

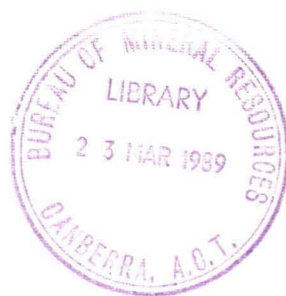
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Report 287

# Groundwater contamination incidents in Australia: an initial survey

G Jacobson and J E Lau



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REPORT 287

GROUNDWATER CONTAMINATION INCIDENTS

IN AUSTRALIA : AN INITIAL SURVEY

by

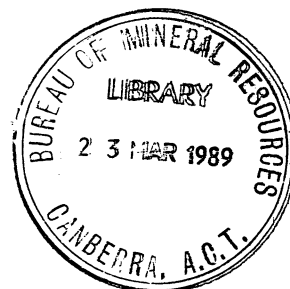
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## ABSTRACT

An inventory of 106 known groundwater contamination incidents in Australia has been compiled. A range of contaminant sources is involved, including industrial effluent, sewage and landfill leachate. Several important regional aquifers are affected: the superficial formations of the Perth Basin; the Gambier Limestone in South Australia; and the Newer Volcanics, and Tertiary sand aquifers near Melbourne. These are all shallow unconfined aquifers that underlie regions of intensive urban, industrial or agricultural development. A range of State legislation is applicable to the control and management of point source contamination, but is unevenly implemented. Surveillance and documentation of the reported incidents is incomplete and more than half of the known incidents are not currently monitored. There may be other, undocumented, cases.



## INTRODUCTION

This report has been prepared at the request of the Groundwater Committee of the Australian Water Resources Council, in order to assess the extent and seriousness of groundwater pollution at the national level, and to assess needs for aquifer protection and monitoring networks. In 1986, a Working Group was appointed, to assist in carrying out the study. Its membership was G. Jacobson (Commonwealth), G. Cargeeg (WA), W. Day (Qld), P. Jolley (NT), M.J. Knight (NSW), A. Shugg (Vic), P.C. Stevenson (Tas) and K.O. Trevarton (SA). G. Jacobson (BMR), Convener of that Group, and J.E. Lau (contract hydrogeologist) undertook the bulk of the work. Information was obtained from questionnaires distributed within State and other agencies, and this was augmented by a literature search using the Streamline and AESIS bibliographic data bases. Details of the incidents were entered into a microcomputer data base from which the tables in this Report have been generated. The Report is based on information available to the end of 1987.

Earlier, in 1979, the Australian Water Resources Council sponsored a national conference on groundwater pollution. This resulted in the delineation of specific problems and recommendations for the development of groundwater quality criteria and for research on particular aspects of groundwater pollution (Lawrence & Hughes, 1981). Since then the issue has received little attention, although public responses to the 'WATER 2000' study by the Department of Resources and Energy in 1982 indicated concern about groundwater pollution in several parts of Australia.

## INVENTORY OF GROUNDWATER CONTAMINATION INCIDENTS

A total of 106 groundwater contamination incidents have been documented in the inventory; of these, 77 are based on open-file information and 29 are based on questionnaire responses regarded as confidential. The inventory is not exhaustive, and there are probably numerous other, unrecorded, incidents. Saline intrusion due to stresses on aquifers or changing land use is not considered in this study.



A series of Tables (1 - 6) presents lists of incidents according to contaminant source, hydrogeologic setting and location.

Of the documented incidents 19 are described as diffuse and 87 as point-source. Most of the diffuse sources are sewage and agricultural fertilisers and are defined by a plume of high nitrate concentration.

An analysis of contaminant sources for all incidents shows the following distribution:-

<u>Contaminant source</u>	<u>Number of incidents</u>
Industrial effluent	32
Sewage	23
Landfill leachate	14
Petroleum products	13
Food processing waste	11
Mining	8
Agriculture	5

A number of industrial effluent incidents are directly related to the chemical industry. Contamination from sewage is generally from areas with a large number of septic tanks.

The total number of incidents per State and Territory is as follows:-

<u>State/Territory</u>	<u>Number of incidents</u>
Victoria	31
Western Australia	26
South Australia	22
New South Wales	8
Queensland	7
Australian Capital Territory	6
Northern Territory	4
Island Territories	2
Tasmania	0

TABLE 1 GROUNDWATER CONTAMINATION INCIDENTS IN THE SUPERFICIAL FORMATIONS, PERTH BASIN

Location	Date	Contaminant type	Plume area (ha)	Major use of aquifer	Effect on water use	Remedial works	Active source	Legislative controls	Current monitoring
Bayswater, Perth	1952	Industrial		Agricultural	Limited	Yes	Yes	Yes	Yes
Bayswater, Perth	1957	Industrial		Agricultural	Limited	Yes	Yes	Yes	Yes
Jandakot	1927	Industrial		Agricultural	Limited	No	Yes	Yes	Yes
Baldivis	1969	Industrial	300	Agricultural	Limited	Yes	Yes	Yes	Yes
Kwinana <sup>1</sup>	1970	Industrial	108	Industrial	Serious	Yes	Yes	Yes	Yes
Kwinana	1975	Petroleum	5	Industrial	Limited	Yes	Unknown	Yes	Yes
Palmyra, Perth	1920	Industrial		Agricultural	Limited	No	Yes	Yes	Yes
Gingin	1983	Industrial		Agricultural	Limited	Yes	No	Yes	No
Capel	1978	Industrial		Agricultural	Limited	Yes	No	Yes	Yes
Australind <sup>2</sup>	1983	Industrial	32	Agricultural	Serious	Yes	No	Yes	Yes
Kwinana <sup>3</sup>	1974	Industrial	200	Industrial	Limited	Yes	Yes	Yes	Yes
Welshpool, Perth	1980	Industrial	6	Agricultural	Serious	No	No	Yes	Yes
Canning Vale <sup>4</sup>	1981	Sewage		Agricultural	Nil	Yes	Yes	Yes	Yes
Morley, Perth	1981	Leachate	10	Agricultural	Nil	No	Yes	Yes	Yes
Perth Metropolitan <sup>5,6</sup>	1900	Sewage	30000	Agricultural	Nil	No	Yes	No	Yes
Stirling, Perth <sup>7</sup>	1962	Leachate	10	Domestic	Nil	No	Yes	No	Yes
Australind <sup>8</sup>	1964	Industrial	140	Other	Nil	No	Yes	No	Yes
Thornlie, Perth <sup>9</sup>	1957	Industrial		Agricultural	Serious	Unknown	No	Unknown	Unknown
Wanneroo, <sup>9</sup>	1975	Food processing		Agricultural	Limited	Unknown	Unknown	Unknown	Unknown
Coogee, Perth	1972	Mining	75	Agricultural	Limited	Yes	Yes	Yes	Yes
Welshpool, Perth <sup>1</sup>	1979	Industrial	2	Agricultural	Limited	Yes	Yes	Yes	Yes
Jandakot <sup>1</sup>	1950	Sewage	2	Agricultural	Limited	No	Yes	Unknown	Unknown
Canning Vale <sup>1</sup>	1980	Sewage		Agricultural	Nil	Unknown	Yes	Unknown	Yes
Jandakot <sup>1</sup>	1950	Sewage		Domestic	Serious	Yes	Yes	Yes	Unknown

<sup>1</sup>Hirschberg, 1981; <sup>2</sup>Whincup & others, 1986; <sup>3</sup>Dept. of Conservation & Environment, 1979; <sup>4</sup>Barber & Davis, 1986; <sup>5</sup>Whelan & Parker, 1981; <sup>6</sup>Appleyard & Bawden, 1987;<sup>7</sup>Bestow, 1981a; <sup>8</sup>Bestow, 1981b; <sup>9</sup>La Brooy, 1981.

TABLE 2 GROUNDWATER CONTAMINATION INCIDENTS IN THE GAMBIER LIMESTONE AND EQUIVALENTS, OTWAY AND MURRAY BASINS

Location	Date	Aquifer	Contaminant type	Plume area (ha)	Major use of aquifer	Effect on water use	Remedial works	Active source	Legislative controls	Current monitoring	
South East Region <sup>1,2,3</sup>	SA	1900	Gambier Limestone	Agricultural	50000	Domestic	Serious	No	Yes	No	Yes
Suttontown	SA	1919	Gambier Limestone	Food processing		Domestic	Limited	No	No	No	No
Mt Gambier	SA	1900	Gambier Limestone	Sewage		Domestic	Limited	No	No	No	No
Kongorong <sup>4</sup>	SA	1924	Gambier Limestone	Food processing		Domestic	Limited	No	No	No	Yes
Moorak	SA	1913	Gambier Limestone	Food processing		Domestic	Limited	No	No	Yes	Unknown
Yahl	SA	1908	Gambier Limestone	Food processing		Domestic	Limited	No	No	No	No
Yahl	SA	1900	Gambier Limestone	Food processing		Domestic	Limited	No	No	No	Unknown
Mt Gambier <sup>5</sup>	SA	1950	Gambier Limestone	Leachate		Domestic	Limited	No	Yes	Yes	Yes
Millicent	SA	1900	Gambier Limestone	Agricultural		Domestic	Serious	No	No	No	No
Mt Schank	SA	1920	Gambier Limestone	Food processing		Domestic	Limited	No	No	Unknown	No
Glencoe West	SA	1900	Gambier Limestone	Food processing		Domestic	Limited	No	No	Yes	No
Glencoe East	SA	1850	Gambier Limestone	Food processing		Domestic	Limited	No	No	Yes	No
Millel <sup>6</sup>	SA	1925	Gambier Limestone	Food processing	100	Domestic	Limited	Yes	No	Yes	Yes
Mt Gambier	SA	1982	Gambier Limestone	Petroleum		Domestic	Nil	No	No	Yes	No
Mt Gambier	SA	1983	Gambier Limestone	Industrial		Domestic	Nil	No	Yes	Yes	Yes
Mt Gambier	SA	1983	Gambier Limestone	Petroleum		Domestic	Nil	Yes	No	Yes	Yes
Bordertown <sup>7</sup>	SA	1961	Murray Group	Agricultural		Domestic	Limited	No	Unknown	Unknown	No
Allansford <sup>8,11</sup>	VIC	1964	Port Campbell Lst	Food processing	150	Domestic	Serious	No	Yes	Yes	No
Warrnambool <sup>9</sup>	VIC	1900	Port Campbell Lst	Sewage		Domestic	Limited	No	Yes	No	No
Mt Gambier <sup>10</sup>	SA	1972	Gambier Limestone	Sewage		Domestic	Limited	No	Yes	No	Unknown

<sup>1</sup>Waterhouse, 1977; <sup>2</sup>Forth, 1981; <sup>3</sup>Harvey, 1983; <sup>4</sup>McPharlin, 1983; <sup>5</sup>Smith, 1980; <sup>6</sup>Barnett & others, 1977; <sup>7</sup>Roberts, 1970; <sup>8</sup>Shugg, 1984b; <sup>9</sup>Shugg, 1987a;

<sup>10</sup>Waterhouse, 1972; <sup>11</sup>Shugg, 1984a;

TABLE 3 GROUNDWATER CONTAMINATION INCIDENTS IN THE FYANSFORD FORMATION AND BRIGHTON GROUP, MELBOURNE<sup>1,2,3</sup>

Location	Date	Aquifer	Contaminant Type	Plume area (ha)	Major use of aquifer	Effect on water use	Remedial works	Active source	Legislative controls	Current monitoring
South Oakleigh	1967	Brighton Group	Leachate	6	Agricultural	Limited	No	No	Yes	No
Springvale	1976	Fyansford-Brighton	Industrial		Agricultural	Limited	No	Yes	Yes	No
Springvale	1967	Brighton Group	Leachate		Agricultural	Limited	No	No	Yes	Yes
Moorabbin	1964	Brighton Group	Industrial		Agricultural	Limited	No	No	No	No
Dingley	1974	Fyansford Fm	Industrial		Agricultural	Limited	No	Yes	Yes	No
Oakleigh	1973	Fyansford-Brighton	Industrial		Agricultural	Limited	No	No	No	No
Brighton	1964	Fyansford-Brighton	Leachate		Agricultural	Limited	No	Unknown	Yes	Yes
Lyndhurst	1979	Brighton Group	Industrial		Agricultural	Limited	No	No	Yes	Yes
Frankston	1970	Brighton Group	Leachate		Agricultural	Limited	No	Yes	Yes	No
Dandenong	1973	Brighton Group	Industrial		Agricultural	Limited	No	Unknown	Yes	No

<sup>1</sup>Shugg, 1984a; <sup>2</sup>Leonard, 1982; <sup>3</sup>Leonard, 1979;

TABLE 4 GROUNDWATER CONTAMINATION INCIDENTS IN CAINOZOIC VOLCANICS, MELBOURNE

Location	Date	Aquifer	Contaminant type	Plume area (ha)	Major use of aquifer	Effect on water use	Remedial works	Active source	Legislative controls	Current monitoring
Tullamarine <sup>1,2</sup>	1971	Older Volcanics	Industrial		Other	Nil	No	Yes	Unknown	Yes
Footscray <sup>3,4</sup>	1950	Newer Volcanics	Industrial	4500	Industrial	Serious	Yes	Unknown	Unknown	Yes
Sydenham <sup>2,5</sup>	1945	Newer Volcanics	Industrial	1	Industrial	Serious	No	No	Yes	Yes
Collingwood <sup>2,6</sup>	1950	Newer Volcanics	Leachate	1	Other	Limited	No	No	No	No
Epping <sup>2,7</sup>	1970	Newer Volcanics	Industrial	1	Industrial	Limited	No	No	No	No
Laverton <sup>4,8</sup>	1967	Newer Volcanics	Industrial	40	Industrial	Serious	No	No	No	Yes
Deer Park <sup>4,9</sup>	1965	Newer Volcanics	Industrial	700	Industrial	Serious	No	No	No	Yes
Albion <sup>4</sup>	1969	Newer Volcanics	Industrial		Industrial	Limited	No	No	Yes	Yes
Alphington <sup>2,10,11</sup>	1972	Newer Volcanics	Leachate		Other	Serious	No	No	No	No

<sup>1</sup>Shugg, 1981a; <sup>2</sup>Shugg, 1984a; <sup>3</sup>Riha, 1977; <sup>4</sup>Leonard, 1979; <sup>5</sup>Shugg, 1981b; <sup>6</sup>Shugg, 1978a; <sup>7</sup>Shugg, 1978b; <sup>8</sup>Riha, 1975; <sup>9</sup>Shugg, 1987a; <sup>10</sup>Shugg, 1978c;

<sup>11</sup>Shugg, 1987b; <sup>12</sup>Riha & Kenley, 1978;

TABLE 5 GROUNDWATER CONTAMINATION INCIDENTS IN FRACTURED SILURIAN ROCKS, CANBERRA REGION

Location	Date	Aquifer	Contaminant type	Plume area (ha)	Major use of aquifer	Effect on water use	Remedial works	Active source	Legislative controls	Current monitoring
Mitchell, Canberra <sup>1</sup>	ACT	1979	Silurian mudstone	Petroleum	10	Other	Nil	No	No	No
Canberra City <sup>2,3</sup>	ACT	1977	Silurian mudstone	Petroleum	1	Other	Nil	Yes	No	Yes
Braddon, Canberra <sup>2</sup>	ACT	1979	Silurian limestone	Petroleum	1	Other	Nil	No	No	Yes
Captains Flat <sup>4,5</sup>	NSW	1962	Silurian shale and volcanics	Mining		Other	Serious	No	Yes	Yes
Pialligo, Canberra <sup>6</sup>	ACT	1978	Silurian mudstone	Leachate	30	Agricultural	Nil	No	Yes	Yes

<sup>1</sup>Jacobson & Henderson, 1983; <sup>2</sup>Jacobson, 1983; <sup>3</sup>Smith & Jacobson, 1981; <sup>4</sup>Jacobson & Sparksman, 1988; <sup>5</sup>Norris, 1986; <sup>6</sup>Jacobson & Evans, 1981;

TABLE 6 GROUNDWATER CONTAMINATION INCIDENTS IN OTHER AUSTRALIAN AQUIFERS

Location		Date	Aquifer	Contaminant type	Plume area (ha)	Major use of aquifer	Effect on water use	Remedial works	Active source	Legislative controls	Current monitoring
Norfolk Island <sup>1</sup>	NOR	1965	Basalt	Sewage	2000	Domestic	Limited	No	Yes	Yes	No
Warburton	VIC	1980	Alluvium	Petroleum	1	Other	Limited	No	No	Unknown	No
Cairns	Q	1983	Alluvium	Petroleum	1	Other	Nil	Yes	No	No	No
Fregon	SA	1985	Proterozoic granite	Petroleum		Domestic	Limited	No	No	No	No
Duntroon, Canberra <sup>2</sup>	ACT	1976	Alluvium	Sewage	25	Other	Nil	No	No	No	No
Hume, Canberra <sup>3</sup>	ACT	1978	Alluvium	Industrial	30	Other	Nil	No	No	No	Yes
Botany, Sydney, <sup>4,5</sup>	NSW	1963	Coastal alluvium	Industrial	400	Industrial	Limited	No	Yes	Yes	No
Minlaton	SA	1986	Cambrian limestone	Petroleum		Agricultural	Limited	No	Unknown	Yes	Unknown
Lucas Heights, Sydney <sup>6,7</sup>	NSW	1955	Hawkesbury Sandstone	Leachate		Other	Limited	No	No	Yes	Yes
Jabiru <sup>8</sup>	NT	1980	Archean gneiss	Mining		Other	Unknown	No	Yes	Yes	Yes
Mary Kathleen <sup>9</sup>	Q	1958	Proterozoic schist	Mining	2	Other	Nil	Yes	Yes	Unknown	Yes
Coffin Bay <sup>10</sup>	SA	1900	Bridgewater Fm	Sewage		Domestic	Limited	No	Yes	Unknown	Unknown
Blunder Tip, Brisbane <sup>11</sup>	Q	1970	Alluvium	Industrial		Other	Unknown	No	Unknown	Unknown	Yes
Corangamite <sup>12</sup>	VIC	1900	Newer Volcanics	Agricultural		Agricultural	Nil	No	Yes	No	No
Home Island <sup>13</sup>	COC	1900	Sand	Sewage	4	Domestic	Limited	No	Unknown	No	No
Ravenswood	Q	1985	Granodiorite	Mining		Agricultural	Serious	Yes	No	Yes	Yes
Perthville	NSW	1980	Palaeozoic granite	Sewage	2	Domestic	Serious	Yes	Unknown	Yes	Yes
Spring Hill	NSW	1975	Basalt	Sewage		Domestic	Limited	Yes	Unknown	Yes	Yes
Hopefield Siding	NSW	1978	Shepparton Fm	Agricultural		Domestic	Nil	No	No	No	Yes
Nepean Peninsula <sup>14</sup>	VIC	1900	Wannaeue Fm	Sewage	3000	Agricultural	Limited	No	Yes	No	Yes
Porepunkah <sup>15</sup>	VIC	1980	Alluvium	Leachate	1	Agricultural	Limited	No	Yes	Yes	No
Tinambra <sup>16</sup>	VIC	1978	Alluvium	Sewage		Domestic	Serious	Unknown	Unknown	No	No
Chelsea, Melbourne	VIC	1957	Alluvium	Industrial		Agricultural	Nil	No	Yes	Yes	No
Rum Jungle <sup>18</sup>	NT	1954	Proterozoic schist	Mining		Other	Serious	Yes	No	Unknown	Unknown
Howard Springs <sup>19</sup>	NT	1970	Bathurst Island Fm	Sewage		Domestic	Limited	Unknown	Yes	Unknown	Unknown
Warburton <sup>20</sup>	WA	1983	Calcrete	Sewage		Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Jamestown <sup>21</sup>	SA	1968	Proterozoic mudstone	Petroleum		Other	Limited	Unknown	Unknown	Unknown	Unknown
Esperance <sup>20</sup>	WA	1900	Coastal alluvium	Sewage		Unknown	Unknown	Unknown	Yes	Unknown	Unknown
Anna Bay	NSW	1986	Coastal alluvium	Petroleum	1	Domestic	Serious	No	Yes	Yes	No
Geelong <sup>22</sup>	VIC	1970	Coastal alluvium	Leachate		Other	Unknown	No	Yes	Yes	Yes
Harrietville <sup>22,23</sup>	VIC	1900	Alluvium	Sewage		Domestic	Serious	Unknown	Unknown	No	No
Woods Point <sup>24</sup>	VIC	1900	Palaeozoic mudstone	Mining		Unknown	Unknown	No	Yes	No	No
Collinsville <sup>25</sup>	Q	1962	Permian coal measures	Mining		Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Noosa <sup>11,26</sup>	Q	1975	Alluvium	Sewage		Other	Nil	Unknown	Unknown	Unknown	Unknown
Narromine	NSW	1986	Alluvium	Leachate		Domestic	Serious	No	Yes	Yes	Yes
Toowoomba <sup>27</sup>	Q	1957	Basalt	Sewage		Domestic	Serious	No	Unknown	Unknown	No
Alice Springs <sup>28</sup>	NT	1986	Alluvium	Sewage		Irrigation	Nil	No	Unknown	Unknown	No
Port Melbourne	V	1987	Alluvium	Petroleum		Other	Nil	No	No	No	Yes

<sup>1</sup>Abell, 1976; <sup>2</sup>Hohnen, 1977; <sup>3</sup>Jacobson & Hohnen, 1980; <sup>4</sup>Johnson, 1981; <sup>5</sup>Smart, 1968; <sup>6</sup>Knight, 1983; <sup>7</sup>Knight & Beck, 1987; <sup>8</sup>Salama, 1986;<sup>9</sup>Flanagan & others, 1983; <sup>10</sup>Barnett, 1983; <sup>11</sup>Zahawi, 1980; <sup>12</sup>Lawrence, 1983; <sup>13</sup>Jacobson, 1976; <sup>14</sup>Shugg, 1985; <sup>15</sup>Shugg, 1980; <sup>16</sup>The Age, 1978; <sup>17</sup>Leonard, 1979;<sup>18</sup>Daniel & others, 1982; <sup>19</sup>Water Divison, 1981; <sup>20</sup>Davidson & Jack, 1983; <sup>21</sup>Bowden, 1969; <sup>22</sup>Shugg, 1984a; <sup>23</sup>Shugg, 1979; <sup>24</sup>Shugg, 1981c; <sup>25</sup>Charles, 1982;<sup>26</sup>Zahawi, 1978; <sup>27</sup>Simmonds, 1962; <sup>28</sup>Hancock & others, 1986.

This distribution to some extent reflects the variation in the degree of investigation of groundwater pollution and the approach taken by State agencies. These are, in turn, dependent on a number of factors of which one is the degree of industrial and urban development and its relationship to major aquifers.

The major regional aquifers affected, which are all unconfined or semi-confined, are:

<u>Aquifer</u>	<u>Number of incidents</u>
Superficial formations, Perth Basin (Table 1)	24
Gambier Limestone and equivalents, Otway and Murray Basins (Table 2)	19
Fyansford Formation and Brighton Group, Port Phillip Basin (Table 3)	10
Cainozoic volcanics, Melbourne (Table 4)	10
Fractured Silurian rocks, Canberra (Table 5)	5

The remaining 38 incidents are distributed among several other aquifers (Table 6). The main problem areas, and the increasingly vulnerable areas, are shallow unconfined aquifers which underlie regions of intensive urban, industrial or agricultural development.

The majority of the contamination incidents (93) are described as being continuous over a period of years. Six incidents are described as having occurred once only and five incidents comprise several discrete occurrences. The time frame for groundwater contamination ranges back to the early years of the century, although most incidents are post-1945. Some 28 incidents appear to have started or been discovered in the 1970's and 16 started in the 1980's. The 1970's saw the introduction of environmental legislation in Australia, including licensing of waste disposal, and the growth of public and governmental awareness of water pollution. Clearly also the increasing number of reported cases relates to increasing urban and industrial development. A total of 46 incidents are described as still occurring, that is the pollution source is still active or leachate is still being generated. Some 42 incidents no longer have active sources, and the situation is unknown in 18 cases owing to the lack of surveillance or documentation.

Information on the areal extent of the pollution plume is available for 39 incidents. The largest plume areas are the nitrate plumes in southeast South Australia (Table 2), the Perth metropolitan area (Table 1) and the Nepean Peninsula, Victoria (Table 6). Information on the volume of contaminated ground is only available for 12 incidents.

A total of 21 cases are described as having serious effects on water use. In general these cases affect drinking water supplies, or have intractable pollutants, or affect surface waters. Another 53 cases are described as having limited effects on water use; 25 cases apparently have no effects on water use; and the effect on water use is unknown in 7 cases.

Remedial measures have been undertaken in 23 of the listed incidents. These measures can be categorized as follows:-

<u>Remedial measures</u>	<u>Number of incidents</u>
Groundwater recovery and treatment, disposal or re-use	12
Closure of site or changed effluent disposal practise	7
Removal of contaminated ground	2
Elimination of source	2

The success of remedial measures is described as great in 6 cases, moderate in 9 cases and limited in 2 cases. In 6 other cases the effectiveness of remedial measures is unknown. In the majority of documented incidents (69), no remedial measures have been undertaken and this includes several cases described as having serious effects on water use.

Legislative controls apparently pertain in 48 incidents but have not always been activated. In 35 cases no legislative controls are applicable; this includes some historic contamination incidents that occurred prior to the introduction of legislation. In some 20 cases the situation with regard to legislative controls is unknown or obscure. The range of State and Territory legislation that applies to groundwater quality is shown in

Appendix 1. The legislative and administrative framework for control of groundwater contamination is different for each State and Territory; in some States there is no clear delineation of institutional responsibility for the problem. Administrative controls, including waste disposal licensing and septic tank regulations, are apparently relevant in 39 of groundwater contamination cases in the inventory.

Current monitoring systems are reported for 50 out of the 106 incidents. The number of monitoring bores ranges from 1 to 30 per incident and the monitoring agencies include State and Local Government agencies and industry. The frequency of monitoring, and the number of parameters monitored, varies considerably. Significantly, 56 cases are apparently not monitored and these include 11 cases that are described as having serious effects on water use.

#### DISCUSSION - THE NATIONAL SITUATION

##### Extent of the known problem

Four important regional aquifers are affected: the superficial formations of the Perth Basin; the Gambier Limestone; the Newer Volcanics; and the Fyansford Formation and Brighton Group in Melbourne. All of these aquifers are shallow, unconfined to semi-confined and underlie the sites of urban, industrial or agricultural development. These regional aquifers require "vulnerability" mapping, pollution transport modelling, and monitoring in a groundwater management framework; and the development of groundwater protection strategies to reduce contaminant sources and ameliorate existing pollution. Elsewhere in Australia groundwater pollution is a local scale problem. The effect is to reduce the actual or potential use of groundwater resources and to put at risk surface water bodies located downgradient from polluted groundwater.

With respect to point source pollution, the number of sources, particularly of liquid wastes, has been substantially reduced by controls. Nevertheless, there is a need for improvement in the selection, design and operation of industrial and domestic waste disposal depots, and the prevention of spills. The existing pollution problem, a legacy of past mistakes, is being addressed to varying degrees by State agencies.



## The unknown problem

The extent of groundwater contamination documented in this inventory must be regarded as only a partial statement of the problem. Many of the known incidents were discovered by accident and there has been little systematic investigation and monitoring of likely pollution sites. An unknown number of landfills, and districts serviced by septic tanks, are discharging effluent to shallow aquifers. Groundwater contamination is difficult to detect as contaminants are often colourless and the parameters of pollution are not always well defined nor revealed by the one-time only standard inorganic analysis. In most groundwater systems, velocities are low and there may be a long time lag before contamination is detected.

## Prevention and cure

Remedial works for groundwater pollution are costly, time-consuming and not always successful. Clearly, prevention is better than cure. Groundwater protection programmes are needed and an important aspect is to provide economic incentives to reduce contaminant sources. Hydrogeological criteria for waste treatment and disposal sites need to be developed.

With respect to non-point source pollution, there is little information available and an evaluation is needed which includes pollution from sewage, land use, herbicides and pesticides.

## Legislation and administration

All Australian States have groundwater protection laws but they vary and are unevenly implemented. The organizational and administrative structure is different in every State and the control of groundwater contamination is not always optimal. A comparison of the effectiveness of State legislation (cf. Clark, 1980) is beyond the scope of this report but could usefully be addressed in a further study.

## National perspective

Groundwater comprises 14% of Australia's water use. By comparison, groundwater comprises 25% of water use in the USA which has fifteen times our population and where it is estimated that 1 - 2% of usable groundwater is polluted (Pye & Patrick, 1983). Australia's present groundwater pollution problem is minor compared with that of the USA.

Nevertheless, Australia's aridity and growing dependence on groundwater makes conservation and protection of stored groundwater resources imperative. Groundwater resources will ultimately be developed to their maximum extent, including the brackish aquifers.

## CONCLUSIONS

1. A total of 106 groundwater contamination incidents are documented for Australia, with the reservation that there may be many other undiscovered incidents. A range of contaminant sources is involved, especially industrial effluent, sewage and landfill leachate.
2. The main regional aquifers affected are the superficial formations of the Perth Basin; the Gambier Limestone and equivalents; the Fyansford Formation and Brighton Group in the Port Phillip Basin; and the Newer Volcanics in Melbourne. These shallow, unconfined to semi-confined aquifers underlie regions of intensive urban, industrial or agricultural development.
3. Remedial measures have been undertaken in 23 cases; the most common measures involve groundwater recovery and treatment, disposal or re-use. The remedial action has been effective in 15 of these cases.
4. A range of State legislation is applicable to the control and management of point-source groundwater contamination but is unevenly implemented. Legislation applicable to non-point source pollution of groundwater is obscure or non-existent.
5. Surveillance of the reported incidents is uneven and the majority of known cases are not currently monitored, including 11 cases that have serious effects on water use.

## RECOMMENDATIONS

1. Effort should be made to identify the unknown groundwater contamination incidents, towards updating the inventory.
2. An assessment should be made of the risk of each groundwater contamination incident to groundwater and surface water. This should be based on background water quality, rate of groundwater flow, type and amount of pollution, attenuation and dilution.

3. Evaluation of non-point source pollution from sewage, land use, herbicides and pesticides is required, towards possible controls.
4. Development of criteria is needed for the location, investigation, monitoring and prevention of groundwater pollution.
5. An examination should be made of the relevant State legislation applicable to non-point and point source pollution of groundwater.

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APPENDIX 1 PRINCIPAL LEGISLATION IN AUSTRALIA RELATING TO GROUNDWATER QUALITY CONTROL (after Hughes, 1981)

STATE	GROUNDWATER LEGISLATION	BASIS OF LEGISLATION	PROVISIONS FOR ENFORCEMENT	REMARKS
NSW	Water Act 1912	Declaration of restricted groundwater areas within which licencees of bores are required to undertake specific action to prevent pollution.	Licensing Penalties	No powers over unlicensed bores which may exist in declared areas or in areas outside declared areas.
	Clean Waters Act	Classification of all groundwaters and specification of prohibited and approved types of waste discharge. i.e. Minimum water quality standards.	Licensing Direct controls Penalties	Overlaps with Water Act, 1912 with respect to administrative approvals. Effectiveness of the legislation is very much dependent on co-operation between administering authorities.
	State Pollution Control Commission Act 1970	Consultation and arrangement with any public authority to undertake measures within its powers to promote pollution control.	Direct powers	Designed to assist the implementation of the substantive provisions of the Water Act 1912 and the Clean Waters Act 1970
	Waste Disposal Act 1970	Within the Metropolitan Waste Disposal Region the Authority has the responsibility to supervise the disposal of waste.	Licensing	Valid only in the Metropolitan area
QLD	Clean Waters Act 1971-76	No program of water classification but conditions attached to a licence to discharge waste may prescribe water quality standards.	Licensing Direct controls Penalties	
SA	Water Resources Act 1976	Water quality provisions prohibit unauthorised discharge of wastes likely to contact (ground) waters, provide for an authorising mechanism, and empower Minister to take action to prevent or minimise pollution and recover costs.	Licensing Direct controls Penalties	All provisions concerning groundwater bores appear in the same Act and are administered jointly
TAS	Underground Water Act 1966	Conditions may be attached to bore licences limiting the use or disposal of groundwater in a protected area.	Licensing Direct Powers Penalties	Areas have not been proclaimed under the Act and the provisions remain untested.
	Environment Protection Act 1973	Standards for groundwater quality are laid down in the Environmental Protection (Water Pollution) Regulations 1974 and legislation is based on the declaration of protected areas.	Licensing Direct controls Penalties	Powers apply only to industrial and trade premises

STATE	GROUNDWATER LEGISLATION	BASIS OF LEGISLATION	PROVISIONS FOR ENFORCEMENT	REMARKS
VIC	Health Act 1958	Approval required for the disposal of any trade or business waste into any source of water supply based on quality standards and objectives.	Direct powers	
	Groundwater Act 1969	Section 44 requires any disposal of matter by a bore to be approved under the Health Act 1958 or by the Minister for Minerals and Energy. Approval may be subject to conditions.	Licensing	Designed to supplement the provisions of the Health Act 1958. Different functions of administering agencies create complexities
	Environment Protection Act 1970	Authority responsible for the co-ordination of all activities relating to waste discharge and pollution control.	Direct controls Penalties	Potential for conflict inherent in division of responsibility between agencies
WA	Rights in Water and Irrigation Act 1914-78	Licences set effluent standards depending on the quality of the receiving waters and use made of them.	Licensing Penalties	The list of prohibited acts does not allow for preventive or remedial action: problems associated with proof and causation
	Metropolitan Water Supply Sewerage and Drainage Act 1909-1978	Declaration of underground water pollution control areas. Within these areas the Board has the power to make by-laws to protect the quality of the groundwater and to control and regulate potentially polluting acts.	Licensing Penalties	Licensing provisions are not as comprehensive as some in other states
	Environmental Protection Act 1971-1975	Act primarily directed to the establishment of environmental policy, co-ordination of all activities to protect the environment and the establishment of standards and criteria.	Direct controls Penalties	Acts ratifying agreements to which the State is a party are exempt
	Control of Water Ordinance 1938-74	Controls only apply within declared water control districts	Direct controls	Provisions are insufficient to provide an adequate framework for protecting groundwater quality
ACT	Water Quality Ordinance 1984	Licenses required to discharge waste into waters including groundwaters.	Licensing Penalties	Valid for the ACT and Jervis Bay



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