currently exists. It is expected that a similar situation would exist for Melbourne.

The indicator used for this process is the cumulative reduction in hydrocarbons in exhaust emissions as shown in Figure 7.9

FIGURE 7.9: AUSTRALIAN DESIGN RULES

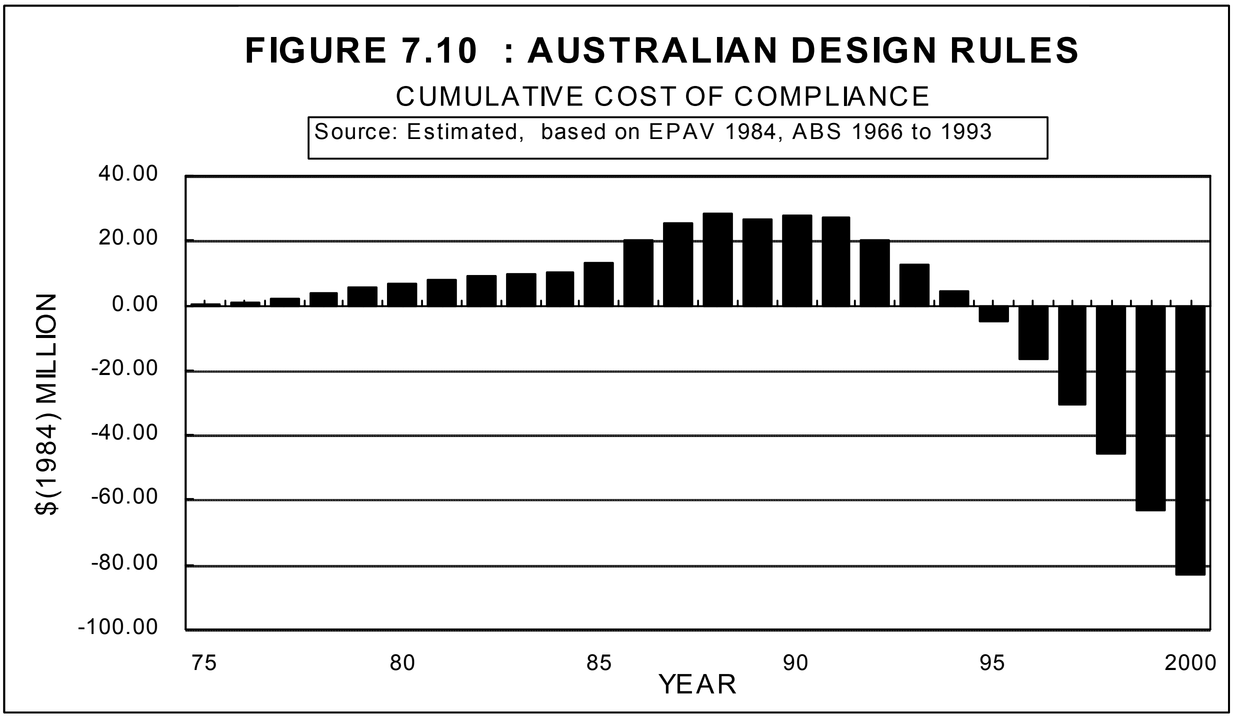
DATE OF START OF NEW EMISSION LIMITS

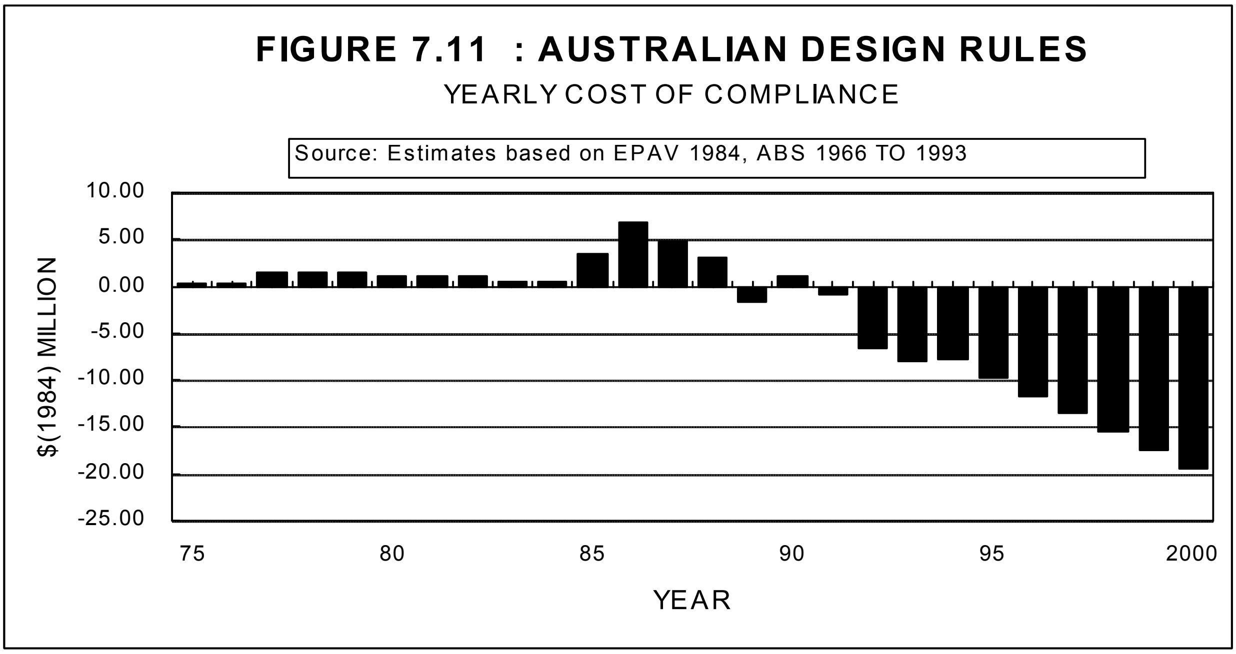


7.9 Allocation of Funds

Because motor vehicles are a major contributor to ozone problem (EPAV 1975) a major part of the solution involved reducing motor vehicle emissions. The EPA reported that while there were costs of implementing the new technology required to control motor vehicle exhaust emissions there were ultimately likely to be savings. Costs and savings involved with the introduction of unleaded petrol and catalytic converters (EPAV 1984) included: operating costs (fuel savings 8 to 10% and maintenance savings $20 to $40 per year; and capital costs (catalysts cost $150 to $250). They calculated that the once off extra costs would take 2 to 3 years to recover with the potential ongoing savings.

Figures 7.10 and 7.11 show how these direct costs (Cumulatively and yearly) vary with time across the estimate Victorian car fleet as it increases with time. Increased costs would have also been incurred by the EPA in extra vehicle testing but these have not been included in the indicator. The indicator used for this process is shown in Figure 7.11.





A number of organisational changes would have occurred in relation to the control of air pollution over the time of this study. Figure 7.12 shows the approximate increase in numbers of EPA staff as their role in pollution control expanded based on data presented in the EPA Annual Reports. It also shows the approximate number of staff employed in the air branch. (EPAV 1971 to 1993).

Figure 7.12 shows the build up of total staff from a commencement actual level of 134 in 1972 to an actual level of about 200 in 1978. Growth was steady to about 250 in 1989 with a sharper rise then to the early 1990s. The air branch followed the overall trend increase in actual people from 36 in 1972 to about 50 in 1978 and through the mid 1980 and then increased to about 80 people.

The indicator chosen (Refer Figure 7.13) to measure this process is the estimated number of people in the air branch based on the limited data shown in Figure 7.12. This increased staff were responsible among other air pollution duties for administering the new controls required on motor vehicle through the Australian Design Rules, testing motor vehicle emissions, and monitoring ozone levels in the atmosphere. A major part of the increase in staff was required to control motor vehicle air pollution and the problem of ozone caused by motor vehicle emissions. (EPAV 1971 to 1993)

In addition to EPA staff vehicle manufacturers would have required extra staff to design and manufacture components to reduce emissions in compliance with the ADRs. These staff numbers have not been included in the indicator.

FIGURE 7.12: EPA VICTORIA STAFF LEVELS

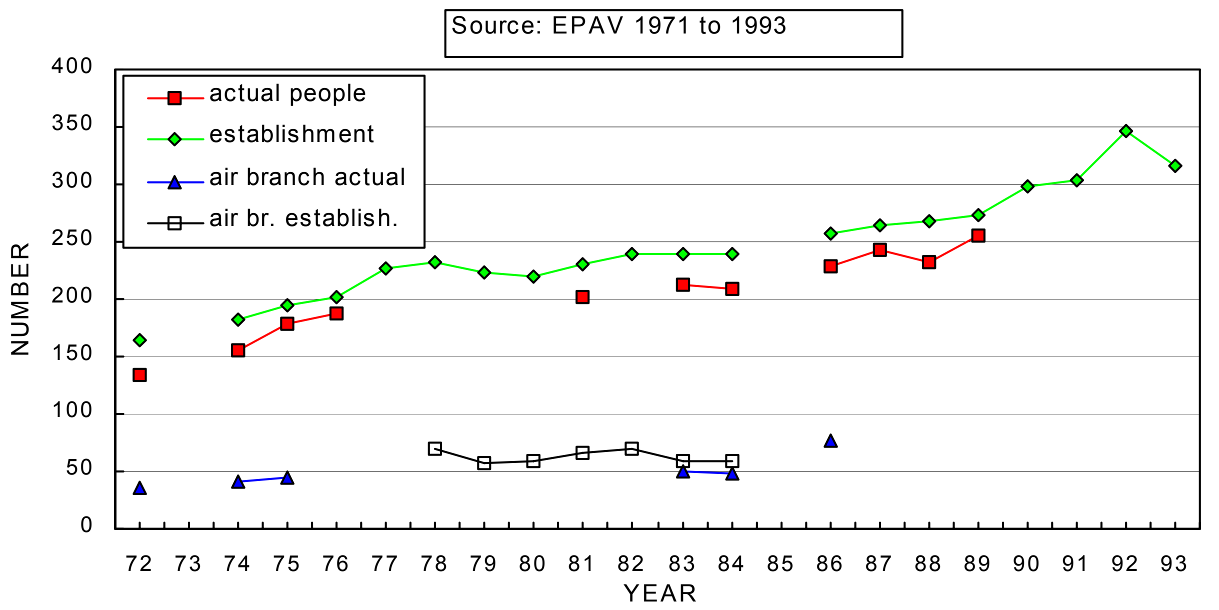
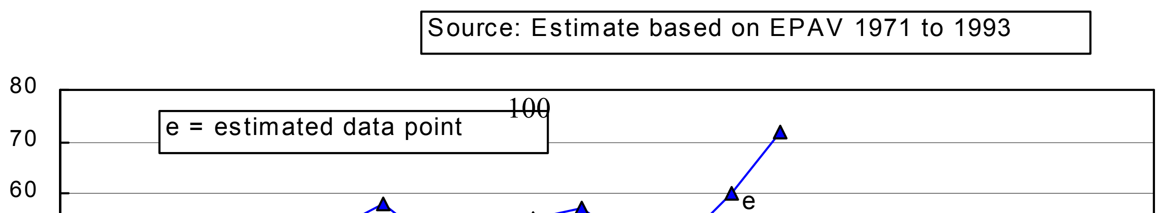


FIGURE 7.13: EPA VICTORIA ESTIMATED STAFF LEVELS

AIR POLLUTION BRANCH



7.11 Solutions in Place and Institutionalised

Once established the process of compliance with ADRs was essentially automatic both during manufacture and policed by periodic testing by the EPA (EPAV 1971 to 1993).

7.12 Extent of the Solution

The diagrams in the next section illustrate the solution to the ozone problem and the partial nature of that solution achieved.

Figure 7.14 shows the average of maximum ozone readings taken from 12 sites in the Melbourne metropolitan area and the maximum values for the years 1973 to 1990. Figure 7.15 shows the number of days that the EPA's ozone one hour acceptable level of 12pphm was exceeded in a year. It should be noted that in the early 1980s more sites were sampled and this would contribute to more exceedences.

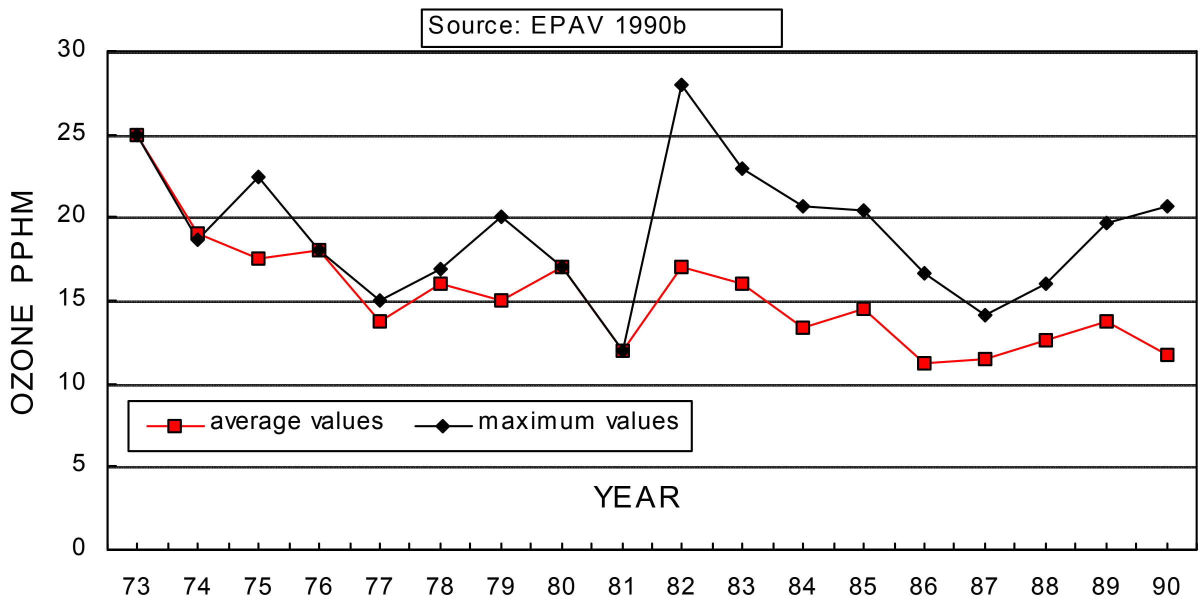
The legislation in the form of ADRs helped reduce the amount of one of the precursors of ozone, hydrocarbons, being emitted into the atmosphere. Figure 7.15 shows that there has been a steady downward trend though maximum values did increase in the early 1980s.

EPA (EPAV 1982) stated in 1982 that there was a considerable ozone problem but that the introduction of catalytic converters and unleaded petrol in 1986 would reduce the problem.

Streeton (1990) said that Melbourne still had in 1990 a major ozone problem though average levels were approaching the then current goal of 12pphm. EPA (EPAV 1990a) believed that there had been some reduction over the period 1982 to 1987 but that this fall has not been sustained probably because of a combination of unfavourable meteorological conditions and slower that expected conversion to unleaded vehicles (i.e. replacement of the old fleet with new vehicles) which had only amounted to 30% of the total fleet. Streeton (1990) believed that the goal should be further reduced to 8pphm.

Figure 7.15 also shows the exceedences of the 1 hour 15pphm level, which was considered by the EPA as a detrimental level. (EPAV 1981) The average ozone values (Figure 7.14) are used as the indicator of this process.

FIGURE 7.14: OZONE READINGS IN MELBOURNE: AV. OF MAXIMUMS FOR YEAR

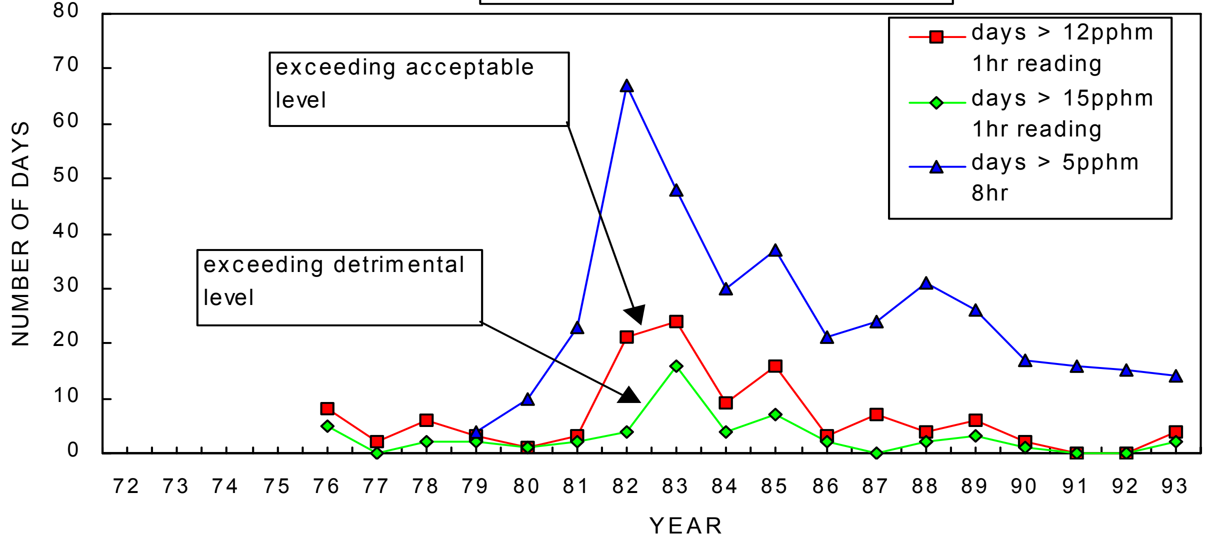


The average values are the average of the yearly 1 hour maximums for 12 sites in Melbourne

The maximum values are the maximums of the yearly 1 hour maximums for 12 sites in Melbourne

FIGURE 7.15: EPA VICTORIA OZONE MONITORING: DAYS EXCEEDING THE OZONE TARGET

Source: EPAV 1971 to 1993



7.13 Processes

Figure 7.16 combines the indicators described in this chapter to illustrate each of the proposed model processes to show the sequence, size, and timing of the processes involved in the solution of Melbourne's ozone problem have over the period 1965 to 1990 that contributed to a solution.

Figures 7.1 to 7.14 presented in this paper represent indicators of the strength of processes and the time over which they were active. In order to visualise the chronology and the overlapping of the processes involved in the solution to the atmospheric ozone pollution problem, Figures 7.2, 7.5, 7.7, 7.8, 7.9, 7.11, 7.13 have been placed on a common time scale as shown in Figure 7.16. This diagram is a key to the understanding the interconnected nature and time frames of the processes.

The main processes are listed on the vertical axes of the diagram. For each process the horizontal axis is a measure of the time over which the process was active in the solution of the pollution problem and the vertical dimension is a measure of the intensity of the process.

The processes *harbinger, people affected, body of knowledge* and *inquiry* are shown as single histogram bars as they are events that do not extend over one year in duration. The other process histograms show the trends over time. Public opinion and political action are shown over the whole period of the case study to contrast the early peaks with the later trough.

7.14 Discussion

Figure 7.16 shows that the identification and recognition of the problem of visual air pollution both photochemical smog took place in the late 1960s and early 1970s (processes *people affected, harbingers*). *Public concern* about this air pollution was being increasingly expressed through among other things increasing numbers of public telephone complaints. There was a fairly steady increase throughout the 1970s and a greater rate on increase throughout the 1980s. This indicator is a more indirect indicator as most of the initial solution actions took place prior to the second build up of public complaints. Increased political action in response to this general public and public authority concern took place in parliament in the early 1970s through parliamentary debates, private members questions, and the passing of legislation. The EPA was formed during this period in 1971 and with powers over air pollution.

A need to undertake further research was identified because at the time there was a lack of scientific knowledge about the causes of and the solutions to the ozone problem. A scientific *body of knowledge* was generated about the problem of atmospheric ozone pollution and the effect of meteorology on levels of air pollution. *Legislation* was promulgated in the adoption of Australian Design Rules to reduce emissions of one of the ozone precursors from motor vehicles. The solutions required *allocation of funds* by motor vehicle manufacturers to design and build better exhaust emission control devices and eventually the motoring public paying higher prices for cars.

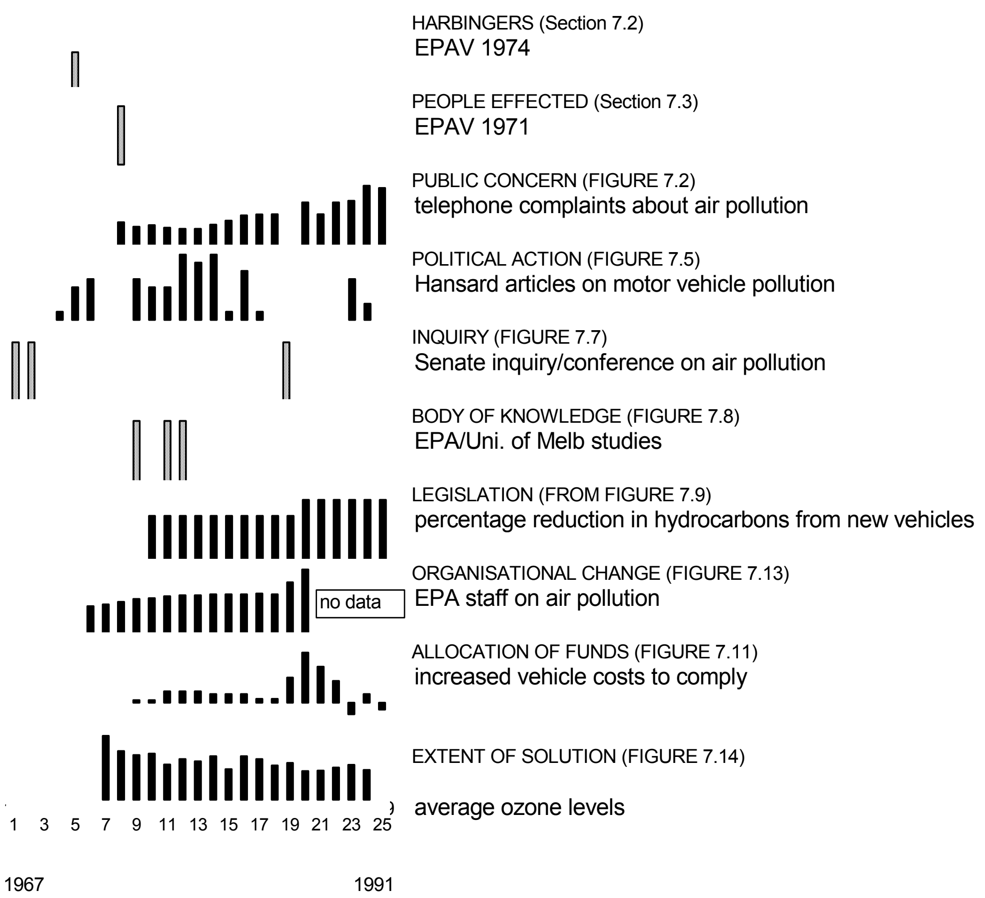
The period of time from when the problem was first identified until a decision was made to actually implement a solution was about 14 years (1971 to 1985) while the time taken to implement a solution was about 7 years (1985 to 1992). By 1989 the solution had resulted in a significant reduction in average ozone levels (See Figure 7.14) to close to the target level of 12pphm. The time taken to fully implement the solution would be even longer if the time taken to replace the motor vehicle fleet with motor vehicles using unleaded petrol was considered.

It is important to note that by 1990 the high levels of the early 1970s had been reduced but they were not always below the target of 12 pphm and the levels appeared to be on the rise again. Also Streeton (1990) recommended that the target should be reduced to 8 pphm. This indicated that while a solution was in place in 1990 it was only a partial solution. It is not clear from the data whether the observed partial solution was the result of compromise in the political process, lack of sufficient knowledge of the real problem, or the inability to forecast the likely future problem when the solutions were initially put in place.

While the indicators chosen represent the magnitude change and duration of the processes it could be suggested that a better proof of the model might be achieved if the indicators of public concern and political action measured ozone pollution rather than air pollution in general. The author does not believe this would be possible because sufficient recorded information to distinguish between the causes of air pollution was not available at the time. (VG 1967 to 1992).

The process diagram Figure 7.16 provides a succinct summary of the processes involved in solving the ozone pollution problem. It illustrates many aspects of the processes: the long time frames involved (over 20 years); the processes (e.g. social and institutional); the methods appropriate to measure the outputs from these processes; the identification of the role of public concern; and the partial nature of the solution. It could be called the political resolution rather than the solution. The case study also illustrates that the model and the methodology for quantifying the processes are valid and practical.

FIGURE 7.16 :PROCESSES INVOLVED IN THE SOLUTION OF MELBOURNE'S OZONE PROBLEM



Notes:

1.Vertical scales are % of largest y value. The first peaks of PUBLIC CONCERN AND POLITICAL ACTION are relevant for the solution but other peaks are shown to illustrate the change that occurs in these indicators.
2. Figure numbers in brackets are references to the detailed figures in this section containing the graph scales.
3. The data after the right hand end of the histograms e.g. after 1991 was not collected or shown as it was not relevant to the time period of the case study

8 BEACH POLLUTION IN SYDNEY

8.1 Historical Context

This section describes the water pollution problem in Sydney caused by sewage pollution of Sydney's beaches.

Pollution caused by the disposal of sewage in Sydney has been a continuing problem since Sydney was settled by European people (Coward 1988). The magnitude of task of disposal of sewage in Sydney and the pollution problems caused have increased as the population of Sydney has increased from approximately 300 000 in the 1880s to over 3 500 000 in the late 1980s.

In general terms sewage has been disposed of at locations that were away from population centres and with treatment methods that were considered adequate and affordable at the time. As the population of Sydney increased and expanded people came into contact with the location and the effects of sewage disposal either through the location of their dwellings or their places of recreation or work. This has produced cycles of pollution creation and pollution abatement since Sydney was settled by Europeans (Coward 1988).

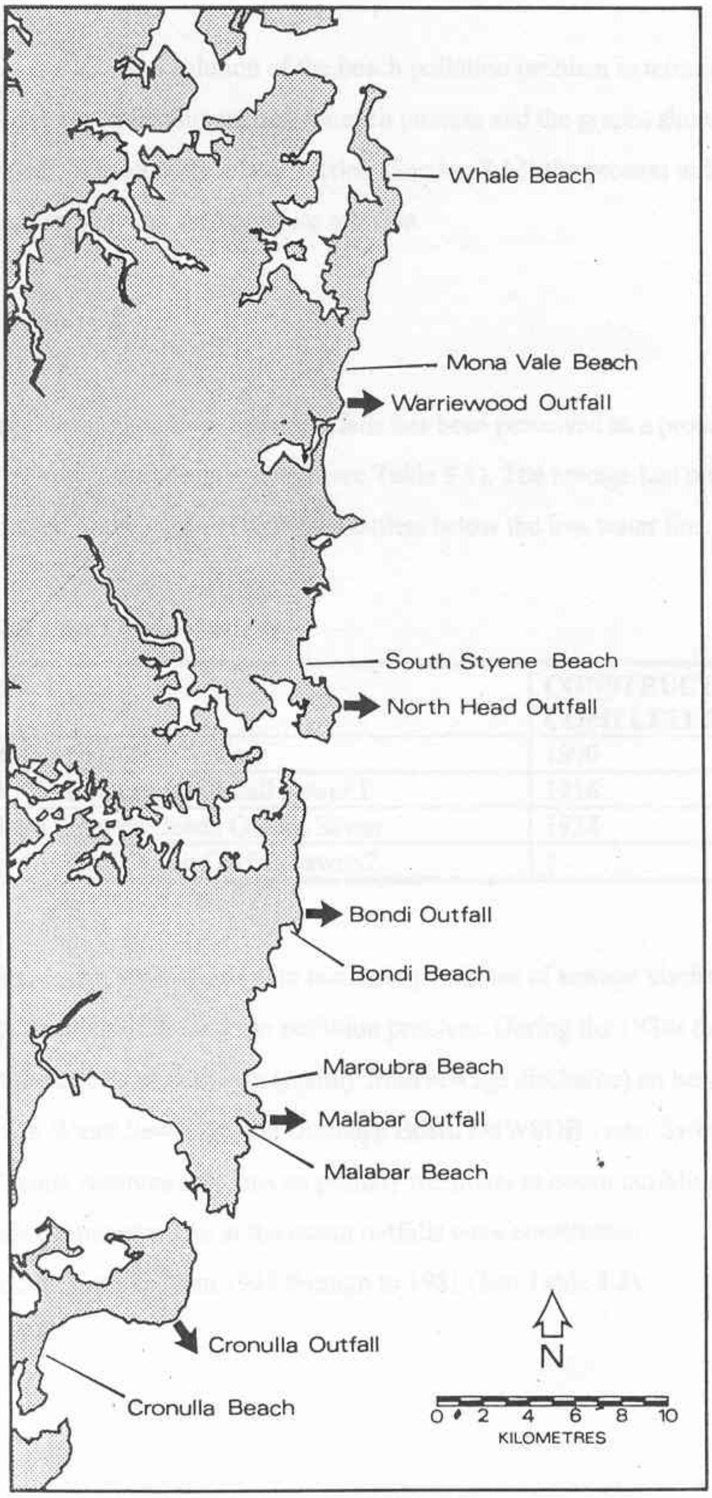
For a large part of this century the majority of Sydney's sewage has been discharged at cliff face outfalls directly into the ocean with a low level of treatment (See Figure 8.1). Cliff face discharge of sewage (with primary treatment or less) has contributed to beaches becoming heavily polluted at times of unfavourable tides and winds. The frequency and severity of pollution have increased over recent years (Water Board 1989 to 1992, see also Figure 8.14). The construction of the deep ocean outfalls which transfer sewage further out to sea (up to 3.6km and at depths of 60m to 80m) have made a significant improvement to the quality of water on beaches. A higher level of treatment at the ocean sewage treatment plants has also improved the quality of the effluent being discharged.

The Water Board (previously MWSDB) has a role in identifying potential problems but other processes are required to enable agreement to be reached that the problem is severe enough to take action. A history of the Water Board (Beder 1989) suggests that the Water Board have not always been the first to tell the public that a potential environmental problem exists. The evidence of this study is that the problem is often brought to the public's attention through the media (Sydney Morning Herald 1963 to 1992) or through the NSW parliament (NSW Government 1968 to 1991).

FIGURE 8.1: SYDNEY'S MAJOR SEWAGE OUTFALLS IN THE 1980s

SHOWING LOCATION OF OUTFALLS AND BEACHES

Source: CCE 1976



The Water Board has a responsibility to plan for and implement the treatment and disposal of sewage. This role requires it to forecast future sewage loads, types of treatment, means of disposal, and capital and operating costs. The political process allocates the money but at a level consistent with perceived affordability and influenced by public concern and pressure.

This chapter discusses the processes that have been involved in solving the problem of beach pollution caused by sewage discharge into the ocean off Sydney's coastline.

Each of the following sections describe the solution of the beach pollution problem in terms of the processes of the proposed model, the indicators chosen for each process and the graphs showing the quantification of these chosen indicators. In a later section (Section 8.13) the process indicators are combined in a process diagram showing the complete solution.

8.2 Problem and People Affected

Pollution of beaches by sewage discharged from ocean outfalls has been perceived as a problem (Coward 1988) from soon after they were commissioned (see Table 8.1). The sewage had minimal treatment before it was discharged to the ocean at cliff face outlets below the low water line.

TABLE 8.1: Sydney's Cliff Face Ocean Outfalls

OUTFALL LOCATION	NAME	**CONSTRUCTION COMPLETED**
Bondi	Bondi Ocean Outfall Sewer	1890
Malabar	South Western Ocean Outfall Sewer 1	1916
North Head	Northern Suburbs Ocean Outfall Sewer	1928
Malabar	South Western Ocean Outfall Sewer 2	?

Source: Water Board (1989 to 1992)

Greater use of beaches and increasing population (with increasing volumes of sewage discharged) probably contributed to the perception of the sewage pollution problem. During the 1930s there were many complaints about the affects of pollution (mainly from sewage discharge) on beaches (Coward 1988). A Metropolitan Water Sewerage and Drainage Board (MWSDB - now Sydney Water Board) report in 1938 made recommendations on primary treatment at ocean outfalls and public debate ensued. Sewage treatment works at the ocean outfalls were constructed progressively at each of the ocean outfalls from 1945 through to 1981 (See Table 8.2).

TABLE 8.2: Sewage Treatment Plant Construction

Ocean outfall location	Sewage treatment plant progressive construction
Bondi	1945 to 1966
Malabar	1959 to 1977
North Head	1968 to 1981

Source: Water Board (1959 to 1988)

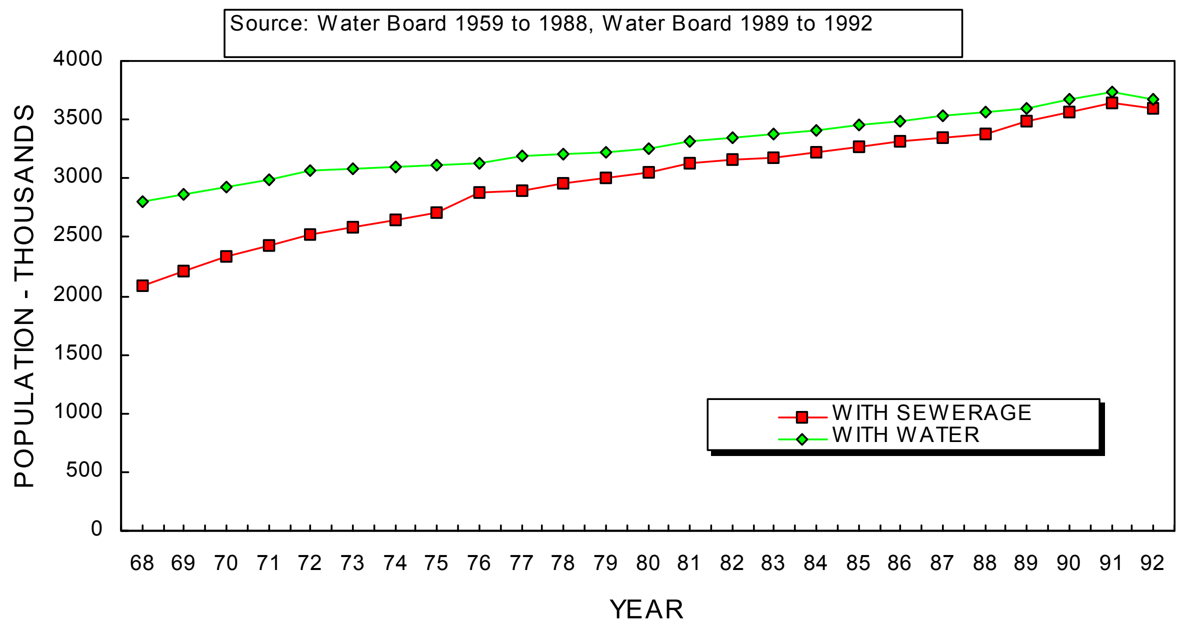
In the early 1960s measurements were made for the MWSDB of beach grease and coliforms on beaches close to Bondi and Malabar ocean outfalls (Coward 1988). These showed levels higher than safe levels necessary for swimming and other body contact beach recreation activities.

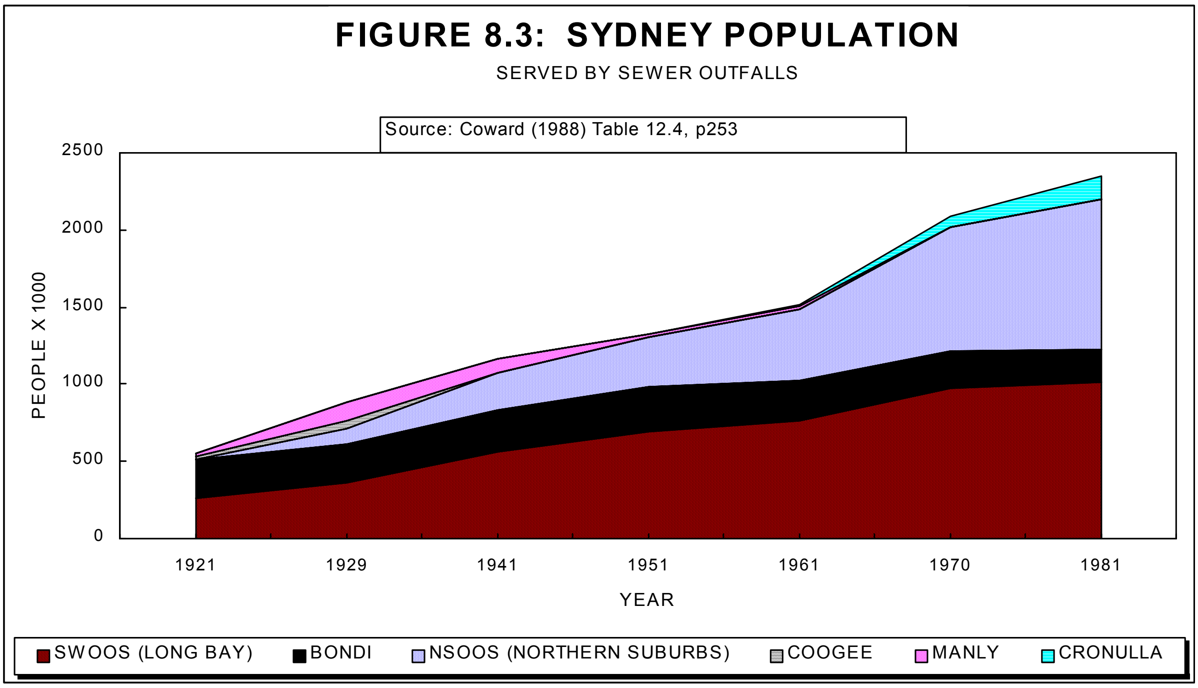
Figure 8.2 shows a steady increase in the population of Sydney served with sewerage. From 1968 to 1981 there was a 50% increase and to 1991 a 70% increase. The difference between the two curves is an approximate measure of the population without sewerage. The population with water increased by only approximately 25% during this period and is an indication of population increase.

Figure 8.3 shows the population of Sydney with their sewage being discharged from cliff face discharges into the sea off Sydney's coast. This represents a significant load of sewage that the waters were required to absorb. Some of the load was ameliorated by the construction of the sewage treatment facilities shown in Table 8.2.

FIGURE 8.2 SYDNEY WATER BOARD

POPULATIONS WITH WATER AND SEWERAGE





The point in time when people first started to be affected by the beach pollution which deep ocean outfalls ultimately solved is probably impossible to determine accurately. This section suggests that concern for beach pollution was an ongoing phenomenon. Tables 8.1 and 8.2 show that solutions in the form of higher levels of treatment have been progressively implemented. For the purposes of this case study the date used for the approximate point of start of *people affected* is when grease was measured on the beaches in the early 1960s as shown in Figure 8.15.

8.3 Harbingers

In the mid 1930s a former Engineer in Chief of the MWSDB proposed that the sewage pollution problem could be solved by outfalls discharging sewage into the ocean further away from the shore. (Coward 1988)

The Water Board in their early reports (Brown and Caldwell 1965) was foreshadowing the need for sewage disposal with outfalls up to 1.5 km off shore. (The deep ocean outfalls as finally constructed were 1.7 to 3.6 km off shore and at a depth of 60 to 80 metres.) This was considered necessary to prevent pollution of beaches and receiving waters and was based on beach pollution levels at the time and a knowledge of the likely growth of Sydney's population.

The indicators chosen to measure this process are the Brown and Caldwell (1967) reports because they predicted that the beach pollution would get worse if further treatment was not undertaken. The treatment consisted of two aspects, firstly the construction of sewage treatment facilities and secondly the construction in the future of deep ocean outfalls.

This indicator is shown in Figure 8.15.

8.4 Public Concern about Beach Pollution

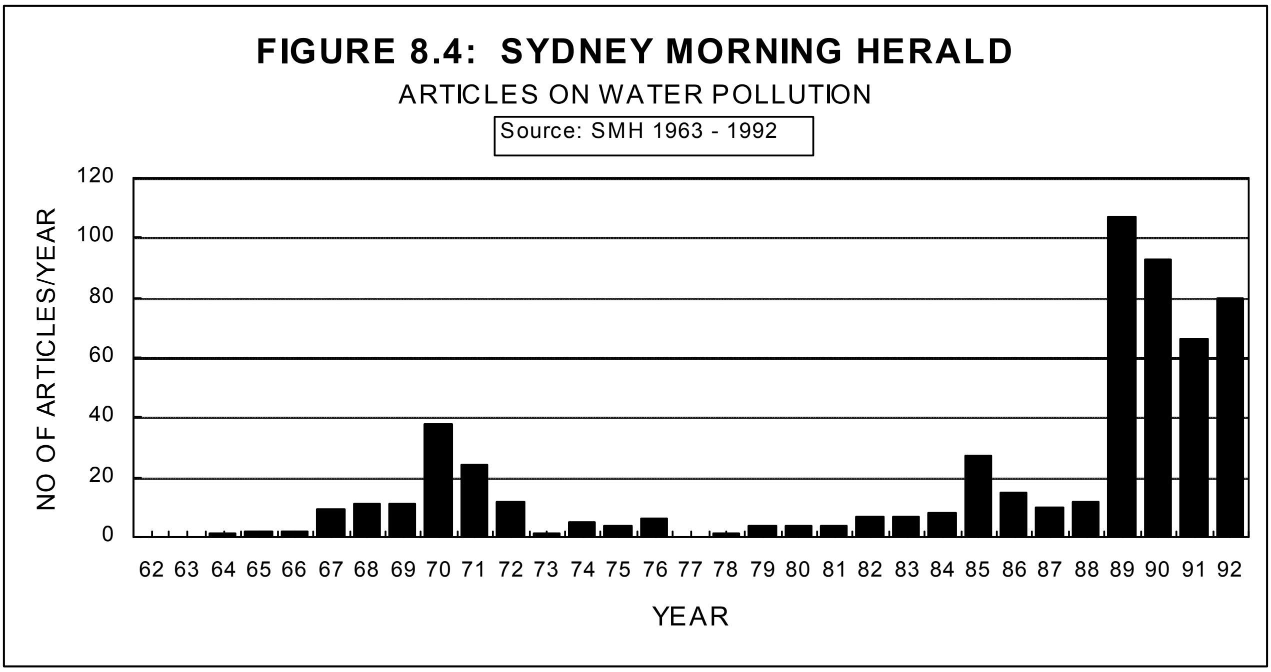
The indicator chosen for this process is the number of articles on water pollution in the Sydney Morning Herald (SMH). Figure 8.4 shows the level of concern for water pollution based on indexed articles from the SMH over a period of 30 years. There was not sufficient data or focused data to measure separately the concern for beach pollution.

On the assumption that articles in the SMH represent a reflection of public opinion or concern, the graph shows a quite significant increase in public concern from 1968 to 1972 with a peak during 1970. (50 articles represents about one per week.) The peak in 1989 is a second stage or point of major public concern about beach pollution. Because of the long time that elapsed in implementing the solution the problem had steadily gown bad enough (See Figure 8.14) to produce another wave of public concern. (Beder 1989)

8.5 Political Action

This public concern is mirrored in political actions taking place around the year 1970. The State Pollution Control Commission (SPCC 1973 to 1990) was formed in June 1971 to bring control of pollution under a single authority and to administer new laws on pollution. It wasn't until May 1974 that the SPCC had taken over full responsibility for administering the Clean Air Act and Clean Waters Act from the Director General of Public Health. The first public SPCC annual report was produced in the financial year ending June 1973.

Figure 8.5 shows the number of pages of NSW Hansard recording parliamentary action on water pollution. A significant part of the measured pages of text refers to debates in both houses of Parliament on the introduction of new legislation under the Clean Waters Acts. Figure 8.6 shows that part of the Hansard data referring to beach pollution only. This shows the Hansard record for beach pollution has well defined peaks on 1969/70, 1981, 1985/85, and 1989/90.



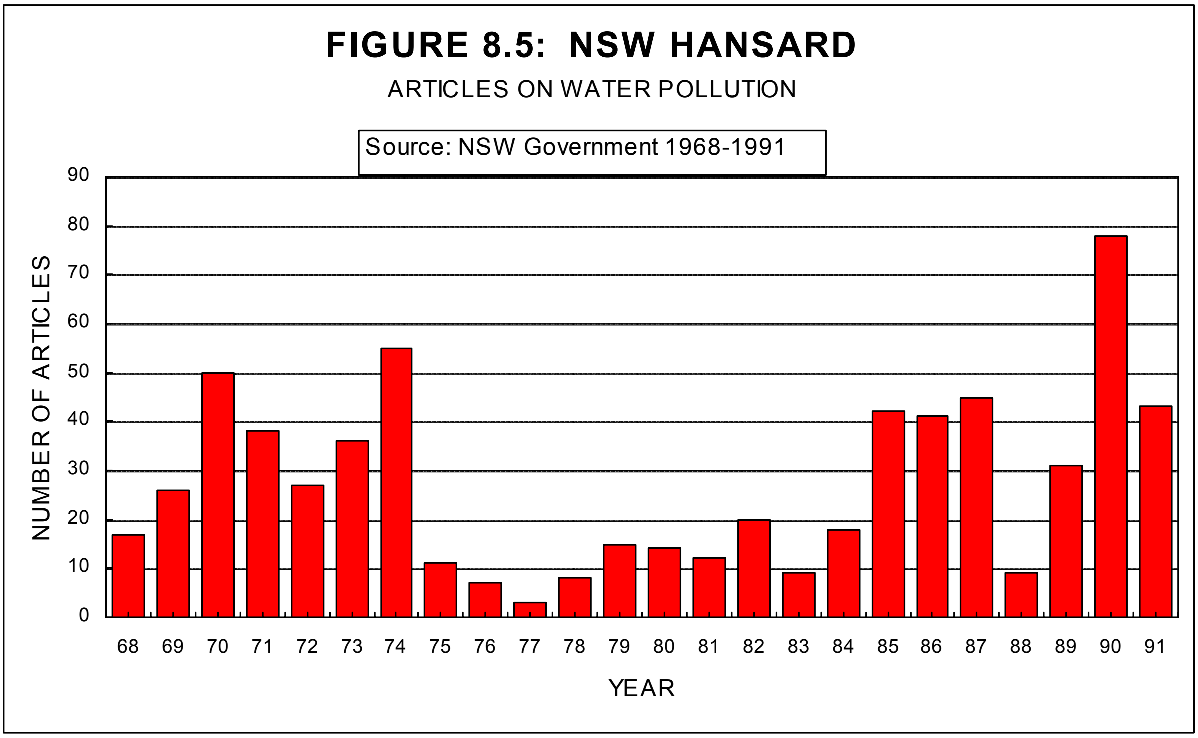
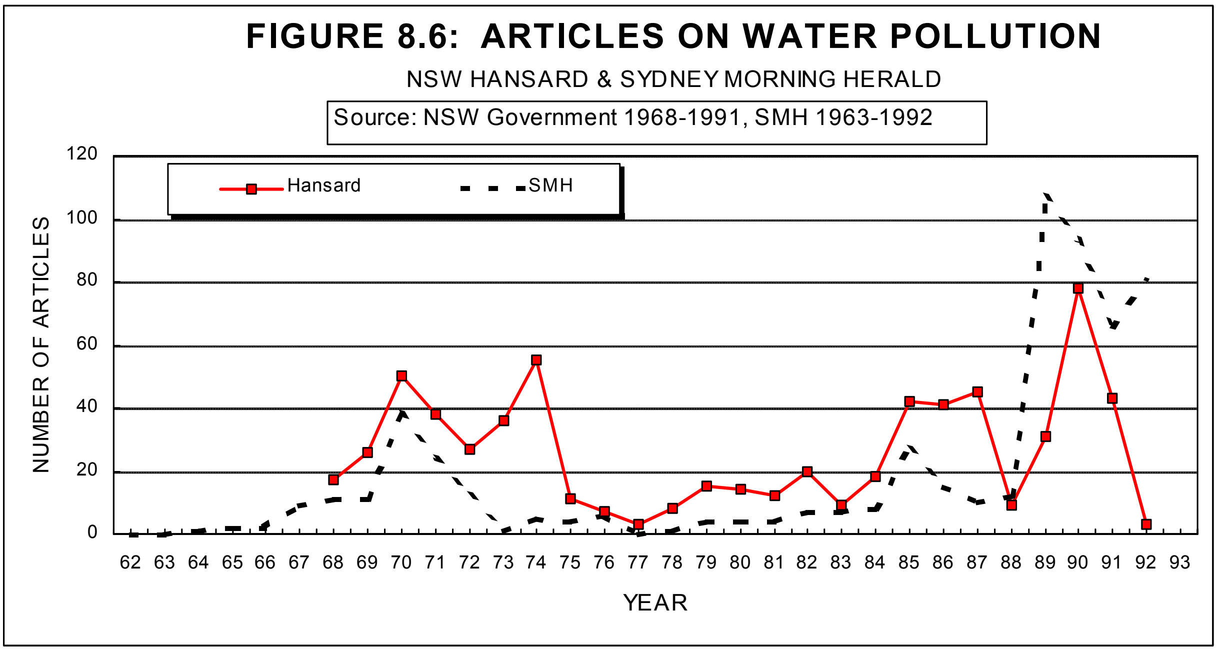
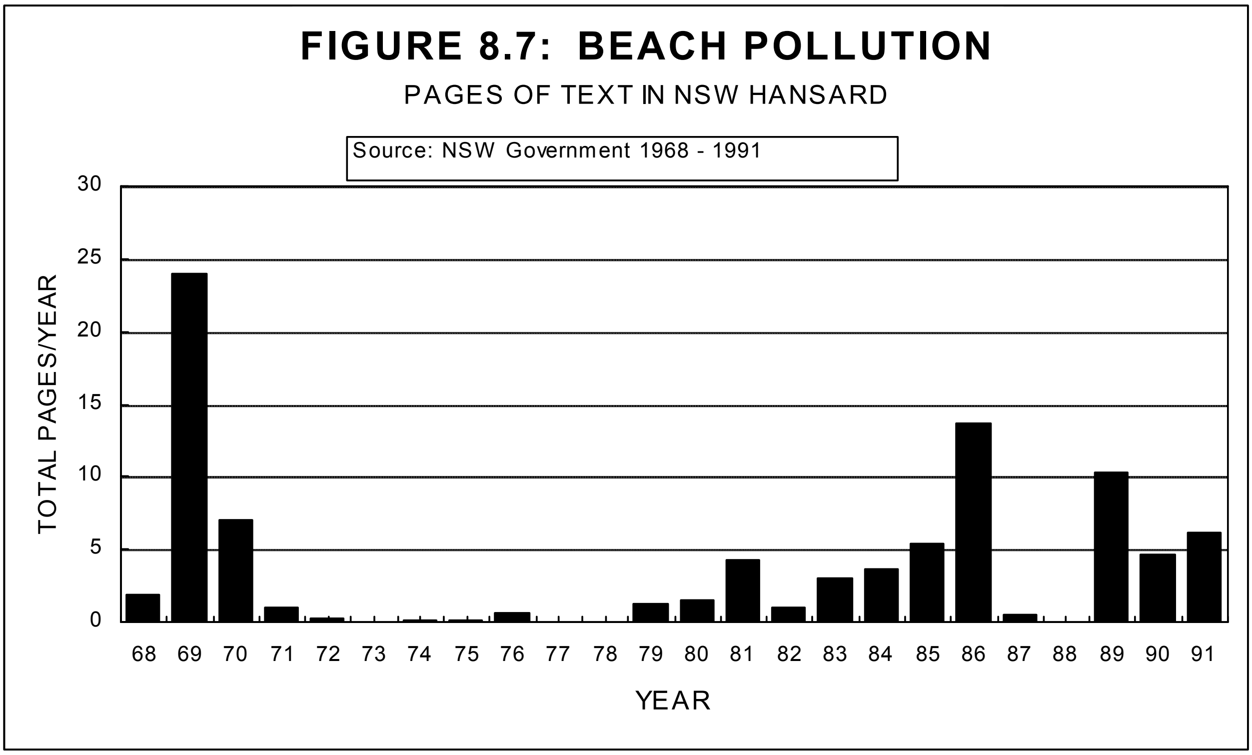


Figure 8.6 shows a comparison of Hansard articles and SMH newspaper articles. A visual correlation is evident between the peaks in the measures of *public concern* in Figure 8.4 and the measure of *public action* in Figure 8.5. Certain actions in parliament (questions, private members statements, Governor's addresses, and the addresses in reply) reflect public concern on topics while the introduction of legislation (and amendments to legislation) tend to follow this concern. The majority of pages on legislation refer to the debate (the second reading) concerning the legislation. It is not possible from the data to determine whether changes in public opinion as measured by

newspaper articles preceded the political action but it is clear that the two processes occurred over similar time periods.



The pages of text in Hansard on beach pollution is a subset of water pollution pages as shown in Figure 8.5 and is shown in Figure 8.7. The indicator used to measure the process *political action* is the pages of text in Hansard on beach pollution as shown in Figure 8.7.



8.6 Body of Knowledge

The two main parameters of the sewage discharged from the cliff face outfalls that effect the quality of the water and the beaches are the discharge volume per year (quantity) and the concentration of pollutants (quality) in that discharge. Sewage is normally about 99% water but it is the 1% of other materials that can cause pollution on beaches. Figures 8.2 and 8.3 indicated the significant increase in sewage flow to the Sydney near shore areas.

The quantity and quantity of sewage was affected by the following factors (Water Board 1959 to 1988): the building of treatment plants at each of the major ocean outfalls (See Table 8.2); the decision by the NSW Government (and SPCC) to divert a large proportion of industrial liquid waste from waterways to the sewer around the mid 1970s; the upgrading the treatment plants at each of the major ocean outfalls in parallel with the construction of the deep ocean outfalls; and the gradual reduction in the quantity of industrial pollutants discharged into the sewers by the imposition of stricter limits on industrial discharges (Trade Waste Agreements).

A body of knowledge was necessary to be generated in order to implement the solution i.e. to design, build, commission and operate deep ocean outfalls. Some of this knowledge was developed in applying engineering practice and overseas experience (Refer to Table 8.3.). More original knowledge about the behaviour of the ocean, winds, and marine life off Sydney's coast had to be generated before the deep ocean outfalls could be built. (Refer to Table 8.3)

Some of the activities necessary to gather this knowledge are shown on the bar chart Figure 8.8. During the period from 1965 to 1992 these activities resulted in the generation of the knowledge necessary for a solution. Like most major pollution problems it is difficult to isolate one problem from others because of their links.

Over the period (1965 to 1984) from the time when the use of deep ocean outfalls were first suggested seriously as a solution to the beach pollution problem a number of independent studies were done to assess the desirability and the feasibility of constructing deep ocean outfalls as a solution. These studies and or reviews (See Table 8.3) undertaken by overseas experts are in addition to ongoing engineering and environmental studies undertaken by the Water Board and the SPCC.

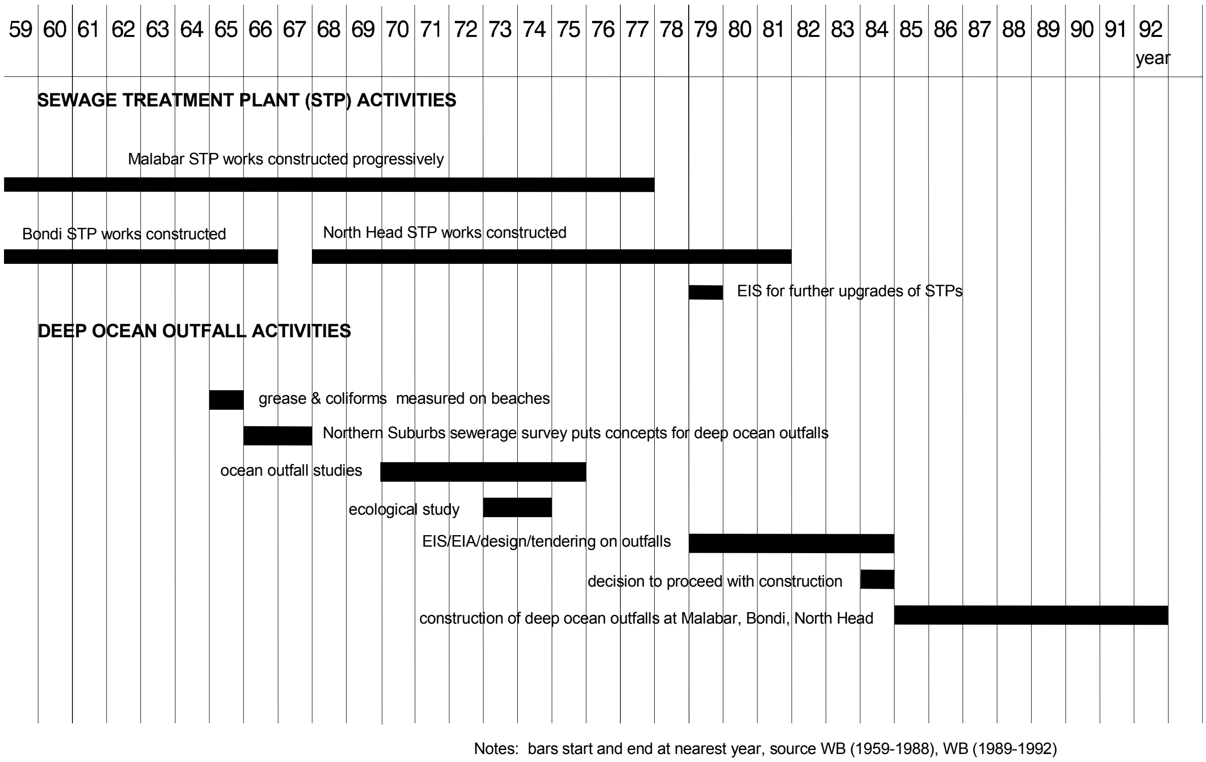


FIGURE 8.8: HISTORY OF SEWAGE TREATMENT PLANT & DEEP OCEAN OUTFALL CONSTRUCTION

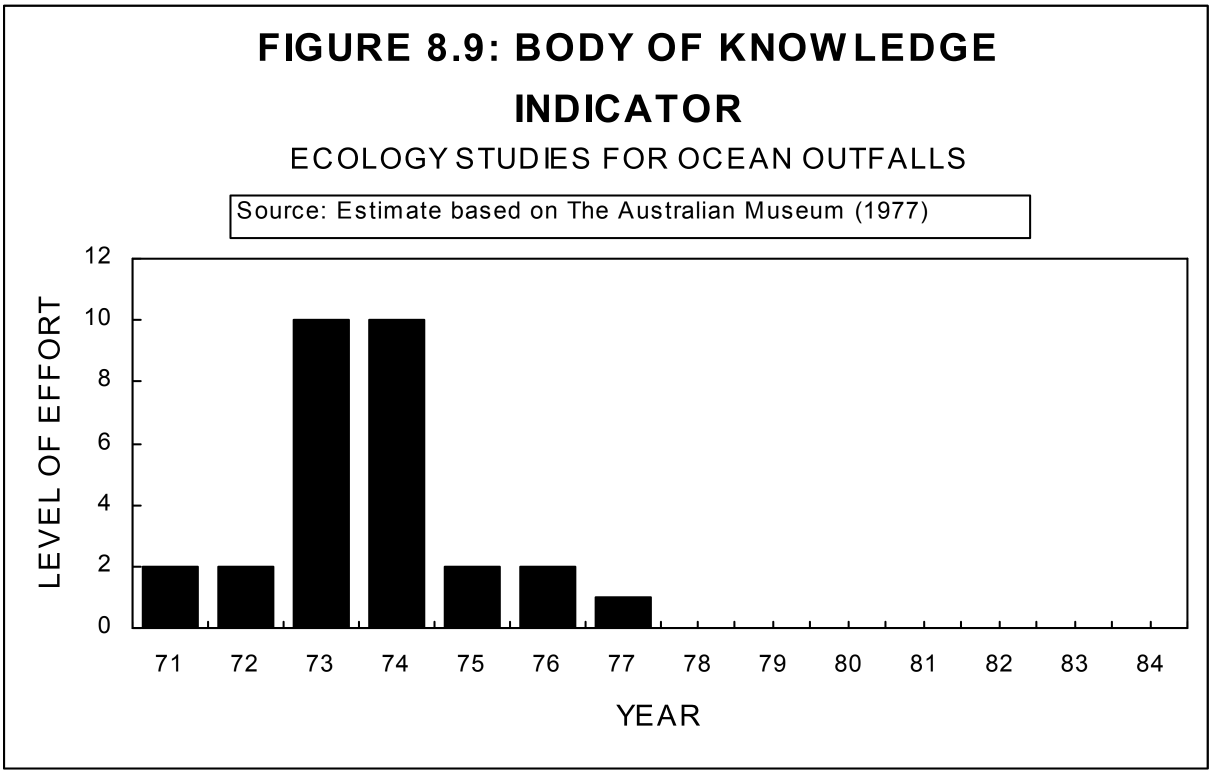
Table 8.3: Major Studies into Deep Ocean Outfalls

Author	Source	Study	Period
Brown and Caldwell (1965)	California, USA	Design Report, Malabar Sewage Treatment Works	May 1665 to July 1965
Brown and Caldwell (1967)	California, USA	Northern Suburbs Sewage Survey	1966 to 1967
Caldwell Connell Engineers (1976)	California, USA Melbourne, Aust	Report on Submarine Outfall Studies	1971 to 1976
Camp Dresser and McKee (1989)	Massachusetts, USA Sydney, Aust	Review of Sydney's Beach Protection Programme	1989

As a part of a feasibility study into the construction of the outfalls (CCE 1976) a major baseline ecological survey (The Australian Museum 1977) was undertaken in the period 1973 to 1975 of the waters off Sydney's coast likely to be impacted by the outfalls.

The other activity that resulted in the developing knowledge about the solution proposed was the design of the outfall and sewage treatment plant upgrades from 1981 to 1983.

The indicator chosen to measure this process is the level of effort to produce and publish the baseline ecological study as shown in Figure 8.9

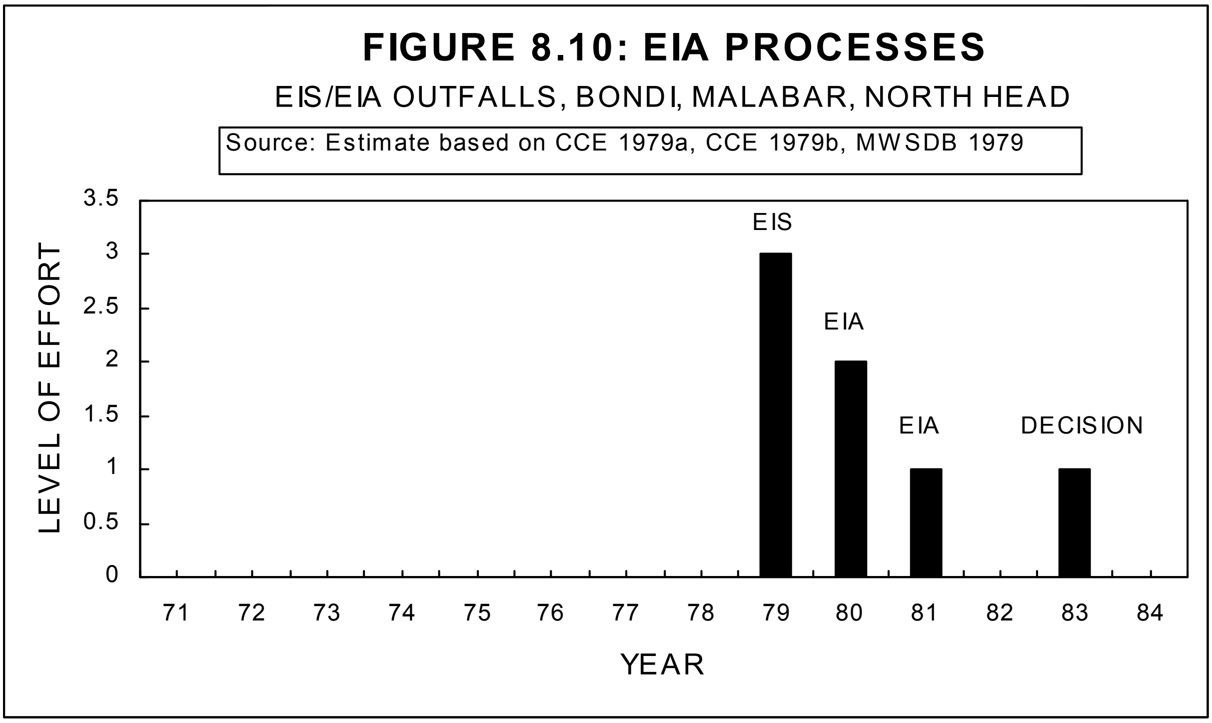


8.7 Inquiry

The major inquiry into the use of ocean outfalls as a solution to the ocean and beach pollution problems were the Environmental Impact Statements (1979 to 1980) for both the outfalls themselves and sewage treatment plant upgrades. These required the outfall discharges to meet the water quality criteria of WP-1 (SPCC circa 1975). The approval of the EIS allowed the proposal to proceed and the outfalls to be detail designed and constructed. (CCE 1979a, CCE 1979b, MWSDB 1979)

The specific data on beach pollution (See Figure 8.6) from Hansard indicates a peak in 1970 that preceded the commencement of deep ocean outfall studies by the Water Board commencing in 1971. The peak in 1981 in Hansard data occurred about the time the Environmental Impact Statements for the deep ocean outfalls had been displayed in public and were being assessed by the SPCC. The peaks in 1985/1986 and 1988/1989 did correspond with heightened public concern shown in Figure 8.5 for SMH data. Production of the many reports on the outfalls could have influenced political debate and public interest.

The indicator chosen for this process is the author's estimate of the level of effort to produce, display and assess the EISs (See Figure 8.10).



8.8 Legislation

Throughout the period significant legislation was enacted that had both a general and specific impact on the solution of the beach pollution problem.

The Clean Waters Act was passed in 1970. The SPCC Act was also passed in 1970 but the SPCC was not fully effective until 1974 when it formally took over administration of the act from the Department of Health.

Significant legislation during the period is shown in Table 8.4.

Table 8.4: Significant Legislation to Control Water Pollution

Year	Act
1970	Clean Waters Act
1970	SPCC Act
1972	Classification of Waters by SPCC
1974	Clean Waters Act transferred to SPCC
1975	All wastes to water require a licence
	Large part of industrial liquid waste diverted to sewer from Sydney's waterways
	WP-1 guidelines for ocean discharge of sewage published by SPCC

Source: SPCC (1973 to 1990)

Stronger legislation on water pollution enabled the SPCC to licence and control pollution of Sydney's waterways and there were significant improvements in some of the rivers because of the diversion of industrial liquid waste discharges from rivers to sewers (albeit the discharges were licensed).

This added to the loads the sewers carried to the ocean treatment plants and eventually discharged to the ocean.

There was an increase in Sydney's population (see Figure 8.2) of about 25% over this period but more importantly there was an increase of about 70% of the population connected to the sewer. The Water Board continued to upgrade treatment plants but this did not appear to significantly reduce beach pollution (Refer Figure 8.14).

The Water Board was obviously aware of potential pollution problems but was constrained by budgetary considerations (Brown and Caldwell 1965). Caldwell Connell (1976) suggested a construction period for the construction of the deep ocean outfalls from 1977 to 1984 but actual construction did not occur until 1984 to 1992 a delay of 7 years. Some of this delay (See Figure 8.8) was taken up with a long approval process: 1980 to 1981 EIS preparation and display; 1981 Environmental Impact Assessment by SPCC; 1982 to 1984 design and tendering; 1985 approval to proceed with construction.

Figure 8.7 and 8.4 showed an increasing political action and public concern through peak measurements about beach pollution over this period. It is not possible with the data to establish causal relationships but increasing action by the Water Board, the SPCC and Government in planning and proceeding with the outfalls ran in parallel with a build up of public concern. Each process probably provided feed back to the other.

What is clear from the data is that the time to identify the need for deep ocean outfalls (or more specifically a solution to current and forecast beach pollution) certainly took a long time - 1960s to 1992. It could be argued that the Water Board has a long planning horizon and needs to be able to plan over a twenty year period. This is certainly the case but this planning should have ensured that deep ocean outfalls were built in the early 1980s to avoid sever beach pollution problems that were evident in the late 1980s and early 1990s.

The evidence points to slow political action because of a low level of public concern and the allocation of budget moneys to other higher priority programs.

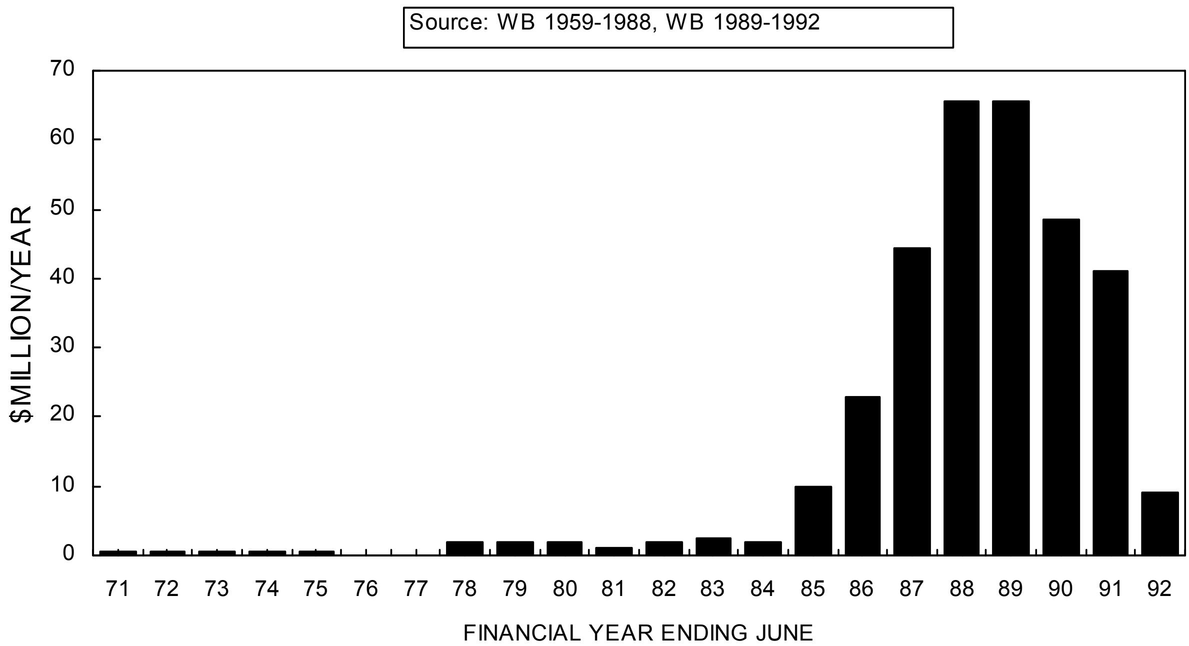
It can be argued that the approval of the EIS in 1981 was the key regulatory process. The stronger argument is that the promulgation of the WP1 guidelines, for the discharge of sewage from deep ocean outfalls was the relevant legislation for this case study. This is the indicator used for this process. This process occurred over less than one year and is shown as a single histogram on Figure 8.15.

8.9 Allocation of Funds

The decision to construct deep ocean outfalls required an allocation of considerable sums of money. Over the early years the money were moderate as payments were made for Water Board staff and consultants to undertake planning and design studies (1971 to 1984). Once approval to construct was given $300 million was required to be spent over 8 years from 1984 to 1992. Figure 8.11 shows the approximate expenditure profile in actual dollars based on information listed in Water Board annual reports (Water Board 1989 to 1992). This is the indicator used for this process.

FIGURE 8.11. DEEP OCEAN OUTFALLS

APPROXIMATE CAPITAL EXPENDITURE



8.10 Organisation Change

A new project organisation was established within the Water Board to manage the design, construction, commissioning of the deep ocean outfalls. Changes in other organisations also occurred to facilitate and maintain the solution as described below.

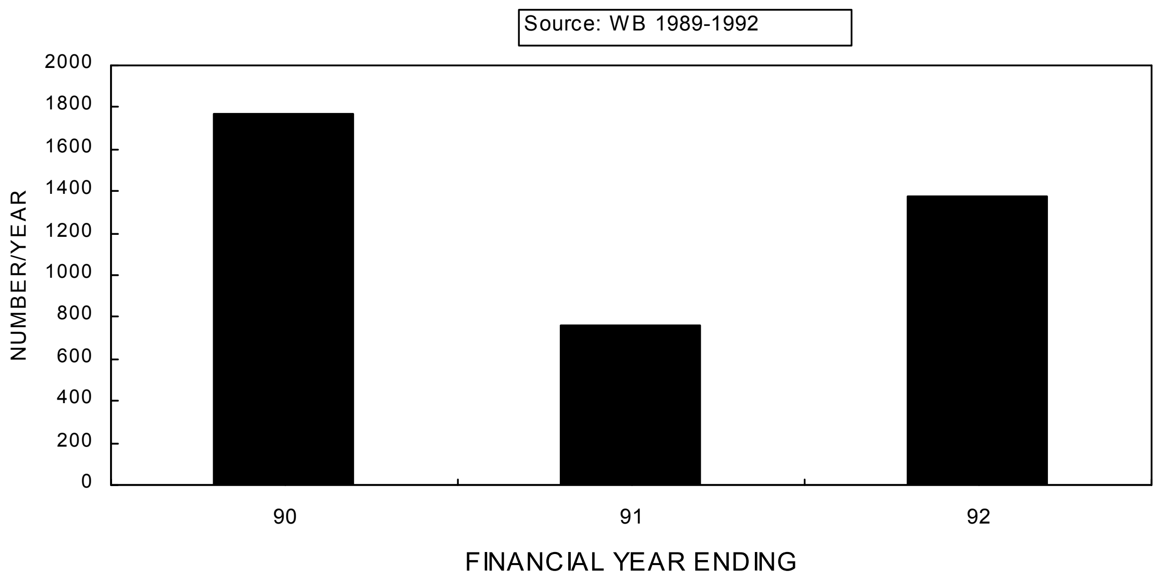
The Water board established the "Surfline" organisation to monitor beach pollution. They were assisted by the Board's Scientific Services group (Water Board annual report 1987). By 1990 the functions of this group were being undertaken by "Beachwatch" service through the SPCC. (WB 1992, WB 1993)

In 1989 the Board started a 5 year monitoring programme to measure the baseline environment (likely to be affected by the changes to ocean outfalls) and to measure changes to the environments of beach and ocean water. This programme was transferred to SPCC in January 1990 though it was still funded by the Water Board. (WB 1992, WB 1993)

The Board established a Trade Waste Branch to control and monitor industrial waste discharges into the sewers (See figure 8.12). (WB 1989 to 1992)

FIGURE 8.12. SYDNEY WATER BOARD

TRADE WASTE AGREEMENTS



The completion of deep ocean outfalls by 1992 (see Table 8.5 below) was the major item in the strategy to reduce beach pollution.

Table 8.5: Deep Ocean Outfall Completion Dates

Deep ocean outfall	Completion date
Malabar	October 1990
North Head	January 1991
Bondi	August 1991 (circa)

Source: (WB 1992, WB 1993)

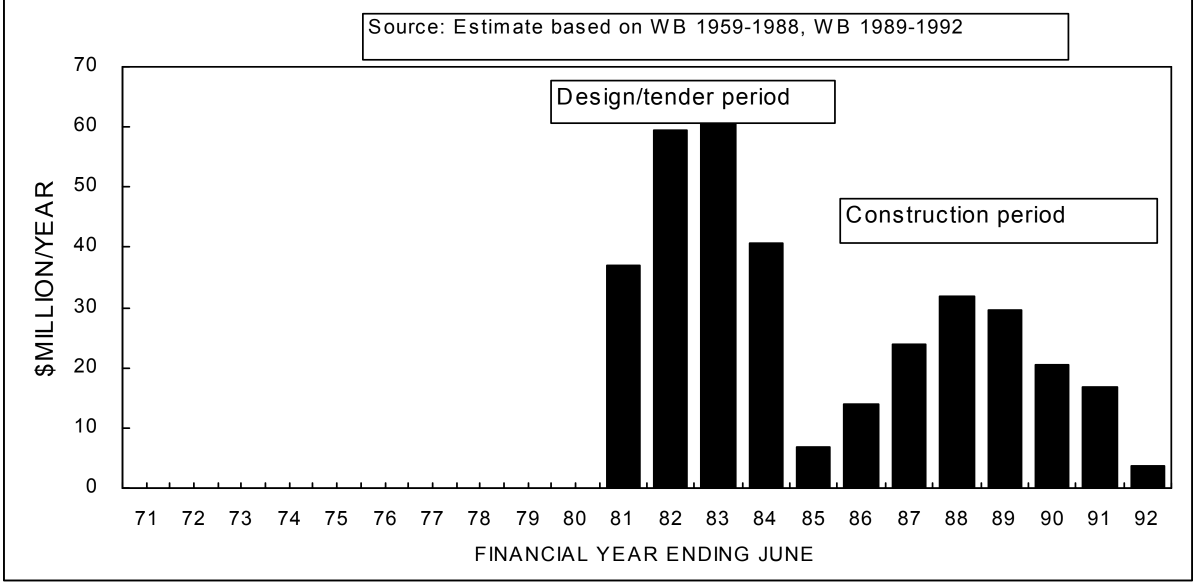
Other organisational and management processes have been instigated to assist the process. They are: improvements in the treatment plant processes to improve the quality of the sewage effluent discharged through the outfalls; baseline and ongoing monitoring of the quality of the ocean water (in shore and off shore) to determine changes caused by building deep ocean outfalls by both the SPCC (now EPA) and the Water Board; monitoring of beaches to assess their quality (suitability for swimming and similar uses) by Beachwatch (part of EPA); and increasing use of Trade Waste Agreements to control the amount and type of industrial waste going into sewers.

The appropriateness of the solution was questioned by the public and parliament especially after episodes of high beach pollution (or public perception of high beach pollution) during 1988 to 1989. This concern was heightened by release of information of a Department of Health report on accumulation of certain chemicals in fish caught of Sydney's coast (Beder 1989). A review of Sydney's Beach Protection programme (mainly the deep ocean outfalls) was undertaken by independent consultants (Camp Dresser & Mckee 1989). This review confirmed that deep ocean outfalls were an appropriate solution but believed that they only partially solved the problem (or potential problem) of beach pollution. They recommended a 20 year programme of further investigations and capital expenditure to improve treatment of sewage before discharge, to upgrade Sydney's sewage and drainage system.

The indicator chosen to measure this process is the new Water Board project organisation as shown in Figure 8.13. It is based on information from Water Board annual reports.

FIGURE 8.13. DEEP OCEAN OUTFALLS

APPROXIMATE WATER BOARD PROJECT TEAM



8.11 Solutions in Place and Institutionalised

It is not easy to extract causal relations from this broad scale data. The organisational model proposed though is not a linear model relying on causal relations but a series of overlapping organisational process of varying strength or intensity.

This particular case study has reviewed the solution of the beach pollution problem caused by discharge of sewage (with minimal primary treatment) at cliff face locations about 50 metres from the high water line. The solution was to discharge the sewage into deeper water at depths of 40m to 80m and up to 3 to 5 kilometres offshore. This is obviously not a complete solution because certain pollutants are still being disposed of at sea and sewage may eventually require further treatment (possibly to secondary level) in the future. Some sewage treatment engineers (personnel communication while at working at the Water Board in 1991) would argue that the treatment of sewage by organisms in the sea is more effective in terms of total environmental impact than other methods. This is a possible future problem.

As suggested earlier in this paper the problem of beach pollution has not been fully solved. Beach pollution can still occur if sewage released 3 to 4 km offshore surfaces and is blown towards shore by combinations of winds and currents. This occurs a lot less frequently that with cliff face outfalls. (Camp Dresser McKee 1989)

In wet weather stormwater drainage onto beaches or into shallow water and can cause severe pollution of beaches after heavy rain (personal communication with Water Board engineers 1991). This storm water contains pollutants from a number of sources: animal faeces, garden waste and runoff, street rubbish, sewage from overflowing sewers (either through design or because of inadequate capacity) into storm water drains. (WB 1993)

Elimination of pollution from stormwater is another major pollution problem that is being addressed by the EPA and the Water Board but is difficult to solve because its sources are diffuse and it is caused in part by the combined actions of many people. (WB 1993)

Perception of beach pollution can be heightened by visible matter in the water (e.g. floating matter from sewage or other origin: grease, plastics, condoms) or dark or dirty water, similar matter on the beach itself, and by illness or disease caused by a visit to the beach. Measurement of beach pollution by Beachwatch (Water Board 1989 to 1992) is by a regular visual examination of the beach sand and beach water and by the measurement of the indicator bacteria E. Coli.

Acceptable levels of visual beach pollution and E.Coli have been established and pollution is deemed to occur if these levels are exceeded.

The main Water Board and Beachwatch indicator of pollution is a secondary indicator in that it is a plot of the percentage of time (based on defined sampling) that beach water exceeds the safe criteria for bathing set for E.Coli. (WB 1989 to 1992).

8.12 Extent of solution

The Water Board have been sampling beach water for over twenty years (Nelson et al 1992, Nelson and Roberts 1993). The raw data was collected over the period 1968 to 1990 and analysed from 1992 onwards. The reported data from these reports and other references listed in this chapter often use different units for the secondary data, which makes comparison difficult.

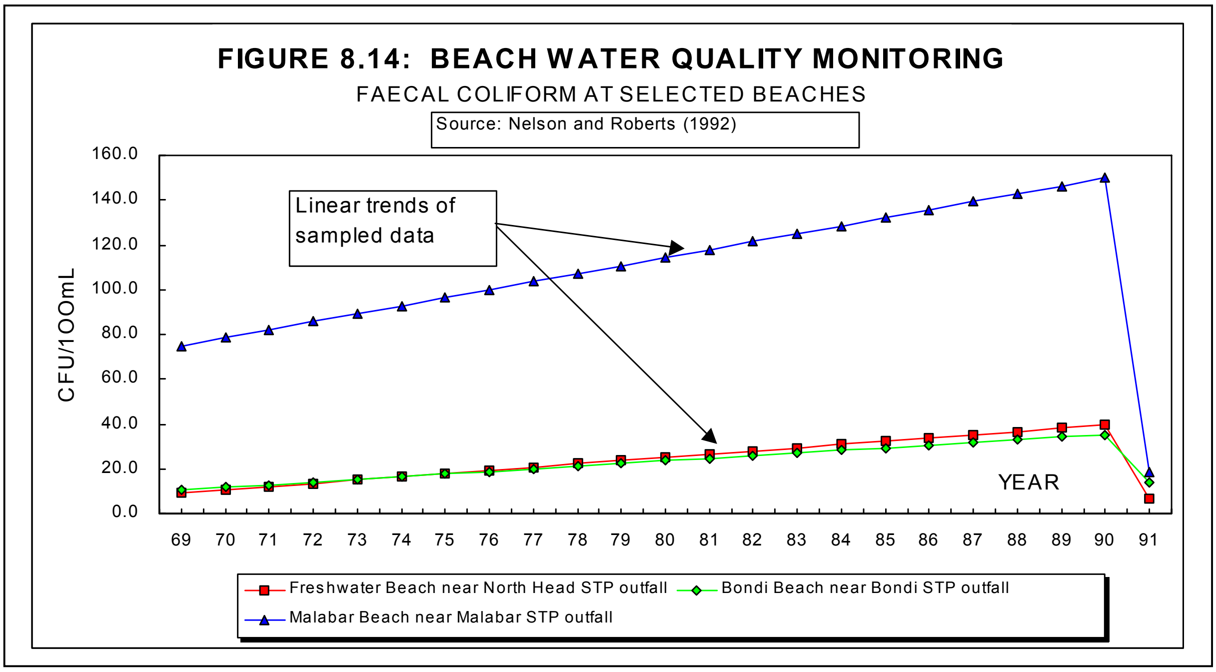
Figure 8.14 below shows the average value for measured faecal coliform in colony forming units per 100 ml. Nelson and Roberts (1993) presented graphs of the data for a number of beaches and used regression analysis to analyse trends over time both polynomial and linear. Figure 8.14 shows these linear trends for the beaches closes to the three major ocean outfalls shown in Figure 8.1.

They show an increasing level of faecal coliform contamination at beaches. Actual levels at beaches (as distinct from averages) were very high resulting in the permanent closure of Malabar Beach and frequent health hazards at other beaches (Water Board 1989 to 1992). Figure 8.14 shows a significant fall in levels in 1991 as the deep ocean outfalls were completed and commissioned (refer Table 8.5). This dramatic improvement is supported by detailed data included in Water Board annual reports (Water Board 1989 to 1992, Water Board 1992, 1993). These detailed reports show beaches complied with standards set for bathing for the majority of the time whereas previously some beaches during summer frequently failed to comply.

The indicator to measure the extent of solution shown in Figure 8.15 is the average of the three graphs of Figure 8.14.

8.13 Processes

Figure 8.15 combines the indicators described in this chapter to illustrate each of the proposed model processes to show the sequence, size, and timing of the processes involved in the solution of the beach pollution problem have over the period 1960 to 1992 that contributed to a solution.



Figures 8.1 to 8.14 presented in this paper represent indicators of the strength of processes and the time over which they were active. In order to visualise the chronology and the overlapping of the processes involved in the solution to the pollution problem, Figures 8.4, 8.7, 8.9, 8.10, 8.11, 8.13, 8.14 have been placed on a common time scale as shown in Figure 8.15. This diagram is a key to the understanding the interconnected nature and time frames of the processes.

The main processes are listed on the vertical axes of the diagram. For each process the horizontal axis is a measure of the time over which the process was active in the solution of the pollution problem and the vertical dimension is a measure of the intensity of the process.

The processes *harbinger, people affected,* and *legislation* are shown as single histogram bars as they are events that do not extend over one year in duration. The other process histograms show the trends over time. *Public opinion* and *political action* are shown over the whole period of the case study to contrast the early peaks with the later trough.

8.14 Discussion

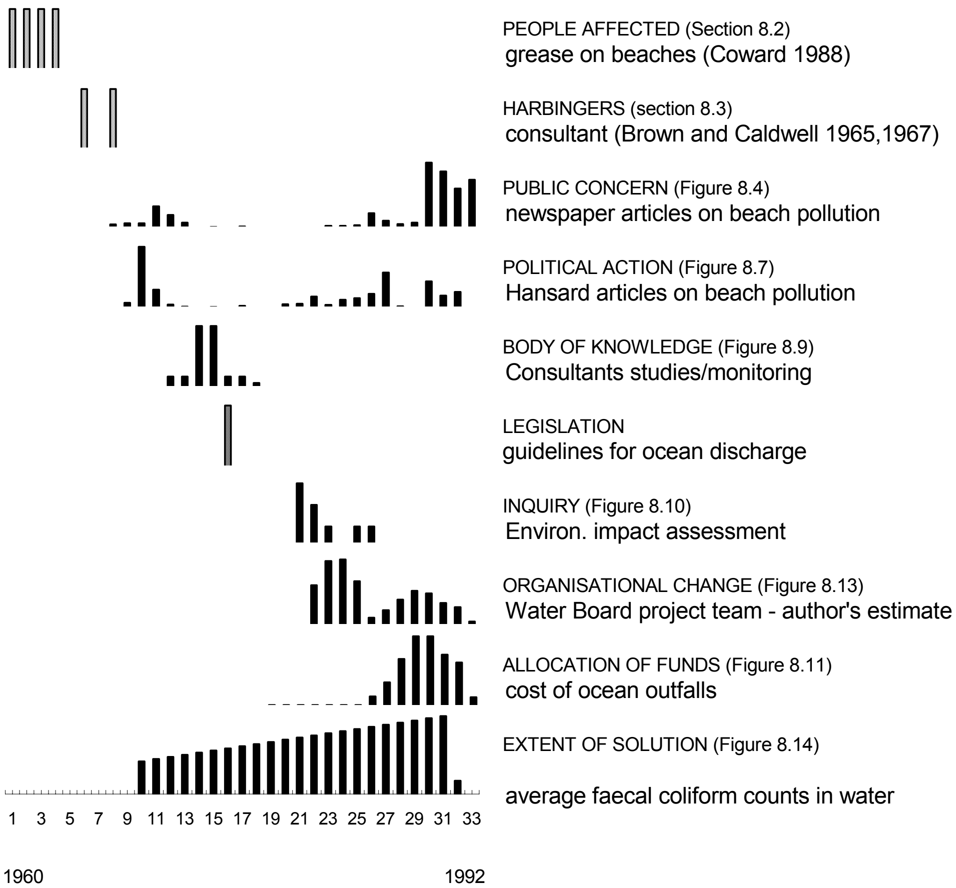
Concern for beach pollution was strong in the years 1969 and 1970. Legislation establishing the SPCC and the Clean Waters Act provided a framework for a solution to the problem. Preliminary studies prior to 1969/70 had indicated a need for deep ocean outfalls to solve the current and future beach pollution problems. Specific studies (both engineering and environmental) from 1971 to 1977 provided the *body of knowledge*. Environmental Impact statements and assessments (1979 to

1981) preceded the decision to proceed in 1983. During this period public concern for beach pollution was evident though not to the level in 1969/70.

Public concern was again high in 1985/86 (after the decision to proceed) and extremely high in 1989/90. This was probably exacerbated by the perception of an increasing beach pollution problem. The increasing population contributed to the quantity of pollutants being discharged.

The deep ocean outfalls were completed in 1990/91 and an almost immediate improvement in beach water quality was noted after apparently deteriorating slowly for the previous 20 years.

FIGURE 8.15: PROCESSES INVOLVED IN THE SOLUTION TO SEWAGE BEACH POLLUTION



Notes:

1. Vertical scales are % of largest y value. The first peaks of PUBLIC CONCERN AND POLITICAL ACTION are relevant for the solution but other peaks are shown to illustrate the change that occurs in these indicators.
2. Figure numbers in brackets are references to the detailed figures in this section containing the graph scales.
3. The data after the right hand end of the histograms e.g. after 1992 was not collected or shown as it was not relevant to the time period of the case study

9 WATER POLLUTION IN THE PARRAMATTA RIVER

9.1 Historical Context

This section describes the water pollution of the upper reaches of the Parramatta River from Lake Parramatta to the Gladesville Bridge from the late 1950s to the late 1970s caused by industrial effluent, sewage overflow, septic tank overflow etc. Refer to Figure 9.1. The water pollution problems experienced by the Parramatta River during this period were similar to those experienced by other rivers and creeks in the Sydney metropolitan area. (SPCC circa 1985)

The Parramatta River has the largest catchment of the rivers that drain into Sydney Harbour - a total of 260 square kilometres (SPCC circa 1985).

A Senate Select Committee (SSC 1970) identified three factors responsible for causing increasing pollution in Australian cities: increasing population; increasing urbanisation (density of population); and increasing industrialisation (use of energy and production of waste). These three factors were all present in the Parramatta River catchment.

Powell (1987) says that from the 1930s onwards articles on the polluted state of the River regularly appeared in the press. Residents complained to councils but very little was done. In 1951 the condition of the river was so bad that netting of fish above Gladesville Bridge was prohibited. A newspaper article complained that " a thick black sludge blankets 10 miles of foreshore area." In 1966 thousands of fish were reported killed in the Parramatta River by the polluted state of the river (Beder 1989).

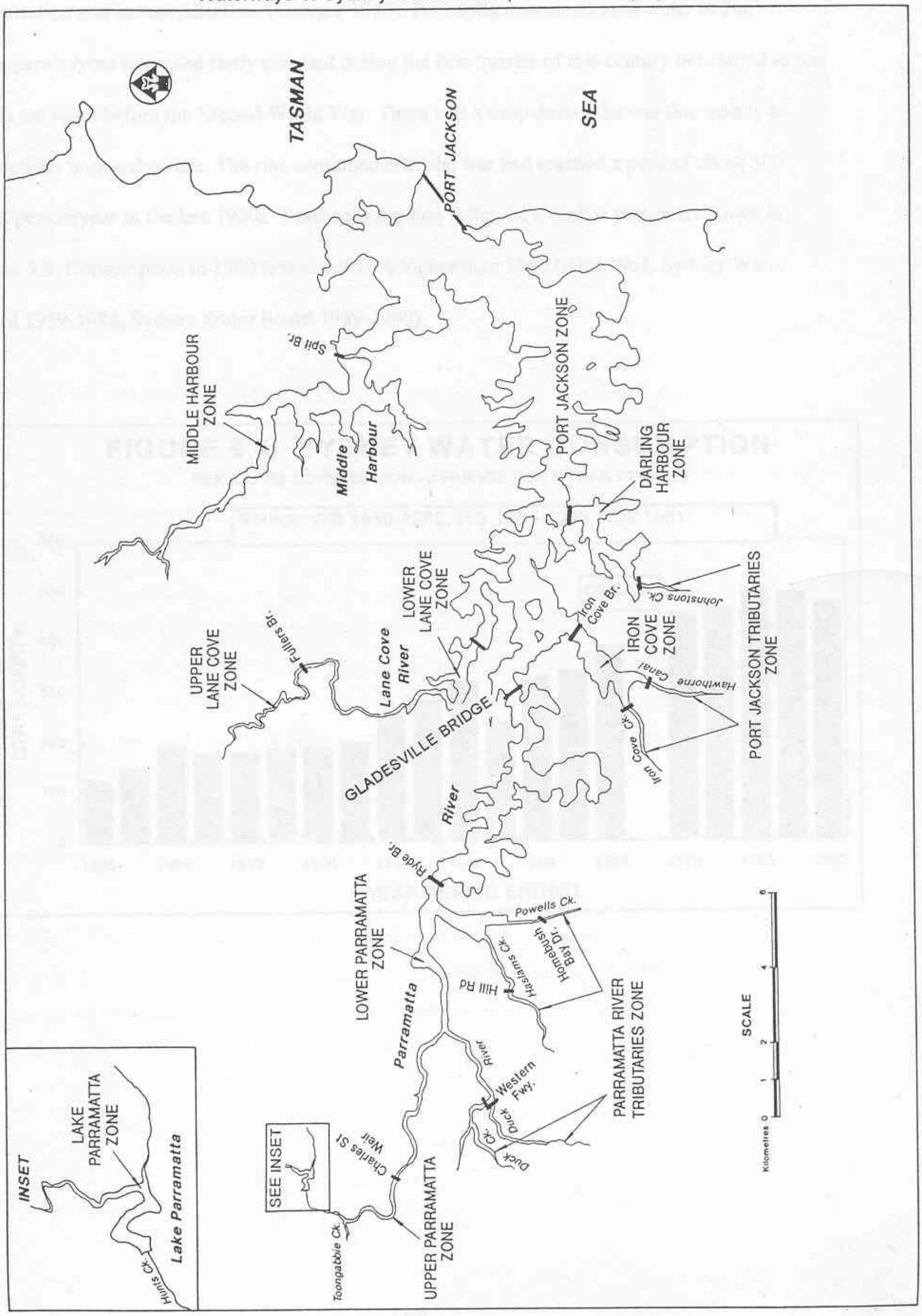
The upper reaches of the Parramatta River suffered in that it had a significant number of discharges of effluent from industry (as well as overflows from the sewerage system and septic tanks) but had little tidal flushing to enable dilution of the effluents. (SPCC circa 1985)

The general trend in the consumption of water is an indicator of increasing industrialisation and an indirect indicator of the increasing production of pollutants (both domestic and industrial) being discharged into waterways (especially in the absence of imposed controls on the discharge of pollutants).

FIGURE 9.1: PARRAMATTA RIVER

SHOWING UPPER REACHES FROM GLADESVILLE BRIDGE TO LAKE PARRAMATTA

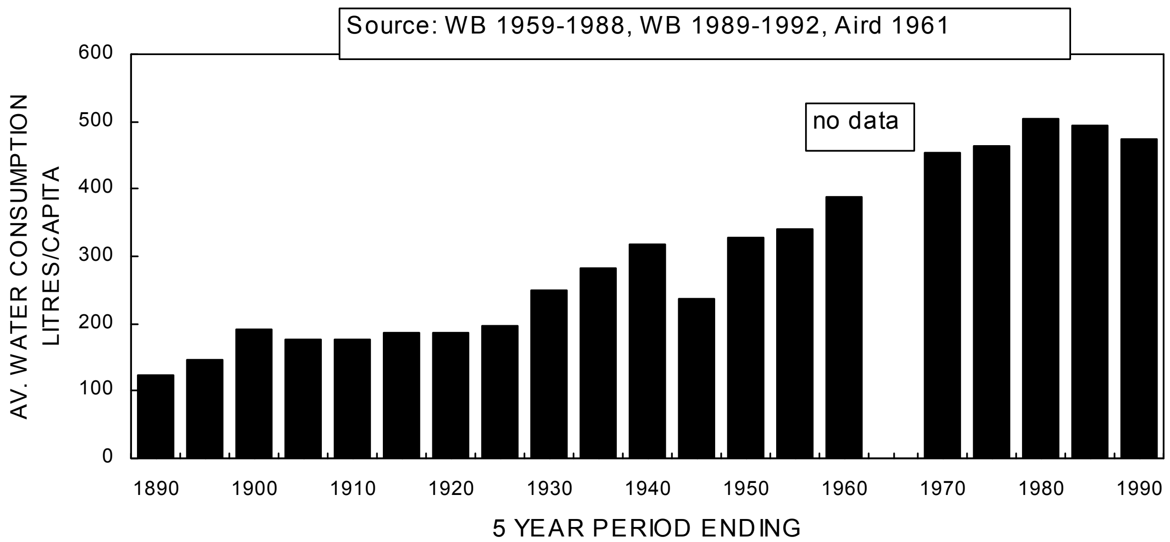
Source: Water Board, 1992, Water Quality Objectives for the Waterways of Sydney and Illawarra, Water Baord, Sydney

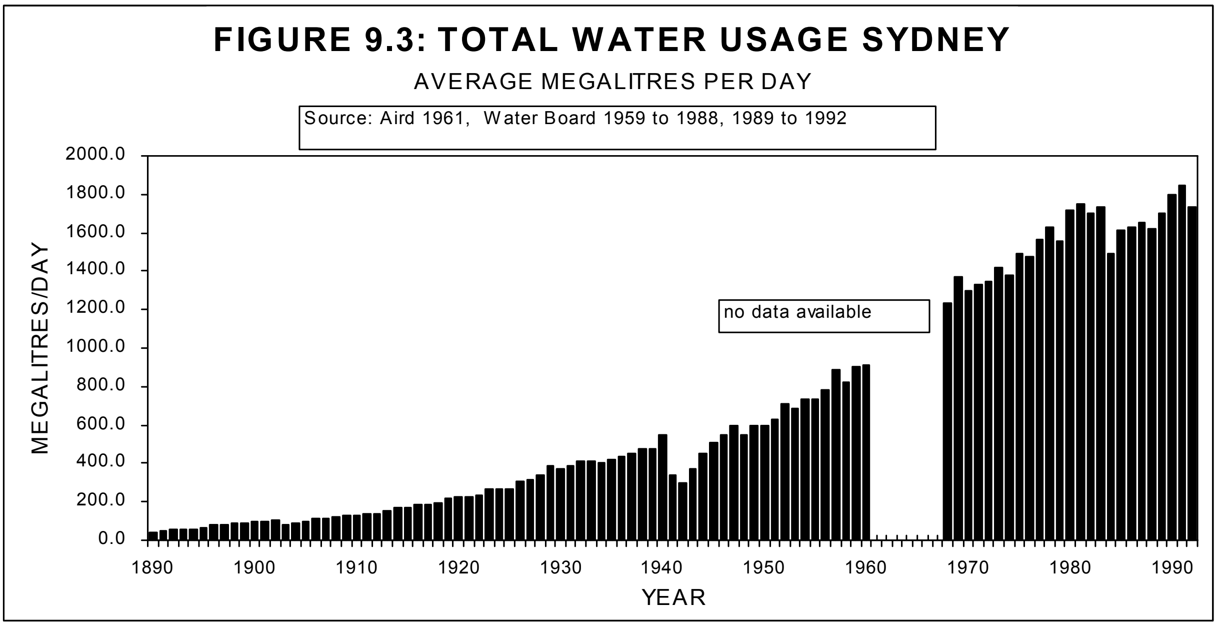


Until adequate water pollution controls were in place increasing water consumption brought with it increasing discharges of pollutants into streams. The consumption of water on a per capita basis (Refer Figure 9.2.) and total consumption (Refer Figure 9.3) have been increasing with growing urbanisation and industrialisation. (Coward 1988). Per capita consumption of water at 200 litres/person/year remained fairly constant during the first quarter of this century but started to rise in the ten years before the Second World War. There was a drop during the war due mainly to restrictions imposed on use. The rise continued after the war and reached a peak of about 500 litres/person/year in the late 1980s. Total consumption followed a similar pattern as shown in Figure 9.3. Consumption in 1960 was about 70% higher than 1946 (Aird 1961, Sydney Water Board 1959-1988, Sydney Water Board 1989-1990).

FIGURE 9.2: SYDNEY WATER CONSUMPTION

PER CAPITA CONSUMPTION - AVERAGE FOR 5 YEAR PERIODS

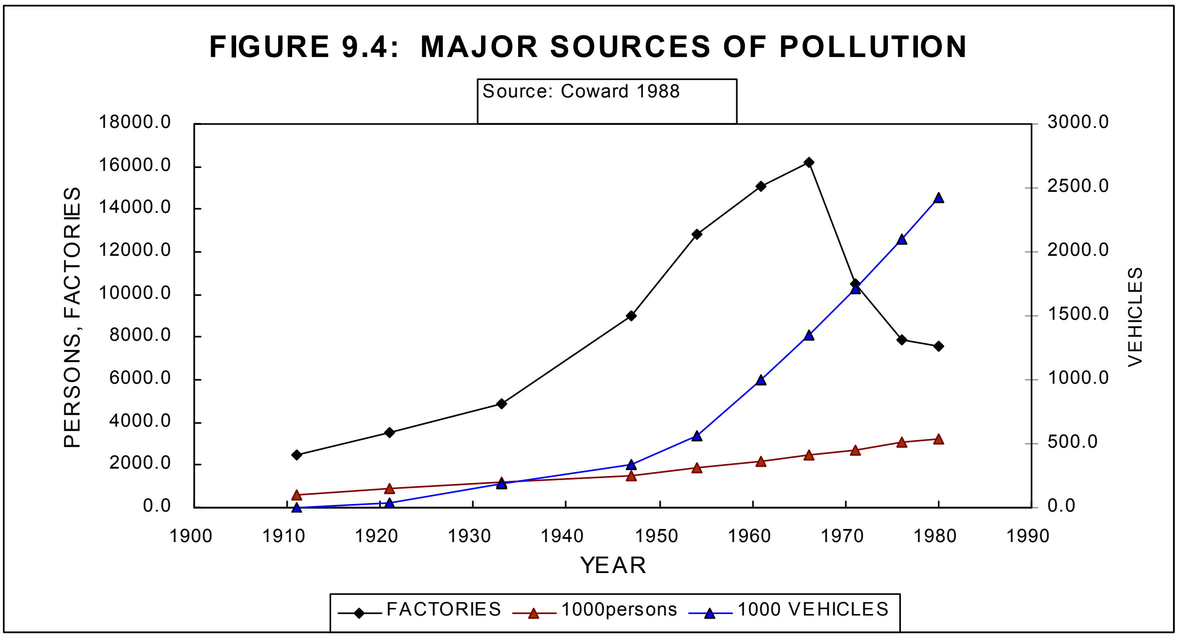


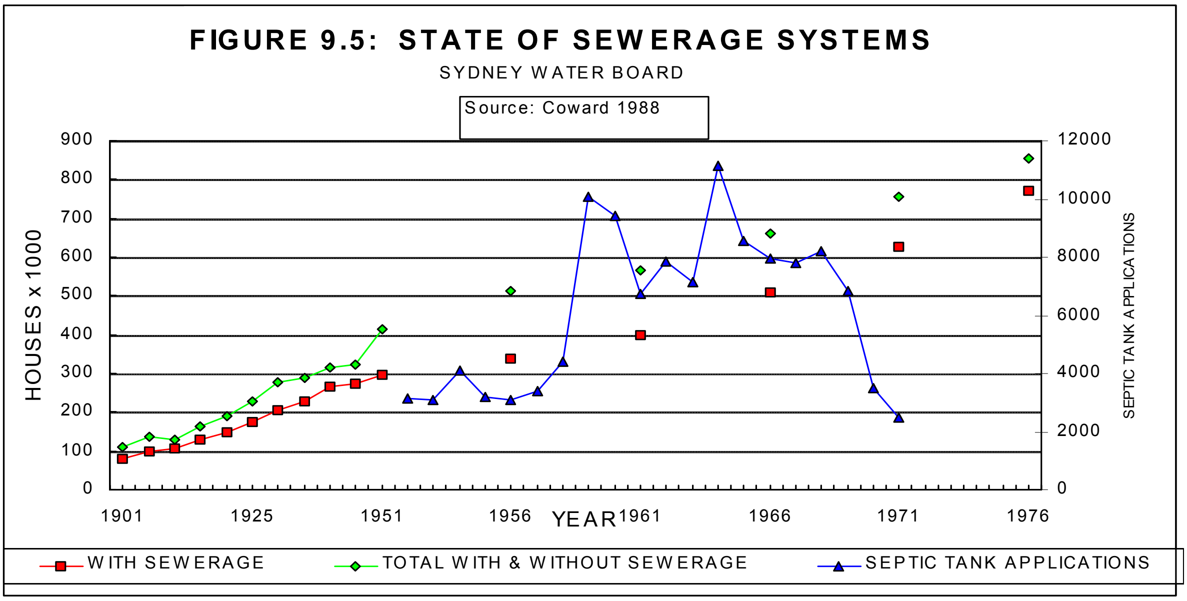


Coward (1988) categorised the major sources of waste flows as households, industry, and transport. Figure 9.4 shows the significant increases (for the period from the end of the war to the early 1960s) in the numbers of people, factories and vehicles in Sydney. This is a further indicator of the significant increases in waste generation and pollution loads to the environment (water, land, and air).

Sewage overflow and septic tank seepage and overflow contributed to the pollution of streams (Coward 1988). Figure 9.5 provides an indication of the trends in sewage generation and disposal. From about 1950 the total population (those with and those without sewerage increased significantly but the gap between these two categories (i.e. total without sewerage) also increased. This is also reflected in the number of septic tank application inspections being undertaken from 1950 to 1965. This is an indication of the increasing potential for septic tank installations to overflow or seep into local watercourse causing pollution.

Each of the following sections describe the solution of the Parramatta River pollution problem in terms of the processes of the proposed model, describe the indicators chosen for each process and provide graphs showing the quantification of these chosen indicators. In a later section (Section 9.13) the process indicators are combined in a process diagram showing the complete solution.





9.2 Problem and People Affected

The previous section showed that since 1945 there was a significant increase in the amount of waste being produced in the Sydney area. Some of this waste in the form of industrial effluent, sewage overflow and septic tank waste etc. found its way into the waterways. This affected all rivers in the populated areas of Sydney including the Parramatta River. (SPCC circa 1985)

The first people to be affected were those using or living near the river. The examples cited from Powell (1987) indicated that as far back as 1930s people were being affected by the polluted state of the river and by the early 1950s the river was perceived as being severely polluted.

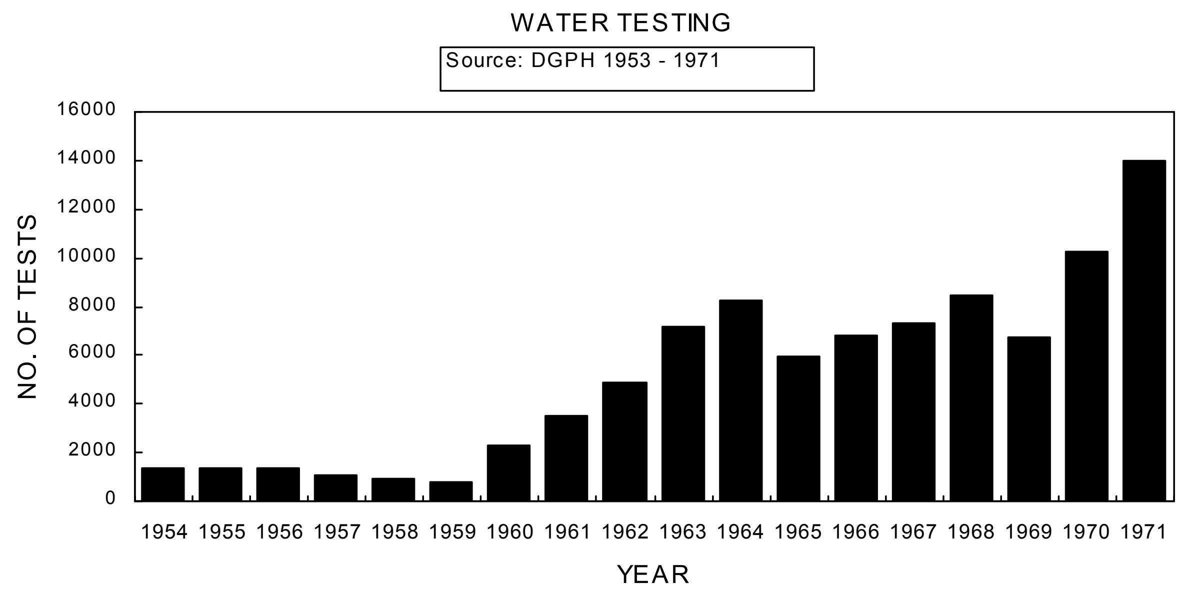
The indicator used for the process *people affected* is the newspaper reports of the 1950s of the polluted state of the river as shown as a single histogram bar in Figure 9.15.

9.3 Harbingers

The Government Analyst's Branch of the Director General of Health in NSW (DGPH 1953 to 1971) was reporting increasing used of their services by Government Authorities for waterways (The Water Conservation and Irrigation Commission, The Sydney Water Board, The Maritime Services Board, and the Fisheries Department) to test water samples for both chemical and bacteriological parameters)

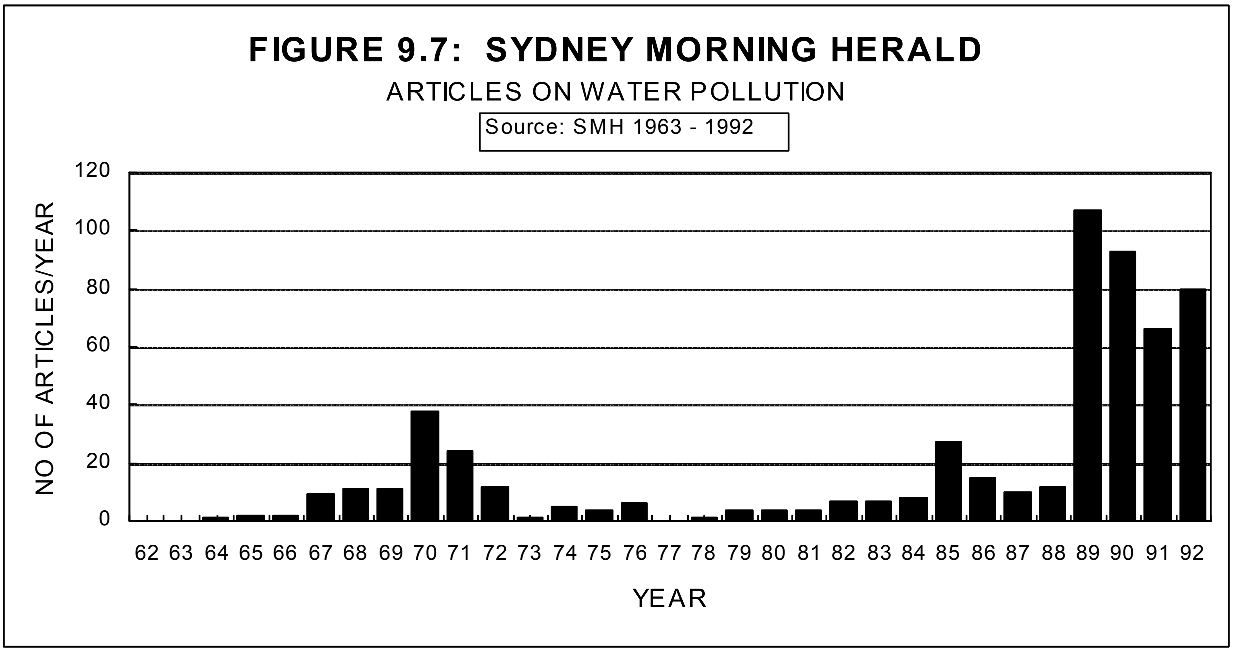
Figure 9.6 shows this dramatic increase in water testing for the period 1958 to 1963. The DGPH 1963 annual report highlighted the increasing attention being paid to stream pollution. Dr D.K. Thistlethwayte who was a research consultant in public health at the University of NSW (Whitington 1968) said "unless something is done about pollution in Sydney in the next 2 to 3 decades it will be in the same mess as USA is now". Both these forecasts (DGPH 1963 and Whitington 1968) are used as indicators for the process *harbinger* as shown in Figure 9.15.

FIGURE 9.6: GOVERNMENT LABORATORIES



9.4 Public Concern

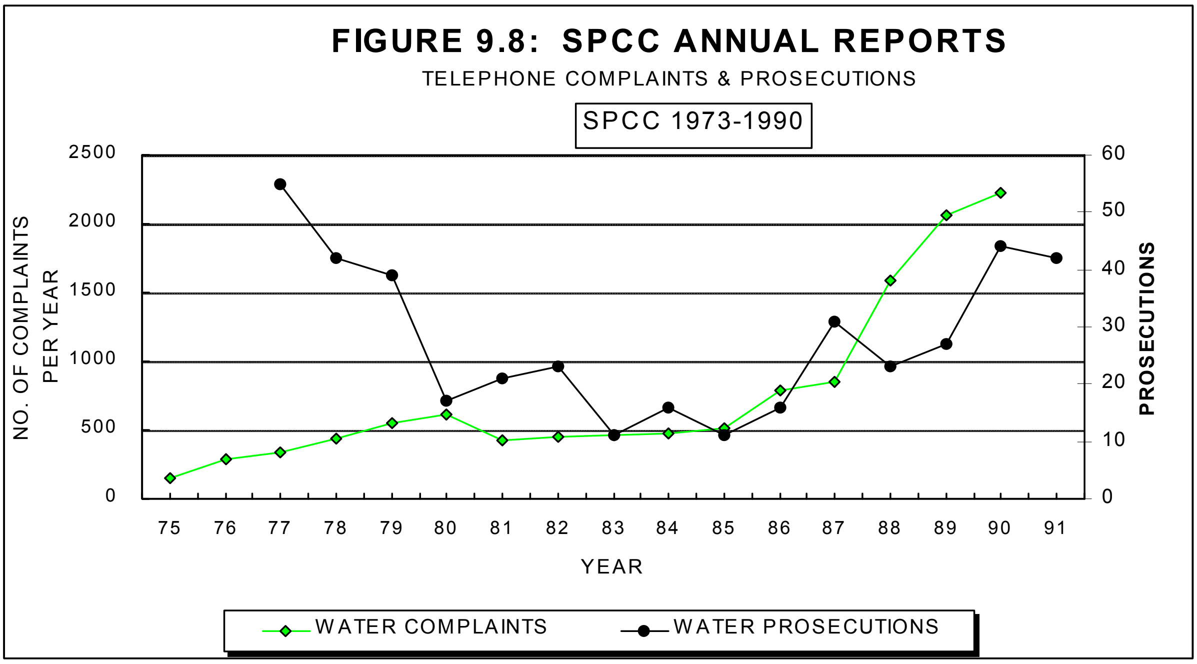
Figure 9.7 shows the number of articles in the SMH per year on the topic of water pollution as an indicator of public concern for water pollution. It shows that from 1964 to 1965 there was an increasing level of concern that increased further during the period 1967 to 1969 with a peak during the early 1970s.



Whitington (1968) expressed concern at the problem of water pollution drawing on evidence presented at the Australian Senate Select Committee enquiry into pollution (SSC 1970). Whitington (1968) says, "little has been done to remedy air and water pollution. Governments have been notoriously slow to act and when public demands for action are lacking governments are less likely to move on their own initiative".

Another indicator of *public concern* for water pollution is shown in Figure 9.8. It shows the large increase in public complaints to the SPCC over the period 1975 to 1980.

The indicator used for this process is the articles from the Sydney Morning Herald on water pollution as shown in Figure 9.7.



9.5 Political Action

Figure 9.9 shows the number of pages of NSW Hansard devoted to water pollution. This represents an indication of political action through parliamentary debates concerning general water pollution in NSW. It shows an increase in political debate from 1968 building up to a peak in 1970 and a later peak in 1974.

The control and monitoring of water pollution or quality was not at the time vested in any single authority in NSW with the Department of Health, Maritime Services Board, and the Sydney Water Board (then the Metropolitan Water Sewerage and Drainage Board (MWSDB)) having major roles. (DGPH 1953 to 1971, WB 1959 to 1988).

Some of the first indicators of organisational action by public authorities were the increased testing of water quality. (See Figure 9.6). The Government Analyst (DGPH 1968a) in its annual reports was starting to mention river pollution as a problem and the need to have a separate laboratory to deal with the increasing water analysis workload.

The Northern Suburbs Sewerage Survey (Brown and Caldwell 1967) included monitoring data from the Maritime Services Board over the period June 1963 to January 1966 which showed very low levels of dissolved oxygen in the Parramatta River caused by discharges into mainly the upper parts of the Parramatta River. These included trade waste from industry and urban runoff. (This would have included sewer overflows or overflows from septic systems.)

The indicator used for the process *political action* is the articles on water pollution from NSW Hansard as shown in Figure 9.9.

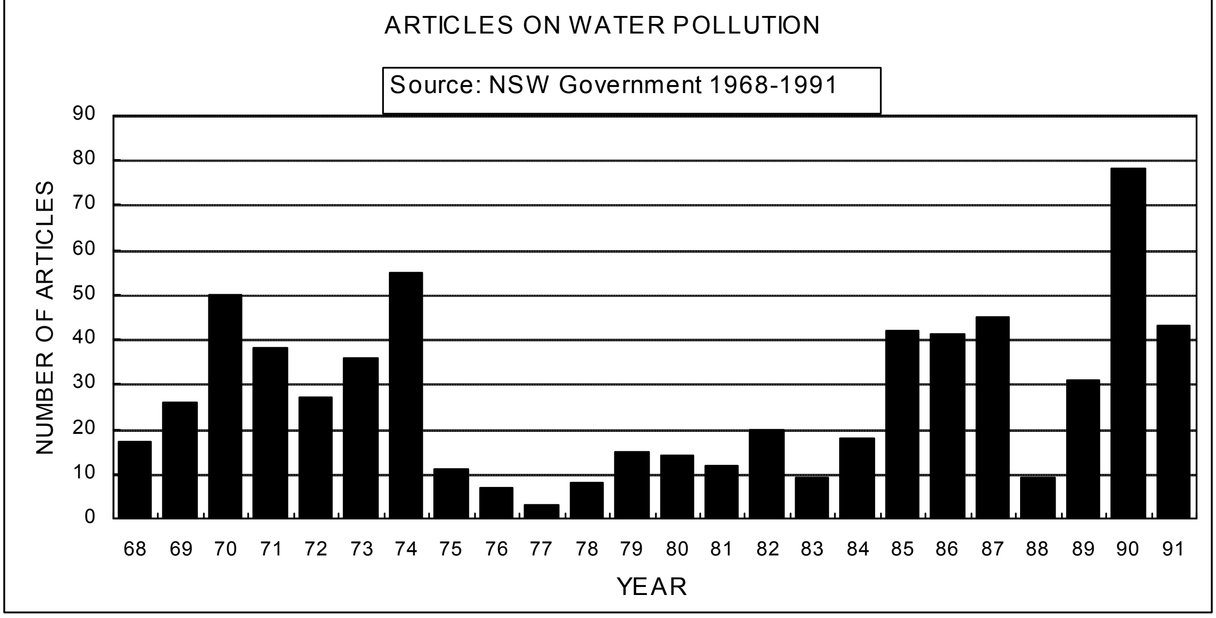


FIGURE 9.9: NSW HANSARD

9.6 Body of Knowledge

A *body of knowledge* on water pollution of water ways was being developed by the increasing amount of water sampling being undertaken (See Figure 9.6) and by specific river water monitoring (including the Parramatta River) and water quality assessment as shown in Figure 9.10. The indicator used for this process is the years over which monitoring occurred as shown in Figure 9.10.

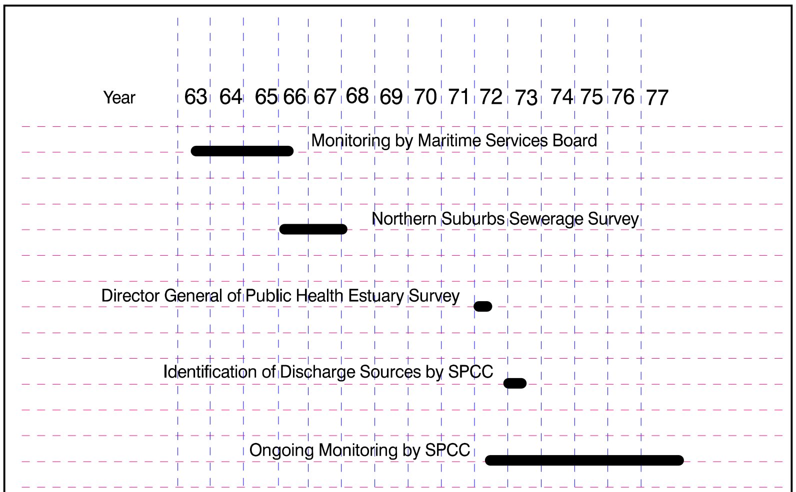


Figure 9.10: Generation of Body of Knowledge through Monitoring Water Quality

Source: DGPH 1953 -1971, SPCC 1977b, Brown and Caldwell 1967, SPCC circa 1985,.

9.7 Inquiries

A number of inquiries were instigated in response to growing public and organisational concern for water pollution. The Australian Senate (SSC 1970) commenced in May 1968 but its final report was not delivered until June 1970. The Senate inquiry found that the main water pollution problems facing Australia related to sewage, industrial effluents, and salinity. These they believed was caused by the lack of an effective pricing system, abysmal ignorance of the causes and consequences, piecemeal and parochial administration of water resources and half hearted and ill directed methods of abatement.

Some of the main recommendations to come from the inquiry included the need for: a national policy; a national body (new organisation); comprehensive approach; and systematic assessment of the problems (generation of a body of knowledge).

An inquiry (Barton 1970) was held in NSW into the problems of waste disposal in Sydney and this included disposal of waste into water bodies and the consequent pollution of these water bodies. The conclusions were that the problems should not have arisen and that they could have been anticipated with co-ordinated authorities in existence. There was also perceived to be a lack of drive and co-ordination. It recommended that the problem needed to be tackled by administration, organisational, and technical means. Its recommendations were for licensing of discharges, staff of Authorities to be augmented (*organisational change*), and formation of a single authority to control liquid and solid waste.

The indicator used for the process *inquiry* is the number of inquiries and the years over which the enquiries occurred: SSC (1970) form 1968 to 1970 and Barton (1970) in 1970 as shown in Figure 9.15.

9.8 Legislation

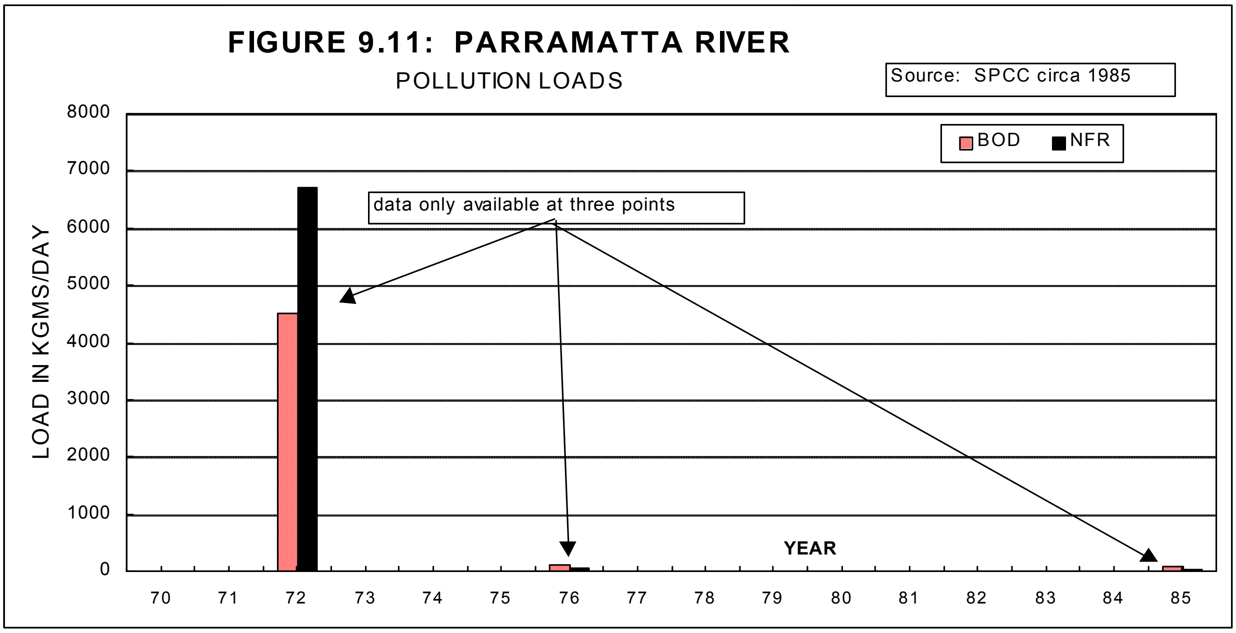
Growing public concern and the results of these two enquiries and others into water pollution were factors influencing the development and the passing of both the Clean Waters Act and the SPCC Act. This helped to reduce the problem of pollution caused by industry by providing a single authority with increased power and funds and introduced penalties for non-compliance.

The initial legislation was controversial at the time and was withdrawn to be redrafted. It then required the development of regulations to become effective. The Clean Waters Act (CWA) was initially administered by the Department of Health until taken over by the State Pollution Control Commission (SPCC) in May 1974. Soon after the SPCC took over the legislation the CWA was amended to increase penalties for pollution. (SPCC 1973 to 1990)

The SPCC/CWA legislation enabled the SPCC to act to identify sources of industry pollution to waterways and to regulate discharges by the licensing of these discharges. This eventually reduced the quantity and improved the quality of these types of discharges. (SPCC 1973 to 1990)

Figure 9.11 shows the reduction in Non Filterable Residue (NFR) and BOD load due to issuing licences to discharge by the SPCC.

The indicator used for this process is the reduction in Basic Oxygen Demand (BOD) discharges as a result of licensing by the SPCC.



9.9 Allocation of Funds

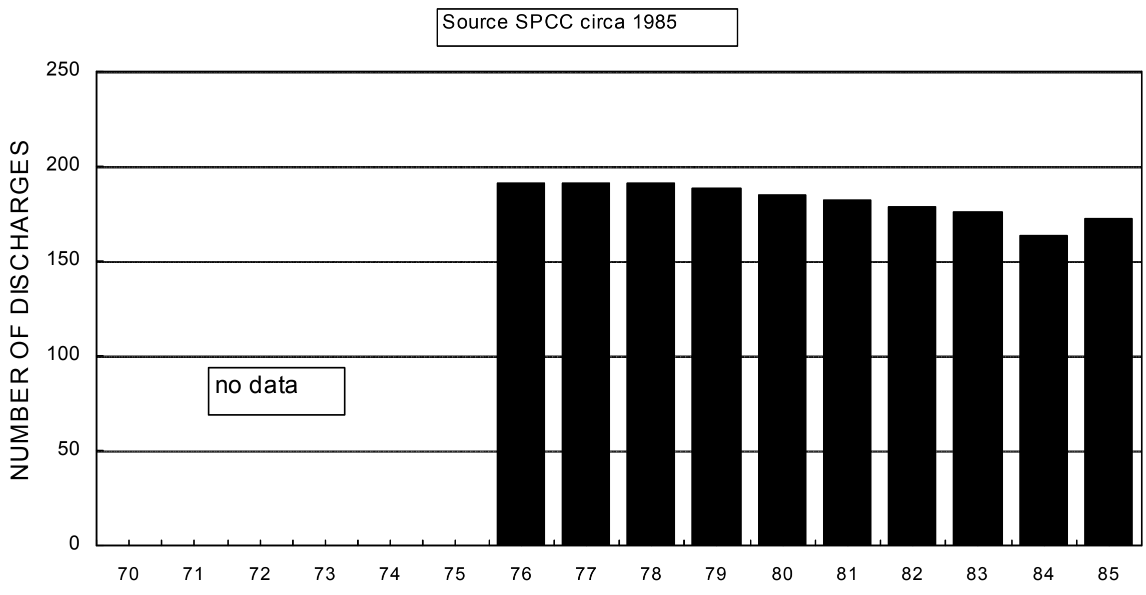
Public funds were allocated for the establishment of a group to manage solutions to water pollution initially within the DGPH and then later within the SPCC (DGPH 1953 to 1971, SPCC 1973 to 1990).

Public funds were also being allocated to increased testing of water by Department of Health. (Refer Figure 9.6) Once the Clean Water Act became effective industry was forced to make funds available either for licensing fees, capital costs for new equipment and fines for non-compliance. The number of licensed discharges could be considered to be related approximately to the amount of work industry needed to undertake to ensure compliance. (Refer to Figure 9.12).

The indicator used for this process is the number of discharges approved by the SPCC as shown in Figure 9.12.

FIGURE 9.12 PARRAMATTA RIVER

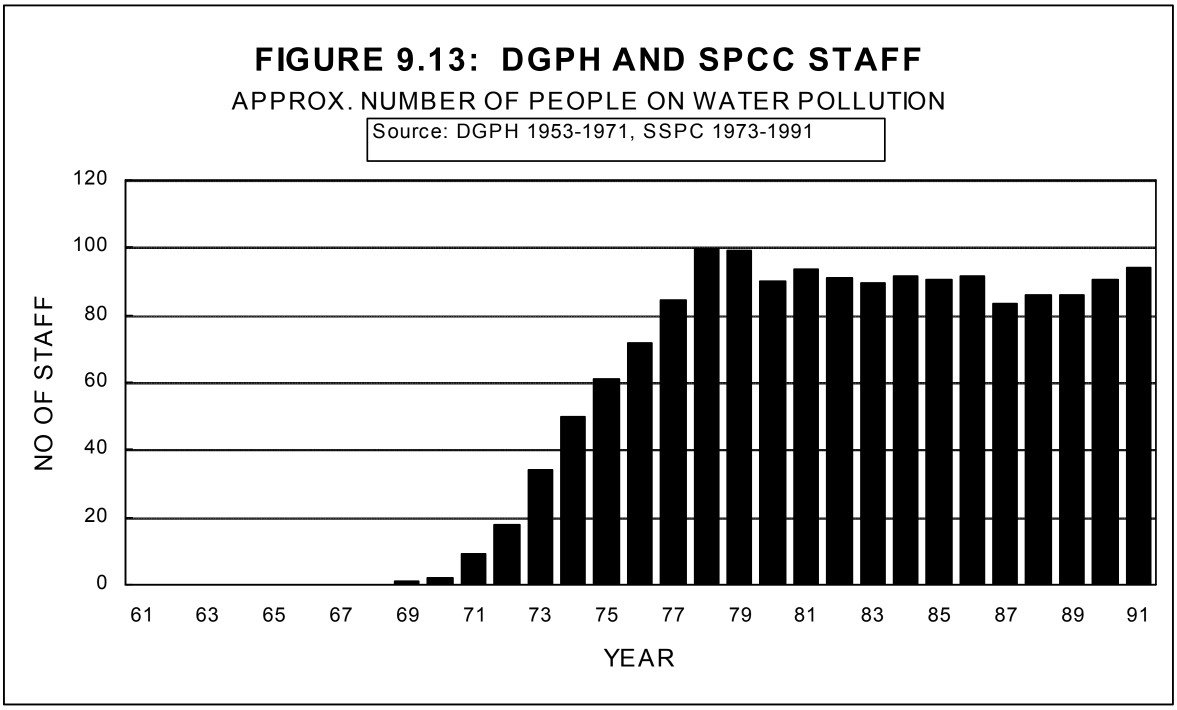
CUMULATIVE REDUCTION IN NO. OF DISCHARGES FROM 1970



9.10 Organisational Change

The major new organisations involved were initially the Clean Waters Branch of the Department of Health and then the State Pollution Control Commission. Figure 9.13 shows the build up in number of people within these organisations with responsibility for water pollution. This is the indicator used for this process.

The gradual increase of numbers is an indicator of progressive organisational development including; development of organisational procedures and systems; the level of funding from the Government; level of responsibility for the legislation (Department of Health administered the Clean Air and the Clean Water Acts until 1974); the effectiveness of the legislation. (It took a number of years until workable legislation and regulations were in place).



9.11 Solutions in Place and Institutionalised

By the late 1970s a lot of the sources of industrial and other discharges into the Parramatta River (and other Sydney rivers and creeks) had been identified and either stopped or licensed. Licensing enabled control over both the quantity and the quality of the discharges. Figure 9.11 shows the dramatic reduction in the pollution load achieved by licensing discharges. It should be noted that a lot of the discharges were redirected to the Water Board sewers (SPCC circa 1985), which then discharge via treatment plants into the ocean (Refer Section 8).

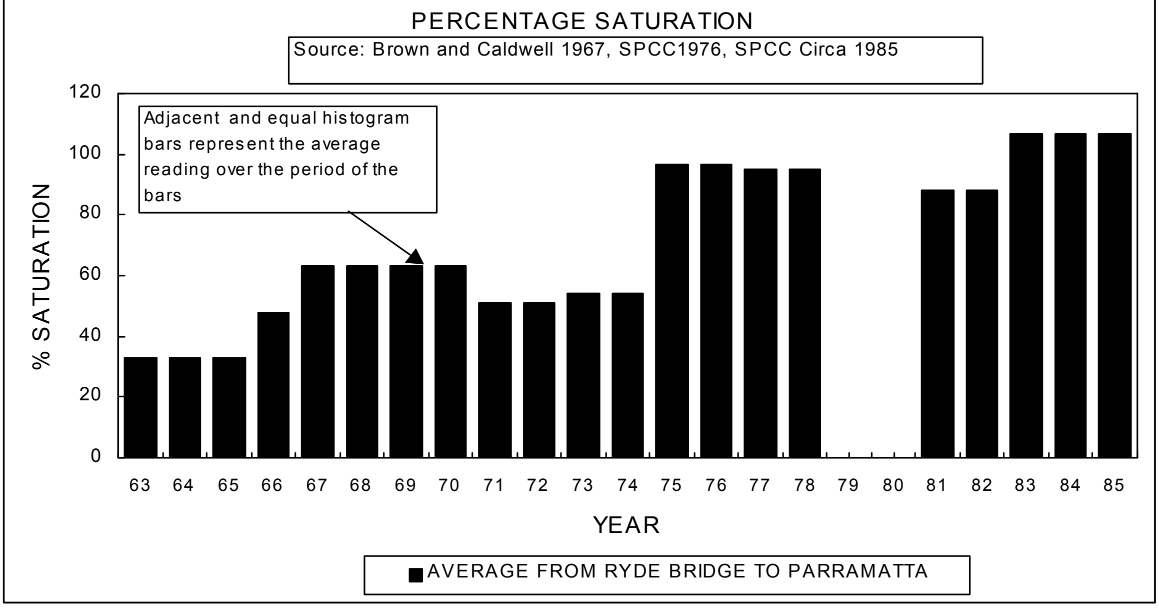
9.12 Extent of the Solution

The major pollution problem perceived at the time in the Parramatta River was the death of aquatic life in the river. Dissolved oxygen (percentage saturation) was used as a measure of the state of oxygenation of the water and consequently its ability to support aquatic life. This was measured in the 1950s and 1960s by the Maritime Services Board (Brown and Caldwell 1967) and the SPCC during the 1970s and afterwards (SPCC Circa 1985). A level of 60% to 70% was considered the minimum level necessary to maintain a healthy ecosystem. Other contaminants like heavy metals, pesticides etc. were not the prime concern of the initial clean up.

Figure 9.14 shows that from mid 1960s to the mid 1970s the average percent saturation was between 40 and 50% though in many cases it was as low as 10% in the upper reaches. If data was available it would probably show that prior to the 1960s and during the War that the dissolved oxygen was much higher and that in the 20 years after the War the quality steadily declined with increasing urbanisation, industrialisation, and population growth. The situation become so bad that public concern expressed itself sufficiently loudly and broadly that the political process was moved to action. Barton (1970) seemed to fail to recognise this necessary process when he said the pollution of the rivers could be avoided.

Figure 9.14 shows that by 1976/77 the effect of licensing and control of industry discharges brought the dissolved oxygen levels up to around 100% on average. There were still trouble spots that took many yeas to solve. Figure 9.14 is an amalgamation of data from three sources.

FIGURE 9.14: PARRAMATTA RIVER OXYGEN LEVELS



9.13 Processes

The chart in Figure 9.15 summarises the main processes and events that occurred from the time the problem of pollution was first identified until a solution was in place.

Figures 9.7, 9.9, 9.10, 9.11, 9.12, 9.13, 9.14 presented in this section represent indicators of the strength of processes and the time over which they were active. In order to visualise the chronology and the overlapping of the processes involved in the solution to the river pollution problem, the figures mentioned above have been placed on a common time scale as shown in Figure 9.15. This diagram is a key to the understanding the interconnected nature and time frames of the processes.

The main processes are listed on the vertical axes of the diagram. For each process the horizontal axis is a measure of the time over which the process was active in the solution of the pollution problem and the vertical dimension is a measure of the intensity of the process.

The process *people affected, harbinger*, and *legislation* are shown as single histogram bars as they are events that do not extend over one year in duration. The other process histograms show the trends over time. *Public opinion* and *political action* are shown over the whole period of the case study to contrast the early peaks with the late trough. The latter peaks in the early 1990s are not related to the solution of the described pollution problem.

9.14 Discussion

Figure 9.15 shows that the processes overlap in time by varying degrees without a simple progression from one process to the next. As the processes represent a multitude of activities by a variety of groups and people a simple progression could not be expected.

Figure 9.15 shows that people were affected by the pollution of the Parramatta river in the early 1950s but it wasn't until the late 1950s and early 1960s that the problem started to be formally acknowledged within the public arena. *Public concern* and *political action* on water pollution was high during the early 1970s. In the early 1960s the DGPH was undertaking significantly more testing of water for pollutants as shown in Figure 9.6. From the early 1960s to the early 1970s there was a significant increase in the *body of knowledge* of the polluted state of the Parramatta River as a result of monitoring as shown in figure 9.10. The first of two enquiries (SSC 1970) focused attention on pollution of waterways Australia wide and the second (Barton 1970) focused attention on inter alia the Parramatta river.

Public funds were allocated for water pollution control firstly within in the DGPH and later within the newly formed SPCC. (Refer Figure 9.13). Private funds were also allocated to the implementing of plant and equipment to reduce water pollution emissions from factories. New organisational branches (*organisational change*) were established in government firstly within in the DGPH and later within the newly formed SPCC. The primary legislation the Clean Waters Act enabled government to identify sources of water pollution and to require licensing of discharges. This primary legislative activity is included in the process *political action*. The secondary legislation and that included in the process *legislation* is the actual licensing of discharges as shown in Figure 9.11.

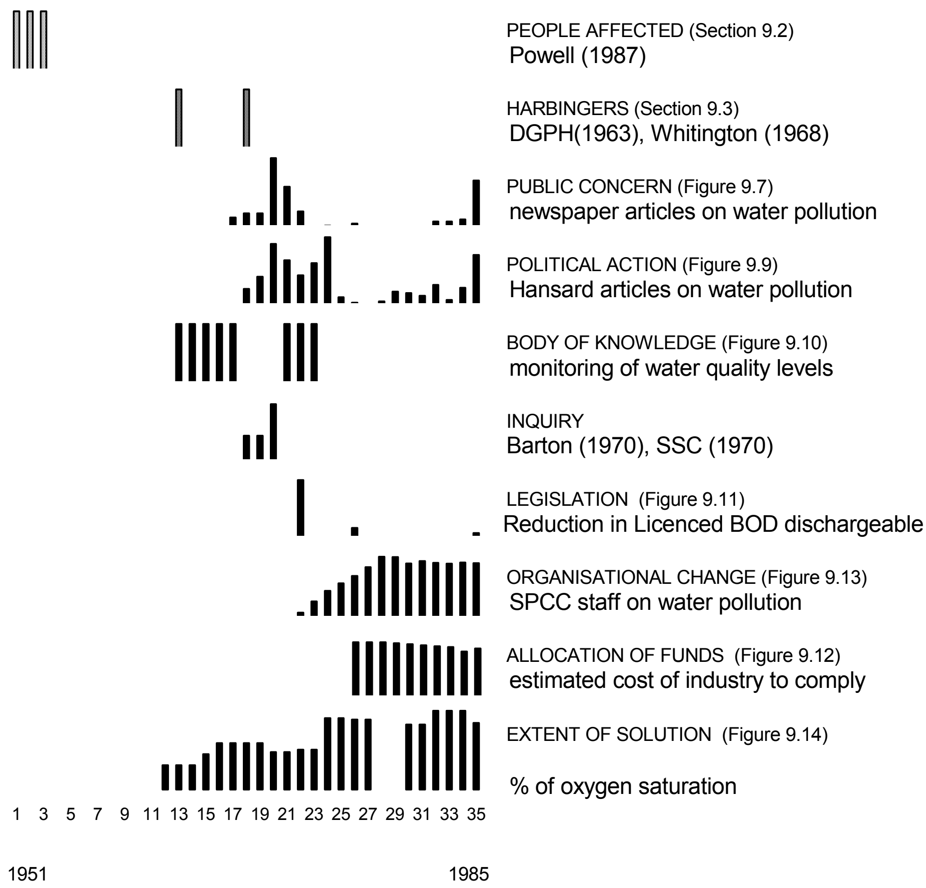
The measure of the extent and timing of the solution of the problem is the average level of oxygen in the river and Figure 9.14 shows the improvement over time.

The period of time from when the problem was first identified until a decision was made to actually implement a solution was about 21 years (1954 to 1975) while the time taken to implement a solution was about 8 years (1975 to 1983).

While the indicators chosen represent the magnitude change and duration of the processes it could be suggested that a better proof of the model might be achieved if the indicators of *public concern* and *political action* measured Parramatta River pollution only. The author does not believe this would be possible because Parramatta River pollution was only one area of water pollution in the Sydney area and the data from the Sydney Morning Herald and the NSW Hansard was not extensive enough to divide it into individual rivers in Sydney without diminishing its accuracy.

The process diagram Figure 9.15 provides a succinct summary of the processes involved in solving the water pollution problem of the Parramatta River. It illustrates many aspects of the processes: the long time frames involved (over 20 years); the social and institutional); the methods appropriate to measure the outputs from these processes; the identification of the role of *public concern*; and the partial nature of the solution. It could be called the political resolution rather than the solution. The case study also illustrates that the model and the methodology for quantifying the processes are valid and practical.

FIGURE 9.15: PROCESSES INVOLVED IN THE SOLUTION TO PARRAMATTA RIVER POLLUTION



Notes:

1. Vertical scales are % of largest y value. The first peaks of PUBLIC CONCERN AND POLITICAL ACTION are relevant for the solution but other peaks are shown to illustrate the change that occurs in these indicators.
2. Figure numbers in brackets are references to the detailed figures in this section containing the graph scales.
3. The data after the right hand end of the histograms e.g. after 1985 was not collected or shown as it was not relevant to the time period of the case study

10 COMPARISON OF CASE STUDY INDICATORS AND RESULTS

10.1 Introduction

In this section the similar process are separately compared across the five case studies. This comparison enables an assessment to be made of the degree of similarity of the same process between case studies and an assessment of whether a consistent similarity confirms that the particular process is a valid and measurable process.

It should be noted that even though the comparison in this section shows that the processes are similar a close examination of the process diagrams (see Figures 5.10, 6.11, 7.16, 8.15, 9.15) shows that the time order of the processes varies slightly. Appendix B contains a discussion of these differences.

The information of this section is extracted from the previous sections describing each of the individual case studies (see Sections 5, 6, 7, 8, and 9).

10.2 People Affected

The first process of the proposed pollution process model is *people affected*. Table 10.1 shows for each case study the group of people affected, when they were affected, and the observed effect based on recorded evidence. The first observed effect in all case studies was a visible manifestation of the pollution.

The air pollution problems grew in parallel as more cars and more industry discharged pollutants. The water pollution problems had been growing for some time and gradually built up over time as more pollutants were discharged to the water.

Table 10.1: People Affected

Case Study	People Affected	Year	Observed effect
Brown Haze Sydney	general population	early 1970s	visible brown haze in winter causing reduced visibility and amenity
Ozone Sydney	general population	early 1970s	visible white haze in summer causing reduced visibility and amenity
Ozone Melbourne	general population	early 1970s	visible haze
Beach Sydney	bathers	1930s onwards then more in mid 1960s	Sewage solid matter observed in ocean waters and on beaches
Parramatta River Sydney	people living near river	1930s onwards, then more in 1960	visibly polluted waters and river banks

(Source: Sections 5.2, 6.2, 7.2, 8.2, and 9.2)

The significance of this process for the model is that it is the first reported occurrence of the pollution. It can be concidered the starting point for the public perception of the problem and the public involvement in its solution. This process was identified and measured in all five case studies.

10.3 Harbingers

The second process of the proposed pollution model is *harbinger*. The word is used to describe a person or group who looks ahead in time and who is able to recognise or predict that a pollution problem will become significant if no action is taken.

Table 10.2 shows for each case study the *harbingers,* the year of their prediction, the type of person or group involved, the basis on which their prediction was made, and their prediction. It shows that the harbingers consist of the following types of people: public authorities with responsibilities for monitoring the polluted medium, engineering consultants advising a public authority, and university researchers. Their predictions were based on a limited amount of monitoring of the polluted medium and their predictions were often projections rather than accurate estimates. It is interesting to note that while knowledge was incomplete, the *harbingers* were able to make early predictions that the problem would get worse if nothing was done. While these predictions were ultimately proven to be factual, they were not (as the case studies demonstrate) sufficient in themselves to cause the promulgation of immediate legislation or regulations to solve the problem.

Table 10.2: Harbingers

Case Study	Harbinger	Year	Type of Group and basis of prediction	Prediction
Brown Haze Sydney	SPCC (1973)	1973	Public Authority, based on limited monitoring.	There was a problem and it would get worse unless backyard burning was controlled
Ozone Sydney	Sullivan (1962), DGPH (1968)	1962 1968	Public officer, based on limited measurements. Public Authority based on limited monitoring of ozone levels.	Could be a problem in the future like Los Angeles. Could be a problem in 1992.
Ozone Melbourne	EPAV (1974)	1974	Public Authority based on limited monitoring of ozone levels.	Could be a problem in the future unless some action is taken
Beach Sydney	Brown and Caldwell (1965)	1965	Water Board engineering consultant based on monitoring and calculations.	Problem will get worse as population grows unless deep ocean outfalls are built.
Parramatta River Sydney	DGPH (1963), Whitington (1968)	1963 1968	Public Authority observations based on water testing. University researcher, based on research.	Highlighted increasing attention paid to stream pollution. Unless something is done in the next 2-3 decades Sydney will be in the same mess that the USA is in now.

Source: Sections 5.3, 6.3, 7.3, 8.3, and 9.3

The table shows that the *harbingers* and their predictions were identified and are similar for each case study.

The significance of this process for the pollution process model is that it is the first time that the significance of the pollution problem is identified, albeit by a small group. The groups though (see

Table 10.2) are authoritative in terms of the problem and maybe influential, though in terms of promulgating a quick solution (as each of these case studies show) not politically powerful enough. In some of the case studies the process *harbinger* comes before the *process people affected* (Refer to Appendix B for discussion of this.). One could envisage this happening where the effects of the pollution problem were not visible e.g. high ozone concentrations measured before a visible haze was evident. Because the predictions made by *harbingers* are authoritative this is a point from which it might be possible to expedite a solution e.g. initiate an early start to focused research i.e. the building of the *body of knowledge.*

This process was identified and measured in all five case studies.

10.4 Public Concern

The third process of the proposed pollution model is *public concern*. The process and its indicator measure the increase in concern about the effects of pollution. Table 10.3 shows the type of indicator used for each case study, the indicated effect and the figure in which the indicator is quantified.

Two indicators of *public concern* for air pollution in Sydney were used. Because they are general indicators and do not measure the concern for the particular type of air pollution they could be used interchangeably. Figure 5.1 shows a peak of concern in 1971 while Figure 6.3 shows a peak of concern in 1971/1972. (The SPCC complaint services was only established in 1970.) At the time of these peaks the nature of brown and white haze pollution was not fully understood scientifically and it was not likely that the public and the media would have been able to distinguish between the two so a general indication of air pollution is adequate. The indicator used for Melbourne was similar to that used for Sydney.

The indicators of *public concern* identified for the water pollution topics in Sydney are the numbers of articles on a particular topic in the Sydney Morning Herald. This is a Sydney newspaper with general distribution throughout the city. Because the pollution problems were fairly widespread in the city it can be argued that this is an appropriate newspaper to use.

There is a counter argument that newspapers local to the Parramatta River valley may be more appropriate measures of concern for Parramatta River pollution. An argument against this is that the number of articles on water pollution in the SMH newspaper is not large (between 1 per month and 1 per week) and a local paper may have even fewer articles. This lack of data would diminish the accuracy of the indicator.

It could be suggested that the number of articles (e.g. on brown haze pollution) could be a more appropriate measure rather than articles on air pollution. This would also subdivide limited data and diminish the accuracy of the indicator. Secondly unless people and reporters are fairly knowledgeable about specific manifestations or causes of air pollution it may be difficult for them to make subtle distinctions between different types of pollution.

Therefore it is reasonable to argue that the broader scale indicators are more accurate in measuring the trends in the process over time when considering the limited historical data that was available. Table 10.3 shows that similar broad indicators were used for each case study and the reference figures show observable increases in public concern for air and water pollution. Increases in *public concern* were measured in all case studies. A sharp reduction in measured concern occurred in the Sydney case studies after the initial increase. The Melbourne data displayed a steadily increasing concern. This could be a function of the indicator chosen and/or limited available data.

Table 10.3: Public Concern

Case Study	Indicator	Indicated effect	Figure/Reference
Brown Haze Sydney	SMH articles on air pollution	Increase in concern in early 1970s then a reduction	5.1/SMH (1963-1992)
Ozone Sydney	public telephone complaints about air pollution	Increase in concern in early 1970s then a reduction	6.3/DGPH (1960-1971), SPCC (1973-1990)
Ozone Melbourne	public telephone complaints about air pollution	Gradual increase in concern in 1970s	7.2/EPAV (1971-1993
Beach Sydney	SMH articles on water pollution	Increase in concern in early 1970s then a reduction	8.4/SMH (1963-1992)
Parramatta River Sydney	SMH articles on water pollution	Increase in concern in early 1970s then a reduction	9.7/SMH (1963-1992)

Source: Sections 5.4, 6.4, 7.4, 8.4, and 9.4

The significance of the process *public concern* is that a significant number of people had become effected and that this concern was manifest through the media or through public complaints to the EPAs of NSW and Victoria. The case studies show this process is contiguous with or slightly preceding political action in the Parliament.

In three case studies the *public concern* (as measured by the number of newspaper articles) was brought about by a visual perception of pollution. This may not always be the case e.g. some forms of pollution are not visible to the majority of the population and public concern if it occurred would arise if at all by indirect means. It could arise by people seeing and hearing information on television or reading of the affects and as a consequence expressing concern. One point that needs to be made is that public concern generated by direct experience is more likely to generate stronger attitudes than indirect experience (see in Table 2.10). The indicators of public concern in the four Sydney case studies also illustrate the issue attention cycle (Downs 1972).

This process was identified and measured in all five case studies.

10.5 Political Action

The fourth process of the proposed pollution model is *political action.*

The indicator of political action used for all case studies is the number of references to the particular pollution topic in the record of NSW parliamentary debates (Hansard) or Victorian parliamentary debates for the Melbourne case study. Use of “the number of pages” on a pollution topic could be used and Figure 4.5 shows that the number of references and number of pages produce a similar pattern over time. The number of pages on a pollution topic produces higher peaks (y axis value) than the number of references especially when new legislation is being introduced. The second reading of most new bills often produces extensive debates extending over many days.

Table 10.4 shows the type of indicator used for each case study and the figure in which the indicator is quantified. The change in the value of the indicators shown in Table 10.4 provide a first indication of topics being formally debated by government. It includes the introduction of new bills (if successful becoming Acts of Parliament), amendments to existing Acts, questions and answers to members questions, and petitions made by the general public. The rise in the value of the indicator shows approximately when the process *political action* commenced and a fall in value when the *political action* reduces.

Table 10.4: Political Action

Case Study	Indicator	Figure	Reference
Brown Haze Sydney	Hansard references to air pollution	5.2	NSW Government (1968-1991)
Ozone Sydney	Hansard references to air pollution from motor vehicles	6.4	NSW Government (1968-1991)
Ozone Melbourne	Victorian Hansard references to air pollution from motor vehicles	7.5	VG 1967-1992
Beach Sydney	Hansard references to beach pollution	8.6	NSW Government (1968-1991)
Parramatta River Sydney	Hansard references to water pollution	9.9	NSW Government (1968-1991)

Source: Sections 5.5, 6.5, 7.5, 8.5, and 9.5

This data (like Table 10.3) in some of the case studies does not measure directly the political action about a particular pollutant problem. Again similar arguments can be advanced that firstly there was not enough information available at the time to enable politicians or their advisers to distinguish between different types of pollution and secondly subdividing limited data would diminish its accuracy as an indicator of change.

The significance of this process is that it is an indication of the initial *political action*, which may produce overarching legislation. Certainly the statements made in Hansard (NSW Government 1968-1991) lead one to the conclusion that the legislation was all that was necessary to produce a solution. But as the case studies show this is often only a start to the legislative or political process.

The process *legislation* (Section 10.8) is where the regulations etc. are enacted that enable promulgation of the solution. The initial legislation often starts the solution as seen by the indicators measuring the level of pollution in Figures 5.10, 6.11, 7.16, 8.15, 9.15 where there is an improvement in the indicator of pollution prior to the full solution being put in place.

This process was identified and measured in all five case studies.

10.6 Body of Knowledge

The fifth process of the proposed pollution model is *body of knowledge*. This is the accumulation of a specific body of knowledge about the pollution topic.

The measures chosen to indicate the generation of a specific *body of knowledge* about the pollution topic shown in Table 10.5 include numbers of people engaged in research on a topic, expenditure levels, engineering studies, and detailed water quality monitoring studies. The case studies showed that specific accumulation of knowledge on the pollution topic often followed a process of low level monitoring or inquiry that indicated or acknowledged that a problem existed. In these case studies it appeared that existing knowledge was not robust enough to underpin a political process of legislation and expenditure. This is important especially when society will have had to spend both public and private money to solve the problem.

Table 10.5: Body of Knowledge

Case Study	Indicator	Figure	Reference
Brown Haze Sydney	people engaged on brown haze research	5.4	Williams et al (1981)
Ozone Sydney	expenditure on the Sydney oxidant study	6.5	Mitchell in Carras and Johnson (1982)
Ozone Melbourne	EPA air and meteorological studies	7.7	EPAV 1975, 1979
Beach Sydney	major engineering studies into deep ocean outfalls	Table 8.3	CCE (1976)
Parramatta River Sydney	monitoring of water quality levels	9.10	DGPH (1953 TO 1971), SPCC (1973 to 1990)

Source: Sections 5.6, 6.6, 7.6, 8.6, and 9.6

Table 10.5 shows the type of indicator used for each case study and the figure in which the indicator is quantified. Each of the figures showed that the accumulation of the *body knowledge* generally succeeded the initial political action and occurred over periods of several years.

The significance of this process is that it confirms that solutions to major pollution problems require extra knowledge as a prerequisite for their solution. This does not mean that the knowledge is fundamentally necessary. It could be argued that there is risk in trying to solve problems with incomplete knowledge - one could solve the wrong problem or use the wrong method of a solution that was unnecessarily expensive e.g. the brown haze problem research identified backyard burning and car emissions as the main causes whereas an initial perception may have been that either of these causes was the sole cause. The other significance is that politicians may require more certainty before they decide or may seek a cheaper solution or even an affordable solution. Maybe at this point research should be invested in the political process to provide a more efficient political solution.

This process was identified and measured in all five case studies.

10.7 Inquiry

The sixth process of the proposed pollution model is *inquiry.* Table 10.6 shows for each case study the type of inquiry and the key outcome of the inquiry for control of pollution.

Inquiry is a process of formally reviewing a problem, bringing the available knowledge and authority to bear. It was part of the promulgation of a solution in most of the case studies. The inquiries (Table 10.6) include a seminal conference on air pollution, Commonwealth of Australia Senate inquiries into air and water pollution, NSW state government inquiry into waste disposal, and at an organisational level an Environmental Impact Assessment process. The two Melbourne conferences identified in the table while related to air pollution did not seem relevant to the solution of the Melbourne ozone pollution problem. They also seemed to be either too early or late to significantly influence the other processes.

Table 10.6: Inquiry

Case Study	Inquiry	Outcome	Year	Reference
Brown Haze Sydney	Conference on air pollution	presented causes of brown haze and controls needed	1982	Carras and Johnson 1982
Ozone Sydney	Senate inquiry on air pollution Conference on air pollution	Presented cause of ozone and controls needed. presented cause of ozone and controls needed	1969 1982	SSC (1969). Carras and Johnson 1982
Ozone Melbourne	Two conferences	Process and indicator not relevant to study	1968, 1984	SSC 1969, EPAV 1984
Beach Sydney	EIS and approval process	EIS identified the impacts of current practices and likely impacts and improvements with deep ocean outfalls	1979-1980	WB (1989-1992)
Parramatta River Sydney	Senate inquiry on water pollution. NSW inquiry into waste disposal.	Identified main pollutants of concern: sewage, industrial effluents, and salinity. Recommended licensing of discharges, single authority to control	1970 1970	SSC (1970) Barton (1970)

Source: Sections 5.7, 6.7, 7.7, 8.7, and 9.7

The significance of this process is that there is formal recognition of the problem and recognition that the problem is severe enough to require political action. It gives added credence to future political actions. Often the inquiry as shown by the case studies covers problems under generic headings e.g. Senate inquiry on water pollution. The inquiry and Royal Commission of Inquiry has been a feature of pollution problems throughout Sydney's history (Coward 1988).

Of all the processes measured this one is probably the one that was the most weakly represented and/or measured. It may be that this process is not always needed or necessary.

10.8 Legislation

The seventh process of the proposed model is *legislation*. Table 10.7 shows for each of the case studies the type of legislation, the indicator used and the regulating authority, and whether the pollution was from many sources or a limited number of sources.

Legislation was passed that effected each of the case studies during the process *political action* described in section 10.4, but the process *legislation* includes more specific legalisation and regulations. The general legislation (mainly the Clean Air Act (1961) and the Clean Water Act (1970)) were important pioneer acts in the solution of pollution problems in the last 30 years in NSW but often further amendments and regulations were required to enable the solutions to the case studies to be implemented as shown in Table 10.7 and discussed below.

Brown haze was controlled by up to 90 individual municipal councils passing regulations to ban private back yard burning. The Clean Air Act was modified to allow the application of Australian Design Rules (ADR) to the control of motor vehicle emissions and consequently the control of ozone pollution. Application of ADR to the control of motor vehicle emissions in Victoria (Melbourne) allowed for the control of ozone. Design guidelines developed by the SPCC set the standards for the design of ocean Sewage Treatment Plants and their discharges to the deep ocean outfalls. Legislation enabled the licensing and control of industrial discharges to the Parramatta River. This same legislation though allowed increased discharges to ocean outfall sewers and in a sense potentially transferred some of the pollution problem to another place and time.

The final column of Table 10.7 shows for comparison the nature of the pollution source and the control authority. In three cases the State Pollution Control Commission (SPCC) controlled compliance though the Sydney Water Board had input into the quality of discharges from ocean Sewage Treatment Plants. In the brown haze case study Municipal councils were the control authority. In the case of Melbourne, the Victorian EPA was the controlling authority.

Table 10.7: Legislation

Case Study	Legislation	Indicator	Figure	Reference	Comments
Brown Haze Sydney	Municipal council regulations on backyard burning.	Number of councils with bans.	5.6	MWDA 1977-1989, SPCC 1973-1990	many points, many authorities - Municipal Councils
Ozone Sydney	Clean Air Act and Australian Design Rules	Limits on hydrocarbon emissions from motor vehicles.	6.6	Forest 1991	many points, one authority - SPCC

Ozone Melbourne	Australian Design Rules	Limits on hydrocarbon emissions from motor vehicles.	7.9	EPAV 1985	many points, one authority - EPA Victoria
Beach Sydney	Design guidelines limiting for ocean discharge of sewage.	Date regulation made	8.15	SPCC (circa 1985, WB (1989-1992)	limited discharge points, one authority - SPCC
Parramatta River Sydney	Clean Waters Act	Licensed discharge load.	9.11	SPCC circa 1985	many discharge points, one authority - SPCC

Source: Sections 5.8, 6.8, 7.8, 8.8, and 9.8

The significance of this process is its demonstration that two steps are often necessary in the legislative process to enact or facilitate a solution to a major pollution problem. There is firstly an overarching or general legislation like the Clean Air Act. Secondly there is later support with specific regulations to address specific problems or to make the enforcement of the prior legislation effective or possible.

This process was identified and measured in all five case studies.

10.9 Allocation of Funds

The eighth process of the proposed model is *allocation of funds*. Table 10.8 shows the indicator used and the figure in which it was quantified.

To implement each solution significant costs were incurred both by private organisations, government Authorities and individuals. The initial burdens fell differently though most of the costs would probably flow through to taxes and into the price of consumer goods.

The indicators shown in Table 10.8 are not a summation of total costs but an indicator of the trend over time of one of the major cost components. The brown haze pollution indicator is the estimated extra costs to Municipal Councils to introduce big garbage bins. The ozone indicator (both Sydney and Melbourne) is an estimate of the increased cost of motor vehicles to comply. The beach pollution indicator is Sydney Water Board's capital costs of construction. The indicator of Parramatta River pollution is the increased costs of industry to comply.

Table 10.8: Allocation of Funds

Case Study	Indicator	Figure	Reference
Brown Haze Sydney	Municipal councils' estimated cost of introducing big garbage bins.	5.10	MWDA 1977-1989
Ozone Sydney	Estimated increased vehicle costs to comply with ADR.	6.8	Cox 1991, SPCC 1973-1990
Ozone Melbourne	Estimated increased vehicle costs to comply with ADR.	7.11	EPAV 1984
Beach Sydney	Capital costs to construct the three deep ocean outfalls.	8.11	WB 1989-1992
Parramatta River Sydney	Number of discharge licences by industry to comply	9.12	SPCC Circa 1985

Source: Sections 5.9, 6.9, 7.9, 8.9, and 9.9

The significance of this process is that the solutions to major pollution problems require the expenditure of a large amount of public and private funds. This could involve state budgetary considerations and with it a layer of caution and delay to ensure funds are spent not only wisely but the expenditure is justified. It is this fact that probably adds significantly to the time taken to implement solutions. (This point is discussed further in section 10.12)

This process was identified and measured in all five case studies.

10.10 Organisational Change

The final process of the proposed pollution model is *organisational change*. This may involve new or changed organisations and organisational development as the changed organisation is established. Table 10.9 shows the types of organisational change that occurred, the indicator used, and the figure where the indicator is quantified.

New organisation or modified organisations may take many forms depending on the nature of the pollution problem to be solved. Table 10.9 shows the use of increased numbers of people in government regulators, as an indicator of organisational change. The build up in the numbers of people occured as the organisation changed in response to the need to define and implement a solution. This indicator of *organisational change* produces a graph in some cases similar to the *allocation of funds* graphs. Each of the case studies required significant changes and/or additions to government organisations to develop and implement the solution and to operate the solution or monitor compliance.

The same indicator was used for the two Sydney air pollution cases as both problems were being solved at the same time. While it would have been desirable to have separate indicators there was not sufficient information available to enable this to be done.

Table 10.9: Organisational Change

Case Study	Types of Organisational Change	Indicator	Figure	Reference
Brown Haze Sydney	Significantly changed government organisation to implement and manage.	Number of people in the DGPH and the SPCC concerned with air pollution.	5.7	DGPH 1960-1971, SPCC 1973-1990
Ozone Sydney	Larger and changed government organisation to manage, minor private organisational changes to implement solution.	Number of people in the DGPH and the SPCC concerned with air pollution.	6.9	DGPH 1960-1971, SPCC 1973-1990
Ozone Melbourne	Larger and changed government organisation to manage, minor private organisational changes to implement solution.	Number of people in the EPA Victoria concerned with air pollution.	7.12	EPAV 1971-1993
Beach Sydney	Large government project team to implement, minor government organisational changes to operate.	Estimated deep ocean outfall project team,	8.13	WB 1989-1992
Parramatta River Sydney	Larger and changed government to implement and manage.	Number of people in the DGPH and the SPCC concerned with water pollution.	9.13	DGPH 1960-1971, SPCC 1973-1990

Source: Sections 5.10, 6.10, 7.10, 8.10, and 9.10

The significance of this process is similar to the previous process *allocation of funds* in that it requires allocation of resources and this contributes to the time taken for a solution. In some respects the indicators overlap in the processes they measure.

This process was identified and measured in all five case studies.

10.11 Extent of Solution

The final indicator used for the pollution process model measures the level of pollution and its change with time. Table 10.10 shows for each case study the indicator used, some other causes that may have affected the level of pollution and the figure where the indicator was quantified.

Selection of an indicator to measure the extent of the solution to the major pollution problems in the case studies presented some difficulties because the pollution occurred over a large area (regional rather than local pollution) whereas monitoring was confined to discrete locations and times and the monitoring was often intermittent during the early stages as the problem was identified and acknowledged.

The indicators used are averages of the measured parameter across time and space. The absolute values of the indicators show how the pollution has been reduced to close to acceptable or legislated levels of pollution though for the purposes of the model the trend is equally important. In all case studies the literature had already identified the trends and provided an explanation of the contributing causes of the change.

The interconnected nature of pollution problems means that the indicators did not solely measure the effect of the case study cause and solution but the indicators were affected by more than one cause as shown in Table 10.10 e.g. brown haze was caused by both backyard burning and motor vehicle emissions.

Table 10.10: Extent of Solution

Case Study	Indicator	Other causes that affect the Indicator	Figure	Reference
Brown Haze Sydney	Average Coefficient of Haze (1968-1985) at selected locations, Average Coefficient of Light Scattering (1974-1990) at selected locations.	Single indicator not continuous over period, other causes (motor vehicles) affect indicator.	5.8 5.9	SPCC 1974-1990, SPCC 1974-1990
Ozone Sydney	Average ozone concentrations at selected locations.	Ozone formation is affected by weather patterns as well.	6.10	Hyde and Johnson 1990
Ozone Melbourne	Average ozone concentrations at selected locations.	Ozone formation is affected by weather patterns as well.	7.14	EPAV 1990b
Beach Sydney	Average faecal coliform at selected beaches close to ocean outfalls.	Some beach pollution caused by urban stormwater runoff.	8.14	Nelson and Roberts 1992
Parramatta River Sydney	Average level of oxygen saturation at selected locations.	Some river pollution caused by urban runoff.	9.14	SPCC circa 1985, Brown and Caldwell 1967

Source: Sections 5.12, 6.12, 7.12, 8.12, and 9.12

The indicators measure not only the time for a solution but the extent of the solution. The figures supporting Table 10.10 show in general that the solution occurred gradually over time. The exception to this is the case study on Beach Pollution in Sydney where the construction of the deep ocean outfalls caused a relatively quick reduction in the pollution level over a one year period after years of a steadily worsening pollution.

As discussed previously in the sections of the case studies, an ultimate solution is not always achieved. Notwithstanding this the figures do show significant reductions in the level of pollution and most of these reductions in the level of pollution occur towards the end of the pollution process though overlapping with some of the previous processes.

10.12 Summary

The process diagrams (Figures 5.10, 6.11, 7.16, 8.15, and 9.15) display each of the indicators used in each of the case studies in a single figure per case study. The indicators of the process diagrams demonstrate empirically the specific processes active in the solution of major regional pollution problems. They also quantify the processes both in relative strength and in duration. These process diagrams show some of the processes overlapping in time and by varying amounts. There is not a simple progression from one process to the next. As the processes represent a multitude of activities by a variety of groups and people a simple progression could not be expected. The order of the process in each of the case studies is not always the same (See Appendix B) but each of the case studies demonstrate empirically that all processes postulated for the model (Section 4.3) are evident to an extent measurable by indicators and have been measured by the use of appropriate indicators.

The process diagrams demonstrate that the identification and recognition of the problem takes place gradually as the severity of the problem increases (*people affected, harbinger, political action)*. Public and media concern (*public concern)* about the pollution comes to be increasingly reported in newspapers. Increased political action (*political action*) in response to this general public and public authority concern takes place in parliament through parliamentary debates, private members' questions, and the passing of general legislation.

A need to undertake further research (*inquiry, body of knowledge*) is often identified because there is insufficient scientific knowledge about the problem and the causes of and the most effective solutions to the problem. The development of this mainly scientific knowledge (*body of knowledge*) about a problem often requires specific research.

The later processes (*inquiry, legislation, allocation of funds, organisational change*) represent a phase where there is general recognition that the problem is significant and where the solutions are implemented. These processes often involve some form of public inquiry (*inquiry)* to legitimise the solution, and then more focused legislation or regulations *(legislation)*. Finally the solution is implemented through applying funds (*allocation of funds*), new organisations and people (*organisational change*). On going monitoring (*extent of solution)* identifies the success or otherwise of the planned solutions.

Table 10.11 shows that the period of time from when a problem is first identified (*people affected, harbinger)* until a decision was made to actually implement a solution (start of *allocation of funds* and *organisational change*) was on average about 17 years (span across studies of 14 to 21 years) while the time taken (*allocation of funds* and *organisational change*) to implement a solution was on average about 8 years (span across studies of 6 to 11 years).

Table 10.11: Time Taken to Implement Solutions (years)

Case Study	**“Identification” to "Decision to Implement Solution"**	**"Decision to Implement Solution" to “Solution”**	**Total Time**
Brown Haze Sydney	15	6	21
Ozone Sydney	15	11	26
Ozone Melbourne	14	7	21
Beach Sydney	18	10	28
Parramatta River Sydney	21	8	29
Averages	**16.6**	**8.4**	**25**

Source: Appendix B

11 SUMMARY OF RESEARCH

11.1 Background

In reading the history of pollution in Sydney since the first European settlement in 1788 (Coward 1988) I noticed a recurring theme in the solution of regional pollution problems, both in terms of similar problems and similar solution processes.

Firstly similar problems kept arising e.g. sewage pollution caused by discharges into the aquatic environment. This first occurred with pollution of Sydney's early water supply, the Tank Stream, in the 1850s. Similar problems were still occurring with beach pollution in the 1990s (Coward 1988). It was as if society was not learning from its earlier mistakes and as if each generation had to learn the same lesson over again.

Secondly similar process were used in the identification and solution of these pollution problems, e.g. Royal commissions or commissions of inquiry were often used, and new legislation and new or changed government organisations were almost always created to implement solutions.

Thirdly it seemed to take a long time to identify a problem, find a solution and implement that solution.

This recurring theme of pollution problems with similar solution processes suggested to me that a model could be developed to explain how pollution problems were solved, how long they took to solve and what were the main processes that were important for their solution. The processes that were of interest to me were the social and institutional processes as distinct from natural or ecological processes.

This model could then be useful in developing and implementing solutions to emerging pollution problems by enabling people to understand the nature of the social and institutional processes involved, the likely timing and association of processes and potential areas where more human intervention could produce quicker and more effective solutions.

Starting from Downs (1972) many authors (Zoetman and Langeweg 1988, De Groot 1989, Adriaanse and Jeltes 1989, Trudgill 1990, Löwgren and Segrell 1991) have proposed models that describe general processes involved in the solution of environmental problems (see section 3.2). These models did not provide all the necessary features I believed were necessary to develop a model specifically for pollution problems. I believed that it was possible to develop a model that could be applied specifically to pollution problems and that could enable the measurement of both the strength and duration of each process.

Firstly the environmental models described in the literature were mostly at a more general level e.g. general environmental problems not specific pollution problems (see section 3.2). This made their application to the measurement of specific pollution problems more difficult.

Secondly most of the authors had not quantified the processes (see section 3.2). I believed this quantification was necessary to enable the model to be useful for planning.

Thirdly the processes were not in general related to specific organisations or institutional types (see section 3.2). I believed that building the model with processes that would be undertaken by specific types of institutions would enable a better quantification of processes. It would also be easier to relate the results of the study to the different types of institutions involved in implementing solutions.

The other area of literature that described process models was the study of public policy development. Jones (1970) identified a framework of the public policy processes involved in resolving specific political problems in the USA. His basic model has been developed and refined by other authors (e.g. Hogwood and Gunn 1983, Rushefsky 1995). And as in the case of general environmental process models, these models were also general and processes were not quantified.

11.2 Pollution Process Model

The pollution process model that I have proposed in this work is consistent with both the general environmental process models and the general policy process models but includes the three features described above as being necessary. The nine processes proposed were based on the review of the history of Australian pollution problems (see Section 2.9).

I have summarised the general processes described for environmental and policy process models in Figure 4.1 (reproduced as Figure 11.1) and compared them with the specific pollution process model that I have proposed. (Refer to Section 4.3 for a detailed description of this figure.)

The nine processes of my proposed specific pollution process model are shown in column 3, Figure 11.1. The specific processes were also selected to be more relevant to the solution of pollution problems, and more related to specific organisations.

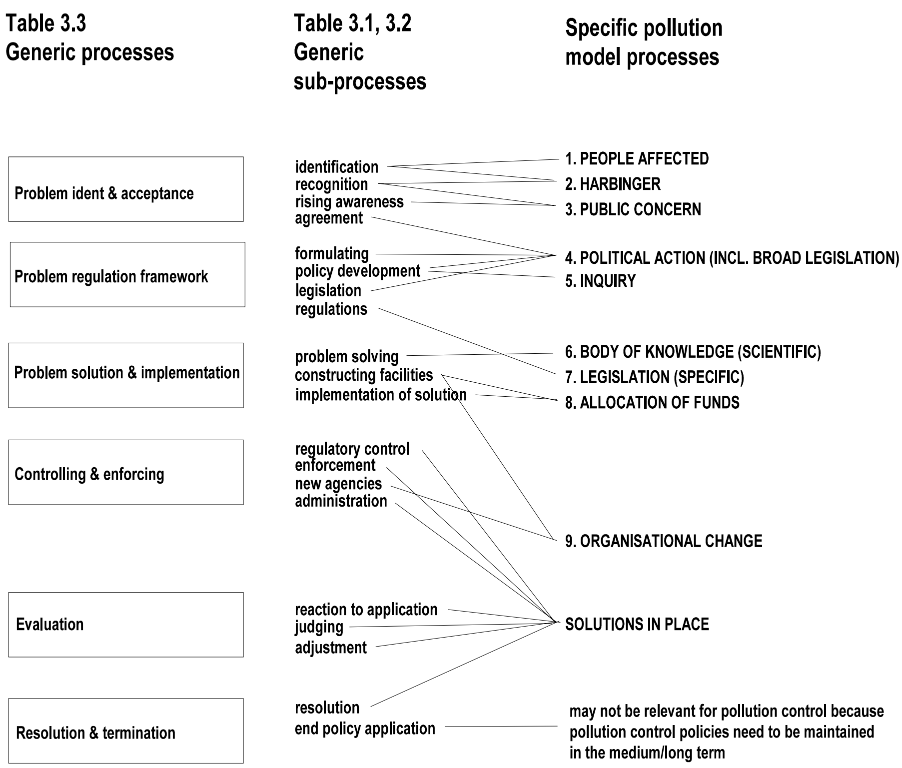
11.3 Quantitative Indicators of Processes

In the quantification of each of the processes, I used indicators (see Section 4.4.3) to measure the relative strength and duration of each process. Indicators were chosen to be representative of the process. This meant that firstly there should be sufficient reliable and consistent data available over the period of the process and secondly the strength of the indicator should vary in proportion to the strength of the process.

The absolute value of the indicator (if it satisfied the above criteria) was less important than its trend over time and its ability to identify when a process commenced and when it was substantially complete.

Peaks in the value of an index were interpreted as an indication of a more intense part of the process. Overlaps in time from one process to the next suggested a level of dependency between the processes. If the indicators and their overlaps supported the logical sequence of the model this was considered an adequate empirical demonstration of the model. If the indicators and their overlapping in time were at variance with the model then the model logic was reviewed.

Figure 11.1: Proposed Pollution Process Model



Some of the indicators used were more general than I would have liked e.g. an indicator measuring concern for air pollution rather than a concern for ozone pollution was used. In these cases sufficient reliable data was not available to accurately measure at the process level. A further argument to support the case for a more general indicator is that there was not sufficient knowledge at the time to scientifically distinguish between the causes of the different types of pollution in a medium e.g. between ozone pollution and brown haze pollution.

11.4 Case Studies

This work has not sought to prove that the model is the only representation of reality but through the use of five case studies it seeks to provide an empirical demonstration of the postulates upon which the proposed model is based and to demonstrate that the model is an adequate representation of reality. The case studies also enable a comparison of the model and its processes for different pollution problems.

Five case studies were used (see section 4.5). They were chosen to be representative of air and water pollution problems that had occurred in Sydney and Melbourne in the years after the Second World War in the period from approximately 1960 to 1990. The case study pollution problems selected were major pollution problems that were regional in nature i.e. they extended across a large part of a large city. The polluting sources in each case study were from distributed rather than single sources and so involved large sections of the community contributing to pollution and suffering from it. By also selecting the same pollution topic in Sydney and Melbourne, a comparison across states operating under different legislation was possible (see ozone pollution in Sydney and Melbourne). The case studies are summarised below.

Air pollution: Sydney's brown haze problem
Sydney's brown haze air pollution problem in the early 1970s was caused in large part by back yard burning and motor vehicle emissions. This case study covered that part caused by domestic backyard burning. The solution to reduce this component of brown haze was to ban backyard burning but not before municipal councils introduced large household garbage bins to allow residents to dispose of rubbish previously burnt in their backyards (see section 5).

Air pollution: Sydney's ozone pollution
Sydney's ozone pollution problem in the early 1970s was caused by emissions from motor vehicles and industry. This case study covered that large part caused by motor vehicle exhaust emissions. The solution to reduce ozone pollution was to progressively introduce stricter motor vehicle emission standards for new vehicles. These emission controls were facilitated by the introduction of unleaded

petrol allowing for the use of a more efficient catalytic converter to remove a large portion of unwanted exhaust gases (see section 6).

Air pollution: Melbourne's ozone pollution
Melbourne's ozone pollution in the early 1970s was caused by emissions from motor vehicles and industry. This case study covered that large part caused by motor vehicle exhaust emissions. The solution to reduce ozone pollution was to progressively introduce stricter motor vehicle emission standards for new vehicles. These emission controls were facilitated by the introduction of unleaded petrol allowing for the use of a more efficient catalytic converter to remove a large portion of unwanted exhaust gases (see section 7).

Water pollution: Sydney's beach pollution
Sydney's beach and surf pollution was caused by cliff face discharge of sewage into the ocean that had limited treatment and urban stormwater runoff, which often contained sewage overflows. The solution to reduce beach pollution component caused by cliff face discharge was to build deep ocean outfalls discharging further out to sea (see section 8).

Water pollution: Parramatta River in Sydney
Pollution of the Parramatta River in Sydney was caused by industry and urban discharges. This case study covered that large part caused by industry discharges. The solution to reduction of pollution caused by industry was to licence discharges and limit the range and concentrations of materials that could be discharged (see section 9).

11.5 Processes

Process diagrams were drawn to show each of the processes quantified with indicators (see Figures 5.10, 6.11, 7.16, 8.15, 9.15). The process diagrams show that the processes proposed for my pollution process model exist in each of the case studies though the time order of the processes is not always the same.

The process diagrams demonstrate that the identification and acceptance of a problem takes place gradually as the problem comes to affect more people. The early processes (*affected party, harbinger, public concern*) are similar to the "issue attention cycle" (Downs 1972) and the problem "identification, acceptance, formulation" phases described in the environmental and public policy process models (see Figure 11.1). Evidence for each of the processes is discussed below.

11.5.1 People Affected

Most of the *people affected* in the five case studies observed pollution as a visual effect (see Table 10.1). The significance of the process *people affected* is that it is the first reported occurrence of the pollution and provided these occurrences can be identified they can give an early indication of a potential problem. Not every pollution event affecting people may eventually become a major problem but there is the potential for it to become so. This suggests that where people become affected by pollution it should be taken more seriously.

11.5.2 Harbinger

I used the term *harbinger* because it conveys the idea that somebody or some group foreshadows a future pollution event and the likely consequences if no action is taken. The *harbinger* is able to make this forecast on a logical basis e.g. a limited amount of monitoring of the effects of the pollution on the medium of air or water. A *harbinger* was evident in each of the case studies and the harbingers were able to make a prediction that the pollution problem would become worse if nothing were done about it. (See Table 10.2). The opinion leaders or elites described in the media model (Parlour et al 1978) perform a similar role in communicating concern to the media and interest groups. Agenda setters (Hogwood and Gunn 1983) are similarly involved in raising an issue or problem and maybe suggesting consequences.

Although the *harbingers*' forecasts in each of the case studies (see Table 10.2) were ultimately realised it does not necessarily follow that all *harbingers* will make accurate predictions, or that it is possible to identify *harbingers* in an early part of the pollution problem. Though if one looks at the types of *harbingers* identified in each of the case studies (see Table 10.2) there is a strong argument for saying that the *harbingers* should be able to make reasonable predictions. The *harbingers* in the case studies included government bodies or persons responsible for pollution monitoring and control, a university researcher, and a consultant studying pollution. Therefore the *harbingers* of the case studies were scientifically literate and would have been expected to be well informed with the latest available information.

11.5.3 Public Concern

Public concern is a central process of my pollution model. Downs' (1972) issue attention cycle identified the phenomenon of increased public concern as the "stage of alarmed discovery and euphoric enthusiasm" where the public becomes aware of the problem. He believed that for a problem to follow this cycle it would need to directly affect a majority of people, its solution would require fundamental changes affecting society and vested interests, and have some value as a media reporting.

His approach was qualitative but later authors (Parlour et al 1978, Anthony 1982, Conrad 1987) using various indicators measured evidence of this issue attention cycle.

The fourth stage of Downs' (1972) five stage model was a gradual decline of public concern once there was a realisation that the solution of the problem would involve a high cost both in money and change in life style. The public and media concern for an issue could also be displaced by other issues in the media and there could be a feeling amongst the media and public that once a problem was solved once institutionalised (Parlour and Schatzow 1978).

My case studies use two types of indicators to measure the change in *public concern*: increased number of media articles and increased public telephone complaints to the government pollution control authority. For this process to be seen as important the indicators needed to show a significant increase in public concern. The indicators for the Sydney pollution case studies (see Figures 5.1, 6.3, 8.4, 9.7) showed an identifiable rise in public concern and a subsequent diminution as suggested by the Downs' (1972) model. The indicator for the Melbourne ozone pollution case study did not clearly show this characteristic (see Figure 7.2) though it may be possible to demonstrate this by more detailed research of the Melbourne newspapers of the time (see Section 7.4).

The strength of public opinion (measured in my case studies as *public concern*) has an influence on political agendas and the pace of policy implementation (Rosenbaum 1991). The case studies demonstrate that a change in *public concern* occurred, was contiguous with political action and this change preceded the achievement of a solution.

Public concern or public opinion could be viewed as an aspect of public attitude and research suggests (see section 3.5) that the links between public attitude and public and government behaviour can be tenuous and difficult to measure. The case studies suggest that the time from change in *public concern* (attitude) to change in public behaviour/government behaviour (problem solved) can be significant. (See Section 10.12). The indicators of public concern increase as more people become directly affected or concerned by the pollution and direct experience is more likely to develop stronger attitudes than indirect experience (Fazio and Zanna 1981, Zimbardo and Lieppe 1991)

11.5.4 Political Action

While the processes *people affected, harbinger, public concern* contribute to the problem identification phase (see Figure 11.1)*, political action* contains the first part of establishment of the regulation framework (see Figure 11.1, Table 3.1) and legitimation (see Table 3.2) but it also contributes to the identification and acceptance of the problem. The indicator I have used for *political action* in all case studies is the level of recorded action in parliament (number of pages in Hansard) about the particular pollution topic. This record includes the introduction of new bills, amendments to existing Acts, questions and answers to member's questions, and petitions made by the general public. The legislation passed during this process commences the solution of the pollution problem but as each case study demonstrates the solution requires later more specific legislation or regulations to fully enable a solution. (See section 10.5 and 10.8).

In the case studies legislation and other political actions measured by the indicators are often general actions concerned with the generic type of pollution e.g. motor vehicle. The chosen indicator reflects this. The indicator does not specifically measure the legislation passed in relation to ozone pollution. The use of a general rather than a specific one was discussed previously (see section 11.3).

This is a good indicator and in all case studies, increases in the value of this indicator occur in conjunction with, or slightly after, rises in *public concern* (see Figure 5.3 for an illustration of this). This is consistent with the writings of Rosenbaum (1991) that the strength of public opinion has an influence on political agendas and the pace of policy implementation.

11.5.5 Inquiry

Arising out of the *political action* is the *process inquiry*. Official inquiries were identified in two of my case studies. Major technical conferences were identified in two case studies and an Environmental Impact Assessment was identified in another. Different forms of official inquiry have been a feature of the solution of Sydney's environmental problems. Coward (1988) lists 41 "official commissioned inquiries" between 1852 and 1976 that relate directly and indirectly to pollution and environmental problems.

Two Melbourne conferences while related to air pollution did not seem relevant to the solution of the Melbourne ozone pollution problem. They were either too early or late to influence the other processes and the content was not particularly relevant.

While the *inquiry* appears to be an important process it was a different type of process in each of the case studies and it occurred at different times relative to *political action* and not always in a logical time sequence.

11.5.6 *Body of Knowledge*

Development of a specific *body of knowledge* about the pollution was a process evident in each case study. The development of the *body of knowledge* was either undertaken by the organisation responsible for controlling the pollution or commissioned by it (see Table 10.5).

Zoeteman and Langeweg (1988) identified a research cycle where solutions to environmental problems are formulated in a controlled scientific manner. This involved an identification phase where scientists looked for substances or harmful effects not earlier identified, followed by analysis of cause and effect, modelling and simulation and finally identification of control scenarios for decision making. My process *body of knowledge* is similar to this research cycle.

The indicators I chose directly measured this research effort e.g. for air pollution, I used the number of people or the expenditure on specific research into brown haze pollution and ozone air pollution. This *body of knowledge* provided a strong scientific base to underpin the implementation of a solution. There is a risk in trying to solve problems with incomplete knowledge - one could solve the wrong problem or use the wrong method that might be unnecessarily expensive e.g. the brown haze problem research identified backyard burning and car emissions as the main causes whereas an initial perception may have been that either of these causes was the sole cause. Conversely there is also a risk of unnecessary delays if we try to be absolutely sure of the right solution.

Scientific people may be often critical of political involvement in the solution of technical problems. Scientists should be heartened by the results of the case studies that demonstrate that while the application of science to pollution problems is not the complete answer, it is a significant component (see Table 10.5).

11.5.7 Legislation

The relationship between the process *legislation* and the process *political action* is interesting. The general environmental models (see Table 3.1) do not contemplate two stages of legislation as identified in my model and neither do the general public policy process models (see Table 3.2). The public policy models though do contemplate development of organisational policy in response to a process of legislation. My process *legislation* is similar to a process of policy formulation and the case studies include municipal council regulations, promulgation of Australian Design Rules for motor vehicle design, environmental regulatory authority design guidelines for sewage treatment, and amendments to the Clean Air Act (see Table 10.7). Therefore the process *legislation* includes not only parliamentary legislation but includes policy development.

11.5.8 Allocation of Funds and *Organisational Change*

The final processes in my model are *allocation of funds* and *organisational change*. These are similar to "controlling and enforcing the solution" of the environmental process models and "administering the policy to the problem" of the policy models (see Table 3.3). The two processes *allocation of funds* and *organisational change* are parallel processes. Approval of the budget for the allocation of funds would logically proceed the actual expenditure of the funds. The indicators for this process measure the expenditure of funds to implement the solution e.g. the ozone case studies use the estimated increase cost of manufacture of motor vehicles necessary for compliance with the new regulations (see Table 10.8).

The solutions to the pollution problems in each of the case studies involved implementing large and expensive technical and engineering projects: the brown haze solution involved the introduction of an alternative garbage collection system (see Section 5); the ozone solution involved modification to the manufacturing plant for the production of motor vehicles (see Section 6 and 7); the beach pollution problem was reduced by constructing deep ocean sewage outfalls (see Section 8); and the Parramatta River pollution was reduced by industry modifying its manufacturing processes and equipment (see Section 9). These large engineering projects, involving many resources, contributed greatly to the time taken for a solution to the pollution problems. This is particularly well illustrated in the case of beach pollution where the project extended over a period of 10 years of design and construction (see Figure 8.13).

The important point in triggering the commencement of the two processes *allocation of funds* and *organisational change* is the actual approval of funds necessary to undertake the technical and engineering projects necessary.

11.6 Sufficiency of Model Processes

The case studies provided an empirical demonstration that the proposed process model provides a good approximation of the social and institutional processes involved in the solution of major regional pollution problems. Notwithstanding this demonstration, there is the possibility that the processes and indicators chosen to measure them were artificial constructs and measurement reinforced the construct.

With this in mind I posed a series of questions (see Section 4.4.2) to test whether the number and type of processes of the empirically demonstrated model were sufficient to explain the main social and institutional processes involved and sufficient to enable the model to be used as a planning tool. These questions were used to test whether the processes proposed and measured by indicators were sufficient and necessary for a solution; and whether they were linked by causal relationships or were influenced by the underlying independent variables not proposed or measured.

An analysis of each of these questions (see Appendix A) argues that the model has the necessary and sufficient processes and has sufficient accuracy to enable it to be used to explain the social and institutional framework of pollution problems, for it to be used as a planning tool and to meet the other aims for it set in this work (See Section 2.1).

The model does not use a systems approach of establishing formal links between processes, feed back loops or a priori relationships to produce a logic flow diagram. A major pollution problem is a complex public policy development and implementation process and a systems approach could have produced a very complex model. It might not have been possible to analyse and to develop a model of practical application. None of the existing models used a rigorous systems approach and I believed that the aims of this work could be met by developing a practical model that was consistent with the approaches adopted by existing models.

The adopted approach could be considered a global or top down approach that attempted to perceive pollution problems from a social and institutional perspective, not necessarily an abstract point of view but a view at a functional process level. Through the use of five case studies it seeks to provide an empirical demonstration of the postulates upon which the proposed model is based. The use of five case studies enables a comparison of the model and its process for different pollution problems.

The proposed processes have been based on the theory of public problem formulation and solution both in the general public policy area and in general environmental areas in Sydney and Melbourne (see table 3.1, 3.2, 3.5 and Figure 11.1). The final selection of processes was also influenced by my assessment of the historical study of the solution to actual pollution problems in Sydney and Melbourne (see Coward 1988 and Section 2.4).

The evidence used in development of the proposed model processes was in a sense circumstantial rather than being sought from direct evidence of a cause and effect relationship with observable links between processes. While no simple links were specifically theorised or measured, a broad logic was proposed. (See Section 4). This proposed broad logic was initially derived somewhat by experience but more by cumulative impressions created by reading works on the history of the solution of actual pollution problems. This broad logic was demonstrated by the case studies. (See Section 10.12 for a summary).

The quantification approach enabled a practical model to be developed and quantified. In a strict scientific sense a cause and effect approach may be more desirable. Later studies could address whether a detailed cause and effect model can be developed and measured and whether this approach achieves anything more than was achieved by the methodology used in this work.

Note: Appendix C contains a copy of a paper by the author that has been accepted for publication by *Environmental Management*. It is a refereed paper and is included as additional evidence.

12 CONCLUSION

12.1 The Thesis

The central thesis of this work is that major regional pollution problems require specific social and institutional processes for their solution and these processes can be predicted and their strength and duration quantified.

12.2 Aim

In proving this thesis the aim of this work was to develop a new quantitative pollution process model and to empirically demonstrate that the proposed model was an acceptable approximation of reality. The new model could then provide a framework for a better understanding of the social and institutional processes that are likely to be involved in the solution of major regional pollution problems. This better understanding could lead to better planning and management of solutions to emerging pollution problems.

The information from the model could also be used to assist in the identification of the processes likely to be needed for solutions to emerging major regional pollution problems and then to be used in forecasting the duration of individual processes and the total solution. The model could also allow the identification of particular processes that might delay the solution and allow the pollution problem to become more severe if they were not completed expeditiously. In addition the model could be used in a proactive sense to identify or suggest actions to shorten the time for a solution and to assist in progressive monitoring and management of the solution.

12.3 Contribution of the Work

Existing models described in the literature (Section 3.0) were mainly qualitative and were models of general public policy development and implementation and of general environmental problem solution. These models were not in a form that could easily be related to specific pollution problems and not in a form that could be easily quantified. This limited their use in providing a framework for understanding the solutions of major regional pollution problems, and in planning the solution of emerging pollution problems

This work has proposed (Section 4) a specific pollution process model and has provided an empirical demonstration (Sections 5, 6, 7, 8 and 9) that the model provides an acceptable approximation of the social and institutional processes involved in the solutions of major regional pollution problems. The pollution process model is more specific to pollution problems and is in a form that can be more directly related to emerging major regional pollution problems. The model has processes that can be more easily quantified by the use of indicators, and can be more easily identified with particular types of organisation.

The empirical demonstration of the pollution process model also confirmed the central thesis of this work allowing a more direct method of defining responsibilities and measurement.

In addition to the above contributions to the knowledge on social and institutional processes, some other interesting features have emerged from the study. Firstly the solution to major regional pollution problem can take up to 25 years (see Table 10.11) from the time a problem is first identified (*people affected*) and up to 8 years from the time a decision is made to implement a solution (see Table 10.11). The implications of this finding are that methods proposed for solving emerging pollution problems should address the pollution level that might exist in 8 years not the level that exists at the time a decision is made to implement a solution i.e. they should address a forecast level of pollution rather than a current level.

Secondly similar pollution problems seem to recur despite the problem apparently being solved. This fact was highlighted by Coward (1988) and is further discussed in this Section 12.4.3)

12.4 Application of the Model

The research findings facilitate the discussion of two important questions. Firstly if one had the benefit of the knowledge from this work at the start of the pollution problems (described in the case studies), could this information have been used to produce better solutions to these pollution problems (see Section 12.4.1) and secondly how can the information contained in this work be used in the future to achieve better solutions to emerging pollution problems? (See Section 12.4.3)

A better solution can be defined as a solution that solves the pollution problem with fewer resources (human and financial) and solves it in a shorter time. A shorter time could also use fewer resources but the main benefit would be less pollution causing emissions, lower levels of pollution and consequently less damage to the environment.

12.4.1 Application to the Case Studies

I have used the shortened term *model* (in italics) in this section to refer to my empirically demonstrated pollution process model.

The *model* suggests that each major pollution problem will require an increase in the *body of knowledge* prior to a full solution being implemented. The *model* also suggests that this increase in the *body of knowledge* occurs after an increase in both *public concern* and *political action*. If this increase in the *body of knowledge* could be achieved prior to or even in conjunction with the increase in *public concern* and *political action* then considerable time might be saved in solving the problem.

One point that would support this argument is the fact that the *harbinger* and the groups developing the *body of knowledge* are either the same or similar types of organisations. This would support a case for the *harbinger* to undertake the necessary research immediately it made its prediction. A reason why this may be difficult to achieve is that the research could require funding and the source of this funding is often governmental. Subject to resolving the funding issue, there is a good argument to support early research on an emerging pollution problem.

One risk of undertaking early research is that there may be no way of knowing at an early stage if the *harbinger'*s prediction will be correct. Spending money early on an emerging pollution problem is in some ways similar to the precautionary principle of Ecologically Sustainable Development (ESD), or similar to the concept of insurance. The precautionary principle of ESD suggests that we should desist or delay undertaking certain activities if there is a potential even if unproved for significant future environmental harm.

In the case studies the *harbinger* was able to make predictions based on limited or intermittent monitoring of the medium (air, water). The gaining of the *body of knowledge* often involved monitoring but over continuous periods. It is difficult to know what parameters to monitor without an understanding of the pollution which may only come with the *body of knowledge* but it seems to me that a programme of broad monitoring reviewed annually would be money well spent. This could enable the extent of the emerging pollution problems to be determined early enabling the pollution to be controlled at an earlier stage.

The state environmental pollution control authorities (EPA 1995, SPCC 1973 to 1990, EPAV 1971 to 1993) do have a programmes of monitoring. These would need to be extended to include a board range of parameters, not only those that seek to measure the areas that are currently recognised as problems areas. State of the Environment reporting currently being implemented in Australia should assist in the process of identification of potential pollution problems (COA 1994).

My model shows that public *concern* works in conjunction with or preceding *political action* on the path towards a solution. This has similar features to the "issue attention cycle" (Downs 1972). Downs (1972) says of the "issue attention cycle" that the initial high level of concern is followed by a diminution of concern as other issues take precedence in the media or as the media perceive that a solution is underway. In the case studies the indicator of *public concern* did diminish from an initially high level. Although the *political action* did occur it could be argued that if the *public concern* remained at a high level then the *political action* and subsequent processes might proceed more expeditiously.

On the basis of this logic it would seem that methods of increasing and maintaining *public concern* could facilitate *political action* and accelerate the results achieved from *political action*. I believe that environmental interest groups recognise this fact and try to exploit it in an effort to stimulate *public concern.*

Public opinion polls (see Section 2.10) are a method of measuring *public concern* and conveying this fact to the politicians. Though it is debatable that measuring *public concern* though opinion polls can increase the level of *public concern*, it could be argued that it would demonstrate the level of *public concern* and this could be beneficial to the expedition of a solution.

State of the Environment reporting is a possible way to help highlight emerging environmental pollution problems, raise public awareness and increase *public concern*. This would need to be done carefully as too much information could generate a blasé attitude. State of the Environment reporting could well raise more issues than the public could assimilate. These other issues could dilute *public concern* for a particular pollution problem (Downs (1972).

The case studies demonstrate that legislation and regulations are often developed during both *political action* and *legislation*. On the surface this suggests a duplication of law making. The early legislation (during *political action*) may have been promulgated with haste to give the appearance of action. It may then require amendments, or regulations at a later date to make it practicable when more scientific knowledge is gathered. E.g. Sydney's ozone pollution problem required a later amendment to the Clean Air Act to allow the Act to apply to motor vehicle emissions. Maybe if the generation of the *body of knowledge* could be started earlier as I discussed above, then the initial *political action* could include both general legislation and specific regulations.

12.4.2 Responsibilities

In the foregoing section it was assumed that the overall solution or individual processes could be manipulated but this presumes that there is an omnipotent organisation capable of doing this. It seems to me as that the processes are undertaken by different groups and it would be difficult for one organisation to control them all.

The early process of problem identification (*people affected*, *harbinger*, *public concern*) seem to occur independently of external organisational control - more driven by the production and manifestation of the pollution. It could be argued that a body like the EPA with financial and legislative support from a government could as the *harbinger* identify potential pollution at an early date and move to put in place controls to avoid the pollution. This is a strong logical argument but the empirical evidence of the case studies suggests otherwise. In the next section (see Section 12.4.3) some of the emerging pollution problems in Sydney are discussed. They are similar in many respects to the case study problems including their cause and their effect but they do not seem to be being solved any more expeditiously than the ones described in the case studies.

Processes where the government (itself or through an agency like an EPA) could exercise some control (e.g. through *political action or inquiry)* are the funding of the generation of a *body of knowledge, legislation and allocation of funds.* As the case studies demonstrate government action can help in initiating processes but the actual control of the processes and their timing are often in the control of other bodies e.g. *inquiry* with the legal system, *body of knowledge* with the research institutions, *allocation of funds* with Treasury, *organisational change* with diverse organisations such as Sydney Water Corporation, motor vehicle manufacturers, and individual householders.

Subject to the last point opportunities could exist for government and an EPA to facilitate the moving from one process to the next more quickly to reduce overlaps and to ensure a more expeditious completion of each activity. Six months saved in each process could save up to 4 years overall.

Certainly if the government planning bodies accepted the process diagrams presented in this work, they would have knowledge to facilitate a more expeditious solution. Knowing that the solution of major regional pollution problems could take over 25 years, they could initiate actions to provide early control of events likely to cause pollution e.g. uncontrolled use of cars with polluting emissions. Conversely it could be argued that knowing that a solution is going to take 25 years could remove any sense of urgency.

One could argue that my work provides strong evidence to justify the application of the precautionary principle to the solution of pollution problems. The precautionary principle suggests that we should desist from or delay undertaking certain activities where there is potential for future environmental harm. If the *harbingers* are to be believed (and I have presented evidence of their credibility) and we ignore their predictions then we as a society are continuing to act to harm the environment. This, it could be argued contravenes the precautionary principle.

12.4.3 Emerging Pollution Problems

The other question I posed at the beginning of Section 12.4 was how could the knowledge developed for my model be used in the future to provide better solutions? Before I answer this question I will summarise several of the emerging pollution problems. This summarisation is based on published information and I have not analysed the problems in the same detail as I have in the case studies of this work so my comments will be general. These emerging pollution problems are similar to the case study problems and one could well ask why they were not anticipated and solved at the same time. This suggests that solutions described in the case studies may have only been partial solutions. Coward (1988) describes how recurring pollution problems have been a feature of 150 years of European settlement in Sydney. It could be argued that solutions only address the most salient manifestations of the problems. Certainly a conclusion from the case studies is that consideration should be given to applying stricter controls or implementing a more comprehensive solution initially because in the long term considerable time and effort could be saved and future problems could be reduced.

Some emerging pollution problems in Sydney are described below.

(a) Brown Haze

Brown haze in winter is again increasing in Sydney's air and is being mainly caused by burning of fossil fuels in house heating stoves, increased motor vehicle emissions caused by increased number of cars and slow replacement of old cars that do not comply with current pollution emission controls (SPCC 1991, 1992 to 1995). A brown haze is increasingly evident over the western regions of Sydney and appears to be growing each year (personal observation, NSW Government 1991). This could represents the start of the process *people affected.* Recently (EPA 1996) a major scientific study (a metropolitan air quality study) was completed and the first results published. This could be the *start of the body of knowledge* process.

(b) Ozone Pollution

Increasing ozone pollution in the western regions of Sydney is occurring and is being caused by the increasing urbanisation of this area (as part of the official planning for Sydney's growth), the concomitant use of cars, and the transfer of ozone by meteorological conditions (wind and air flow) produced by the more easterly regions of Sydney. A major conference was held in Sydney in 1991 to address this problem (NSW Government 1991). This could represents the *inquiry* stage. Recently (EPA 1996) a major scientific study (a metropolitan air quality study) was completed and the first results published. This could be the start of the body *of knowledge* process.

(c) Ocean Pollution

Ocean water pollution is potentially being caused by the increasing sewage pollution discharged to the ocean albeit discharged further to sea and away from beaches. The beaches and beach water as well still suffer from polluted stormwater discharges from urban runoff and from overflow of raw sewage from overloaded sewerage mains into Sydney harbour. (Water Board 1992, 1993). The deep ocean outfalls and upgrade of the Sewage Treatment Plants did not address all these problems. Recently a major program (the Clean Waterways programme) was initiated by the Sydney Water Board (1989 to 1994) to assess the water pollution problems caused by sewage effluent discharge and options for solution. This could represent either the *inquiry* stage or the *body of knowledge* stage or a combination of both.

(d) River Pollution

River pollution caused by urban runoff, soil erosion and sewage overflow is increasing. The case study of the Parramatta River was concerned with measuring substances that depleted the life giving oxygen in the river. The current focus on pollution is on the substances the add nutrients (particularly phosphorus and nitrogen) to the water that increase algal problems. The Clean Waterways programme referred to above also addressed river pollution but only that component caused by the Sydney Water Board's sewage effluent discharges. This could represent the processes *inquiry* or *body of knowledge* or a combination of both.

Each of these emerging pollution problems appears to be at a point in the middle part of their solution and based on the data from this study could be 5 to 10 years away from a solution (see Table 10.11, Appendix B).

Each of these emerging pollution problems appears to be in a stage about *inquiry* and development of a *body of knowledge*. No decision has been reported on what the solutions will be. The remaining processes are *legislation, allocation of funds,* and *organisational change*. These problems are therefore the middle part of my process cycle (see Figure 11.1) though as I have discussed above I believe the greatest potential for improving solutions lies in the early processes. I previously discussed the issue of *public concern* and the impact this appears to have had in each of the case studies especially at the start of the solution.

If one studies the case study indicators for *public concern* (see Figures 5.1, 6.3, 7.2, 8.4, 9.7) one will notice that the indicators rise towards the end of the solution period. This could be caused by two effects. Firstly solutions have taken so long to implement that the problem has grown significantly worse and the sense of solution being in place has long been forgotten by the public and media. Secondly it may be an emerging though similar problem.

In the case of the case study on beach pollution (See *public concern* indicator of Figure 8.4) the first reason applies. Based on this evidence a second increase in *public concern* has the potential to hasten a solution. As I have discussed this increase can occur naturally (sic) as more people are personally effected and with more lasting effects on public opinion (see Table 3.6), but this requires the pollution problem to become worse. If a high level of public concern could be generated by the media or by community or special interest groups this may well achieve the same effect but I believe that this level needs to be sustained at least until the *legislation* or regulations are passed, the *allocation of funds* occurs and the *organisational change*s are underway. If the level is not sustained then the processes could well resume their normal course and probably compete with other issues for political attention.

Bührs and Bartlett (1993) discuss two extremes of policy making, reactive policy making and anticipatory policy making, and comment that "Anticipatory Policy making may be common wisdom, but reactive policy making is common practice." They suggest that reactive policy making responds to crises, for example environmental crises. This is a similar concept to the concept illustrated in this work, that solutions are driven by an increasing level of public concern. Anticipatory policy making expects society to anticipate problems and solve them before they become severe (Bührs and Bartlett 1993). The empirical evidence from the case studies of this work does not support the view that we have successfully anticipated major regional pollution problems and moved logically to their solution, at least not in a reasonable time frame.

Notwithstanding these portents of gloom, one would hope that the emerging pollution issues could be identified early and actions taken to prevent them becoming significant or major problems as I discussed in Section 12.4.1 and 12.4.2. In the discussion in Section 12.4 I have suggested ways in which the information from my model can be used to support a better approach to solving pollution problems and ways to facilitate better solutions.

12.5 Suggested Planning Methodology

This work demonstrates that the solutions to major regional pollution can take up to 25 years from the time they are first identified (*people affected*) to the time a solution is achieved. This implies that the solutions to emerging pollution problems should address the pollution level that is forecast to occur approximately 25 years from the time the problem is first identified (*people affected*) or approximately 10 years from the time when the decision is made to implement a solution (see table 10.11).

In the previous section I discussed ways the information about the model could be used to produce better solutions to emerging major regional pollution problems. The information could also be used as a part of a planning methodology which I develop in this section.

Firstly the information on the nature and extent of solutions required could be used to allow planners to become aware of each process required and the time frames necessary to achieve solutions. Secondly the model framework could enable planners to set up similar models for the solution of other emerging pollution problems ensuring that the key processes are identified and allowing attention to be focused on the processes that may be shortened by political or management action.

Thirdly the model could be used as a communication tool. By understanding the likely processes, their likely interdependencies, and their likely time frames, planners and policy makers could have the opportunity to communicate to politicians and the public the likely consequences of a delay in acting. This could also assist policy makers and public interest groups to focus on areas or processes where early action could well hasten solutions e.g. early heightening of *public concern* or early start to developing a *body of knowledge* (see Section 12.4.1).

An approach to the planning and management of solutions to emerging regional pollution problems could include the following steps: establishment of an historical data base of the solution to similar problems (similar to graphical process of the model shown in Figures 5.10, 6.11, 7.16, 8.15, 9.15); production of a model of the likely processes (including process indicators) required for a solution of the emerging problem based on this data base and current knowledge about the emerging pollution problem; promulgation of this model with the general public and decision makers to obtain commitment to achieving or bettering of the forecast dates and to identify actions that could be undertaken to reduce the duration of critical processes; monitoring progress against the indicators; reporting progress against the process model with identification of processes that need expediting, and recommendations for recovery of delays.
The opportunity to select better indicators would be available because the indicators could be selected (and then measured) on the basis of the fitness for purpose rather than on the basis of available historical information as I was required to do.

12.6 Future Research

Two processes that were identified during the research but were not included in the process model may be significant in the future. They are the effect of individual or peak pressure groups and the use of formal public participation. While I did not included them as separate processes they were measured to some degree in the quantification of the other processes. A public participation or consultation process could be introduced early to elicit more effective ways to solve an emerging problem and to obtain and maintain an ongoing public support.

The model describes major regional pollution problems and the case studies used were of major regional pollution. The literature identified that Australia had suffered from local pollution problems consistently since Europeans had arrived in the late 1770s but as shown earlier in this work the emergence of regional pollution problems was in the main tied to economic growth after the second World War (Coward 1988). The data showed an increasing level of concern during the late 1980s and early 1990s to the present and this occurred at about the same time as increasing concern for global pollution problems was evident. A model could be developed to cover global pollution problems but this would require extensive data collection from international sources.

Other areas where future research would be valuable are discussed below.

A more detailed cause and effect model could be developed to assess whether this type of model provides a better approximation to the social and institutional processes involved and whether it would provide a better planning and management tool.

Case studies from other Australian cities, and other countries and for other pollutants could be quantified to assess the universality of the pollution process model.

State of the Environment reporting could be assessed to determine if it offers information that could lead to early identification and acceptance of emerging problems but more importantly whether it enables more expeditious solutions.

Further research could be undertaken to develop better indicators of the social and institutional processes involved. Research could also be undertaken into the political process to determine if this could be made more efficient and effective in the solution of pollution problems.

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