

# Sources of AgVet Data (Monitoring) in Australia

A consideration of monitoring information, gaps in available data and future monitoring requirements.

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We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

**Amendments**

The Australian Environment Agency Pty Ltd reissued this document on 30 May 2023 to reflect comments received from the Queensland Government following its publication. The third paragraph on page 48 was revised to more accurately reflect the work of the Great Barrier Reef Catchment Loads Monitoring Program (GBRCLMP). Corresponding changes were also made to the summary of the Reef 2050 Water Quality Improvement Plan on page 76 of the report.

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## Introduction

The pesticides and veterinary medicines regulatory framework provides important protection for the Australian community. Responsibility for the current regulatory system is shared between the Commonwealth, state and territory governments. The Australian Pesticides and Veterinary Medicines Authority (APVMA) is the independent statutory authority responsible for assessing and registering pesticides and veterinary medicines for supply in Australia. State and territory governments are responsible for controlling the use of pesticides and veterinary medicines beyond the point of retail sale. The Department of Agriculture, Forestry and Fisheries, is responsible for Australian Commonwealth policy on pesticide and veterinary medicines regulation.

The agricultural and veterinary (agvet) chemicals regulatory system aims to ensure that the agvet chemicals used in Australia are safe and effective. The department is currently investigating how they can better monitor the effectiveness of the agvet chemicals regulatory system and provide assurance that the controls on these products are effective and not leading to poor environmental or human health outcomes.

The project consists of several stages:

1. Identification of relevant sources of data on the use and fate of agvet chemicals in Australia;
2. Assessment of the data sources to determine how relevant they are to the department’s requirements;
3. Identification of gaps in the sources of data; and
4. Provision of final recommendations to the department on which data sources should be included and where new data gathering programs should be developed.

Data sources consisted of state and national government data bases and literature papers describing (generally) environmental monitoring programs. Data format, accessibility, costs and any other impediments to obtaining the data have been considered.

## Initial identification of data sources

The report covering identification of data sources in Australia is provided as Appendix 1: Research and analysis of pesticides and veterinary medicines data sources. In some cases, requests for information were sent to several areas within one overall organisation. The data sources that were considered acceptable for this project following assessment (see Section 3) are listed here. The full details for the monitoring programs and the links to the data sources are provided in Appendix 2: Reliability and representativeness of pesticides and veterinary medicines identified data sources.

* 2009/2010 Pesticide Residue Water Sampling and Analysis Program: Emigrant Creek and Wilsons River Water Supply Systems.
* Allinson G, Allinson M, Myers J and Pettigrove V. Use of novel rapid assessment tools for efficient monitoring of micropollutants in urban storm water (SWF Project 8OS – 8100). Centre for Aquatic Pollution Identification Management (CAPIM). 2014. The University of Melbourne, Parkville, Victoria 3025, Australia.
* Allinson G, Zhang P, Bui A, Allinson M, Rose G, Marshall S and Pettigrove V. Pesticide and trace metal occurrence and aquatic benchmark exceedances in surface waters and sediments of urban wetlands and retention ponds in Melbourne, Australia. Environ Sci Pollut Res Int. July 2015; 22(13):10214-26.
* Allinson M, Zhang P, Bui A, Muyers J, Pettigrove V, Rose G, Salzman S, Walters R and Allinson G. Herbicides and trace metals in urban waters in Melbourne, Australia (2011–12): concentrations and potential impact. Environ Sci Pollut Res 2017. 24, 7274–7284.
* Allinson G, Allinson M, Bui A. et al. Pesticide and trace metals in surface waters and sediments of rivers entering the Corner Inlet Marine National Park, Victoria, Australia. Environ Sci Pollut Res 2016. 23, 5881–5891.
* Allinson G, Bui A, Zhang P. et al. Investigation of 10 Herbicides in Surface Waters of a Horticultural Production Catchment in Southeastern Australia. Arch Environ Contam Toxicol 2014. 67, 358–373.
* Burdekin Shire Council – Drinking Water Quality Management Plan.
* Campbell G, Mannetje A, Keer S, Eaglesham G, Wang X, Lin C, Hobson P, Toms L-M, Douwes J, Thomas K, Mueller J and Kaserzon S. Characterisation of glyphosate and AMPA concentrations in the urine of Australian and New Zealand populations. Science of the Total Environment. 15 November 2022. Vol 857, 157585.
* Catchment and Drinking Water Quality Micro Pollutant Monitoring program – Passive Sampling. Report 10 – Summer 2019. Queensland Alliance for Environmental Health Sciences, University of Queensland.
* Central Highlands Water - Water Quality Report.
* Coleambally Irrigation – Water quality monitoring results.
* Cooke R, Whiteley P, Jin Y, Death C, Weston M, Carter N and White J. Widespread exposure of powerful owls to second-generation anticoagulant rodenticides in Australia spans an urban to agricultural and forest landscape, Science of The Total Environment, 2022. Volume 819, 153024.
* Department of Water. A baseline study of contaminants in groundwater at disused waste disposal sites in the Swan Canning catchment. Water Science technical series Report No 4, December 2009. Government of Western Australia.
* Department of Water. A baseline study of contaminants in the sediments of the Swan and Canning estuaries. Water Science technical series Report No 6, February 2009. Government of Western Australia.
* Department of Water. A baseline study of organic contaminants in the Swan and Canning catchment drainage system using passive sampling devices. Water Science technical series Report No 5, December 2009. Government of Western Australia.
* EPA Victoria – Emerging contaminants assessment 2019-20: Summary of results. Publication 1879, September 2020.
* Flinders Shire Council – Drinking Water Quality Management Plan.
* Food monitoring programs (Department of Health, Government of Western Australia).
* Fredericks D and Palmer D. Assessment of Pesticides in Aquatic Organisms – Ord River WA. Department of Environment, Government of Western Australia, Water Resource 2008. Technical Series Report No 40.
* FSANZ, 25th Australian Total Diet Study.
* Hook S, Doan H, Gonzago D, Musson D, Du J, Kookana R, Sellars M and Kumar A. The impacts of modern-use pesticides on shrimp aquaculture: An assessment for north eastern Australia, Ecotoxicology and Environmental Safety, 2018, Volume 148 770-780.
* Kennedy K., Bentley C, Paxman C, Heffernan A, Dunn A, Kaserzon S and Mueller J. Final Report - Monitoring of organic chemicals in the Great Barrier Reef Marine Park using time integrated monitoring tools (2009-2010). The University of Queensland, The National Research Centre for Environmental Toxicology (Entox) 2010.
* Laicher D, Benkendorff K, White S, Conrad S, Woodrow R, Butcherine P and Sanders C. Pesticide occurrence in an agriculturally intensive and ecologically important coastal aquatic system in Australia, Marine Pollution Bulletin, 2022. Volume 180, 113675.
* Lettoof D, Bateman P, Aubret F. et. al. The Broad-Scale Analysis of Metals, Trace Elements, Organochlorine Pesticides and Polycyclic Aromatic Hydrocarbons in Wetlands Along an Urban Gradient, and the Use of a High Trophic Snake as a Bioindicator. Arch Environ Contam Toxicol 2020. 78, 631–645.
* Lohr M. Anticoagulant rodenticide exposure in an Australian predatory bird increases with proximity to developed habitat. Science of the Total Environment 2018. 643: 134-144.
* Marshal S, Sharley D, Jeppe K, Sharp S, Rose G and Pettigrove V. Potentially Toxic Concentrations of Synthetic Pyrethroids Associated with Low Density Residential Land Use. Frontiers in Environmental Science 22 November 2016, Vol 4 (75).
* Murray Irrigation – Compliance and monitoring.
* Murrumbidgee Irrigation – Water quality results.
* National residue Survey results and publication.
* Oliver D, Kookana R, Anderson J, Cox J, Fleming N, Waller N and Smith L, Off-site transport of pesticides from two horticultural land uses in the Mt. Lofty Ranges, South Australia, Agricultural Water Management, 2012, Volume 106, 60-69.
* Pay J, Katzner T, Hawkins C, Barmuta L, Brown W, Wiersma J, Koch A, Mooney N and Cameron E, Endangered Australian top predator is frequently exposed to anticoagulant rodenticides, Science of The Total Environment, 2021. Volume 788, 147673.
* Pesticide Water Monitoring Results (last updated July 2014) – Tasmanian Government.
* QLD Government – Reef 2050 Water Quality Improvement Plan.
* Rose G, Zhang P, Bui A, Allen D and Allinson G. Melbourne Water and DPI agrochemicals in Port Philip catchment project report 2009-10. A report to the Centre for Aquatic Pollution, Identification and Management (CAPIM), the University of Melbourne. Future Farming Systems Research, DPI Queenscliff Centre, Queenscliff, Victoria. 2011.
* Sánchez-Bayo F and Hyne R. Detection and analysis of neonicotinoids in river waters – Development of a passive sampler for three commonly used insecticides, Chemosphere, 2014. Volume 99, 2014, 143-151.
* Sidhu, J., Gernjak, W. and Toze, S. (Editors) (2012). Health Risk Assessment of Urban Stormwater. Urban Water Security Research Alliance CSIRO 2012. Technical Report No. 102.
* Smith R, Turner R, Vardy S, Huggins R, Wallace R and Warne M. An evaluation of the prevalence of alternate pesticides of environmental concern in Great Barrier Reef catchments: RP57C, 2016.
* Targeted AgChem Residue Program (Agriculture Victoria).
* The Bundaberg Regional Council (BRC) Drinking Water Quality Management Plan (DWQMP).
* The Pesticide Detectives: national assessment of pesticides in waters.
* Vic EPA - “Emerging contaminants in recycled water project, 2021”.
* Victoria EPA; Vic State Government: Bellarine Peninsula: Legacy and emerging contaminant sampling and analysis (2018–2019) – Publication 1870, May 2020.
* Vincente-Beckett V, Noble R, Packet R, Verwey P, Ruddle L, Munksgaard N and Morrison H. Pesticide, polycyclic aromatic hydrocarbon and metal contamination in the Fitzroy Estuary, Queensland, Australia. Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management. 2006.
* Water Corporation (Western Australia).
* WaterNSW – Annual water quality monitoring report.
* Weaver T, Ghadiri H, Hulugalle N and Harden S. Organochlorine pesticides in soil under irrigated cotton farming systems in Vertisols of the Namoi Valley, north-western New South Wales, Australia, Chemosphere, 2012. Volume 88, Issue 3, 336-343.
* Wightwick A, Bui A, Zhang P. et al. Environmental Fate of Fungicides in Surface Waters of a Horticultural-Production Catchment in Southeastern Australia. Arch Environ Contam Toxicol 2012, 62, 380–390.
* Yoshikane M, Kay W, Shibata Y, Inoue M, Yanai T, Kamata R, Edmonds J and Morita M. Very high concentrations of DDE and Taxaphene residues in crocodiles from the Ord River, Western Australia: An investigation into possible endocrine disruption. Journal of Environmental Monitoring. 2006, Volume 8, 649-661.

## Assessment of data sources

The data sources were assessed for their reliability, relevance and representativeness for the purposes of this project. Outcomes of this assessment were used to determine their suitability for monitoring the effectiveness of the agvet chemicals regulatory system.

### Summary of results

The largest number of data sources are for environmental monitoring. However, only a small number of these represent long-term monitoring and the results available are generally for local scenarios (limited geographic range) and as a “snapshot” in time (limited by no temporal analysis available). The results are summarised in tabular form below. Currently, the most comprehensive monitoring program underway in Australia in terms of geographic area, linking to land use, sampling frequency and duration of the program is the QLD Government – Reef 2050 Water Quality Improvement Plan. However, this program only monitors a small number (n = 22) of pesticides. Some finalised monitoring programs in other states were more comprehensive in terms of the number of sites or the number of chemicals, but these programs were only performed for a short period of time.

While there were only a small number of produce data sources identified, these tend to be quite comprehensive. The National Residue Survey is a very large and structured monitoring program with data available for a long period of time. It considers residues for >600 individual chemicals in a large range of plant and animal food matrices. The FSANZ 25th Australian Total Diet Study is comprehensive, assessing for >130 chemicals. These residue surveys also tested for veterinary medicines in meat products. It is also understood that industry undertakes routine monitoring of produce for contaminants (for example, Coles and Woolworths). While some private organisations were contacted, no further information was provided to this project.

No suitable data sources were identified for monitoring agvet chemicals in humans. Work health and safety (WHS) laws require that workers health be monitored and WHS regulators be notified when workers are exposed to unsafe levels of hazardous chemicals, including agvet chemicals. However, WHS regulators were not able to provide useful information about workers exposure to agvet chemicals. Similarly, those public health authorities who responded to enquiries did not hold useful information about human exposure to agvet chemicals. Further work may be needed to engage these organisations, and make any data they hold reportable and usable. Alternatively, if the department wishes to obtain human health monitoring data directly it could consider initiating its own monitoring programs (see Section 4 – analysis of data gaps). The analysis of each data source that passed the screen for reliability, relevance and representativeness is provided in Appendix 2: Reliability and representativeness of pesticides and veterinary medicines identified data sources. The results are summarised in Section 3.2 below for the range of environmental monitoring data sources.

### Overview of environmental data sources

#### National monitoring

Table National sediment sources

| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| --- | --- | --- | --- | --- | --- | --- |
| 04 | Highly diverse (national program) | >100 | 110 | 43 | National | Bifenthrin |

* **Surface/groundwater** – None identified
* **Urban stormwater** – None identified
* **Drinking water** – None identified
* **Soil** – None identified
* **Wildlife** – None identified

#### Queensland

Table Queensland surface/groundwater sources

| Data source ID  | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| --- | --- | --- | --- | --- | --- | --- |
| 32 | Agriculture, tropical/subtropical | 7 | 29 | 17 | Regional | Diuron, 2,4-D, Atrazine, Hexazinone, Metolachlor. |
| 43 | Agriculture (grazing) | 1 | 8 | 4 | Local | Atrazine, Tebuthiuron, Diuron |
| 40 | Agriculture (intensive) | 55 | 66 | 26 | Local | Atrazine, Hexazinone, Diuron, Chlorpyrifos |
| 57 | Conservation, dryland cropping, forestry, grazing, tropical/subtropical cropping (bananas, sugarcane, horticulture). | 28 | 22 | 8 | Regional | Diuron, Imidacloprid, Atrazine, Metolachlor, Hexazinone |
| 59 | Conservation, grazing, sugarcane and horticulture. | 6 | 151 | 51 | Regional | Diuron, Atrazine, 2,4-D, Metribuzin, Metolachlor, Isoxaflutole, MCPA |
| 38 | Inshore reef areas (marine) | 12 | 33 | 18 | Regional | Diuron, Atrazine, hexazinone, simazine, chlorpyrifos. |

Table Queensland urban stormwater sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 30 | Residential (including with open space), city, urban roads, commercial and one larger catchment incorporating residential, commercial and agriculture. | 2 | 15 | 6 | Regional | Diuron, Simazine, 2,4-D, MCPA, Triclopyr |

Table Queensland drinking water sources

| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| --- | --- | --- | --- | --- | --- | --- |
| 39 | Drinking water supply catchment | 3 | 64 | 38 | Local | None exceeding guideline levels |
| 41 | Catchment wide - grazing, irrigated sugar cane | 15 | ≥9 | ≥4 | Local | Atrazine, diuron. |
| 45 | Drinking water supply catchment | 10 | ≥5 | ≥5 | Local  | Atrazine, Hexazinone, Bromacil, 2,4-D |
| 46 | Drinking water supply catchment | 36 | 41 | 25 | Regional | Atrazine, Metsulfuron-methyl, Simazine, 2,4-D, Hexazinone, Metolachlor, Propiconazole, Tebuthiuron, Endosulfan, DDT |

Table Queensland sediment sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 25 | Urban, intensive agriculture, forestry, broadacre cropping. | 151 | 82 | 39 | Regional | DDE, DDT, Aldrin, Chlordane, Dieldrin, Chlorpyrifos, Simazine, Diazinon |

* **Soil** – None identified
* **Wildlife** – None identified

#### New South Wales

Table New South Wales surface/groundwater sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 31 | Mixed (residential, orchards, mixed farms, turf farm, golf course) | 13 | 5 | 5 | Local | Specific for neonicotinoids. Acetamiprid, Imidacloprid, Thiacloprid. |
| 33 | Agriculture (horticulture) | 6 | 168 | 55 | Local | Imidacloprid, Methomyl, Dimethoate, Terbuthylazine, Terbutryn, Omethoate, Pyrimethanil, Triadimenol.  |
| 27 | Agricultural irrigation area | 2 | 3 | 2 | Local |  |
| 34 | Agricultural irrigation area | 6 | 11 | 8 | Local | Atrazine, metolachlor, simazine |
| 35 | Agricultural irrigation area | 5 | 10 | 7 | Local | Diuron, Atrazine, Metolachlor |

Table New South Wales urban stormwater sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 30 | Residential (including with open space), city, urban roads, commercial and one larger catchment incorporating residential, commercial and agriculture. | 2 | 15 | 6 | Regional | Diuron, Simazine, 2,4-D, MCPA, Triclopyr |

Table New South Wales drinking water sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 28 | Water filtration plants | 10 | 11 | 8 | Local | None above limit of reporting. |
| 36 | Drinking water supply catchment | 4 | 27 | 19 | Local | None above limit of reporting. |

Table New South Wales soil sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 47 | Historic - cotton use | 3 | 8 | 7 | Local | DDT (as DDD and DDE), Endrin, Endosulfan. |

* **Sediment** – None identified
* **Wildlife** – None identified

#### Victoria

Table Victorian surface/groundwater sources

| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| --- | --- | --- | --- | --- | --- | --- |
| 21 | Agriculture (pasture) | 17 | 39 | 16 | Local | Prometryn, Simazine |
| 22 | Agriculture (horticulture), water supply | 18 | 10 | 4 | Local | Simazine, Atrazine, Pendimethalin |
| 23 | Agriculture (horticulture), water supply | 18 | 24 | 6 | Local | Myclobutanil, Trifloxystrobin, Metalaxyl, Difenoconazole, Pyrimethanil |
| 48 | Mixed (urban and agriculture) | 4 | n/a | n/a | Local | Simazine, Atrazine.  |
| 50 | Urban, Peri-urban | 29 | 52 | 31 | Local | Simazine, Atrazine, Metalaxyl, Imidacloprid, Prometryn  |
| 53 | Background, low-intensity agriculture (grazing), high-intensity agriculture (cropping, horticulture), urban residential, and urban industrial. | 101 | n/a | n/a | Statewide | Simazine |

Table Victorian urban stormwater sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 19 | Urban (housing, industrial, mixed) | 5 | 31 | 7 | Local | Simazine, MCPA, Diuron, Atrazine. |
| 20 | Urban, Peri-urban | 24 | 24 | 14 | Local | Simazine, Atrazine, Metalaxyl, Terbutryn. |
| 30 | Residential (including with open space), city, urban roads, commercial and one larger catchment incorporating residential, commercial and agriculture. | 2 | 15 | 6 | Regional | Diuron, Simazine, 2,4-D, MCPA, Triclopyr |
| 06 | Urban, Suburban, constructed wetlands, regional town | 8 | 29 | 7 | Local | Atrazine, Simazine, Diuron, 2,4-D, MCPA, Triclopyr. |

Table Victorian drinking water sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 42 | Drinking water supply catchment | 13 | 105 | 51 | Regional | Atrazine, Simazine, 2,4-D, Triclopyr. |

Table Victorian soil sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 48 | Mixed (urban and agriculture) | 4 | n/a | n/a | Local | Dieldrin |
| 53 | Background, low-intensity agriculture (grazing), high-intensity agriculture (cropping, horticulture), urban residential, and urban industrial. | 101 | n/a | n/a | Statewide | p'p-DDE; Dieldrin. |

Table Victorian sediment sources

| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| --- | --- | --- | --- | --- | --- | --- |
| 05 | Urban | 111 | 32 | 14 | Regional | Diuron, permethrin, bifenthrin, triclosan and carbaryl. |
| 20 | Urban, Peri-urban | 24 | 17 | 10 | Local | Bifenthrin |
| 21 | Agriculture (pasture) | 17 | 39 | 17 | Local | Prometryn |
| 22 | Agriculture (horticulture), water supply | 18 | 10 | 4 | Local | Simazine |
| 23 | Agriculture (horticulture), water supply | 18 | 24 | 6 | Local | Myclobutanil, Pyrimethanil |
| 48 | Mixed (urban and agriculture) | 4 |  |  | Local | Dieldrin, DDT (as p,p’-DDE) |
| 50 | Urban, Peri-urban | 48 | 52 | 31 | Local | Simazine, Bifentrhin, Dieldrin, DDT (as p,p'-DDE) |
| 53 | Background, low-intensity agriculture (grazing), high-intensity agriculture (cropping, horticulture), urban residential, and urban industrial. | 101 | n/a | n/a | Statewide | Bifentrhin, Dieldrin, DDT, p,p’-DDE |

Table Victorian wildlife sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 63 | Powerful owl | 18 | 181 | 69 | Statewide | Brodifacoum, Bromadiolone, Pindone. DDT (as breakdown product p,p’-DDE) |

#### Tasmania

Table Tasmanian surface/groundwater sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 15 | Mixed (state government structured program) | 83 | 26 | 14 | Statewide | 2,4-D, Simazine, MCPA, Metalaxyl. |

Table Tasmanian wildlife sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 62 | Tasmanian wedge tailed eagle | 50 | 8 | 8 | Regional | Specific for anticoagulant rodenticides. Brodifacoum, Flocoumafen, Bromadiolone. |

* **Urban stormwater** – None identified
* **Drinking water** – None identified
* **Soil** – None identified
* **Sediment** – None identified

#### South Australia

Table South Australian surface/groundwater sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 26 | Agriculture (horticulture, orchards) | 2 | 14 | 7 | Local | Chlorpyrifos, Carbaryl, Fenarimol, Penconazole, Procymidone, Pirimicarb |

Table South Australian sediment sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 25 | Urban; intensive agriculture (market gardening,orchards, vines); forestry; broadacre cropping | 151 | 82 | 19 | Regional | DDT, aldrin, chlordane, chlorpyrifos, simazine, diazinon. |

* **Urban stormwater** – None identified
* **Drinking water**– None identified
* **Soil** – None identified
* **Wildlife** – Non identified

#### Western Australia

Table Western Australian surface/groundwater sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 10 | Mixed (industrial, residential, conservation, agriculture.) | 10 | 25 | 12 | Local | Diuron, Simazine, Atrazine |

Table Western Australian drinking water sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 09 | Drinking water supply catchment | >100 | 99 | 50 | Statewide | n/a |

Table Western Australian sediment sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 24 | Urban, Peri-urban | 4 | 21 | 21 | Local | Dieldrin |
| 12 | Historic agriculture prior to urbanisation | 20 | 15 | 10 | Local | Dieldrin, DDT (as p,p’-DDE) |

Table Western Australian wildlife sources

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Data source ID | Catchment description | Number of sites / samples | Number of pesticides monitored | Number of pesticides listed | Scale | Pesticides most detected |
| 07 | Crocodiles | 40 | 10 | 10 | Local | DDT, hexachlorobenzene, heptachlor, dieldrin, chlordane, mirex. |
| 14 | Southern Boobook (owl) | 73 | 8 | 8 | Regional | Specific for anticoagulant rodenticides. Brodifacoum, Bromadiolone, Difenacoum. |
| 08 | Fish | 47 | - | - | Local | DDT (including its breakdown products) were found in 100% of samples, dieldrin in 97% of samples and mirex in 90% of samples. Aldrin, chlordane heptachlor and HCB were found in 70-80% of samples. |

* **Urban stormwater** – None identified
* **Soil** – None identified

## Analysis of data gaps

This project is being undertaken to determine how the department can better monitor the effectiveness of the agvet chemicals regulatory system and provide assurance that the controls on these products are effective and not leading to poor environmental or human health outcomes. The ability to link monitoring data to controls placed on active constituents and their chemical products during regulatory assessment is seen as one way of being able to monitor the effectiveness of the system.

While a large number of data sources have been identified, it is apparent that there are significant gaps in terms of what has been monitored, matrices monitored and being able to link detections back to regulatory controls. To elucidate on reasons for this, gaps are considered both in terms of active constituents and monitored media; and in terms of the regulatory assessments themselves.

### Gaps in current existing data for agvet chemical surveillance

The accepted data sources including information on their access and availability are described in more detail in Appendix 2: Reliability and representativeness of pesticides and veterinary medicines identified data sources. Several sources are from published literature and these often require subscriptions for access, or are required to be purchased. The department has obtained access for this project so holds all published literature data sources. Some sources owned by various state government departments/agencies require a request but will generally be made available. In some cases, the data may be held by the testing laboratories rather than the department/agency reporting the data. For data sources obtained during this project, no significant access issues were identified.

#### Limitations in data described in data sources

The data sources identified are only considered in this project in terms of the chemicals looked for, and the chemicals found. Detections of chemicals are not meant to imply that they pose a risk to humans and the environment, only that they are found outside their area of application and within a monitoring program. Contemporary controls such as runoff restraints and downwind buffer zones are not designed to prevent all chemical moving off site. They are designed to ensure the chemical does not move off site at an exposure level that exceeds an acceptable toxicity/ecotoxicity level. Findings in the data sources as reported do not correlate exposure with effects.

While some data sources considered extensive suites of chemicals, there is no way of tracking back the products that were actually used in the monitored catchments over the monitoring period because no corresponding use data exist. Therefore, it is not clear (and can’t be identified) whether all active constituents would actually have been used during the monitoring program. A zero detection therefore, does not necessarily mean the substance will not move off-site. Conversely, it is not known if all active constituents used in a particular catchment over a monitoring period were actually monitored for. This increases overall uncertainty in results.

#### Gaps in sources of data

Gaps can be considered absolute or partial. Absolute data gaps are those where no sources of data were identified. These are as follows where no data sources in Australia over the last 20 years have been identified:

* Human biomonitoring (1 study only was obtained – See Appendix 2: Reliability and representativeness of pesticides and veterinary medicines identified data sources). In Australia, in certain circumstances, the model Worker Health and Safety (WHS) Regulations place duties on persons conducting business or undertakings (PCBUs) to provide health monitoring to workers. These requirements arise if the worker is carrying out work with hazardous chemicals including lead and asbestos. In addition, the work being carried out must be the kind of work specified in the WHS Regulations. A PCBU has the duty to determine if health monitoring is required. This can include pesticides, and, for example, Safe Work Australia provides a health monitoring guide for organophosphate pesticides.[[1]](#footnote-2) While only one study was obtained through this project for human biomonitoring, such information would be useful to monitor exposure from various activities including pest control operators (for example, mixing and loading chemical products; applying products), and for workers who may be exposed following application when working in treated crops.
* Veterinary medicines outside residues analysis in meat produce. While limited information is available on some veterinary medicines present in meat produce, other forms of contamination may be present. Exposure to land and water may occur from topical treatment to animals from wash-off, or from excretion following oral or injection treatment. Apart from potential residues in the target animal, assessment of such medicines considers exposure to soil, water and often, dung from treated animals. Some monitoring following veterinary treatments would help determine the suitability (or otherwise) of standard assessment assumptions.
* Environment – atmospheric monitoring. Pesticides can move through the atmosphere as spray (droplet) drift at the time of application, or in some cases, as vapour where they are sufficiently volatile to lift off the target area of application. This can have implications for human exposure and unintended off-target damage, for example, if volatile herbicides are exposed to non-target vegetation.
* Environment – all matrices (water, soil, sediment, air) generally associated with broadacre (dryland) cropping regions. There is a general lack of monitoring data in the different environmental matrices that can be used to link back to use in large acreage cropping, for example, cereals and pastures. Monitoring to fill this gap would be useful to support the need for reviews, or determine the suitability of standard exposure assessment assumptions depending on the substance being monitored and when monitoring is undertaken.

With respect to human biomonitoring, while only one study was obtained for the 20-year time frame applied in this project, it is clear activity has been undertaken in the past. In their 2005 performance outcomes monitoring report, the APVMA has significant information related to monitoring public health impacts from agvet chemical use with data drawn from the Australian Bureau of Statistics, Poisons Information Centres. Data relating to calls related to pesticide use and data relating to hospital admissions held by the Australian Institute of Health and Welfare relating to admissions due to acute pesticide poisoning. The information was reported for the years 1997-2001.

In a recent study, monitoring of cholinesterase in red blood cells (AChE) is reported.[[2]](#footnote-3) This was not reviewed as a data source because it did not directly measure for pesticides. However, AChE inhibition may be a symptom of organophosphate (OP) insecticide toxicity.

Partial data gaps are considered for areas where data sources are identified, but gaps remain in the monitoring programs or their findings. This is a difficult issue to resolve because monitoring programs are undertaken generally for a specific purpose. The most comprehensive long term environmental monitoring program currently in Australia is the QLD Government – Reef 2050 Water Quality Improvement Plan. This program is designed to meet the requirements of the QLD government and the list of chemicals assessed for reflects this. However, for the purposes of the current DAFF project, the Reef 2050 Water Quality Improvement Plan only analyses samples for 22 pesticides which is a fraction of the number considered “priority” based on identified concerns for human health and the environment. The Reef 2050 Water Quality Improvement Plan provides excellent work linking detections back to land use, but only within the small suite of substances being analysed for, and within a specific geographic region.

Monitoring that can’t be directly linked back to use patterns have limited use other than to note their presence and off-site movement and more fit for purpose data could be developed through targeted baseline monitoring (for example, to understand expected levels in humans, produce and the environment from current use patterns for particular substances) and operational monitoring (for example, to understand levels in different matrices following assessment and regulatory action). Such targeted monitoring can be undertaken on both spatial and temporal scales if needed. For substances where registration assessments pre-date current methodology, monitoring results do not allow an analysis of the effectiveness of contemporary regulatory assessments and may be difficult to interpret without the chemicals in question going through a chemical review.

It is not surprising that none of the identified data sources, with the possible exception of the food residues monitoring programs, can directly be used by DAFF to assess the effectiveness of the regulatory system, because they were not specifically developed for this purpose. It is clear that some (generally published literature) were developed to prosecute the case for regulatory action, for example, monitoring anticoagulant rodenticides in predator wildlife or neonicotinoids in urban stormwater runoff.

In terms of the number of sites monitored in different states, monitoring was dominated in Victoria and Queensland over the last 20 years (see Figure 1). In Victoria, there were >300 sites where sediment monitoring occurred. These were mainly around Melbourne and Port Phillip Bay, which also dominated the surface water and soil measurements taken in this state. There was one national program considering sediment sampling where approximately 110 sites were sampled around the country (not shown in Figure 2).

Figure Environmental monitoring – number of sites over 20 years for different matrices



Apart from the national sediment monitoring program, no sediment sampling results were identified for NSW or TAS. Surface water monitoring results were identified in all states, but the number of sites was generally low, particularly in NSW, SA and WA, and these included drinking water catchments, not just sites linked to agricultural activities. Data sources with measurements in soil were generally low.

While the overall number of sites may assist in understanding the scale of available monitoring, an important factor in further interpretation relates to the number of pesticides that were analysed. Generally, the overall number in a given monitoring program was relatively low. Around 55% of data sources for environmental monitoring analysed for <25 substances (see Figure 3), and many of these were not identified as having a concern to human health or the environment based on the list provided in Appendix A1.2 – List of agvet chemicals from international conventions and APVMA chemical review lists identified with known human health or environmental concerns. Future surveillance systems could take this issue into account in further prioritising substances for monitoring activities.

Figure Environmental monitoring – number of substances analysed for in different sources



Approximately 77% of sources only analysed for up to 25 substances identified in Appendix A1.2 – List of agvet chemicals from international conventions and APVMA chemical review lists identified with known human health or environmental concerns (Figure 3).

Figure Environmental monitoring – number of listed\* substances analysed for in different sources



\* Listed substances for this project as identified in Appendix A1.2

#### Data sources that meet the criteria set out by the department

The programs identified that analyse produce for residues, in particular the National Residue Survey with support from the FSANZ 25th Australian Total Diet Study, can be considered to meet the department’s needs for this project. The National Residue Survey is a nationwide monitoring program that analyses for >600 individual active constituents and is undertaken annually thereby providing long term results.

No other single monitoring source could be identified as meeting the department’s needs for this project with the possible exception of the Queensland Government Reef 2050 – Water Quality Improvement Plan. However, the results from this program are limited in geographic range and in the number of pesticides analysed for.

This finding is not surprising given monitoring programs are not generally not devised for this specific purpose. If the aim of a particular program is to support the veracity of the National Registration Scheme regulatory assessment process and effectiveness of regulatory controls, more targeted approaches are probably needed. These are expected to be most effective when performed for specific substances and in a number of local release scenarios. A possible exception may be where substances have concerns over volatility and wider exposure may require a more regional approach.

Future work may consider the ability to apply data sources more holistically than in isolation. From the information obtained during this project, such an approach will not be easy because monitoring programs differ in their purposes and are generally not coordinated with other programs in different areas of the country. It will be difficult to consider findings around the country as a collective data source where programs are short lived and undertaken at different times in different regions.

Importantly, the data sources identified may be useful in determining what substances have been detected in different matrices, but they generally are not suitable for issues important to DAFF in determining effectiveness of the regulatory scheme for the following reasons:

1. Substances that are shown to be present are not able to be linked to risk. Regulatory assessments performed in the National Registration Scheme are risk-based meaning that a substance can be present but the risk remains acceptable if the level is below that deemed to result in a potential risk. Current monitoring results do not link exposure to effects, and the regulatory acceptable level is something determined during scientific assessment of a substance by the APVMA;
2. The available monitoring, while often being able to associate presence of chemicals with overall land use, are generally not suitable for linking back to point sources. Further, the monitoring information represents a snapshot at the time of sampling. There is no information available on where and when substances detected were applied. For example, duration between application and sampling is unknown so actual levels determined can’t be correlated with application activities. Nonetheless, future work could initially benefit from a more detailed collation and analysis of the monitoring information identified in this report which may provide a starting point to deliver on some of the recommendations from the “[Final Report of the Independent Review of the Pesticides and Veterinary Medicines Regulatory System in Australia](https://haveyoursay.agriculture.gov.au/agvet-chemicals-regulatory-reform)”.
3. There is no ability to assess the range of agricultural chemical products that were used in areas where sampling has occurred so if a monitoring program only assesses for a small number of substances, it is possible a larger number may have been applied during the sampling period but these substances are not being looked for.
4. Further, without an understanding of the range of products used during a sampling program, the suite of chemicals assessed for may include a range of substances that were not actually used. Therefore, non-detects in such situations will not allow a conclusion that such substances will not be present off site following their use.

### Programs for potential response and resolution – point source contamination

Programs that direct potential response and resolution to point source contamination issues, agricultural industry practices and stewardship are discussed in this section.

Point source pesticide monitoring in key countries that Australian regulators, government and community consider reputable and adopting leading standards of regulation and pesticide monitoring are summarised as benchmarks for potential future programs in Australia.

#### Produce monitoring systems

Produce monitoring provides a measurable and traceable indicator of the type of pesticides used in agricultural production, while also providing evidence or absence of harmful pesticide residues in locally produced or imported food product. Produce monitoring can be used as a measurable indicator of pesticides and veterinary medicines used (often at trace or levels close to the limit of quantification) within a production or catchment area, regardless of the reported pesticide or veterinary medicine product use declared in reporting by producers. Crop and animal food products in most cases, can also be easily traced back to the point source of production, particularly with most Australian hoofed animal meat products supported through the National Livestock Identification System. [[3]](#footnote-4)

Most grains, and animal meat products and some horticultural products exported from Australia are part of the National Residue Survey with results widely publicised, however the sources or location of products which test positive for pesticide residues is kept confidential and managed through internal commercial industry processes. In some countries such as the United Kingdom for example, there is considerable transparency around where food product is found with pesticide residues exceeding maximum residue limits (MRL).

**Netherlands** - Conducts produce monitoring of fruit and vegetables.[[4]](#footnote-5) The residue monitoring focuses largely on the growing phase. Before harvest, samples of diverse types of fruit and vegetables are taken and checked for about 25 pesticides. The results of the residue analysis are used to determine when the crop can be harvested. About 20 per cent of the batches sampled in the cultivation phase are checked again after the harvest. A second round of sampling takes place on the auction floor and is intended as a method of monitoring the first sampling. Auction samples, unlike the samples taken in the cultivation phase, can be seen as representative of the products that enter the market.

**United Kingdom** - Produce monitoring[[5]](#footnote-6) is carried out In the United Kingdom (UK) with specific product and site of sale breaches publicly tabled.[[6]](#footnote-7) In 2021 the Department for Environment, Food and Rural Affairs, Expert Committee on Pesticide Residues in Food (PRiF) program tested 397 different pesticides in each of the foods surveyed, with 1,085 samples of 25 different foods tested.

**USA** – The United States (US) Food and Drug Administration (FDA) selectively tests a broad range of imported and domestic commodities for approximately 800 pesticide residues.*[[7]](#footnote-8)* FDA may also carry out focused sampling surveys for specific commodities or selected pesticide chemical residues of special interest. In addition, FDA monitors the levels of pesticide chemical residues in foods prepared for consumption in its Total Diet Study (TDS), an ongoing program that monitors contaminants and nutrients in the average US diet.

**Canada** - The Canadian Food Inspection Agency (CFIA) residue-monitoring program provides assurance of the safety of supply of fresh produce. The most recent annual report covers 2018-2019.[[8]](#footnote-9) The proper use of pesticides is monitored through federal government evaluation programs which include residue testing. The National Chemical Residue Monitoring Program (NCRMP) is an annual CFIA regulatory surveillance program, which verifies compliance in foods to Canadian standards and guidelines for chemical residues and contaminants. Over 115,000 tests for residues of veterinary drugs, pesticides, metals, and contaminants were performed on approximately 16,800 NCRMP and Food Safety Oversight (FSO) monitoring samples.

In addition to the published Australian National Residue Survey reports focussed on export product, local fruit and vegetable product testing is conducted. FreshTest[[9]](#footnote-10) is an Australian Chamber of Fruit and Vegetable Industries or Fresh Markets Australia (FMA) initiative to provide low cost MRL (chemical residue) and microbial testing for wholesalers and their growers in Australia’s central markets. These tests in contrast to overseas programs are however confidential and are used for verification for food safety and Quality Assurance systems. In addition, major Australian supermarkets conduct mandatory pesticide residue testing of food products as part of their supplier certification, however this residue testing is also confidential.[[10]](#footnote-11)

#### Environment and water monitoring

Environment and water monitoring for pesticides is characterised by government water regulators and agricultural authorities, which are generally structured surveys, such as in the case of the Netherlands, but in some cases unstructured such as in Canada.

**Netherlands** – Water Boards monitor the use of pesticides in agriculture and horticulture.[[11]](#footnote-12) An integral task of water boards is to manage and maintain sufficient quality of surface water as a source for drinking water. Dutch water boards have a well-established program for monitoring pesticide contamination of surface waters. These results link the use of plant protection products to pesticide concentrations in surface water.

The Dutch Board for the Authorisation of Plant Protection Products and Biocides (CTGB)*[[12]](#footnote-13)* assess whether plant protection products and biocidal products are safe for humans, animals and the environment before these products can be sold and used in the Netherlands. The Netherlands publicly publishes environmental survey findings in a Pesticide Atlas,*[[13]](#footnote-14)* which is updated following the release of the land use correlation. The Netherlands CTGB always uses the most recent monitoring data in order to ascertain whether there are exceedances of the authorization threshold.

In the Pesticides Atlas, it can be found which active substances and metabolites occur in the Dutch surface waters, based on monitoring data of water managing bodies. The Pesticide Atlas contains information regarding exceedances of thresholds, long-term trends in concentration and the link with land use.

**European Union** – The European Union (EU) funded H2020 FAIRWAY Project[[14]](#footnote-15) aims to review approaches for the protection of drinking water resources from pollution by nitrogen and pesticides. The program aims to: identify and further develop cost-effective and innovative measures and governance approaches that will protect drinking water supplies while increasing agricultural sustainability. FAIRWAY took a multi-actor approach to facilitate effective cooperation between actors from different sectors and levels including: farmers, advisors, drinking water companies, scientists and policy makers. The practical experiences from 13 case studies in 12 countries were analysed in five research themes to identify the barriers and success factors associated with achieving water quality targets.

**United Kingdom** - Pesticides are actively monitored in UK drinking water and is reported annually by the Drinking Water Inspectorate.[[15]](#footnote-16) The reports cover water quality testing and results, public confidence in drinking water, events and technical audit activity. They also contain a summary of all results of the water companies regulatory sampling program and a list of all the cautions and prosecutions carried out by the Inspectorate. Published reports cover private water supplies in England and Wales. The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR) place controls on the storage of pesticides and their use in the proximity of the water environment in Scotland. The Scottish Drinking Water Protection Scheme targets specific areas for monitoring, including pesticide contamination within drinking water catchments.[[16]](#footnote-17)

**USA** – The US EPA, along with US states, implements regulations that protect US drinking water from source to tap*[[17]](#footnote-18)* – EPA requires community water systems to deliver a Consumer Confidence Report, also known as an annual drinking water quality report, sent annually to their customers, providing information about local drinking water quality. This includes reports on specific pesticide contamination at identified water catchments and wells.[[18]](#footnote-19)

**Canada** - Water catchment monitoring[[19]](#footnote-20) appears to have reduced in formal intensity since 2011 studies.[[20]](#footnote-21) The Pesticides Indicator[[21]](#footnote-22) (official name: Indicator of the Risk of Water Contamination by Pesticides) managed by Agriculture and Agri-Food Canada evaluates the relative risk of water contamination by pesticides across agricultural areas in Canada. It can be used to assess pesticide inputs to cropland and the amount of pesticide transported to surface and ground water. This indicator has tracked pesticide risk associated with Canadian agricultural activities from 1981 to 2011. The Canadian government has been unable to update this indicator for 2016, due to a delay in availability of proprietary data required by this model.

The focus of these international water monitoring programs is on drinking water and associated water catchments. While much of the Australian water monitoring for pesticides is also focussed on drinking water catchments, in contrast there has been a considerable broader Australian environmental pesticide monitoring focus in key catchment areas such as the Great Barrier Reef. There is currently limited producer industry-levy funded and agricultural industry agency delivered environmental monitoring programs, with the AUSVEG EnviroVeg pilot project[[22]](#footnote-23) being an example of potential future programs.

#### Producer pesticide use monitoring

Users of pesticides and veterinary medicine products in most agricultural applications are regulated in most developed countries to record use, crop stage, key weather or animal health conditions when using products. In most countries, only manual hand-written records are required, however some countries, in particular the Netherlands and California USA require detailed reporting use of pesticide and plant nutrient inputs. There is considerable risk of inaccurate or falsified reporting by users and producers to surveys and reporting of use to regulators. In most countries, there is no regulatory requirement for recording or reporting of home garden use of pesticides except for certified pesticide application contractors.

**Netherlands** – Producers must have a crop protection monitoring system and must keep track of all pesticide use measures taken each growing season.[[23]](#footnote-24) This includes recording the use of biological agents or mechanical weed control, crop rotation, choice of crops and basic planting material, emission reduction measures, and use of crop protection agents. These data are summarised in a comprehensive pesticide use survey conducted every few years.[[24]](#footnote-25),[[25]](#footnote-26)

**United Kingdom** - Pesticide usage monitoring forms part of an obligation under the Food and Environment Protection Act (1985) for post-registration monitoring of pesticides approved for use. FERA Pesticide Usage Surveys*[[26]](#footnote-27)* presents pesticide usage data relating to Great Britain from 1990 onwards and for the United Kingdom from 2010 onwards. The program of pesticide usage surveys*[[27]](#footnote-28)* is commissioned by the independent Expert Committee on Pesticides and funded by the charge on the agrochemicals industry. Data is collected by the Pesticide Usage Survey Teams at FERA Science Ltd, the Scottish Agricultural Science Agency and the Agri-Food and Biosciences Institute of Northern Ireland. Since 2010 the surveys have followed a biennial cycle with arable, potato storage, soft fruit and orchards being conducted in even years (2010, 2012, 2014, 2016 etc.) and outdoor vegetable and edible protected crops in odd years (2011, 2013, 2015, 2017 etc.). Surveys of grassland & fodder crops (last survey 2017) and amenity situations (last survey 2016) are conducted every four years. The Pesticide Usage Monitoring Group (PUMG) records the use of crop protection products in Northern Ireland.*[[28]](#footnote-29)* This cyclical program examines pesticide usage in all sectors of the agricultural and horticultural industries. Principally, the data collected provides information for consideration by the UK Expert Committee on Pesticides. The data may also be used by those involved in residue testing, environmental impact studies, public information, evaluation and regulation of trends in pesticide usage.

**USA** - The National Agricultural Statistics Service (NASS) Agricultural Chemical Use Program[[29]](#footnote-30) is USDA’s official source of statistics about on-farm chemical use and pest management practices. Since 1990, NASS has surveyed US farmers to collect information on the chemical ingredients they apply to agricultural commodities through fertilizers and pesticides. On a rotating basis, the program currently includes fruits; vegetables; major field crops such as cotton, corn, potatoes, soybeans, and wheat; and nursery and floriculture crops. The program also collects information on the pest management practices farmers implement to reduce their dependence on agricultural chemicals (e.g., practices that make pesticides more effective or are an alternative to pesticides). Historically, data has also been periodically collected on chemicals used post-harvest and in livestock production. Detailed summaries of the volume of pesticide product use per crop is publicly available.

**California, USA** – In 1990, California became the first state to require full reporting of agricultural pesticide use[[30]](#footnote-31) in response to demands for more realistic and comprehensive pesticide use data. Under the program, all agricultural pesticide use must be reported monthly to county agricultural commissioners, who in turn, report the data to the California Department of pesticide Regulation. California has a broad legal definition of "agricultural use" so the reporting requirements include pesticide applications to parks, golf courses, cemeteries, rangeland, pastures, plus along roadside and railroad rights-of-way. In addition, all postharvest pesticide treatments of agricultural commodities must be reported along with all pesticide treatments in poultry and fish production as well as some livestock applications. The primary exceptions to the reporting requirements are home-and-garden use and most industrial and institutional uses. Pesticide use summary reports are published annually, as well as GIS spatial data of pesticide use by township and section.

**Canada** – Only limited pesticide use information has been nationally collected in the Canadian Farm Environmental Management Survey, the most recent from 2011.[[31]](#footnote-32) Pesticide use surveys in Canada are less structured, with some provinces such as Ontario conducting surveys of use in agricultural crops[[32]](#footnote-33) and Alberta publishing pesticide sales.[[33]](#footnote-34)

Australian pesticide use reporting is limited to the annual report of product sales data by the APVMA[[34]](#footnote-35) generated by registrant reporting to the regulator. This is however de-identified and aggregated sales data that is categorised into agricultural or veterinary product types, each containing greater than 5 products to ensure individual product holders or companies are not identifiable in the publication of annual product sales data reports. There is clearly a considerable difference in the transparency of use of individual pesticide product in Australia compared with the USA and EU, however there is limited information available as a detailed national data set in Canada.

## Future surveillance delivery and reporting systems

There is considerable global debate around reporting options to represent current practice and improvement of agricultural pesticides and veterinary medicines. Pesticide use frequency indices are being used in Europe as a measure of change or improvement in pesticide use. There has been discussion around the use of these indices in Australian agricultural sustainability frameworks, however the issues with these indices detailed below suggest they do not reflect or encourage change to best practice pesticide stewardship.

### Treatment frequency indices

**Treatment frequency indices** (TFI) were developed by Denmark in 2008 and replaced the simple measurements of the applied pesticide volume as indicator.[[35]](#footnote-36) It has since been in use in several other countries worldwide as a national or regional indicator or as part of projects. The TFI is:

Calculated by the theoretical number of pesticide treatments per hectare, based on standard dose rates of active ingredients, and the amount of pesticides sold yearly. An advantage of the TFI is that the indicator can be aggregated into a single value, e.g. a TFI of 1 is equivalent to one full dose applied on a certain agricultural area. As the TFI is not related to the active substances used, no relation can be established to elevated concentrations of single substances in raw water. One constraint of the TFI is that progress towards products with lower toxicity cannot be covered by the indicator: the TFI does not account for the chemical or toxic properties of some specific substances of the pesticide. Additionally, ecological effects or damages cannot directly be assigned to pesticide applications, since interactions and intermediate steps often have a major influence on pesticide environmental behaviour. Consequently, a reduction in treatment frequency is not sufficient to reach conclusions regarding trends in environmental and health risks, even though a correlation is commonly assumed.

The French Indicator of Frequency of Treatment (IFT),[[36]](#footnote-37) which is similar to the Dutch TFI, is used to measure the use of pesticides on farms and its evolution over time.

The Environmental Yardstick for Pesticides (EYP)[[37]](#footnote-38) has been developed as a tool for farmers in the EU to select pesticides with the least environmental impact and to quantify the impact of their use. For each pesticide the yardstick assigns environmental impact points for the risk to water organisms, the risk of groundwater contamination and the risk to soil. There are three EYP output values:

Acute risk to water organisms (most sensitive organism); risk of groundwater contamination; acute and chronic risk to soil organisms. The potential risk is expressed in environmental impact points (EIPs). The more EIPs a pesticide gets, the higher its impact on the environment. The EIPs are based on the predicted environmental concentration (PEC) in a certain compartment and the maximum permissible concentration (MPC) set by the Dutch government. The EIP are initially assigned for a standard application of 1 kg active ingredient per hectare. For different rates of application, the number of EIP is multiplied by the actual dose.

The score on the yardstick depends on chemical properties (persistence and mobility in soil, toxicity) of both active ingredient and principal metabolites, dose rate, organic matter content of the soil (influences transportation in soil), time of application (influences degradation and transportation in soil), method of application (influences the amount of emission to surface water) and distance to surface water (influences the amount of emission to surface water). The data on degradation rates, adsorption coefficients, toxicity to aquatic organisms and toxicity to soil organisms are drawn from data sheets compiled by the Dutch Regulatory Committee for agrochemicals.

As the name indicates the EYP only considers environmental effects of pesticides. EYP is not as widely used, as for example as the Environmental Impact Quotient (EIQ), but has been applied to assess the impact of pesticide use in integrated and conventional potato production in the Netherlands. EYP calculates PEC values but rather than comparing these values to LC/LD/EC/ED50 and NOEC values they are multiplied by pesticide toxicity data to produce Environmental Impact Points.

There has been significant Australian agricultural industry discussion and concern with the suggested use of a single multi-criteria indicator or TFI approach. A pesticide treatment frequency index (TFI) is not likely to be an appropriate path forward as an industry indicator as the agricultural industry will continue to use new generation safer and environmentally safe synthetic pesticides and the volume of product use could well increase with scale of industry expansion. Also, the type of pesticide, relative toxicity and environmental risks will change (i.e. it could either be a synthetic/natural/biological/biochemical pesticide used in either conventional or organic systems). For example, organic agriculture in the coming years is likely to see an increase in the use of natural and biological pesticides. It has been suggested that the ratio of control measures (mechanical, biological pesticides, genetic technology, natural or organic pesticides, synthetic pesticides etc) is a more appropriate indicator.

### Australian industry sustainability frameworks and pesticide use reporting

There has been clearly identified Australian agricultural industry strategic intent to improve and report to stakeholders and markets on defined sustainability frameworks, including the use of agricultural pesticides and veterinary medicines.

**Grains** - industry sustainability framework includes responsible stewardship[[38]](#footnote-39) throughout the value chain,[[39]](#footnote-40) caring for our environment and protecting Australia’s biosecurity underpin our productivity, profitability and global reputation. Core objectives include the industry being engaged in incentivised environmental stewardship programs, plus redesign, reduce and/or develop alternative chemical use whilst ensuring productivity, safety and environmental outcomes. Targets include:[[40]](#footnote-41) Demonstrate science-based best practices in pest, weed and disease control while ensuring productivity, safety and environmental outcomes. Desired outcome: Australian grain productivity and market access is enhanced by demonstrating best practice crop protection.

It is noted industry submissions to the Independent review of the pesticides and veterinary medicines regulatory system in Australia[[41]](#footnote-42) that the grains industry and Australian state farming member organisations in-principle collectively support environmental pesticide monitoring based on agreed international scientific standards with effective solutions to identify cause of issues identified through monitoring. This includes consideration to industry funding support, as per the existing National Residue Survey model[[42]](#footnote-43) with capability to identify the source of a problem.

**Horticulture** - industry sustainability framework includes ensuring movement of soil, nutrients and chemicals into the environment are minimised.[[43]](#footnote-44) Indicators include:

* Container production uses growing medium that minimises nutrient loss
* Use of erosion management strategies on drains and drainage areas in high risk run-off areas e.g. minimal slope, sealed or grassed or vegetated
* Use of systems to filter run-off water from container-grown production systems and packing sheds
* By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment

**Red Meat Industry** - Australian beef and lamb producer’s industry sustainability framework has a veterinary medicine focus on antimicrobial stewardship,[[44]](#footnote-45) feedlots covered by an antimicrobial stewardship plan, compliance with antibiotic MRLs and vaccination rates for clostridial diseases.[[45]](#footnote-46) The outcome is maintaining the efficacy of antimicrobials so that infections in humans and animals remain treatable is of critical importance. This priority looks at industry use of antibiotics and surveillance programs to detect resistance to them. The particular surveillance focus is antimicrobial resistance of bovine respiratory disease pathogens.

### Integration with current and future pesticide user reporting systems

Farm management software for use in business management is an essential component of best management practice. For example, over 90% of agronomists and over 80% of Australian grain production is managed using Agworld[[46]](#footnote-47) with 40+ million ha use globally.

All major global tractor and agricultural equipment manufacturers have adopted the AgGateway Ag Data Application Programming Toolkit (ADAPT toolkit) to integrate machine control and software systems. The Australian developed cloud based farm software Agworld is just one of 240+ agricultural machine manufacturers and software providers working towards this common standard.[[47]](#footnote-48) ADAPT provides industry standard tools to simplify communication between growers, their machines, and their software partners. It is the product of many years’ work by more than a dozen companies and experts collaborating through AgGateway. This has clearly become the dominant global standard and it will be the platform on which all field sprayer control interfaces will communicate with farm management software and pesticide use recording and reporting systems in the future.

AgGateway is also leading the Closed Loop Spray Charter[[48]](#footnote-49) which aims to support, farmers and contractors the best possible use and application of crop protection products. Principally to “help growers avoid mistakes,” to achieve “compliance and traceability,” and prove out good “stewardship of product usage.” “Closed Loop Spray” means “end-to-end documentation and resource identification” and not “real-time feedback-driven control.” It should be noted that AgGateway is now collaborating with the EU based ATLAS Agricultural Interoperability and Analysis System.[[49]](#footnote-50) The goal of ATLAS is the development of an open interoperability network for agricultural applications and to build up a sustainable ecosystem for innovative data-driven agriculture.

The Closed Loop Spray Charter initiative is being led by AgGateway Europe, however the intended scope is global and is in the early stages of establishing an international working group.[[50]](#footnote-51) The aim is to support producers of chemical crop protection products, contractors, and farmers in the use and application of crop protection products. This approach will require elabels such as Syngenta’s proprietary Smart eLabel system[[51]](#footnote-52) to capture pesticide label information at the correct level of data to meet regulatory and stewardship needs.[[52]](#footnote-53)

There are limited examples of digital data recording systems in animal health and application of veterinary medicine. Accurate weight is crucial for effective dosing of individual animals and for reporting antimicrobial usage.[[53]](#footnote-54) Automated weight and dose systems such as Automed[[54]](#footnote-55) are examples of integrated solutions. Smart ear tag sensors can track the feeding, temperature, behaviour and movement of livestock and monitor vital signs for early indications of illness. Animal ID, particularly with smart tags is a core component of supporting application and digital recording of veterinary medicine use in animals.[[55]](#footnote-56)

These systems in development in the future will provide efficient and accurate automated recording of pesticide use in agricultural field operations and allow future opportunity for seamless and non-corruptible electronic reporting, particularly using block chain technologies, to demonstrate stewardship of best management practices and meet regulatory obligations. It is realistic to expect that these systems will start to become standardised and widely adopted in the next 5+ years.

## Future environmental surveillance options and technologies including near real-time sensor measurement of off-target environmental impacts

Traditional laboratory-based analysis techniques do not currently provide fast and efficient technology frameworks to support real-time or near-real-time detection of pesticides. Current advances in pesticide detection sensors focus on improving sensitivity and selectivity through the use of nanomaterials, in sensor assemblies and new biosensors, including electrochemical, optical, nano-colorimetric, piezoelectric, chemo-luminescent and fluorescent techniques.[[56]](#footnote-57) In addition there has been considerable progress in development of micro gas chromatography for chemical detection[[57]](#footnote-58) and laser-induced breakdown spectroscopy to discriminate pesticide-contaminated products in a rapid manner.[[58]](#footnote-59) While there are no current commercial examples of field based real-time sensor based surveillance systems for agricultural pesticide detection, the following summary review of technologies highlights the opportunity for future development and deployment of sensor based pesticide detection in the atmosphere, water catchments and soil.

### Real-time pesticide detection in the atmosphere

Off-target spray drift damage and potential impacts on food safety and trade issues affect all agricultural industries, across a broad range of pesticides. There is also wider environmental impacts on native remnant vegetation and vegetation adjacent to production systems.[[59]](#footnote-60) The financial impact on agricultural industry is also significant for off-target spraying, with phenoxy spray drift costing an estimated $18 million in annual cotton production losses,[[60]](#footnote-61) up to $7 million loss from a single drift event affecting vineyards[[61]](#footnote-62) and $1 million loss in tomato crops.[[62]](#footnote-63) Cotton, viticulture and horticulture crops are particularly sensitive to spray drift from Group 4 herbicides (phenoxy herbicides including 2,4-D) which are high value crops that if impacted can catalyse social license challenges for the grains industry. Therefore, there is a need for a technology that not only detects risks of herbicide spray drift from phenoxy herbicides such as 2,4-D, but also can be used as a tool to manage herbicide stewardship and protection of surrounding sensitive crops, and in turn strengthening industry social license.

Direct contact off-target pesticide drift remains an issue that is principally managed through determination of spray buffer zones for a given sprayer setup. Vapour drift is however the final frontier in pesticide spray drift science. Conventional drift is relatively well understood to be a function of droplet size, release height, wind speed, influence of surface temperature inversions and to a lesser extent temperature, relative humidity, crop interactions and evaporation rates. Vapour drift on the other hand is not well understood and unlike droplet drift does not appear to be a generic phenomenon across all pesticides. Vapour drift management has been a challenge to all stakeholders for decades and there are no commercially available tools to measure this in real-time. Existing approaches involve sample collection and subsequent processing back at the laboratory, by which time impacts may have occurred at a landscape scale.

Gas chromatography (GC) has been used for organic and inorganic gas detection with a range of applications including screening for chemical warfare agents, breath analysis for diagnostics or law enforcement purposes, and air pollutants/indoor air quality monitoring of homes and commercial buildings.[[63]](#footnote-64) Metal-organic frameworks (MOFs) as stationary phases for chromatography, the application of MOFs for one- and two-dimensional micro-gas chromatography (µGC and µGC × µGC) has demonstrated determination of the partition coefficients for toxic industrial chemicals, using µGC and µGC × µGC systems.[[64]](#footnote-65) Using these µGC sensors with capillary columns with the first using a 0.50-μm film of nonpolar dimethyl polysiloxane and the second using a 0.25-μm film of polar trifluoropropylmethyl polysiloxane, operated with atmospheric pressure air as the carrier gas enabled the complete separation of an 18-component vapour mixture of common solvents in air in 3.5 min.[[65]](#footnote-66)

This µGC technology has developed further[[66]](#footnote-67) resulting in a small, consumable-free, low-power, ultra-high-speed comprehensive µGC×µGC system consisting of microfabricated columns, nanoelectromechanical system (NEMS) cantilever resonators for detection, and a valve-based stop-flow modulator is demonstrated. The separation of a highly polar 29-component chemical mixture in less than 7 seconds, and just over 4 seconds after the ensemble holdup time is demonstrated with a downstream flame ionization detector. The analysis time of the second dimension was 160 ms, and peak widths in the second dimension range from 10–60 ms. Data from a continuous operation testing over 40 days and 20000 runs of the µGC × µGC columns. The µGC × µGC -NEMS resonator system generated second-dimension peak widths as narrow as 8 ms with no discernible peak distortion due to under-sampling from the detector. This µGC × µGC -NEMS technology, which has primarily been developed for field detection of chemical weapons in a battlefield environment, has already been validated to detect more than 42 different security sensitive chemical compounds of interest in real-time to a limit of quantification (LOQ) equivalent to laboratory grade equipment.

Alternatively, a hybrid, nanomaterial based gas-sensing array has also been developed for the detection of chlorpyrifos. Using a sensing array utilising nanoparticles (NPs) as the conductive layer of the device while four distinctive polymeric layers (superimposed on top of the NP layer) act as the gas-sensitive layer.[[67]](#footnote-68)

Cavity ring-down spectroscopy (CRDS) is an established technique for gas sensing that is newly emerging in the field of optical biosensing, which has also been adapted for use in liquids, providing a highly sensitive method for quantitative real-time biosensing.[[68]](#footnote-69) CRDS technology has successfully been used to measure aerosol dispersion of copper chloride and has potential as a sensitive real-time analytical technique for aerosol detection and quantification.[[69]](#footnote-70) This technology has been commercialised by RingIR[[70]](#footnote-71) for real-time gas sensing, including detection of the chemical fumigants phosphine, methyl bromide and sulfuryl fluoride.

### Real-time pesticide detection in catchments and drinking water

Chemical sensors are attractive instruments for real-time water quality and safety analysis. The optimal electrochemical or optical properties of such sensors will depend on the concentration of chemical analytes in a body of water. These types of sensors are already widely applied to the analysis of natural and potable water.[[71]](#footnote-72) Gas chromatography–mass spectrometry (GC–MS) has also been widely applied for pesticide monitoring because of its high sensitivity and specificity and for the potential of multi-residue and multi-class analysis.[[72]](#footnote-73)

Real-time autonomous measurement of pesticides that combines continuous sampling and on-site measurements with a high-resolution mass spectrometer has been demonstrated in a small agricultural catchment, continuously measuring 60 pesticide compounds at 20 minutes resolution for 41 days during the growing season.[[73]](#footnote-74)

A recent review of monitoring of pesticides in water matrices and the analytical criticalities[[74]](#footnote-75) details that; sample pre-concentration and extraction methodologies have advantages and limitations, but all require good operator preparation and almost always special tools involving a large combination of analytical techniques applied in multiple configurations. Increasingly necessary to develop multi-residual methods, reliable, safe for the operator, which request small organic solvent and sufficiently sensitive to reach the standards set by the specific regulations. However, PPPs with more specific chemical structures, such as glyphosate, are excluded from the multi-residual approaches, for which a particular and specific methodology is required. Liquid-liquid extraction (LLE) is a simple method usually used for water samples. The main advantage of this technique is the large availability of studies in the literature, which provide information on the proper selection of organic solvents, the pH and temperature conditions and the achievable LOD/LOQ. It is also a simple and relatively inexpensive method. The evolution of analytical techniques has seen, in recent years, the progressive diffusion of Solid-Phase Extraction (SPE) that uses columns or disks of different materials, able to retain the active substances present in water samples and then release them from the washing action of small quantities of suitable solvents. Similarly to LLE, also regarding SPE, the loss of the most volatile analytes during solvent evaporation can occur, affecting the overall analyte recovery.

Use of fluorescence‐based biosensing has also been demonstrated for the detection of organophosphate (OP) pesticides in water samples and drinkable food using a mutant of the thermostable esterase‐2 from Alicyclobacillus acidocaldarius (EST2‐S35C) as a bioreceptor for OP pesticides.[[75]](#footnote-76)

In addition, a sensor construct employing a universal FR-4 substrate gold interdigitated electrodes with active sensing elements based on selective antibodies (proteins) and polymeric network structures – poly(3,4-ethylenedioxythiophene) has successfully been developed to detect glyphosate and atrazine, with potential to perform combinatorial assessment and subsequently-multiplexed analysis of pesticide antigens.[[76]](#footnote-77)

A recent detailed review of real-time water sensing technology shows that[[77]](#footnote-78) there are still many obstacles for having a one sensing approach that would satisfy different situations. The most successful systems based on chemical sensing or its combination with other methods rely on specificity of a coating material that is capable of accurate detection of certain water pollutants, with molecularly imprinted polymers providing an increased flexibility for the designing of those systems. Novel trends include using microwave spectroscopy and chemical materials integration for achieving a higher sensitivity to and selectivity of pollutants in water.

There is exponential growth in the number of publications on real-time water quality monitoring with chemical sensors (Figure 4).

Figure Number of publications on “Real-Time Water Quality Monitoring with Chemical Sensors” in the last 50 years77



### Near real-time pesticide detection in soils

Traditional soil measurement techniques are primarily laboratory-based analysis such as ion chromatography (IC), inductively coupled plasma-optical emission spectrometry/mass spectrometry (ICP-OES/MS), gas chromatography−mass spectrometry (GC-MS), and chemiluminescence.

Electrochemical biosensors contain biological recognition elements (e.g., microorganisms and enzymes) that specifically reacts with the target of interest, and then converts such changes into electrical signals (e.g., current, voltage, and resistance).[[78]](#footnote-79) Biosensors can achieve low detection limits for contaminants due to the selective binding of the targets. One potential application of electrochemical biosensors in the soil environment is to detect agrochemicals, such as pesticides, herbicides and fertilizers.[[79]](#footnote-80) Specifically, biosensors have been used for the determination of organophosphate and carbamate pesticides based on the inhibition of cholinesterase activity.[[80]](#footnote-81) However, the analyte needs certain incubation period (e.g., minutes to hours) to inhibit the activity of the immobilized enzyme, resulting in steadily declining signals over time (e.g., hours).[[81]](#footnote-82)

Using a paper-based substrate, namely, office paper plus a portable electrochemical connection, loading bio-hybrid nanosized probes (Prussian blue, carbon black, and butyrylcholinesterase), has successfully in situ measured pesticide contents in EU agricultural soils, up to 3 µg/mL, characterized by a low detection limit of 1.3 ng/mL, with good correlation in comparison with LC–MS analysis.[[82]](#footnote-83)

Handheld instruments based on laser-induced breakdown spectroscopy (LIBS) are a promising sensor technique for the in-field determination of various soil parameters.[[83]](#footnote-84) LIBS could be used in many aspects, like soil, soil pollution, plant nutrients, cereals and seeds, fruits and vegetables, agri-foods, plant stressed by heavy metals, pesticide residues, etc.[[84]](#footnote-85) The pesticides chlorpyrifos, carbendazim, dimethoate, imidacloprid and cypermethrin have been successfully detected in in green leafy vegetable using LIBS.[[85]](#footnote-86)

### Surveillance options that enable targeted government and industry response to point source issues

Atmospheric sensors such as µGC technology would be particularly useful in detecting chemical volatile trespass in the environment in real-time, such as integration with existing mesonet weather station and air-temperature inversion alert systems,[[86]](#footnote-87),[[87]](#footnote-88) air stability or air-temperature inversions being a major factor in chemical trespass of pesticides, particularly volatiles inkling phenoxy herbicides. The potential deployment of µGC sensors could also be potentially combined with the recently commissioned super computing capability from the Bureau of Metrology[[88]](#footnote-89) to interpolate data between sensor towers and potentially triangulate a localised region of point source contamination. The technology could also be potentially used at field borders as a detection alert for sensitive crops or vegetation, with potential for automatic reporting of pesticide trespass. The µGC technology is also likely to be used as a surrogate sensor for monitoring downwind spray volatiles when using autonomous pesticide application systems.

Sensors detailed above highlight that real-time pesticide detection in water is a realistic potential option, particularly if specific pesticide surveillance targets are defined. Some of these sensors in combination with detailed watershed modelling support could potentially be deployed with response teams following initial real-time detection to monitor upstream point source contamination of pesticides to a defined local area.

Traditional laboratory based methods are likely to remain the mainstay for initial detection of pesticides in soils, delivering results with a high level of confidence. Most soils will also generally remain in-situ, aiding detection and point source contamination determination, except in circumstances of significant soil or water erosion. The use of rapid real-time sensor based pesticide detection systems will however support rapid detailed survey of contaminated or affected areas and technology such as LIBS enables simple collection of soil cores for contamination analysis of stratified depths.

## Recommendations

Section 4.1.3 provides a discussion on data sources identified in this project that meet the Department’s requirements. Apart from residues analysis in meat and plant-based food product, the data sources are dominated by environmental matrices (surface water, sediment, wildlife). Assessment of these data sources has identified that, while many may be useful in determining what substances have been detected in different matrices, but they generally are not suitable for issues important to DAFF in determining effectiveness of the regulatory scheme for a number of reasons (see Section 4.1.3). The following recommendations are based around this determination.

### Potential development of new data gathering programs

**Recommendation 1**: The department considers the discussion in Section 4.1.3 regarding gaps in the current Australian data sources; and the information provided in Section 4.2 with respect to international activities in different data gathering programs.

**Recommendation 2**: The department considers, as a starting point for future work, and to deliver on some of the recommendations from the “[Final Report of the Independent Review of the Pesticides and Veterinary Medicines Regulatory System in Australia](https://www.agriculture.gov.au/agriculture-land/farm-food-drought/ag-vet-chemicals/better-regulation-of-ag-vet-chemicals/independent-review-agvet-chemical-regulatory-framework)”, undertaking a more detailed analysis of the monitoring information identified in this report. Such analysis will aid prioritising substances for future surveillance programs.

### Surveillance options enabling targeted government and industry response to point source issues

**Recommendation 3**: The department considers the future surveillance delivery and reporting systems identified in Section 5 of this report.

**Recommendation 4**: The department considers the future environmental surveillance options and technologies including near real-time sensor measurement of off-target environmental impacts identified in Section 6 of this report as potential options to inform future monitoring programs.

**Recommendation 5**: The department recognises that there is no commercial near real-time sensor measurement technology currently available to measure the off-target environmental impacts identified in Section 6 and future deployment will require investment in development of this technology.

**Recommendation 6**: The department undertakes targeted baseline monitoring to inform chemical review activities.

It is considered possible to link the need for regulatory assessments to monitoring. Undertaking targeted monitoring, for example, in known use areas for substances prior to a chemical review commencing may assist in identifying whether the chemical of interest is in fact moving off site. Such monitoring could then be redone following implantation of controls at the end of the review.

**Recommendation 7**: The department undertakes targeted operational monitoring to confirm effectiveness of regulatory controls

For new chemicals no monitoring data will be available prior to a regulatory assessment being completed. The assessment will identify controls based on the data set and proposed use pattern. In order to confirm the effectiveness of these controls, it may be appropriate to undertake targeted monitoring in the first seasons of use following registration. Similarly, such targeted monitoring could be implemented in use areas following completion of chemical reviews to confirm or otherwise the effectiveness of regulatory controls identified during the review.

## Appendix 1: Research and analysis of pesticides and veterinary medicines data sources

### Methodology

Sources were determined through two mechanisms. The first was a desktop review of available data sources (monitoring; volumes of use) from within Australia over the last 20 years.

The second component included a survey by telephone and/or email potential holders of data (human biomonitoring, animal-based food sources, plant-based food sources, air, soil, surface water, ground water, wildlife) including relevant state and territory departments including those responsible for health, agriculture and environment., APVMA and research institutions.

Through consultation (see Appendix A1.1: Contacts and organisations approach through survey consultation for list) a total of 64 contacts were approached covering government (state and federal), research institutions and private companies. In total, 44 different organisations were contacted.

Responses from 19 contacts were received, representing 18 different organisations. This represents an organisation response of 41% with some additional responses received later.

Sources of data at this stage were separated between literature reports and databases. Essentially, any government agency held information was allocated a “database” designation even if the data were only obtained from short term projects.

The different sources of data were assessed only briefly for this component of the project. The region (down to state/territory level), matrix (see Table 24) and chemicals analysed for were recorded. In many cases, the full list of chemicals is not yet available as often only chemicals detected were reported. In the case of the National Residue Survey, the full list of chemicals has not yet been compiled due to the complexity of this program.

A time frame of 20 years was agreed to base the analysis on as it was considered changes to farming practices in that period make data older than 20 years to lack relevance for this exercise. To date, 54 data sources have been identified that fall within the 20-year timeframe applied for the project.

### Chemicals to be considered

The project aims to consider all agvet chemicals currently or previously used in Australia. Specific consideration is to be given to those agvet chemicals listed under the international conventions to which Australia is a party; and to agvet chemicals with known human health and environmental risks.

A list has been developed therefore, for these priority chemicals taking into consideration of pesticides listed in the Rotterdam Convention (Priority Informed Consent chemicals) and Stockholm Convention (Persistent Organic Pollutants), and cross referenced to the APVMA chemical review list of chemicals including those identified in the 2015 consultation round. Chemicals are priorities for review by the APVMA based on health and/or environmental concerns and available monitoring data will also focus on substances in this list.

In considering the APVMA lists, some priority substances were identified as groups, for example, 2nd generation anticoagulant rodenticides and triazole fungicides. The individual chemicals within these groups have been included in the list and groups themselves have been removed. For example, triazole fungicides have been listed individually as difenoconazole, metconazole, myclobutanil, propiconazole, prothioconazole, tebuconazole and triadimefon. There is some limited overlap between chemicals on these different lists. Through cross-referencing, a final list of 167 chemicals was identified for specific consideration. This list is provided at Appendix A1.2 – List of agvet chemicals from international conventions and APVMA chemical review lists identified with known human health or environmental concerns.

### Analysis of data sources identified at stage 1

The sources were separated based on the type of data, eg, whether data related to human biomonitoring, residues analysis in food produce, or environmental sampling. These were further separated base on the matrix in which sampling occurred.

For environmental sampling, sources have been assigned a “scale” to reflect whether monitoring has occurred in urban catchments, non-urban catchments, or mixed (both urban and non-urban). This is likely to be refined further in the next phase of the project, for example, to consider whether non-urban catchments relate to agricultural land uses or to drinking water catchments.

The results of this initial investigation are reported in Table 24.

Table Summary of types of data held for different matrices from identified data sources

| Type | Matrix | Scale | Number of data sources identified |
| --- | --- | --- | --- |
| Human | Blood | n/a | 0 |
| Human | Breast milk | n/a | 0 |
| Human | Muscle | n/a | 0 |
| Human | Other | n/a | 1 |
| Produce | Meat | n/a | 2 |
| Produce | Plant | n/a | 6 |
| Environment | Surface water | Urban | 5 |
| Environment | Surface water | Non urban | 24 |
| Environment | Surface water | Mixed | 11 |
| Environment | Sediment | Urban | 3 |
| Environment | Sediment | Non urban | 4 |
| Environment | Sediment | Other | 7 |
| Environment | Ground water | Urban | 0 |
| Environment | Ground water | Non urban | 1 |
| Environment | Ground water | Mixed | 3 |
| Environment | Soil | Urban | 2 |
| Environment | Soil | Non urban | 0 |
| Environment | Soil | Mixed | 3 |
| Environment | Wildlife | Urban | 0 |
| Environment | Wildlife | Non urban | 3 |
| Environment | Wildlife | Mixed | 1 |
| Environment | Air | - | 0 |

It is seen from Table 24 that no data sources for human biomonitoring or atmospheric monitoring have been found. With respect to human biomonitoring, the APVMA and all relevant state OH&S agencies have been contacted with only two responses received. These were from the APVMA and SafeWork NSW. SafeWork NSW advised that they have undertaken compliance programs in the past to assess and assist agricultural and veterinary chemicals users meet their WHS regulatory obligations but have not undertaken any detailed exposure or health monitoring. Therefore, they do not hold any data sources with respect to monitoring data (including ongoing monitoring programs) for agricultural and veterinary chemicals that can be of assistance.

Available sources are dominated by surface water monitoring. This includes sources from drinking water catchments, urban surface water (eg, stormwater runoff) and surface waters linked to agricultural land uses. Surface water data sets comprise 55% of those data sources identified to date. However, this does not give an idea of scale of monitoring programs. Further, while there are 5 data sets identified with respect to produce monitoring, the National Residue Survey is a large program with extensive data collected over a long period of time so a limited number of data sources should not be related to a general lack of data in a particular area.

Apart from the National Residue Survey, probably the most comprehensive and structured monitoring program currently in Australia is Great Barrier Reef Catchment Loads Monitoring Program (GBRCLMP), which was established in 2006 for monitoring nutrients and total suspended solids, and expanded in 2009 to include pesticides, to assist in evaluating the progression towards the water quality targets of the Reef 2050 Water Quality Improvement Plan. This is an evolving program. The most up to date publication indicating the number of pesticide monitoring sites and basins covered by the GBRCLMP and South East Queensland Catchment Loads Monitoring Program (SEQCLMP) is the [Pesticide Reporting Portal](https://storymaps.arcgis.com/stories/c0f0c6d7d88a4fd3a5541fe59f41ff75) (PRP). That online publication provides data for 38 active sites, representing 35 catchments, 25 Basins, and 7 NRM regions (Cape York, Wet Tropics, Burdekin, Mackay Whitsunday, Fitzroy, Burnett Mary, South East Queensland). There are also data for approximately 13 historical sites that are not currently monitored. The 2020-21 [GBRCLMP Condition Report](https://storymaps.arcgis.com/stories/7ff8ce06ba644774923e939a7fd24f52) provides site numbers for that monitoring year, and is the most recently published data for pesticide monitoring under the Reef 2050 Water Quality Improvement Plan. For that year pesticides were monitored at 22 end-of-catchment sites, 4 sub-catchment sites and 8 fine-scale monitoring sites.

Table 25 and Table 26 provide an indication of regions (states and territories) from where monitoring activities have been undertaken. These are generally dominated in the eastern states of Queensland, New South Wales and Victoria. It was noted by some state authorities (SA EPA; TAS EPA) that funding for monitoring is not available. While these states used to undertake regular monitoring of water ways, these programs ceased between 2004 and 2014. Nonetheless, interrogation of the data sources for all monitoring does not indicate a discernible trend towards monitoring activities changing substantially over time – see Figure 5.

Table Summary of identified data sources containing produce residues monitoring by region

| Matrix | QLD | NSW | VIC | TAS | SA | WA | ACT | NT |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Meat1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Plant1 | 2 | 2 | 3 | 2 | 2 | 5 | 2 | 2 |

1) From the National Residue Survey and FSANZ 25 Australian Total Diet Study where n = 2. The results do not differentiate between different states and territories but random sampling is assumed to cover all states and territories.

Table Summary of identified data sources containing environmental monitoring by region

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Matrix | QLD | NSW | VIC | TAS | SA | WA | ACT | NT |
| Surface water | 14 | 9 | 13 | 1 | 1 | 2 | n/a | n/a |
| Sediment | 1 | 1 | 12 | 1 | 2 | 2 | n/a | 1 |
| Ground water | 1 | n/a | n/a | n/a | n/a | 3 | n/a | n/a |
| Soil | n/a | 1 | 4 | n/a | n/a | n/a | n/a | n/a |
| Wildlife | n/a | n/a | n/a | n/a | n/a | 4 | n/a | n/a |

Figure Number of data sources with monitoring undertaken in different years, 2002-2021



### Chemicals monitored within data sources

From all sources, where possible, the range of chemicals analysed for have been included. This list is incomplete because some sources require additional information with only substances detected being reported in the primary source document, or the chemicals themselves not identified. Over 160 substances have been analysed from more than one data source, or in more than one matrix. There are more than 30 substances that have been analysed for in multiple data sources or in multiple matrices within the same data source. These are reported in Table 27.

Table Frequency of pesticides analysed for in data sources where n ≥10

| Active | Number of data sources/ matrices |
| --- | --- |
| Atrazine | 32 |
| DDT (also as p,p’-DDD and p,p’-DDE) | 28 |
| Simazine | 27 |
| Diuron | 24 |
| Chlorpyrifos | 21 |
| Hexazinone | 18 |
| Metolachlor | 18 |
| 2,4-D | 17 |
| Dieldrin | 16 |
| Prometryn | 16 |
| Imidacloprid | 15 |
| Bifenthrin | 14 |
| Chlordane | 14 |
| Endosulfan | 14 |
| MCPA | 13 |
| Heptachlor | 12 |
| Malathion | 12 |
| Diazinon | 12 |
| Dimethoate | 12 |
| Propiconazole | 12 |
| Pendimethalin | 11 |
| Permethrin | 11 |
| Aldrin | 11 |
| Ametryn | 11 |
| Tebuthiuron | 11 |
| Metalaxyl | 10 |
| Trifluralin | 10 |
| Carbaryl | 10 |
| Fenamiphos | 10 |
| Fipronil | 10 |

## Appendix A1.1: Contacts and organisations approach through survey consultation

| Organisation | State | Response received |
| --- | --- | --- |
| ACT Government | ACT | n/a |
| Environment, Planning and Sustainable Development Directorate | ACT | n/a |
| WorkSafe ACT | ACT | - |
| University of Melbourne (CAPIM) | National | Yes |
| RMIT (and previously, CAPIM) | National | n/a |
| Griffith University | National | Yes |
| APVMA | National | Partial |
| National Residue Survey | National | Yes |
| Australian Water Quality Centre | National | n/a |
| Woolworths | National | n/a |
| CSIRO | National | Yes |
| Environment Protection Authority | NSW | n/a |
| Department of Primary Industries | NSW | n/a |
| Environment Protection Authority | NSW | n/a |
| NSW Department of Primary Industries | NSW | n/a |
| SafeWork NSW | NSW | Yes |
| Environment NSW | NSW | Yes |
| Coleambally Irrigation | NSW | Yes |
| NT Government | NT | n/a |
| NT WorkSafe | NT | n/a |
| Department of Agriculture and Fisheries | QLD | n/a |
| Workplace Health and Safety Queensland | QLD | n/a |
| TropWATER (James Cook University) | QLD | n/a |
| Department of Environment and Science | QLD | Yes |
| University of Queensland | QLD | n/a |
| Primary Industries and Regions SA | SA | n/a |
| SafeWork SA | SA | n/a |
| SA Water | SA | Yes |
| SA EPA | SA | Yes |
| South Australian Research and Development Institute (SARDI) | SA | n/a |
| Department of Natural Resources and Environment | TAS | n/a |
| WorkSafe Tasmania | TAS | n/a |
| Agriculture Victoria | VIC | Yes |
| Department of Jobs, Precincts and Regions | VIC | n/a |
| WorkSafe Victoria | VIC | n/a |
| EPA VIC | VIC | Yes |
| Corangamite Catchment Management Authority | VIC | n/a |
| VIC EPA | VIC | Yes |
| Melbourne Water | VIC | n/a |
| RMIT | VIC | n/a |
| Department of Primary Industries and Regional Development | WA | Yes |
| Health WA | WA | n/a |
| Department of Water and Environment Regulation | WA | n/a |
| Department of Mines, Industry Regulation and Safety | WA | n/a |
| ChemCentre WA | WA | n/a |
| Department of Biodiversity, Conservation and Attractions | WA | n/a |
| Department of Water and Environment Regulation | WA | n/a |
| Health WA | WA | Yes |

## Appendix A1.2 – List of agvet chemicals from international conventions and APVMA chemical review lists identified with known human health or environmental concerns

| Chemical | Stockholm Convention | Rotterdam Convention | APVMA Review List | APVMA 2015 prioritisation |
| --- | --- | --- | --- | --- |
| 2,4,5-T | n/a | Yes | n/a | n/a |
| 2,4-D | n/a | n/a | Yes | n/a |
| Abamectin  | n/a | n/a | Yes | n/a |
| Acephate | n/a | n/a | n/a | Yes |
| Acetamiprid  | n/a | n/a | Yes | n/a |
| Acrolein  | n/a | n/a | Yes | n/a |
| Alachlor | n/a | Yes | n/a | n/a |
| Aldicarb | n/a | Yes | Yes | n/a |
| Aldicarb  | n/a | n/a | Yes | n/a |
| Aldrin | Yes | Yes | n/a | n/a |
| Alpha-cypermethrin  | n/a | n/a | Yes | n/a |
| Amitrole | n/a | n/a | n/a | Yes |
| Arsenic timber treatments  | n/a | n/a | Yes | n/a |
| Atrazine  | n/a | n/a | Yes | n/a |
| Avoparcin  | n/a | n/a | Yes | n/a |
| Azinphos-ethyl  | n/a | n/a | Yes | n/a |
| Azinphos-methyl | n/a | Yes | Yes | n/a |
| Benomyl  | n/a | n/a | Yes | n/a |
| Bifenthrin  | n/a | n/a | Yes | n/a |
| Binapacryl | n/a | Yes | n/a | n/a |
| Bioresmethrin  | n/a | n/a | Yes | n/a |
| Brodifacoum  | n/a | n/a | Yes | n/a |
| Bromadiolone  | n/a | n/a | Yes | n/a |
| Bromoxynil  | n/a | n/a | Yes | n/a |
| Bromsalans  | n/a | n/a | Yes | n/a |
| Captafol | n/a | Yes | n/a | n/a |
| Carbaryl  | n/a | n/a | Yes | n/a |
| Carbendazim  | n/a | n/a | Yes | n/a |
| Carbofuran | n/a | Yes | Yes | n/a |
| Carbon disulfide  | n/a | n/a | Yes | n/a |
| Chlordane | Yes | Yes | n/a | n/a |
| Chlordimeform | n/a | Yes | n/a | n/a |
| Chlorfenvinphos  | n/a | n/a | Yes | n/a |
| Chlorobenzilate | n/a | Yes | n/a | n/a |
| Chlorothalonil | n/a | n/a | n/a | Yes |
| Chloroxuron  | n/a | n/a | Yes | n/a |
| Chlorpropham  | n/a | n/a | Yes | n/a |
| Chlorpyrifos  | n/a | n/a | Yes | n/a |
| Chlortetracycline  | n/a | n/a | Yes | n/a |
| Clanobutin sodium  | n/a | n/a | Yes | n/a |
| Clothianidin  | n/a | n/a | Yes | n/a |
| Coumaphos  | n/a | n/a | Yes | n/a |
| Coumatetralyl  | n/a | n/a | Yes | n/a |
| Creosote  | n/a | n/a | Yes | n/a |
| Crystal (gentian) violet  | n/a | n/a | Yes | n/a |
| Cyanazine | n/a | n/a | n/a | Yes |
| Cypermethrin  | n/a | n/a | Yes | n/a |
| Cyromazine  | n/a | n/a | Yes | n/a |
| DDT | Yes | Yes | n/a | n/a |
| Deltamethrin  | n/a | n/a | Yes | n/a |
| Demeton-S-methyl  | n/a | n/a | Yes | n/a |
| Diazinon  | n/a | n/a | Yes | n/a |
| Dichlorvos  | n/a | n/a | Yes | n/a |
| Dicofol | Yes | n/a | n/a | n/a |
| Dicyclanil  | n/a | n/a | Yes | n/a |
| Dieldrin | Yes | Yes | n/a | n/a |
| Difenacoum  | n/a | n/a | Yes | n/a |
| Difenoconazole | n/a | n/a | n/a | Yes |
| Difethialone  | n/a | n/a | Yes | n/a |
| Diflubenzuron  | n/a | n/a | Yes | n/a |
| Dimethoate  | n/a | n/a | Yes | n/a |
| Dimetridazole  | n/a | n/a | Yes | n/a |
| Dinitro-ortho-cresol (DNOC) and its salts | n/a | Yes | n/a | n/a |
| Dinoseb and its salts and esters | n/a | Yes | n/a | n/a |
| Dinotefuran  | n/a | n/a | Yes | n/a |
| Diphacinone  | n/a | n/a | Yes | n/a |
| Diquat  | n/a | n/a | Yes | n/a |
| Diuron  | n/a | n/a | Yes | n/a |
| Doramectin  | n/a | n/a | Yes | n/a |
| EDB (1,2-dibromoethane) | n/a | Yes | n/a | n/a |
| Endosulfan | Yes | Yes | Yes | n/a |
| Endrin | Yes | n/a | n/a | n/a |
| Ethidimuron  | n/a | n/a | Yes | n/a |
| Ethylene dibromide  | n/a | n/a | Yes | n/a |
| Ethylene dichloride | n/a | Yes | n/a | n/a |
| Ethylene oxide | n/a | Yes | n/a | n/a |
| Fenamiphos  | n/a | n/a | Yes | n/a |
| Fenbutatin oxide | n/a | n/a | n/a | Yes |
| Fenitrothion  | n/a | n/a | Yes | n/a |
| Fenthion  | n/a | n/a | Yes | n/a |
| Fipronil  | n/a | n/a | Yes | n/a |
| Flocoumafen  | n/a | n/a | Yes | n/a |
| Flumethrin  | n/a | n/a | Yes | n/a |
| Fluoroacetamide | n/a | Yes | n/a | n/a |
| Glyphosate  | n/a | n/a | Yes | n/a |
| Halquinol  | n/a | n/a | Yes | n/a |
| HCH (mixed isomers) | Yes | Yes | n/a | n/a |
| Heptachlor | Yes | Yes | n/a | n/a |
| Hexachlorobenzine | Yes | Yes | n/a | n/a |
| Hexazinone | n/a | n/a | n/a | Yes |
| Imidacloprid  | n/a | n/a | Yes | n/a |
| Inorganic arsenic  | n/a | n/a | Yes | n/a |
| Ivermectin | n/a | n/a | Yes | n/a |
| Kitasamycin  | n/a | n/a | Yes | n/a |
| Levamisole | n/a | n/a | n/a | Yes |
| Lindane | Yes | Yes | n/a | n/a |
| Malathion  | n/a | n/a | Yes | n/a |
| Mercury compounds | n/a | Yes | n/a | n/a |
| Metal phosphides | n/a | n/a | n/a | Yes |
| Metconazole | n/a | n/a | n/a | Yes |
| Metham sodium  | n/a | n/a | Yes | n/a |
| Methamidophos | n/a | Yes | Yes | n/a |
| Methazole  | n/a | n/a | Yes | n/a |
| Methidathion  | n/a | n/a | Yes | n/a |
| Methiocarb  | n/a | n/a | Yes | n/a |
| Methomyl | n/a | n/a | n/a | Yes |
| Methyl bromide  | n/a | n/a | Yes | n/a |
| Metoxuron  | n/a | n/a | Yes | n/a |
| Mevinphos  | n/a | n/a | Yes | n/a |
| Milbemycin  | n/a | n/a | Yes | n/a |
| Mirex | Yes | n/a | n/a | n/a |
| Mirex  | n/a | n/a | Yes | n/a |
| Molinate  | n/a | n/a | Yes | n/a |
| Monocrotophos | n/a | Yes | Yes | n/a |
| Moxidectin  | n/a | n/a | Yes | n/a |
| Myclobutanil | n/a | n/a | n/a | Yes |
| Neomycin  | n/a | n/a | Yes | n/a |
| Neonicotinoids  | n/a | n/a | Yes | n/a |
| Nicarbazin  | n/a | n/a | Yes | n/a |
| Oleandomycin  | n/a | n/a | Yes | n/a |
| Omethoate  | n/a | n/a | Yes | n/a |
| Paraquat  | n/a | n/a | Yes | n/a |
| Parathion | n/a | Yes | n/a | n/a |
| Parathion-ethyl  | n/a | n/a | Yes | n/a |
| Parathion-methyl  | n/a | n/a | Yes | n/a |
| Pentachlorophenol | n/a | Yes | n/a | n/a |
| Permethrin | n/a | n/a | n/a | Yes |
| Phenothiazine  | n/a | n/a | Yes | n/a |
| Phorate | n/a | Yes | n/a | Yes |
| Picloram | n/a | n/a | n/a | Yes |
| Pindone  | n/a | n/a | Yes | n/a |
| Polihexanide  | n/a | n/a | Yes | n/a |
| Procymidone  | n/a | n/a | Yes | n/a |
| Propargite | n/a | n/a | n/a | Yes |
| Propetamphos  | n/a | n/a | Yes | n/a |
| Propiconazole | n/a | n/a | n/a | Yes |
| Prothiconazole | n/a | n/a | n/a | Yes |
| Robenidine  | n/a | n/a | Yes | n/a |
| Sheep ectoparasiticides  | n/a | n/a | Yes | n/a |
| Simazine | n/a | n/a | n/a | Yes |
| Sodium fluororacetate (1080)  | n/a | n/a | Yes | n/a |
| Spinosad  | n/a | n/a | Yes | n/a |
| Streptomycin/Penicillin  | n/a | n/a | Yes | n/a |
| Strychnine  | n/a | n/a | Yes | n/a |
| Sulfadiazine  | n/a | n/a | Yes | n/a |
| Sulfadimidine  | n/a | n/a | Yes | n/a |
| Sulfadoxine  | n/a | n/a | Yes | n/a |
| Sulfaquinoxaline  | n/a | n/a | Yes | n/a |
| Sulfatroxazole  | n/a | n/a | Yes | n/a |
| Sulfonamides  | n/a | n/a | Yes | n/a |
| Sulfur dioxide generating pads or sheets  | n/a | n/a | Yes | n/a |
| Tebuconazole | n/a | n/a | n/a | Yes |
| Temephos  | n/a | n/a | Yes | n/a |
| Thiacloprid  | n/a | n/a | Yes | n/a |
| Thiamethoxam  | n/a | n/a | Yes | n/a |
| Thiophanate-methyl  | n/a | n/a | Yes | n/a |
| Toxaphene | Yes | Yes | n/a | n/a |
| Triademefon | n/a | n/a | n/a | Yes |
| Tribufos  | n/a | n/a | Yes | n/a |
| Tributyl tin compounds | n/a | Yes | n/a | n/a |
| Trichlorfon | n/a | Yes | n/a | Yes |
| Triflumuron  | n/a | n/a | Yes | n/a |
| Triforine  | n/a | n/a | Yes | n/a |
| Tylosin  | n/a | n/a | Yes | n/a |
| Vinclozolin  | n/a | n/a | Yes | n/a |
| Virginiamycin  | n/a | n/a | Yes | n/a |
| Warfarin  | n/a | n/a | Yes | n/a |

## Appendix 2: Reliability and representativeness of pesticides and veterinary medicines identified data sources

### Methodology

#### Reliability

The reliability of the data is a key initial consideration because without knowledge of how studies have been conducted all other considerations may be irrelevant. Screening for reliability can be done relatively quickly to filter out unreliable studies and enable the end users to focus further resources on those studies considered most reliable.

The assessment approach is based on that suggested in OECD (2000).[[89]](#footnote-90) In undertaking this analysis, a pragmatic approach has been adopted and the following criteria have been modified to those identified in OECD (2000) to better reflect the required use of the monitoring data for the department’s objectives.

Table Criteria for assessing reliability of data sources

| Criteria | Fully described | Somewhat described | Not described |
| --- | --- | --- | --- |
| What has been analysed (substances identified)? | 3 | 2 | 0 |
| Analytical method (described appropriately) | 3 | 2 | 0 |
| Minimum level of detection (identified?) | 3 | 2 | 0 |
| Matrix characteristics (soil, water, sediment etc) | 3 | 2 | 0 |
| Sample methodology (adequately described?) | 3 | 2 | 0 |
| Sampling frequency and pattern (adequately described?) | 3 | 2 | 0 |
| Location specific (identifiable with coordinates?) | 4 |  | 0 |
| Location general (generally identifiable) | - | 2 | 0 |
| Dates of sampling adequately identified? | 3 | 2 | 0 |

A cut-off score of 16 was assigned to accept the reliability of a data set. However, a degree of flexibility has been applied. For example, data sets that do not specifically describe sampling methodology or identify limits of detection have generally been assigned a score of “Somewhat described” where laboratories performing analysis have been identified as these would be expected to have appropriate analytical methodology and reference chemicals.

Of the data sources identified in phase 1 of this project, the majority were sufficiently described to pass the reliability assessment.

#### Relevance/representativeness

The relevance and representativeness of the data have been based on scientific judgement as there are no ranking criteria that can be listed as guidance for these attributes. In undertaking the analysis, the department’s main objective with respect to this project has been the most influential factor, that is, how data sources can be applied in monitoring the effectiveness of the agvet chemicals regulatory system and provide assurance that the controls on products are affecting and not leading to poor environmental or human health outcomes.

The following attributes of the data sources were considered for this purpose:

Table Considerations for assessing relevance and representativeness of data sources

|  |  |
| --- | --- |
| Parameter | Explanation |
| Includes listed? | Listed for this purpose means substances on the list of agvet chemicals from international conventions and APVMA chemical review lists identified with known human health or environmental concerns (Appendix A1.2 of Interim Report for Milestone 1). |
| Catchment type | Required characteristics of the catchment type, for example, urban, peri-urban, agricultural, conservation, drinking water. |
| Location | General information on the location of the monitoring activity. |
| Number of sites | How many sites were monitored in a particular monitoring program or research activity? |
| Temporal | Were the data suitable for a temporal assessment (eg, several seasons in a year, or data available over several years? |
| Spatial | Were the data suitable for a spatial assessment (monitoring undertaken over a larger geographic area)? |
| Land use link | Is it possible to link the monitoring results with an associated land use? |

From this analysis, data were considered **relevant** if they described monitoring results for pesticides regulated by the APVMA. Relevance was enhanced if the test list included chemicals identified in the priority list established for this project, however, it was not considered a requirement as there may be newer pesticides in a test suite of substances.

Data sets were considered **representative** if they could readily be linked to a land use. It should be noted in this context, association with a land use does not allow particular sources of chemical exposure to be identified. For example, detections of fungicides in horticultural catchments in sampling locations identified by coordinates does not imply observed substances have come from farms adjoining the sampling point. However, it may be inferred that general chemical use for the agriculture in that catchment may be contributing. In general, specific sources of chemicals can’t be identified. The exception is for sampling undertaken in irrigation areas where irrigation drains are sampled. However, in these situations, the suite of pesticides analysed is generally quite small and dictated by environmental protection licenses.

The analysis of the different data sources for those that met acceptance criteria for this project are provided below.

### Environment

#### Water

##### Non-urban surface waters

|  |
| --- |
| General Information |
| ID | 21 |
| Reference | Allinson, G., Allinson, M., Bui, A. et al. Pesticide and trace metals in surface waters and sediments of rivers entering the Corner Inlet Marine National Park, Victoria, Australia. Environ Sci Pollut Res 23, 5881–5891 (2016). |
| URL | https://doi.org/10.1007/s11356-015-5795-6Supplementary information available. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water |
| Reliability rating |
| Substances ID | Yes (n = 39) |
| Analysis/LOD | Yes/Yes (described in detail in supplementary information) |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (general) |
| Dates | Yes |
| Score | 23 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 16) |
| Catchment type | Surface water, Agricultural use (pasture) catchment |
| Location | Corner Inlet catchment, Victoria |
| Number of sites | 17 |
| Temporal | Limited. Samples collected monthly over a 6 month period. |
| Spatial | No. |
| Land use link | The sites were selected based on their relative positions within the Corner Inlet catchment or reference locations, e.g., head of catchment, mid catchment, and lower catchment, in known agricultural areas, or in forestry or national parks and were considered to be a broad representation of the wide range of waterways found in the catchment, across the major soil types and land use in the region. |
| Main substances detected | Prometryn, Simazine |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for non-urban land uses including agriculture, forestry and national parks. |
| Ease of Access |  |
| Reporting format | Results available in tabular form in a Microsoft Word document. |
| Individual values | Yes (in supplementary information). |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

|  |
| --- |
| General Information |
| ID | 22 |
| Reference | Allinson G, Bui A, Zhang P. et al. Investigation of 10 Herbicides in Surface Waters of a Horticultural Production Catchment in Southeastern Australia. Arch Environ Contam Toxicol 2014. 67, 358–373. |
| URL | https://doi.org/10.1007/s00244-014-0049-zSupplementary information available. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water |
| Reliability rating |
| Substances ID | Yes (n = 10) |
| Analysis/LOD | Yes/Yes (described in detail in supplementary information) |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (general, but overall catchment is specific – same sites as ID 23) |
| Dates | Yes (spring and summer, September 2008-March 2009 |
| Score | 23 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 4) |
| Catchment type | Surface water, Mixed use (see “Land use link” below) |
| Location | Yarra catchment, Victoria |
| Number of sites | 18 |
| Temporal | Limited. 2 seasons. |
| Spatial | Limited. Within Yarra catchment. |
| Land use link | Yes. Three sites were located on the Yarra River to reflect integrated impacts and six sites were located on the lower reaches of major tributaries. Eight sites were located in the Woori Yallock catchment where a wide variety of intensive agricultural activities operate. Two sites were reference sites located in forested water supply catchments |
| Main substances detected | Simazine, Atrazine, Pendimethalin |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for non-urban land uses including intensive agriculture (horticulture) and forestry. |
| Ease of Access |
| Reporting format | Results available in tabular form in the main PDF published paper. |
| Individual values | No. Mean, median, minimum, maximum and frequency of detection reported. |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

|  |
| --- |
| General Information |
| ID | 23 |
| Reference | Wightwick AM, Bui AD, Zhang P. et al. Environmental Fate of Fungicides in Surface Waters of a Horticultural-Production Catchment in Southeastern Australia. Arch Environ Contam Toxicol 2012. 62, 380–390. |
| URL | https://doi.org/10.1007/s00244-011-9710-y  |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water |
| Reliability rating |
| Substances ID | Yes (n = 24) |
| Analysis/LOD | Yes/Yes  |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (general, but overall catchment is specific – same sites as ID 22) |
| Dates | Yes (spring and summer, September 2008-March 2009 |
| Score | 23 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 6) |
| Catchment type | Surface water, Mixed use (see “Land use link” below) |
| Location | Yarra catchment, Victoria |
| Number of sites | 18 |
| Temporal | Limited. 2 seasons. |
| Spatial | Limited. Within Yarra catchment. |
| Land use link | Yes. Three sites were located on the Yarra River to reflect integrated impacts and six sites were located on the lower reaches of major tributaries. Eight sites were located in the Woori Yallock catchment where a wide variety of intensive agricultural activities operate. Two sites were reference sites located in forested water supply catchments |
| Main substances detected | Myclobutanil, Trifloxystrobin, Metalaxyl, Difenoconazole, Pyrimethanil |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for non-urban land uses including intensive agriculture (horticulture) and forestry. |
| Ease of Access |
| Reporting format | Results available in tabular form in the main PDF published paper. |
| Individual values | No. Mean, maximum, 95% CI and frequency of detection reported. |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

|  |
| --- |
| General Information |
| ID | 26 |
| Reference | Oliver D, Kookana R, Anderson J, Cox J, Fleming N, Waller N and Smith L. Off-site transport of pesticides from two horticultural land uses in the Mt. Lofty Ranges, South Australia, Agricultural Water Management, 2012. Volume 106, 60-69. |
| URL | https://doi.org/10.1016/j.agwat.2011.06.004  |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water |
| Reliability rating |
| Substances ID | Yes (n = 14) |
| Analysis/LOD | Yes/No  |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (general, but overall catchment is specific) |
| Dates | Yes (2006-2009) |
| Score | 20 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 7) |
| Catchment type | Surface water, Horticulture (Apple and cherry orchards) |
| Location | Mt. Lofty Ranges, South Australia |
| Number of sites | 2 |
| Temporal | Yes. Sampling undertaken over several years (2006-2009) |
| Spatial | No. |
| Land use link | Yes. The two streams monitored drained from apple and cherry orchards. |
| Main substances detected | Chlorpyrifos, Carbaryl, Fenarimol, Penconazole, Procymidone, Pirimicarb. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for horticultural land use, specifically, chemical application in apple and cherry orchards. |
| Ease of Access |
| Reporting format | Results available in tabular form in the main PDF published paper. |
| Individual values | No. Mean, maximum, 95% CI and frequency of detection reported. |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

|  |
| --- |
| General Information |
| ID | 31 |
| Reference | Sánchez-Bayo F and Hyne R, Detection and analysis of neonicotinoids in river waters – Development of a passive sampler for three commonly used insecticides, Chemosphere, 2014. Volume 99, 143-151. |
| URL | http://dx.doi.org/10.1016/j.chemosphere.2013.10.051  |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water |
| Reliability rating |
| Substances ID | Yes (n = 5) |
| Analysis/LOD | Yes/Yes |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Generally identifiable) |
| Dates | Yes (29 January and 7 February 2013 following high rainfall events) |
| Score | 23 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 5) |
| Catchment type | Peri-urban (see Land use link below) |
| Location | Around Sydney, NSW. |
| Number of sites | 13 |
| Temporal | No. |
| Spatial | No. |
| Land use link | Yes. Land uses identified with sampling areas include residential, orchards, mixed farms, turf farm, golf course. |
| Main substances detected | Acetamiprid, Imidacloprid, Thiacloprid. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for 5 neonicotinoid pesticides regulated by the APVMA, all of which are identified in the priority list established for this project. It is **representative** for urban stormwater runoff. |
| Ease of Access |
| Reporting format | Results available in tabular form in the main PDF report. |
| Individual values | Yes, provided in the published report. |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

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| --- |
| General Information |
| ID | 32 |
| Reference | Hook S, Doan H, Gonzago D, Musson D, Du J, Kookana R, Sellars M and Kumar A. The impacts of modern-use pesticides on shrimp aquaculture: An assessment for north eastern Australia, Ecotoxicology and Environmental Safety, 2018. Volume 148, 770-780. |
| URL | https://doi.org/10.1016/j.ecoenv.2017.11.028  |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water |
| Reliability rating |
| Substances ID | Yes (n = 29) |
| Analysis/LOD | Yes/Yes |
| Matrix ID | Yes |
| Methodology | Not fully described. |
| Locations | Yes (Generally identifiable) |
| Dates | Yes (September 2016 to December 2017) |
| Score | 20 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 17) |
| Catchment type | Generally agricultural (tropical/sub-tropical) |
| Location | Wet Tropics in QLD to Clarence catchment in NSW. |
| Number of sites | 7 |
| Temporal | No. Date range was for total sampling, only 1 sampling date per site. |
| Spatial | Yes. Sampling performed from the Wet Tropics in QLD to Clarence catchment in NSW. |
| Land use link | Yes. The study was considering water inflows for shrimp farming. Use is in tropical/sub-tropical regions. Multiple land uses upstream (e.g. sugar-cane farming, banana farming, beef cattle and urbanisation) considered possible. |
| Main substances detected | Diuron, 2,4-D, Atrazine, Hexazinone, Metolachlor. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is **representative** for tropical/sub-tropical agricultural runoff. |
| Ease of Access |
| Reporting format | Results available in tabular form in the main PDF report. |
| Individual values | Yes, provided in the published report. |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

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| --- |
| General Information |
| ID | 33 |
| Reference | Laicher D, Benkendorff K, White S, Conrad S, Woodrow R, Butcherine P and Sanders C. Pesticide occurrence in an agriculturally intensive and ecologically important coastal aquatic system in Australia, Marine Pollution Bulletin, 2022. Volume 180, 2022, 113675. |
| URL | https://doi.org/10.1016/j.marpolbul.2022.113675Supplementary information available. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water |
| Reliability rating |
| Substances ID | Yes (n = 168) |
| Analysis/LOD | Yes/Yes |
| Matrix ID | Yes |
| Methodology | Not fully described. |
| Locations | Yes (Generally identifiable) |
| Dates | Yes (January to April, 2019) |
| Score | 23 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 55) |
| Catchment type | Horticulture (tomato; blueberry) to habitat protected area. |
| Location | Double Crossing Creek, a coastal waterway in the Sandy Beach and Woolgoolga catchment area in northern NSW, Australia |
| Number of sites | 6 |
| Temporal | No. |
| Spatial | No. |
| Land use link | Yes. Sampling was undertaken in areas associated with horticulture (glass house and field – blueberries), and from forested areas. |
| Main substances detected | Imidacloprid, Methomyl, Dimethoate, Terbuthylazine, Terbutryn, Omethoate, Pyrimethanil, Triadimenol.  |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is **representative** for comparison of detections to different land uses. |
| Ease of Access |
| Reporting format | Results available in tabular form in the supplementary information. |
| Individual values | Yes, provided in the supplementary information. |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

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| General Information |
| ID | 43 |
| Reference | Vincente-Beckett V, Noble R, Packet R, Verwey P, Ruddle L, Munksgaard N and Morrison H. Pesticide, polycyclic aromatic hydrocarbon and metal contamination in the Fitzroy Estuary, Queensland, Australia. Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management. 2006. ISBN 1 921017 62 7 |
| URL | n/a |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water |
| Reliability rating |
| Substances ID | Yes (n = 8) |
| Analysis/LOD | Yes/No |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Generally identifiable) |
| Dates | Yes (2003/4 and 2004/5 wet seasons) |
| Score | 20 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 4) |
| Catchment type | Large river basin catchment (non-urban). |
| Location | Fitzroy catchment, Queensland (Rockhampton). |
| Number of sites | 1 |
| Temporal | Limited. Two wet seasons monitored. |
| Spatial | No. |
| Land use link | Partial. The sampling site is end of river flow for the Fitzroy River at Rockhampton which will include runoff from the wider (very large) catchment – dominated by grazing. |
| Main substances detected | Atrazine, Tebuthiuron, Diuron |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a small number of pesticides regulated by the APVMA, some of which are identified in the priority list established for this project. It is potentially **representative** for agricultural land uses dominated by grazing. |
| Ease of Access |
| Reporting format | Results available in tabular. |
| Individual values | Yes, provided in the supplementary information. |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

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| General Information |
| ID | 10 |
| Reference | Department of Water. A baseline study of organic contaminants in the Swan and Canning catchment drainage system using passive sampling devices. Water Science technical series Report No 5, December 2009. Government of Western Australia. |
| URL | n/a |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water |
| Reliability rating |
| Substances ID | Yes (n = 25) |
| Analysis/LOD | Partially/Partially |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Generally identifiable) |
| Dates | Yes (September 2006 to August 2007) |
| Score | 21 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 12) |
| Catchment type | Urban and peri-urban stormwater drains (artificial and natural creeks/rivers) |
| Location | Around Perth, WA |
| Number of sites | 10 |
| Temporal | Limited. Monitoring over several seasons but in one year. |
| Spatial | No. |
| Land use link | Yes. The different catchments feeding monitoring sites are well categorized for land use. These are mixed but dominated by different land uses such as industrial, residential, conservation, agriculture. |
| Main substances detected | Diuron, Simazine, Atrazine |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a small number of pesticides regulated by the APVMA, some of which are identified in the priority list established for this project. It is potentially **representative** for a variety of land uses. |
| Ease of Access |
| Reporting format | Results available in tabular form in the report. |
| Individual values | Yes. |
| Cost/impediments | Nil. Publicly available. |

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| General Information |
| ID | 15 |
| Reference | Pesticide Water Monitoring Results (last updated July 2014) |
| URL | https://nre.tas.gov.au/water/water-monitoring-and-assessment/pesticide-monitoring https://nre.tas.gov.au/Documents/Baseline%20Monitoring%20Program.pdf  |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Surface water) |
| Reliability rating |
| Substances ID | Yes (n = 26) |
| Analysis/LOD | No/No |
| Matrix ID | Yes |
| Methodology | No |
| Locations | Yes (Specific with coordinates) |
| Dates | Yes (2005 to 2014) |
| Score | 16 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 14) |
| Catchment type | Various – structured monitoring in a large number of streams and rivers throughout the state. |
| Location | Around Tasmania |
| Number of sites | 83 |
| Temporal | Yes. Pesticide Water Monitoring Program was run from 2005 to 2014 |
| Spatial | Yes. Throughout Tasmania. |
| Land use link | No. |
| Main substances detected | Very few detections, but those most often detected included 2,4-D, Simazine, MCPA, Metalaxyl. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project and was developed as part of a structured state government long term monitoring program. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is considered **representative** because it was specifically implemented as a means to increase knowledge and understanding as to the nature and extent of pesticide contamination of rivers and streams in Tasmania. |
| Ease of Access |
| Reporting format | Results available in tabular form in PDF report. |
| Individual values | Yes. |
| Cost/impediments | Nil. Publicly available. |

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| General Information |
| ID | 40 |
| Reference | Shaw M, Silburn D, Lenahan M and Harris M. Pesticides in groundwater in the Lower Burdekin floodplain. Brisbane: Department of Environment and Resource Management, Queensland Government. 2012. ISBN: 978-1-7423-0953. |
| URL | https://www.des.qld.gov.au/\_\_data/assets/pdf\_file/0026/81935/rti-13045-pesticides-in-groundwater.pdf  |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Ground water and surface water) |
| Reliability rating |
| Substances ID | Yes (n = 66) |
| Analysis/LOD | Yes/No |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Specifically identified) |
| Dates | Yes (Single sampling event in August 2011) |
| Score | 22 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 26) |
| Catchment type | Agricultural use area on coastal flood plain. |
| Location | Lower Burdekin floodplain (south east of Townsville, QLD) |
| Number of sites | 53 (bores); 2 (surface water) |
| Temporal | No. |
| Spatial | No. |
| Land use link | Yes. Sampling undertaken in agriculturally intensive area based on map in report. |
| Main substances detected | Atrazine, Hexazinone, Diuron, Chlorpyrifos. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is considered **representative** for ground and surface water exposure in an agricultural catchment. |
| Ease of Access |
| Reporting format | Results available in tabular form in PDF report. |
| Individual values | Yes for two water samples, Max and Mean for sediment samples. |
| Cost/impediments | Nil. Publicly available. |

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| General Information |
| ID | 48 |
| Reference | Vic EPA; Vic State Government: Bellarine Peninsula: Legacy and emerging contaminant sampling and analysis (2018–2019) – Publication 1870 May 2020 |
| URL | https://www.epa.vic.gov.au/-/media/epa/files/publications/1870.pdf |
| Other information | This report by EPA provides an assessment of pesticides, PFAS, metals and selected industrial chemicals contaminant concentrations in surface soils in areas of the Bellarine Peninsula region and in water and sediments in the Barwon River catchment to further inform assessment of the potential risk for exposure to these environmental contaminants. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Surface water) |
| Reliability rating |
| Substances ID | Somewhat (stated as organochlorines, organophosphates, synthetic pyrethroids, herbicides and fungicides. Specific chemical list not provided.) |
| Analysis/LOD | No/Yes (Laboratory identified so analytical information would be available if required). |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Generally identified) |
| Dates | Yes (Single sampling events in June 2019) |
| Score | 18 |
| Relevance and Representativeness |
| Includes listed? | Yes (actual number not identified.) |
| Catchment type | Barwon River Catchment. Residential, but previously used for agriculture. |
| Location | Bellarine Peninsula (Geelong to Ocean Grove, Victoria). |
| Number of sites | 4 aquatic (water, sediment, soil).  |
| Temporal | No. |
| Spatial | No. |
| Land use link | Yes. The provided map (and confirmed with Google Maps) shows the sampling sites to be situated in a mix of urban and agricultural land uses. |
| Main substances detected | Simazine, Atrazine. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in an urban and peri-urban catchment. |
| Ease of Access |
| Reporting format | Results available in tabular form in PDF report. |
| Individual values | Yes. |
| Cost/impediments | Nil. Publicly available. |

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| General Information |
| ID | 50 |
| Reference | Rose G, Zhang P, Bui A, Allen D and Allinson G. Melbourne Water and DPI agrochemicals in Port Philip catchment project report 2009-10. A report to the Centre for Aquatic Pollution, Identification and Management (CAPIM), the University of Melbourne. Future Farming Systems Research, DPI Queenscliff Centre, Queenscliff, Victoria. 2011. |
| URL | https://www.vgls.vic.gov.au/client/en\_AU/search/asset/1146643/0 |
| Other information | The study focused on the assessment of agrochemical loads and the impacts within the peri-urban and urban fringes of Melbourne. Although primarily focusing on unprotected catchments, two reference sites (protected catchments) for the Yarra (Donnelly’s weir and Starvation Creek), and two sites of significant urban impact (Darebin and Merri Creeks) were included. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Surface water) |
| Reliability rating |
| Substances ID | Yes (n = 52) |
| Analysis/LOD | Yes/Yes |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Generally identified) |
| Dates | Yes (2009-2010) |
| Score | 22 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 31) |
| Catchment type | Urban and peri-urban fringes |
| Location | Melbourne, VIC (including Port Philip Bay sub-catchments) |
| Number of sites | 29 surface water. NB, this study also describes results for 24 constructed urban wetland sites. These are reported in “Urban Stormwater” below as Source ID 20. |
| Temporal | No. |
| Spatial | No. |
| Land use link | Yes. |
| Main substances detected | Simazine, Atrazine, Metalaxyl, Imidacloprid, Prometryn  |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in an urban and peri-urban catchment. |
| Ease of Access |
| Reporting format | Results available in tabular form in PDF report. |
| Individual values | Yes. |
| Cost/impediments | Nil. Publicly available. |

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| General Information |
| ID | 53 |
| Reference | EPA Victoria – Emerging contaminants assessment 2019-20: Summary of results. Publication 1879, September 2020. |
| URL | https://www.epa.vic.gov.au/about-epa/publications/1879 |
| Other information | The study was undertaken to enable the EPA to further identify the extent and magnitude of emerging and legacy contaminants across Victoria, to inform where there may be priority areas, regulatory responses, and identify sectors to work with to prevent and reduce environmental pollution. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Surface water) |
| Reliability rating |
| Substances ID | The summary results have been provided by EPA Victoria. The results from the monitoring program are considered reliable for the purpose of this project but full details have not been requested. |
| Analysis/LOD |
| Matrix ID |
| Methodology |
| Locations |
| Dates |
| Score |
| Relevance and Representativeness |
| Includes listed? | Yes (from limited information in overview.) |
| Catchment type | Agriculture (low intensity- grazing; high intensity – cropping and horticulture); urban residential; urban industrial; background. |
| Location | Across Victoria |
| Number of sites | 101 |
| Temporal | No. |
| Spatial | Yes. |
| Land use link | EPA selected sites representing five land use types: background, low-intensity agriculture (grazing), high-intensity agriculture (cropping, horticulture), urban residential, and urban industrial. |
| Main substances detected | In water, concentrations of pesticides detected ranged from 0.0074 to 1.42 µg/L across all land use types. For example, herbicide simazine was only detected in water (<0.01 – 1.3 µg/L, and most frequently in sites with urban industrial and urban residential land uses. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in different catchment types. The full data set can be requested from EPA Victoria if required for later use. |
| Ease of Access |
| Reporting format | Full results available from EPA Victoria. |
| Individual values | Yes. |
| Cost/impediments | None identified |

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| General Information |
| ID | 27 |
| Reference | Murray Irrigation – Compliance and monitoring. |
| URL | https://www.murrayirrigation.com.au/water/system/compliance-and-monitoring/Annual compliance reports can be obtained from this site. |
| Other information | Murray Irrigation undertakes monitoring based on their Environmental Protection Licence1. This license only requires three substances to be monitored, namely, Molinate, Thiobencarb and Atrazine. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Surface water – irrigation area drains) |
| Reliability rating |
| Substances ID | Yes (n = 3). |
| Analysis/LOD | No (probably available on request) |
| Matrix ID | Yes |
| Methodology | Somewhat |
| Locations | Yes |
| Dates | Yes |
| Score | 16 |
| Relevance and Representativeness |
| Includes listed? | Yes (2 of the 3 substances analysed for are listed for this project) |
| Catchment type | Irrigated agriculture |
| Location | Murray Irrigation area (around Deniliquin, NSW) |
| Number of sites | 2 |
| Temporal | Yes – Compliance reports available over long term (>10 years) |
| Spatial | No. |
| Land use link | Yes – results are specific to an agricultural irrigation area. |
| Main substances detected | Only three substances tested for. Several years contain no data due to very low flows without monitoring. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for some pesticides regulated by the APVMA, including two identified in the priority list established for this project. It is considered **representative** for surface water exposure in an irrigated agricultural system, however, the suite of chemicals tested is very small compared to likely pesticides being used in the irrigation area. |
| Ease of Access |
| Reporting format | Results reported in PDF document. |
| Individual values | Yes. |
| Cost/impediments | Nil. Publicly available. |

1. https://apps.epa.nsw.gov.au/prpoeoapp/ViewPOEOLicence.aspx?DOCID=226027&SYSUID=1&LICID=5014

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| General Information |
| ID | 34 |
| Reference | Coleambally Irrigation – Water quality monitoring results. |
| URL | https://www.colyirr.com.au/water-quality (monthly water quality results from 2017 can be downloaded at this site) |
| Other information | Coleambally Irrigation undertakes monitoring based on their Environmental Protection Licence1. This license only identifies the chemicals that require monitoring. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Surface water – irrigation area drains) |
| Reliability rating |
| Substances ID | Yes (n = 11). |
| Analysis/LOD | No (probably available on request) |
| Matrix ID | Yes |
| Methodology | Somewhat |
| Locations | Yes |
| Dates | Yes |
| Score | 16 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 8) |
| Catchment type | Irrigated agriculture |
| Location | Coleambally Irrigation area (Riverina region, NSW) |
| Number of sites | 6 |
| Temporal | Yes – Compliance reports available over long term (>10 years) |
| Spatial | No. |
| Land use link | Yes – results are specific to an agricultural irrigation area. |
| Main substances detected | Atrazine, metolachlor, simazine (based on 2017 data used for example). |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in an agricultural irrigation area catchment. |
| Ease of Access |
| Reporting format | Online and downloadable in Microsoft excel spreadsheet. |
| Individual values | Yes. |
| Cost/impediments | Nil. Publicly reported |

1.https://static1.squarespace.com/static/5af3b1ae70e8023a6ac7a10b/t/5d2d16fbd83c2900011da3f7/1563236092745/EPL+4652+-+Coleambally+Irrigation.pdf

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| General Information |
| ID | 35 |
| Reference | Murrumbidgee Irrigation – Water quality results. |
| URL | https://www.mirrigation.com.au/water/water-quality/water-quality-results/licence-site-monitoring-water-quality-results (monthly water quality results from 2017 can be downloaded at this site) |
| Other information | Murrumbidgee Irrigation undertakes monitoring based on their Environmental Protection Licence1. This license only identifies the chemicals that require monitoring. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Surface water – irrigation area drains) |
| Reliability rating |
| Substances ID | Yes (n = 10). |
| Analysis/LOD | No (probably available on request) |
| Matrix ID | Yes |
| Methodology | Somewhat |
| Locations | Yes |
| Dates | Yes |
| Score | 16 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 7) |
| Catchment type | Irrigated agriculture |
| Location | Murrumbidgee Irrigation area (Riverina region, NSW) |
| Number of sites | 5 |
| Temporal | Yes – Compliance reports available over long term (>5 years) |
| Spatial | No. |
| Land use link | Yes – results are specific to an agricultural irrigation area. |
| Main substances detected | Diuron, Atrazine, Metolachlor (based on random sample of monthly reports over time from different sites). |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in an agricultural irrigation area catchment. |
| Ease of Access |
| Reporting format | Online and downloadable in Microsoft excel spreadsheet. |
| Individual values | Yes. |
| Cost/impediments | Nil. Publicly reported |

1. https://apps.epa.nsw.gov.au/prpoeoapp/ViewPOEOLicence.aspx?DOCID=182989&SYSUID=1&LICID=4651

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| General Information |
| ID | 57 |
| Reference | QLD Government – Reef 2050 Water Quality Improvement Plan |
| URL | The program is comprehensive. A starting point is found at: https://www.reefplan.qld.gov.au/  |
| Other information | The risk baseline methodology is reported in Warne et al, 2020.1 This reference provides a description of those sites used to calibrate and estimate the Pesticide Risk Baseline (PRB) in 2019. The most up to date publication indicating the number of sites and basins covered by the GBRCLMP and SEQCLMP is the [Pesticide Reporting Portal](https://storymaps.arcgis.com/stories/c0f0c6d7d88a4fd3a5541fe59f41ff75) (PRP). |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Surface water – range of different land uses including tropical/subtropical agriculture) |
| Reliability rating |
| Substances ID | Yes (n = 22). |
| Analysis/LOD | Yes (probably available on request) |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes |
| Dates | Yes |
| Score | 25 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 8) |
| Catchment type | Varied – well characterized in the monitoring program |
| Location | Great Barrier Reef catchment areas on Queensland east coast. |
| Number of sites | 30 |
| Temporal | Yes – pesticide concentration data for 2015/2016 to 2017/2018 were used to derive the Pesticide Risk Baseline and are used for comparative purposes for monitoring results obtained in subsequent years.  |
| Spatial | Yes. The reef plan applies to all catchments, from the Burnett Mary to Cape York regions inclusive, that discharge to the Great Barrier Reef. |
| Land use link | Yes – results for catchments are linked to dominant land uses including conservation, dryland cropping, forestry, grazing, tropical/subtropical cropping (bananas, sugarcane, horticulture). |
| Main substances detected | Diuron, Imidacloprid, Atrazine, Metolachlor, Hexazinone (data not provided. This is based on the identified risk drivers and assessment in Spilsbury et al, 20202). |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in exposed to a large range of land uses. |
| Ease of Access |
| Reporting format | Microsoft Excel |
| Individual values | Yes. |
| Cost/impediments | None identified. The data set is very large and needs to be requested through the Department of Environment and Science, Queensland Government. |

1. https://www.publications.qld.gov.au/ckan-publications-attachments-prod/resources/c65858f9-d7ba-4aef-aa4f-e148f950220f/pesticide-risk-baseline-project-report.pdf?ETag=a9665f53d62acabcddcc9fbe38e025b5;

2. Spilsbury FD, Warne MSJ, Backhaus T. Risk Assessment of Pesticide Mixtures in Australian Rivers Discharging to the Great Barrier Reef. Environ Sci Technol. 2020 Nov 17;54(22):14361-14371. doi: 10.1021/acs.est.0c04066. Epub 2020 Nov 2. PMID: 33136377.

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| General Information |
| ID | 59 |
| Reference | Smith R, Turner R, Vardy S, Huggins R, Wallace R and Warne M. An evaluation of the prevalence of alternate pesticides of environmental concern in Great Barrier Reef catchments: RP57C, 2016. |
| URL | https://www.publications.qld.gov.au/dataset/alternate-pesticides-gbr-catchments/resource/efaa76da-5714-45a5-ba40-30476d9e214e  |
| Other information | n/a |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Surface water – range of different land uses including tropical/subtropical agriculture) |
| Reliability rating |
| Substances ID | Yes (n = 151). |
| Analysis/LOD | Yes  |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes |
| Dates | Yes (1 July 2012 and 30 June 2013) |
| Score | 25 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 51) |
| Catchment type | Varied – well characterized in the monitoring program |
| Location | The six sites were the North Johnstone, Tully and Herbert Rivers in the Wet Tropics, Barratta Creek in the Lower Burdekin, and Pioneer River and Sandy Creek in the Mackay-Whitsundays. |
| Number of sites | 6 |
| Temporal | No. |
| Spatial | Yes. |
| Land use link | Yes – dominant land uses in different sampling locations included conservation, grazing, sugarcane and horticulture. |
| Main substances detected | Diuron, Atrazine, 2,4-D, Metribuzin, Metolachlor, Isoxaflutole, MCPA. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in exposed to a large range of land uses. |
| Ease of Access |
| Reporting format | Graphically presented in PDF. |
| Individual values | No. The median and ranges are provided graphically for detected chemicals. |
| Cost/impediments | None identified. The results would be more useable if the raw data could be obtained, which may be requested from the Queensland Government. |

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| General Information |
| ID | 38 |
| Reference | Kennedy K, Bentley C, Paxman C, Heffernan A, Dunn A, Kaserzon S and Mueller J. Final Report - Monitoring of organic chemicals in the Great Barrier Reef Marine Park using time integrated monitoring tools (2009-2010). The University of Queensland, The National Research Centre for Environmental Toxicology (Entox). 2010. |
| URL | See Table footnote 1 |
| Other information | n/a |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Marine water – 12 inshore sites in the Great Barrier Reef Marine Park) |
| Reliability rating |
| Substances ID | Yes (n = 33). |
| Analysis/LOD | Yes/Yes |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes |
| Dates | Yes (2009-2010) |
| Score | 25 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 18) |
| Catchment type | Varied – well characterized in the monitoring program |
| Location | Monitoring was conducted at sites within five major Natural Resource Management Regions (Cape York, Wet Tropics, Burdekin, Mackay Whitsunday, and Fitzroy) |
| Number of sites | 12 |
| Temporal | No. |
| Spatial | Yes. |
| Land use link | Yes – dominant land uses in different catchments discharging to the Great Barrier Reef Marine Park vary depending on location and can include conservation, grazing, sugarcane and horticulture.  |
| Main substances detected | Diuron, Atrazine, hexazinone, simazine, chlorpyrifos. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in exposed to a large range of land uses. |
| Ease of Access |
| Reporting format | Reported in PDF. |
| Individual values | No. % detect, range and maximum values provided. |
| Cost/impediments | Nil. Publicly available. |

1.https://www.academia.edu/23539827/Final\_Report\_Monitoring\_of\_organic\_chemicals\_in\_the\_Great\_Barrier\_Reef\_Marine\_Park\_using\_time\_integrated\_monitoring\_tools\_2009\_2010\_

Source ID: 55. In the initial information gathering stage, the Environment Protection Authority, Victoria, advised on an “Emerging contaminants in recycled water project, 2021”. This project contains monitoring data from influent and effluent waters from 30 x wastewater treatment plants and includes pesticides, pharmaceuticals and personal care products, and endocrine disruption chemicals. The control and ownership rests with Vic EPA, contact Dr Minna Saaristo Senior Scientist – Emerging contaminants, Land and Waste Sciences, EPA Science (minna.saaristo@epa.vic.gov.au). However, it was noted that because this project is a collaboration between water corporations and EPA Science, releasing any data will need to be approved by the water corporations involved. The data are maintained in Microsoft Excel and PDF forms.

##### Urban stormwater

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| General Information |
| ID | 19 |
| Reference | Allinson M, Zhang P, Bui A, Muyers J, Pettigrove V, Rose G, Salzman S, Walters R and Allinson G. Herbicides and trace metals in urban waters in Melbourne, Australia (2011–12): concentrations and potential impact. Environ Sci Pollut Res 2017. 24, 7274–7284. |
| URL | https://doi.org/10.1007/s11356-017-8395-9Supplementary information available. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Surface water (Urban stormwater) |
| Reliability rating |
| Substances ID | Yes (n = 31) |
| Analysis/LOD | Yes/Yes |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (generally) |
| Dates | Yes |
| Score | 23 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 7) |
| Catchment type | Urban |
| Location | In and around Melbourne, Victoria |
| Number of sites | 5 |
| Temporal | Yes, short time frame (6 months) |
| Spatial | Limited |
| Land use link | Sites represent the mix of urban land uses in Melbourne i.e. predominantly housing, mixed urban and industrial. |
| Main substances detected | Simazine, MCPA, Diuron, Atrazine. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for urban stormwater runoff in surface water for urban land use. |
| Ease of Access |
| Reporting format | Results available in tabular form in a Microsoft Word document. |
| Individual values | Yes (in supplementary information). |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

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| General Information |
| ID | 20 |
| Reference | Allinson G, Zhang P, Bui A, Allinson M, Rose G, Marshall S and Pettigrove V. Pesticide and trace metal occurrence and aquatic benchmark exceedances in surface waters and sediments of urban wetlands and retention ponds in Melbourne, Australia. Environ Sci Pollut Res Int. 2015 Jul; 22(13):10214-26. |
| URL | https://doi.org/10.1007/s11356-015-4206-3 |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water |
| Reliability rating |
| Substances ID | Yes (n = 24) |
| Analysis/LOD | Yes/Yes (described in detail in supplementary information) |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (general) |
| Dates | Yes |
| Score | 23 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 14) |
| Catchment type | Urban and peri-urban wetlands |
| Location | In and around Melbourne, VIC. |
| Number of sites | 24 |
| Temporal | No. Samples collected at one time point only. |
| Spatial | Limited, but greater analysis of detections by site ID will give a degree of spatial analysis from highly urbanized to peri-urban locations. |
| Land use link | Sites were chosen to obtain broad representation of the wide range of urban stormwater treatment wetland designs found in Melbourne, across the major soils types in the region and representing both new developments and well established suburbs. |
| Main substances detected | Simazine, Atrazine, Metalaxyl, Terbutryn. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for urban stormwater runoff. |
| Ease of Access |
| Reporting format | Results available in tabular form in a Microsoft Word document. |
| Individual values | Yes (in supplementary information). |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

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| General Information |
| ID | 30 |
| Reference | Sidhu J, Gernjak W and Toze S. (Editors). Health Risk Assessment of Urban Stormwater. CSIRO 2012. Urban Water Security Research Alliance Technical Report No. 102.  |
| URL | http://www.urbanwateralliance.org.au/publications/UWSRA-tr102.pdf  |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water |
| Reliability rating |
| Substances ID | Yes (n = 15) |
| Analysis/LOD | Yes/No  |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Specific with coordinates) |
| Dates | Yes (May 2011 to February 2012) |
| Score | 25 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 6) |
| Catchment type | Surface water, Urban stormwater, Brisbane, Melbourne, Sydney. |
| Location | Brisbane (n = 2), Melbourne (n = 2), Sydney (n = 2). |
| Number of sites | 6 |
| Temporal | Limited. Sampling undertaken over 12 months. |
| Spatial | Yes. |
| Land use link | Yes. Land uses associated with stormwater sampling included residential (including with open space), city, urban roads, commercial and one larger catchment incorporating residential, commercial and agriculture. |
| Main substances detected | Diuron, Simazine, 2,4-D, MCPA, Triclopyr |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for urban stormwater runoff. |
| Ease of Access |
| Reporting format | Results available in tabular form in the main PDF report. |
| Individual values | No. Min, median, max and 25th, 75th and 90th percentages reported along with frequency of detection. |
| Cost/impediments | Nil. Publicly available. |

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| General Information |
| ID | 06 |
| Reference | Allinson G, Allinson M, Myers J and Pettigrove V. Use of novel rapid assessment tools for efficient monitoring of micropollutants in urban storm water (SWF Project 8OS – 8100). Centre for Aquatic Pollution Identification Management (CAPIM). The University of Melbourne, Parkville, Victoria 3025, Australia. 2014. |
| URL | https://waterportal.com.au/swf/images/swf-files/8os---8100-capim-micropollutants-project-m4-final-report.pdf  |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Storm water) |
| Reliability rating |
| Substances ID | Yes (n = 29) |
| Analysis/LOD | Yes/Yes |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Generally identifiable) |
| Dates | Yes (October 2012 to February 2013) |
| Score | 22 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 7) |
| Catchment type | Urban sites receiving storm water |
| Location | Melbourne, VIC |
| Number of sites | 8 |
| Temporal | No. |
| Spatial | No. |
| Land use link | Yes. Land uses from the urban catchments included inner urban; suburban; bioretention system for stormwater harvesting and irrigation, wetland system for stormwater harvesting and irrigation, regional town catchment and a rain garden system for storm water harvesting and irrigation. |
| Main substances detected | Atrazine, Simazine, Diuron, 2,4-D, MCPA, Triclopyr. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is considered **representative** for urban stormwater catchments. |
| Ease of Access |
| Reporting format | Results available in tabular form in PDF report. |
| Individual values | Yes. |
| Cost/impediments | Nil. Publicly available. |

##### Drinking water

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| General Information |
| ID | 09 |
| Reference | Water Corporation (Western Australia) |
| URL | https://www.watercorporation.com.au/About-us/Our-performance/Drinking-water-quality - Separate annual water quality reports available at this site. |
| Overall information: | This is an ongoing monitoring program by a water authority. To verify the delivery of safe drinking water and to assess the aesthetic quality of the drinking water, Water Corporation (WA) run an extensive water quality monitoring program. They analyse more than 71,800 samples from water sources, treatment plants and pipe networks that supply our customers, and almost 302,000 individual analyses performed by independent laboratories. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Drinking water) |
| Reliability rating |
| Substances ID | Yes (n = 99 – uncertain if this differs per year) |
| Analysis/LOD | No – but expected to be available from testing laboratory. |
| Matrix ID | Yes |
| Methodology | No but expected could be provided if requested. |
| Locations | Yes (Generally identifiable) |
| Dates | Yes (Ongoing water authority monitoring program) |
| Score | 16 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 50) |
| Catchment type | Drinking water catchments |
| Location | Western Australia |
| Number of sites | >100 around the state |
| Temporal | Yes – on going monitoring program |
| Spatial | Yes – sampling around Western Australia |
| Land use link | Yes. Drinking water supply taken from drinking water catchments. |
| Main substances detected | Not identifiable from internet based sources. The Water Corporation was contacted to determine accessibility of the raw data. Their response simply pointed to the web information, but the raw data may be available if requested by DAFF. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project and was developed as part of a structured water authority long term monitoring program. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. However, in the publicly available data, the results only refer to exceedances of overall pesticides to health guidelines, not to limits of detection. If the raw data could be obtained, they would be considered **representative** for drinking water catchments. |
| Ease of Access |
| Reporting format | Results available in tabular form in PDF report. |
| Individual values | Not in the publicly available reports. |
| Cost/impediments | Nil. Publicly available for annual reports. Water Corporation has been contacted through the online query form to obtain information on availability of individual monitoring data including costs and impediments to obtaining these data. |

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| General Information |
| ID | 39 |
| Reference | Flinders Shire Council |
| URL | https://www.flinders.qld.gov.au/reporting-water-sewerage/water-sewerage-reporting - Separate annual water quality reports available at this site. |
| Overall information: | This is an ongoing monitoring program by a water authority. The information is from the Drinking Water Quality Management Plan (DWQMP) report for Flinders Shire Council where reports over several years are available. For pesticides, sampling occurs 4 times per annum with 2-3 samples taken at each sampling stage (based on latest annual report).  |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Drinking water from bores) |
| Reliability rating |
| Substances ID | Yes (n = 64 – uncertain if this differs per year) |
| Analysis/LOD | No – but expected to be available from testing laboratory. |
| Matrix ID | Yes |
| Methodology | No but expected could be provided if requested. |
| Locations | Yes (Specifically identified) |
| Dates | Yes (Ongoing water authority monitoring program) |
| Score | 16 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 38) |
| Catchment type | Drinking water catchments with sampling from bores |
| Location | Hughenden, QLD |
| Number of sites | 3 |
| Temporal | Yes – on going monitoring program |
| Spatial | No. |
| Land use link | Yes. Drinking water supply taken from bores. |
| Main substances detected | The latest available annual report (2020/2021) has been used as a reference point. Of the pesticides analysed for, none exceeded the guideline level (≤0.7 µg/L for all analytes). |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project and was developed as part of a structured water authority long term monitoring program. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. Analyses was also undertaken for many legacy chemicals listed in the Stockholm Convention. However, in the publicly available data, the results only refer to exceedances of overall pesticides to health guidelines, not to limits of detection. If the raw data could be obtained, they would be considered **representative** for drinking water catchments noting these results relate to bore water samples. |
| Ease of Access |
| Reporting format | Results available in tabular form in PDF report. |
| Individual values | Yes, but only reported as number of samples per chemical exceeding specific water quality criteria. |
| Cost/impediments | Nil. Publicly available for annual reports. |

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| General Information |
| ID | 41 |
| Reference | Burdekin Shire Council |
| URL | https://www.burdekin.qld.gov.au/downloads/file/1455/drinking-water-quality-management-plan - Provides raw water quality results for the period 2013-2020. |
| Overall information: | The Burdekin Shire Council performs water quality testing at various sites in Ayr, Alva Beach, Brandon, Home Hill, Giru and Mt Kelly. Quarterly water quality sampling is performed at various sites within the Shire. Samples are sent to the Queensland Forensic & Scientific Services laboratory in Brisbane for Heavy Metal, Pesticide and Chemical analysis. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Drinking water from bores) |
| Reliability rating |
| Substances ID | Yes (Total number unclear as it appears only positive detections reported) |
| Analysis/LOD | No – but expected to be available from testing laboratory. |
| Matrix ID | Yes |
| Methodology | No but expected could be provided if requested. |
| Locations | Yes (Specifically identified) |
| Dates | Yes (2013-2020 in this publication) |
| Score | 17 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 4 out of the 9 pesticides where positive detections were reported) |
| Catchment type | Drinking water catchments with sampling from bores |
| Location | Hughenden, QLD |
| Number of sites | 15 |
| Temporal | No. The results cover a sampling period of 8 years, but results are pooled for reporting. |
| Spatial | No. |
| Land use link | Yes. The Burdekin Catchment as a whole, over 90% is grazing land. While this impacts the water quality within the Haughton River, this is not the most relevant land use for the water supplies of Ayr, Home Hill and Mount Kelly, where irrigated sugar cane farming dominates. |
| Main substances detected | Atrazine, diuron. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project and was developed as part of a structured local council long term monitoring program. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. Analyses was also undertaken for many legacy chemicals listed in the Stockholm Convention. However, in the publicly available data, the results only refer to exceedances of overall pesticides to health guidelines, not to limits of detection. If the raw data could be obtained, they would be considered **representative** for drinking water catchments noting these results relate to bore water samples. |
| Ease of Access |
| Reporting format | Results available in tabular form in PDF report. |
| Individual values | No. Average, maximum and number of positive detections reported. |
| Cost/impediments | Nil. Publicly available. |

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| General Information |
| ID | 42 |
| Reference | Central Highlands Water - Water Quality Report (using 2020-21 for reference) |
| URL | https://www.chw.net.au/community/water-quality - gives access to water quality reports dating back to 2011/12. |
| Overall information: | A range of pesticides are monitored in untreated source water for each supply on an annual basis. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Drinking water from streams, dams and bores) |
| Reliability rating |
| Substances ID | Yes (n = 105) |
| Analysis/LOD | No – but expected to be available from testing laboratory. |
| Matrix ID | Yes |
| Methodology | No but expected could be provided if requested. |
| Locations | Yes (Specifically identified) |
| Dates | Generally – single annual samples for analysis |
| Score | 17 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 51) |
| Catchment type | Drinking water sourced from stream diversions, on-stream storages and groundwater bores |
| Location | Central Highlands region of Victoria. |
| Number of sites | 13 separate water supply systems |
| Temporal | Yes – there are water quality reports for several years. |
| Spatial | Limited – 13 sites throughout the Central Highlands region of Victoria. |
| Land use link | Yes. Drinking water supply catchments. |
| Main substances detected | Atrazine, Simazine, 2,4-D, Triclopyr. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project and was developed as part of a structured water authority long term monitoring program. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is considered **representative** for drinking water catchments noting these results relate to bore and surface water samples. |
| Ease of Access |
| Reporting format | Results available in tabular form in PDF report. |
| Individual values | Yes for substances where a positive detection at any water supply system was identified. |
| Cost/impediments | Nil. Publicly available. |

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| General Information |
| ID | 45 |
| Reference | The Bundaberg Regional Council (BRC) Drinking Water Quality Management Plan (DWQMP) - (using 2020-21 for reference) |
| URL | See table footnote 1 - gives access to water quality reports dating back to 2017/18. |
| Overall information: | The Bundaberg Regional Council carries out full and comprehensive pesticide analysis on a routine basis. The results available in the annual reports only include detections that have an Australian Drinking Water Guideline Health Value. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Drinking water from reservoirs) |
| Reliability rating |
| Substances ID | Yes (positive results only reported. The full suite of chemicals tested for is not reported) |
| Analysis/LOD | No/Yes – but expected analytical method to be available from testing laboratory. |
| Matrix ID | Yes |
| Methodology | No but expected could be provided if requested. |
| Locations | Yes (Specifically identified) |
| Dates | Generally – sampling undertaken quarterly |
| Score | 19 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = ≥5 – only positive results have been reported) |
| Catchment type | Drinking water sourced from stream diversions, on-stream storages and groundwater bores |
| Location | Bundaberg region, QLD. |
| Number of sites | Up to 10 separate water supply systems |
| Temporal | Yes – there are water quality reports for several years. |
| Spatial | Limited. |
| Land use link | Yes. Drinking water supply catchments. |
| Main substances detected | Atrazine, Hexazinone, Bromacil, 2,4-D |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project and was developed as part of a structured water authority long term monitoring program. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is considered **representative** for drinking water catchments noting these results relate to surface water samples. |
| Ease of Access |
| Reporting format | Results available in tabular form in PDF report. |
| Individual values | Yes for substances where a positive detection at any water supply system was identified. |
| Cost/impediments | Nil. Publicly available. |

1. https://www.bundaberg.qld.gov.au/water-services/water-supply/3#:~:text=The%20Bundaberg%20Regional%20Council%20(BRC,Safety%20and%20Reliability)%20Act%202008

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| General Information |
| ID | 46 |
| Reference | Catchment and Drinking Water Quality Micro Pollutant Monitoring program – Passive Sampling. Report 10 – Summer 2019. Queensland Alliance for Environmental Health Sciences, University of Queensland. |
| URL | See table footnote 1. |
| Other information | As the bulk supplier of drinking water to South East Queensland, Seqwater maintains a Catchment and Drinking Water Quality Micro Pollutant Monitoring Program to ensure safe and reliable supply of the region’s drinking water source reservoirs. The aim of this program is to identify and understand the presence of micro-pollutants in the source water reservoirs. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Drinking water) |
| Reliability rating |
| Substances ID | Yes (n = 41) |
| Analysis/LOD | Yes/No |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Specifically identified) |
| Dates | Yes (Single sampling events from December 2018 to February 2019) |
| Score | 22 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 25) |
| Catchment type | Drinking water catchments, South East Queensland. |
| Location | South East Queensland |
| Number of sites | 36  |
| Temporal | No. |
| Spatial | Yes throughout SE Queensland. |
| Land use link | Yes. Representative of drinking water catchments. |
| Main substances detected | Atrazine, Metsulfuron-methyl, Simazine, 2,4-D, Hexazinone, Metolachlor, Propiconazole, Tebuthiuron, Endosulfan, DDT (as metabolites). NOTE, these substances were observed in ≥70% of sites. A total of 30 herbicides/ insecticides accumulated in samplers with percent detection at sampling sites ranging from 3% - 97%. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is considered **representative** for surface water exposure drinking water catchments. |
| Ease of Access |
| Reporting format | Results available in tabular form in PDF report. |
| Individual values | No - % detection, minimum and maximum reported for positive detections. |
| Cost/impediments | Nil. Publicly available. |

1. [The University of Queensland, Queensland Alliance for Environmental Health Sciences, Catchment and Drinking Water Quality Micro Pollutant Monitoring Program - Passive Sampling 2019](https://www.seqwater.com.au/sites/default/files/2019-12/DWQMP%20Report%202018-19%20-%20Enclosure%202b%20-%202019%20Summer%20Catchment%20and%20Drinking%20Water%20Quality%20Micro%20Pollutant%20-%20Monitoring%20Program%20%E2%80%93%20Passive%20Sampling.PDF)

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| General Information |
| ID | 28 |
| Reference | WaterNSW – Annual water quality monitoring report. (2020-21 report used as reference). |
| URL | https://www.waternsw.com.au/water-quality/quality/reports  |
| Other information | WaterNSW publishes an annual water quality monitoring report each year. The reports provide an overview of the WaterNSW's water quality sampling and results throughout the storages and catchments.  |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Drinking water – water filtration plants monitored) |
| Reliability rating |
| Substances ID | Yes (n = 11) |
| Analysis/LOD | No – but expected to be available from testing laboratory |
| Matrix ID | Yes |
| Methodology | No |
| Locations | Yes (Water infiltration plants identified) |
| Dates | Yes (Generally – quarterly sampling) |
| Score | 16 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 8) |
| Catchment type | Drinking water catchments, Sydney. |
| Location | Sydney water catchment |
| Number of sites | 5 water infiltration plants; 10 stations.  |
| Temporal | No. |
| Spatial | No. |
| Land use link | Yes. Representative of drinking water catchments. |
| Main substances detected | None above limit of reporting. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, many of which are identified in the priority list established for this project. It is considered **representative** for drinking water monitored in water filtration plants. |
| Ease of Access |
| Reporting format | Results available in tabular form in PDF report. |
| Individual values | No – Minimum, median, maximum reported. |
| Cost/impediments | Nil. Publicly available. |

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| --- |
| General Information |
| ID | 36 |
| Reference | 2009/2010 Pesticide Residue Water Sampling and Analysis Program: Emigrant Creek and Wilsons River Water Supply Systems |
| URL | https://rous.nsw.gov.au/file.asp?g=RES-XNZ-67-51-23  |
| Other information | This report examines the 2010 results of a targeted pesticide water monitoring program conducted by Rous Water in the Emigrant Creek and Wilsons River water supply systems |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Surface water – water supply catchment). |
| Reliability rating |
| Substances ID | Yes (n = 27). |
| Analysis/LOD | No/Yes |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes |
| Dates | Yes (Spring/summer, 2009/2010) |
| Score | 22 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 19) |
| Catchment type | Varied – well characterized in the monitoring program |
| Location | Rous County Council (Lismore, NSW) |
| Number of sites | 4 |
| Temporal | No. |
| Spatial | No. |
| Land use link | Yes – Water supply catchment area. |
| Main substances detected | No detections exceeding level of reporting. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water in a water supply catchment area. |
| Ease of Access |
| Reporting format | PDF. |
| Individual values | No. No detections exceeding level of reporting were identified. |
| Cost/impediments | Nil. Publicly available. |

##### Groundwater

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| --- |
| General Information |
| ID | 11 |
| Reference | Department of Water. A baseline study of contaminants in groundwater at disused waste disposal sites in the Swan Canning catchment. Water Science technical series Report No 4, December 2009. Government of Western Australia. |
| URL | https://www.dpaw.wa.gov.au/images/documents/conservation-management/riverpark/reports/a-baseline-study-of-contaminants-in-groundwater-at-disused-waste-disposal-sites-in.pdf |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Water (Ground water) |
| Reliability rating |
| Substances ID | Yes (n = 32) |
| Analysis/LOD | Partially/Partially |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Generally identifiable) |
| Dates | Yes (May 2006 to May/June 2007) |
| Score | 21 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 17) |
| Catchment type | Urban and peri-urban stormwater drains (artificial and natural creeks/rivers) |
| Location | Around Perth, WA |
| Number of sites | 3 |
| Temporal | Limited. Monitoring over several seasons but in one year and only 3 sampling times. |
| Spatial | No. |
| Land use link | Yes. The sites were disused waste disposal sites. |
| Main substances detected | No pesticides were detected. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a small number of pesticides regulated by the APVMA, some of which are identified in the priority list established for this project. It is **not considered representative** because it relates to waste disposal sites that are no longer used. There is no ability to identify wastes or link these to historic use. |
| Ease of Access |
| Reporting format | Results available in tabular form in the report. |
| Individual values | Yes. |
| Cost/impediments | Nil. Publicly available. |

#### Soil

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| --- |
| General Information |
| ID | 47 |
| Reference | Weaver T, Ghadiri H, Hulugalle N and Harden S. Organochlorine pesticides in soil under irrigated cotton farming systems in Vertisols of the Namoi Valley, north-western New South Wales, Australia, Chemosphere, 2012. Volume 88, Issue 3, 336-343. |
| URL | http://dx.doi.org/10.1016/j.chemosphere.2012.03.008  |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Soil |
| Reliability rating |
| Substances ID | Yes (n = 8) |
| Analysis/LOD | Yes/No |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Specific, with coordinates) |
| Dates | Yes (2000-2002) |
| Score | 22 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 7) |
| Catchment type | Agriculture (cotton) |
| Location | Lower Namoi Valley, NSW |
| Number of sites | 3 |
| Temporal | No. |
| Spatial | No. |
| Land use link | Yes. Legacy chemicals used in agriculture in the sampled area prior to their use ceasing. |
| Main substances detected | DDT (as DDD and DDE), Endrin, Endosulfan. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a legacy substances listed in the Stockholm Convention and identified in the priority list established for this project. It is **representative** for describing continual levels of legacy chemicals. |
| Ease of Access |
| Reporting format | Results available in tabular form in the PDF published report. |
| Individual values | No. Mean and range provided in publication. |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

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| --- |
| General Information |
| ID | 48 |
| Reference | Vic EPA; Vic State Government: Bellarine Peninsula: Legacy and emerging contaminant sampling and analysis (2018–2019) – Publication 1870 May 2020 |
| URL | https://www.epa.vic.gov.au/-/media/epa/files/publications/1870.pdf |
| Other information | This report by EPA provides an assessment of pesticides, PFAS, metals and selected industrial chemicals contaminant concentrations in surface soils in areas of the Bellarine Peninsula region and in water and sediments in the Barwon River catchment to further inform assessment of the potential risk for exposure to these environmental contaminants. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Soil |
| Reliability rating |
| Substances ID | Somewhat (stated as organochlorines, organophosphates, synthetic pyrethroids, herbicides and fungicides. Specific chemical list not provided.) |
| Analysis/LOD | No/Yes (Laboratory identified so analytical information would be available if required). |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Generally identified) |
| Dates | Yes (Single sampling events in June 2019) |
| Score | 18 |
| Relevance and Representativeness |
| Includes listed? | Yes (actual number not identified.) |
| Catchment type | Barwon River Catchment. Residential, but previously used for agriculture. |
| Location | Bellarine Peninsula (Geelong to Ocean Grove, Victoria). |
| Number of sites | 4 aquatic (water, sediment, soil) plus 4 public areas for additional soil.  |
| Temporal | No. |
| Spatial | No. |
| Land use link | Yes. The provided map (and confirmed with Google Maps) shows the sampling sites to be situated in a mix of urban and agricultural land uses. |
| Main substances detected | Dieldrin. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for soil exposure from previous agricultural land use and current mixed use. |
| Ease of Access |
| Reporting format | Results available in tabular form in PDF report. |
| Individual values | Yes. |
| Cost/impediments | Nil. Publicly available. |

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| --- |
| General Information |
| ID | 53 |
| Reference | EPA Victoria – Emerging contaminants assessment 2019-20: Summary of results. Publication 1879, September 2020. |
| URL | https://www.epa.vic.gov.au/about-epa/publications/1879 |
| Other information | The study was undertaken to enable the EPA to further identify the extent and magnitude of emerging and legacy contaminants across Victoria, to inform where there may be priority areas, regulatory responses, and identify sectors to work with to prevent and reduce environmental pollution. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Soil  |
| Reliability rating |
| Substances ID | The summary results have been provided by EPA Victoria. The results from the monitoring program are considered reliable for the purpose of this project but full details have not been requested.These can be obtained including the monitoring results from:Dr Minna SaaristoSenior scientist – Emerging Contaminants, Land & Waste SciencesEmail: minna.saaristo@epa.vic.gov.au |
| Analysis/LOD |
| Matrix ID |
| Methodology |
| Locations |
| Dates |
| Score |
| Relevance and Representativeness |
| Includes listed? | Yes (from limited information in overview.) |
| Catchment type | Agriculture (low intensity- grazing; high intensity – cropping and horticulture); urban residential; urban industrial; background. |
| Location | Across Victoria |
| Number of sites | 101 |
| Temporal | No. |
| Spatial | Yes. |
| Land use link | EPA selected sites representing five land use types: background, low-intensity agriculture (grazing), high-intensity agriculture (cropping, horticulture), urban residential, and urban industrial. |
| Main substances detected | In soils, insecticide p’p-DDE was detected from <1 up to 150 µg/kg, and dieldrin from <1 up to 38 µg/kg across all land use types. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in different catchment types. The full data set can be requested from EPA Victoria if required for later use. |
| Ease of Access |
| Reporting format | Full results available from EPA Victoria. |
| Individual values | Yes. |
| Cost/impediments | None identified |

#### Sediment

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| --- |
| General Information |
| ID | 05 |
| Reference | Marshal S, Sharley D, Jeppe K, Sharp S, Rose G and Pettigrove V. Potentially Toxic Concentrations of Synthetic Pyrethroids Associated with Low Density Residential Land Use. Frontiers in Environmental Science, 22 November 2016. Vol 4 (75).  |
| URL | https://www.frontiersin.org/articles/10.3389/fenvs.2016.00075/full http://journal.frontiersin.org/article/10.3389/fenvs.2016.00075/full#supplementary-material |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Sediment |
| Reliability rating |
| Substances ID | Yes (n = 32) |
| Analysis/LOD | Yes |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (specific with coordinates) |
| Dates | Yes |
| Score | 25 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 14) |
| Catchment type | Urban wetlands aligned with subterranean stormwater drains. |
| Location | In and around Melbourne, Victoria |
| Number of sites | 111 |
| Temporal | No. Samples collected between February and April in 2015. |
| Spatial | Limited.  |
| Land use link | Catchment land use was dominated by residential, parkland, and commercial use, with smaller proportions of institutional and industrial use. |
| Main substances detected | Highest concentrations in sediment were observed for diuron, permethrin, bifenthrin, triclosan and carbaryl. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including 14 substances identified in the priority list established for this project. It is **representative** for urban stormwater runoff with partitioning to sediments for urban land use. |
| Ease of Access |
| Reporting format | Values within supplementary information – tabulated in Microsoft Word document |
| Individual values | Yes (in supplementary information) |
| Cost/impediments | Free – open access article |

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| --- |
| General Information |
| ID | 20 |
| Reference | Allinson G, Zhang P, Bui A, Allinson M, Rose G, Marshall S and Pettigrove V. Pesticide and trace metal occurrence and aquatic benchmark exceedances in surface waters and sediments of urban wetlands and retention ponds in Melbourne, Australia. Environ Sci Pollut Res Int. 2015 Jul;22(13):10214-26. |
| URL | https://doi.org/10.1007/s11356-015-4206-3 |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Sediment |
| Reliability rating |
| Substances ID | Yes (n = 17) |
| Analysis/LOD | Yes/Yes (described in detail in supplementary information) |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (general) |
| Dates | Yes |
| Score | 23 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 10) |
| Catchment type | Urban and peri-urban wetlands |
| Location | In and around Melbourne, VIC. |
| Number of sites | 24 |
| Temporal | No. Samples collected at one time point only. |
| Spatial | Limited, but greater analysis of detections by site ID will give a degree of spatial analysis from highly urbanized to peri-urban locations. |
| Land use link | Sites were chosen to obtain broad representation of the wide range of urban stormwater treatment wetland designs found in Melbourne, across the major soils types in the region and representing both new developments and well established suburbs. |
| Main substances detected | Bifenthrin. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for urban stormwater runoff with partitioning to sediments for urban land use. |
| Ease of Access |
| Reporting format | Results available in tabular form in a Microsoft Word document. |
| Individual values | Yes (in supplementary information). |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

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| --- |
| General Information |
| ID | 21 |
| Reference | Allinson, G., Allinson, M., Bui, A. et al. Pesticide and trace metals in surface waters and sediments of rivers entering the Corner Inlet Marine National Park, Victoria, Australia. Environ Sci Pollut Res 2016. 23, 5881–5891. |
| URL | https://doi.org/10.1007/s11356-015-5795-6Supplementary information available. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Sediment |
| Reliability rating |
| Substances ID | Yes (n = 39) |
| Analysis/LOD | Yes/Yes (described in detail in supplementary information) |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (general) |
| Dates | Yes |
| Score | 23 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 16) |
| Catchment type | Surface water, Agricultural use (pasture) catchment |
| Location | Corner Inlet catchment, Victoria |
| Number of sites | 17 |
| Temporal | Limited. Samples collected monthly over a 6 month period. |
| Spatial | No. |
| Land use link | The sites were selected based on their relative positions within the Corner Inlet catchment or reference locations, e.g., head of catchment, mid catchment, and lower catchment, in known agricultural areas, or in forestry or national parks and were considered to be a broad representation of the wide range of waterways found in the catchment, across the major soil types and land use in the region. |
| Main substances detected | Prometryn |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for non-urban land uses including agriculture, forestry and national parks. |
| Ease of Access |
| Reporting format | Results available in tabular form in a Microsoft Word document. |
| Individual values | Yes (in supplementary information). |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

|  |
| --- |
| General Information |
| ID | 22 |
| Reference | Allinson G, Bui A, Zhang P. et al. Investigation of 10 Herbicides in Surface Waters of a Horticultural Production Catchment in Southeastern Australia. Arch Environ Contam Toxicol 2014. 67, 358–373. |
| URL | https://doi.org/10.1007/s00244-014-0049-zSupplementary information available |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Sediment |
| Reliability rating |
| Substances ID | Yes (n = 10) |
| Analysis/LOD | Yes/Yes (described in detail in supplementary information) |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (general, but overall catchment is specific) |
| Dates | Yes (spring and summer, September 2008-March 2009 |
| Score | 23 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 4) |
| Catchment type | Surface water, Mixed use (see “Land use link” below) |
| Location | Yarra catchment, Victoria |
| Number of sites | 18 |
| Temporal | Limited. 2 seasons. |
| Spatial | Limited. Within Yarra catchment. |
| Land use link | Yes. Three sites were located on the Yarra River to reflect integrated impacts and six sites were located on the lower reaches of major tributaries. Eight sites were located in the Woori Yallock catchment where a wide variety of intensive agricultural activities operate. Two sites were reference sites located in forested water supply catchments |
| Main substances detected | Simazine |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for non-urban land uses including intensive agriculture (horticulture) and forestry. |
| Ease of Access |
| Reporting format | Results available in tabular form in the main PDF published paper. |
| Individual values | No. Mean, median, minimum, maximum and frequency of detection reported. |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

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| --- |
| General Information |
| ID | 23 |
| Reference | Wightwick AM, Bui AD, Zhang P. et al. Environmental Fate of Fungicides in Surface Waters of a Horticultural-Production Catchment in Southeastern Australia. Arch Environ Contam Toxicol 2012. 62, 380–390. |
| URL | https://doi.org/10.1007/s00244-011-9710-y  |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Sediment |
| Reliability rating |
| Substances ID | Yes (n = 24) |
| Analysis/LOD | Yes/Yes  |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (general, but overall catchment is specific – same sites as ID 22) |
| Dates | Yes (spring and summer, September 2008-March 2009 |
| Score | 23 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 6) |
| Catchment type | Surface water, Mixed use (see “Land use link” below) |
| Location | Yarra catchment, Victoria |
| Number of sites | 18 |
| Temporal | Limited. 2 seasons. |
| Spatial | Limited. Within Yarra catchment. |
| Land use link | Yes. Three sites were located on the Yarra River to reflect integrated impacts and six sites were located on the lower reaches of major tributaries. Eight sites were located in the Woori Yallock catchment where a wide variety of intensive agricultural activities operate. Two sites were reference sites located in forested water supply catchments |
| Main substances detected | Myclobutanil, Pyrimethanil |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is **representative** for non-urban land uses including intensive agriculture (horticulture) and forestry. |
| Ease of Access |
| Reporting format | Results available in tabular form in the main PDF published paper. |
| Individual values | No. Mean, maximum, 95% CI and frequency of detection reported. |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

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| --- |
| General Information |
| ID | 24 |
| Reference | Lettoof DC, Bateman PW, Aubret F. et al. The Broad-Scale Analysis of Metals, Trace Elements, Organochlorine Pesticides and Polycyclic Aromatic Hydrocarbons in Wetlands Along an Urban Gradient, and the Use of a High Trophic Snake as a Bioindicator. Arch Environ Contam Toxicol 2020. 78, 631–645. |
| URL | https://doi.org/10.1007/s00244-020-00724-z  |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Sediment |
| Reliability rating |
| Substances ID | Yes (n = 21 organochlorine pesticides, identified in supplementary material) |
| Analysis/LOD | Yes/Yes  |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Specifically, with coordinates) |
| Dates | Yes (spring and summer, September 2008-March 2009 |
| Score | 25 |
| Relevance and Representativeness |
| Includes listed? | Yes (organochlorine pesticides) |
| Catchment type | Urban, Peri-urban lakes. |
| Location | Perth, Western Australia |
| Number of sites | 4 |
| Temporal | No. Single time collection (December 2018) |
| Spatial | Limited – 4 sites down an urban gradient. |
| Land use link | Urban, peri urban (heavily modified to minimally modified locations) |
| Main substances detected | Dieldrin |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a legacy substances listed in the Stockholm Convention and identified in the priority list established for this project. It is **representative** for describing continual levels of legacy chemicals. |
| Ease of Access |
| Reporting format | Results available in tabular form in the main PDF published paper. |
| Individual values | No. Mean, maximum, 95% CI and frequency of detection reported. |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

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| General Information |
| ID | 12 |
| Reference | Department of Water. A baseline study of contaminants in the sediments of the Swan and Canning estuaries. Water Science technical series Report No 6, February 2009. Government of Western Australia. |
| URL | https://www.water.wa.gov.au/\_\_data/assets/pdf\_file/0007/3130/83909.pdf |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Sediment |
| Reliability rating |
| Substances ID | Yes (n = 15) |
| Analysis/LOD | Yes/Yes |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Specific with coordinates) |
| Dates | Yes (September 2006 to August 2007) |
| Score | 23 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 10) |
| Catchment type | Sites in this study were generally located downstream from stormwater drains and/or in the vicinity of disused waste disposal sites that were identified as priority areas in a previous investigation. |
| Location | Around Perth, WA |
| Number of sites | 20 |
| Temporal | Limited. Monitoring over several seasons but in one year. |
| Spatial | No. |
| Land use link | No. The OC pesticides assessed for were likely applied in agricultural uses prior to the urbanization around many of the sample sites.  |
| Main substances detected | Dieldrin, DDT (as p,p’-DDE) |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of legacy chemicals listed in the Stockholm Convention and identified in the priority list established for this project. It is **representative** in that it demonstrates the continual persistence of legacy chemicals, but these detections are not able to be liked directly to land use. |
| Ease of Access |
| Reporting format | Results available in tabular form in the report. |
| Individual values | No. Only values exceeding a sediment quality guideline were reported. |
| Cost/impediments | Nil. Publicly available. |

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| --- |
| General Information |
| ID | 04 |
| Reference | The Pesticide Detectives: national assessment of pesticides in waters. |
| URL | https://www.rmit.edu.au/about/schools-colleges/science/research/research-centres-groups/aquatic-environmental-stress/pesticide-detectives |
| Description | Funded by the Department of Industry, Innovation and Science, Pesticide Detectives is a collaborative project combining the scientific expertise of RMIT University’s Aquatic Environmental Stress Research Group (AQUEST) scientists and Citizen Science volunteers in the collection of sediment samples from waterways across Australia. The program has now concluded. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Sediment |
| Reliability rating |
| Substances ID | Yes (n = 110) |
| Analysis/LOD | No/Yes Analysis method expected to be available from RMIT. LODs reported in interactive map for chemicals screened at sampling sites. |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Identifiable to location on interactive map: https://www.google.com.au/maps/d/viewer?mid=1wfAfAHIq5OFugMZzjVIR3Nj-ds2zRFUc&ll=-27.082741497285035%2C137.49261074777033&z=5)  |
| Dates | Yes (2019-2020) |
| Score | 19 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 43) |
| Catchment type | Sampling performed by volunteers around the country. A large variety of catchments have been sampled (rural, conservation, peri-urban, urban). |
| Location | Around Australia |
| Number of sites | >100 |
| Temporal | No – single samples per site. |
| Spatial | Yes. Sampling sites around the country. |
| Land use link | Potentially. Land uses for individual sampling locations can be identified on the interactive map by scrolling in. (https://www.google.com.au/maps/d/viewer?mid=1wfAfAHIq5OFugMZzjVIR3Nj-ds2zRFUc&ll=-27.082741497285035%2C137.49261074777033&z=5) |
| Main substances detected | Bifenthrin |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a large number of pesticides regulated by the APVMA including several chemicals identified in the priority list established for this project. It is possibly **representative** for considering sediment contaminants for a large range of land uses, however, considerable additional work would be required to establish any such links. |
| Ease of Access |
| Reporting format | Results available in Microsoft excel (https://www.rmit.edu.au/content/dam/rmit/rmit-images/research/institutes-centres-and-groups/aquest/tabulated-results-all-pesticide-detections-sep-2019-to-jul-2020.xlsx). |
| Individual values | No. Only values for substances detected have been reported. Sampling sites from the interactive map appear to report all substances screened for at a site, however, so individual values could be extracted. |
| Cost/impediments | Nil. Publicly available. |

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| General Information |
| ID | 48 |
| Reference | Vic EPA; Vic State Government: Bellarine Peninsula: Legacy and emerging contaminant sampling and analysis (2018–2019) – Publication 1870 May 2020 |
| URL | https://www.epa.vic.gov.au/-/media/epa/files/publications/1870.pdf |
| Other information | This report by EPA provides an assessment of pesticides, PFAS, metals and selected industrial chemicals contaminant concentrations in surface soils in areas of the Bellarine Peninsula region and in water and sediments in the Barwon River catchment to further inform assessment of the potential risk for exposure to these environmental contaminants. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Soil |
| Reliability rating |
| Substances ID | Somewhat (stated as organochlorines, organophosphates, synthetic pyrethroids, herbicides and fungicides. Specific chemical list not provided.) |
| Analysis/LOD | No/Yes (Laboratory identified so analytical information would be available if required). |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Generally identified) |
| Dates | Yes (Single sampling events in June 2019) |
| Score | 18 |
| Relevance and Representativeness |
| Includes listed? | Yes (actual number not identified.) |
| Catchment type | Barwon River Catchment. Residential, but previously used for agriculture. |
| Location | Bellarine Peninsula (Geelong to Ocean Grove, Victoria). |
| Number of sites | 4 aquatic (water, sediment, soil) plus 4 public areas for additional soil.  |
| Temporal | No. |
| Spatial | No. |
| Land use link | Yes. The provided map (and confirmed with Google Maps) shows the sampling sites to be situated in a mix of urban and agricultural land uses. |
| Main substances detected | Dieldrin and DDT (as p,p’-DDE). |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for soil exposure from previous agricultural land use and current mixed use. |
| Ease of Access |
| Reporting format | Results available in tabular form in PDF report. |
| Individual values | Yes. |
| Cost/impediments | Nil. Publicly available. |

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| --- |
| General Information |
| ID | 50 |
| Reference | Rose G, Zhang P, Bui A, Allen D and Allinson G. Melbourne Water and DPI agrochemicals in Port Philip catchment project report 2009-10. A report to the Centre for Aquatic Pollution, Identification and Management (CAPIM), the University of Melbourne. Future Farming Systems Research, DPI Queenscliff Centre, Queenscliff, Victoria. 2011. |
| URL | https://www.vgls.vic.gov.au/client/en\_AU/search/asset/1146643/0 |
| Other information | The study focused on the assessment of agrochemical loads and the impacts within the peri-urban and urban fringes of Melbourne. Although primarily focusing on unprotected catchments, two reference sites (protected catchments) for the Yarra (Donnelly’s weir and Starvation Creek), and two sites of significant urban impact (Darebin and Merri Creeks) were included. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Sediment |
| Reliability rating |
| Substances ID | Yes (n = 52) |
| Analysis/LOD | Yes/Yes |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Generally identified) |
| Dates | Yes (2009-2010) |
| Score | 22 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 31) |
| Catchment type | Urban and peri-urban fringes |
| Location | Melbourne, VIC (including Port Philip Bay sub-catchments) |
| Number of sites | 24 from surface systems plus 24 constructed urban wetland sites. |
| Temporal | No. |
| Spatial | No. |
| Land use link | Yes. |
| Main substances detected | Simazine, Dieldrin, DDT (as p,p’-DDE), Bifenthrin (surface system samples)DDT (as p,p’-DDE), Bifenthrin, Simazine (urban wetland samples). |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for aquatic sediments exposure in an urban and peri-urban catchment. |
| Ease of Access |
| Reporting format | Results available in tabular form in PDF report. |
| Individual values | Yes. |
| Cost/impediments | Nil. Publicly available. |

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| --- |
| General Information |
| ID | 53 |
| Reference | EPA Victoria – Emerging contaminants assessment 2019-20: Summary of results. Publication 1879, September 2020. |
| URL | https://www.epa.vic.gov.au/about-epa/publications/1879 |
| Other information | The study was undertaken to enable the EPA to further identify the extent and magnitude of emerging and legacy contaminants across Victoria, to inform where there may be priority areas, regulatory responses, and identify sectors to work with to prevent and reduce environmental pollution. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Sediment  |
| Reliability rating |
| Substances ID | The summary results have been provided by EPA Victoria. The results from the monitoring program are considered reliable for the purpose of this project but full details have not been requested.These can be obtained including the monitoring results from:Dr Minna SaaristoSenior scientist – Emerging Contaminants, Land & Waste SciencesEmail: minna.saaristo@epa.vic.gov.au |
| Analysis/LOD |
| Matrix ID |
| Methodology |
| Locations |
| Dates |
| Score |
| Relevance and Representativeness |
| Includes listed? | Yes (from limited information in overview.) |
| Catchment type | Agriculture (low intensity- grazing; high intensity – cropping and horticulture); urban residential; urban industrial; background. |
| Location | Across Victoria |
| Number of sites | 101 |
| Temporal | No. |
| Spatial | Yes. |
| Land use link | EPA selected sites representing five land use types: background, low-intensity agriculture (grazing), high-intensity agriculture (cropping, horticulture), urban residential, and urban industrial. |
| Main substances detected | In sediments, the insecticide bifenthrin, a key ingredient in termiticides for residential housing, was detected in 34% of sites from <1 up to 79 µg/kg. The insecticide DDT was detected from <1 to 200 µg/kg and its metabolite p’p-DDE was detected from <1 to 170 µg/kg. Dieldrin was detected at 26% of sites with concentrations ranging from <1 to 39 µg/kg, |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for surface water exposure in different catchment types. The full data set can be requested from EPA Victoria if required for later use. |
| Ease of Access |
| Reporting format | Full results available from EPA Victoria. |
| Individual values | Yes. |
| Cost/impediments | None identified |

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| --- |
| General Information |
| ID | 25 |
| Reference | South Australia EPA. A snapshot of pesticides in South Australian Aquatic Sediments |
| URL | https://www.epa.sa.gov.au/files/8537\_aquatic\_pesticides.pdf |
| Other information | This project provided a snapshot survey of pesticides in aquatic sediments across South Australia, conducted in 2003 with 151 sediment samples collected. These sites represented (a) a cross-section of the state’s inland and estuarine waters and (b) a diversity of catchment land uses. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Sediment  |
| Reliability rating |
| Substances ID | Yes (n = 82). |
| Analysis/LOD | No/No  |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes |
| Dates | Yes (July 2003) |
| Score | 19 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 39) |
| Catchment type | Sites representative of a range of landuses including urban; intensive agriculture (market gardening,orchards, vines); forestry; broadacre cropping. |
| Location | Around South Australia |
| Number of sites | 151 |
| Temporal | No. |
| Spatial | Yes. |
| Land use link | Yes – Urban, intensive agriculture, forestry, broadacre cropping. |
| Main substances detected | Historically used pesticides were found at several sites. The most common was DDE (14 sites), which is a breakdown product of DDT. The other historical pesticides found were aldrin (3 sites), chlordane (2 sites), dieldrin (3 sites), lindane (1 site), DDT (1 site) and DDD (2 sites).Currently used pesticides found in sediments included chlorpyrifos (3 sites), simazine (4 sites) and diazinon (1 site). |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for sediments in aquatic systems with exposure from a large range of land uses. |
| Ease of Access |
| Reporting format | Tabular in PDF. |
| Individual values | Yes, for positive detections. |
| Cost/impediments | Nil. Publicly available. |

#### Wildlife

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| --- |
| General Information |
| ID | 07 |
|  | Yoshikane M, Kay W, Shibata Y, Inoue M, Yanai T, Kamata R, Edmonds J and Morita M. Very high concentrations of DDE and Taxaphene residues in crocodiles from the Ord River, Western Australia: An investigation into possible endocrine disruption. Journal of Environmental Monitoring. 2006, Volume 8, 649-661. |
| URL | http://xlink.rsc.org/?DOI=b518059gSupplementary information available. |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Wildlife (livers and body fat from estuarine crocodiles) |
| Reliability rating |
| Substances ID | Yes (n = 10, mixed isomers or degradates for parent actives counted as 1) |
| Analysis/LOD | Yes/no |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (specific with coordinates) |
| Dates | Yes |
| Score | 22 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 10). All actives tested for were OP legacy chemicals |
| Catchment type | Irrigation area catchment including downstream and upstream |
| Location | Three locations along the Ord River in Western Australia. |
| Number of sites | 3 covering samples from 40 individual animals |
| Temporal | Yes in that the results report current detections of chemicals where use ceased almost 30 years before sampling. |
| Spatial | No. |
| Land use link | Yes. Legacy chemicals used for cotton growing in the irrigation catchment area between 1964 and 1974. |
| Main substances detected | DDT, hexachlorobenzene, heptachlor, dieldrin, chlordane, mirex. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a legacy substances listed in the Stockholm Convention and identified in the priority list established for this project. It is **representative** for describing continual levels of legacy chemicals identified in tissues of wildlife decades are cessation of use. It is not representative in terms of linking exposure to current land use. |
| Ease of Access for Monitoring Data |
| Reporting format | Values in supplementary information provided in PDF format. |
| Individual values | Yes, reported in supplementary information. |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

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| General Information |
| ID | 14 |
| Reference | Lohr M. Anticoagulant rodenticide exposure in an Australian predatory bird increases with proximity to developed habitat. Science of the Total Environment 2018. 643: 134-144. |
| URL | https://doi.org/10.1016/j.scitotenv.2018.06.207 |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Wildlife (Livers, Southern Boobook (owl species), Ninox boobook) |
| Reliability rating |
| Substances ID | Yes (n = 8) |
| Analysis/LOD | Yes/Yes |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Somewhat (described but not identified on map or by coordinates) |
| Dates | Not identified (apparently recorded but not provided in publication) |
| Score | 17 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 8; first and second generation anticoagulants). |
| Catchment type | Varied – native, agricultural, peri-urban, urban. |
| Location | Yes (73 birds, most originating in more densely settled urban and peri-urban areas in the south-west of Western Australia in and around the city of Perth.) |
| Number of sites | 73 individual liver samples. |
| Temporal | Yes. The difference in AR exposure observed between boobook carcasses recovered in winter and those recovered in summer potentially reflects increased risk of exposure during winter when rodents make up a larger proportion of the diet. |
| Spatial | Yes – sampling was taken from a wide geographic region. |
| Land use link | Yes. Exposure of predator avian wildlife to second generation anti-coagulants is only expected to occur through consumption of contaminated prey. |
| Main substances detected | Brodifacoum, Bromadiolone, Difenacoum. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results in a predator avian species for first and second generation anticoagulant rodenticides that are regulated by the APVMA and in the priority list established for this project. It is **representative** for identifying exposure from a use pattern. It is not representative for determining exposure from a known use quantity. |
| Ease of Access |
| Reporting format | PDF publication |
| Individual values | No. Minimum, maximum and mean levels reported. Individual values may be available from lead author (m.lohr@acu.edu.au) |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

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| --- |
| General Information |
| ID | 62 |
| Reference | M. Pay J, Katzner T, Hawkins C, Barmuta L, Brown W, Wiersma J, Koch A,. Mooney N and Cameron E. Endangered Australian top predator is frequently exposed to anticoagulant rodenticides, Science of The Total Environment, 2021, Volume 788, 2021, 147673. |
| URL | https://doi.org/10.1016/j.scitotenv.2021.147673Supplementary information available |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Wildlife (Livers, Tasmanian wedge-tailed eagle Aquila audax fleayi) |
| Reliability rating |
| Substances ID | Yes (n = 8) |
| Analysis/LOD | Yes/Yes |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (generally identifiable) |
| Dates | Yes (Eagles were collected as carcasses found opportunistically throughout Tasmania between 1996 and 2018). |
| Score | 23 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 8; first and second generation anticoagulants). |
| Catchment type | Mainland Tasmania. |
| Location | Mainland Tasmania |
| Number of sites | 50 individual liver samples. |
| Temporal | No. |
| Spatial | Yes – sampling was taken from a wide geographic region. |
| Land use link | The following agricultural land use categories were grouped within the total land area used in the spatial analysis:Land use category:* Dairy sheds and yards
* Horse studs
* Piggeries
* Poultry farms
* Saleyards/stockyards
* Grazing native vegetation
* Native and exotic pasture mosaic
* Woody fodder plants
* Pasture legumes
* Pasture legumes and grass mixture
* Sown grasses
* Irrigated woody fodder plants
* Irrigated pasture legumes
* Irrigated pasture legumes and grass mixture
* Irrigated sown grasses
* Cropping
* Perennial horticulture
* Seasonal horticulture
* Irrigated cropping
* Irrigated perennial horticulture
* Irrigated seasonal horticulture
* Unclassified agriculture
* Farm buildings and infrastructure
 |
| Main substances detected | Brodifacoum, Flocoumafen, Bromadiolone. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results in a predator avian species for first and second generation anticoagulant rodenticides that are regulated by the APVMA and in the priority list established for this project. It is **representative** for identifying exposure from a use pattern. It is not representative for determining exposure from a known use quantity. |
| Ease of Access |
| Reporting format | PDF publication with supporting information in Microsoft Excel and Microsoft Word |
| Individual values | Yes – supplementary Microsoft Excel spreadsheet.  |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

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| --- |
| General Information |
| ID | 63 |
| Reference | Cooke R, Whiteley P, Jin Y, Death C, Weston M, Carter N and White J, Widespread exposure of powerful owls to second-generation anticoagulant rodenticides in Australia spans an urban to agricultural and forest landscape, Science of The Total Environment, 2022. Volume 819, 2022, 153024. |
| URL | http://dx.doi.org/10.1016/j.scitotenv.2022.153024Supplementary information available |
| General Information |
| ID | 08 |
| Reference | Fredericks, DJ and Palmer, D W 2008, Assessment of Pesticides in Aquatic Organisms – Ord River WA., Department of Environment, Government of Western Australia, Water Resource Technical Series Report No 40. |
| URL | See table footnote: (1) |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Wildlife (Liver and muscle, Powerful owl, Ninox strenua) |
| Reliability rating |
| Substances ID | Yes (n = 181) |
| Analysis/LOD | Yes/Yes |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (generally identifiable) |
| Dates | Yes (Eight found dead in 2020/21; 10 collected over 2004-2019). |
| Score | 23 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 69). |
| Catchment type | Across Victoria with 1 sample from New South Wales. |
| Location | Generally across Victoria |
| Number of sites | 18 individual liver or muscle samples. |
| Temporal | No. |
| Spatial | Yes – sampling was taken from a wide geographic region. |
| Land use link | The following land use categories were grouped within the total land area used in the spatial analysis:Land use category:* Peri-urban with agriculture (n = 6)
* Urban fringe, low roads (n = 5)
* Urban fringe, moderate roads (n = 2)
* High urbane (n = 2)
 |
| Main substances detected | Brodifacoum, Bromadiolone, Pindone. DDT (as breakdown product p,p’-DDE) |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results in a predator avian species for first and second generation anticoagulant rodenticides that are regulated by the APVMA and in the priority list established for this project. It is **representative** for identifying exposure from a use pattern. It is not representative for determining exposure from a known use quantity. |
| Ease of Access |
| Reporting format | PDF publication with supporting information in Microsoft Word |
| Individual values | No – Only detections reported |
| Cost/impediments | Cost of publication. Department has already obtained this publication. |

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| General Information |
| ID | 08 |
| Reference | Fredericks DJ, and Palmer DW. 2008, Assessment of Pesticides in Aquatic Organisms – Ord River WA., Department of Environment, Government of Western Australia, 2008, Water Resource Technical Series Report No 40. |
| URL | See table footnote: (1) |
| Type of monitoring information |
| Compartment | Environment |
| Matrix | Wildlife (Fish) |
| Reliability rating |
| Substances ID | Yes (n = 8) |
| Analysis/LOD | Partially |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Yes (Specific) |
| Dates | Yes (2005-2006). |
| Score | 16 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 8). |
| Catchment type | Agricultural irrigation area. |
| Location | In and downstream of the Ord River Irrigation Area (around Kununurra, WA). |
| Number of sites | 7 exposure, 11 reference; 29 fish samples |
| Temporal | No. |
| Spatial | No. |
| Land use link | Yes. The sampling is centered around the Ord River Irrigation Area where Ops were used in cotton prior to 1974. |
| Main substances detected | All chemicals tested for were found in fish samples. DDT (including its breakdown products) were found in 100% of samples, dieldrin in 97% of samples and mirex in 90% of samples. Aldrin, chlordane heptachlor and HCB were found in 70-80% of samples. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results in aquatic organisms for a range of OC chemicals listed in the Stockholm Convention and identified in the priority list for this project. It is **representative** continuing to demonstrate the persistence and accumulative potential of the legacy chemicals analysed. |
| Ease of Access |
| Reporting format | PDF publication with supporting information in Microsoft Word |
| Individual values | Yes. |
| Cost/impediments | Nil. Publicly available. |

1.https://www.parliament.wa.gov.au/publications/tabledpapers.nsf/displaypaper/4013033cb21f13c1ee5fe0bf4825847900043329/$file/tp-3033.pdf

### Produce

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| General Information |
| ID | 61 |
| Reference | National residue Survey results and publication |
| URL | https://www.agriculture.gov.au/agriculture-land/farm-food-drought/food/nrs/nrs-results-publications |
| Other information | The Department of Agriculture, Fisheries and Forestry (DAFF) publish the results of all animal and plant products tested under the National Residue Survey. Test result information is available through residue testing data sets (published each financial year) and commodity/summary brochures for the most recent year. |
| Type of monitoring information |
| Compartment | Produce (residues in food) |
| Matrix | Plant and animal food types. |
| Reliability rating |
| Substances ID | Yes (n = 614 in 2020-21). |
| Analysis/LOD | Yes/Yes |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Not applicable for residues monitoring. |
| Dates | Yes |
| Score | 21 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 60 in 2020-21) |
| Produce type | Comprehensive and well characterised.Plant produce residue monitoring including produce type monitored available at: https://www.agriculture.gov.au/agriculture-land/farm-food-drought/food/nrs/plant-product-testingAnimal produce residue monitoring including produce type monitored available at: https://www.agriculture.gov.au/agriculture-land/farm-food-drought/food/nrs/animal-residue-monitoring |
| Number of sites | Not defined |
| Temporal | Potentially through comparison of results from different years. |
| Spatial | No. The origin of samples is not defined. |
| Land use link | Not applicable for residues results. |
| Main substances detected | Can be obtained from analysis of monitoring datasets for years of interest. Available at: https://www.agriculture.gov.au/agriculture-land/farm-food-drought/food/nrs/nrs-results-publications |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for considering levels of pesticides exceeding MRLs in different produce (plant and animal) for human dietary exposure. |
| Ease of Access |
| Reporting format | Available online. Release of NRS data is governed by the National Residue Survey Administration Act 1992. |
| Individual values | Yes. Available online. |
| Cost/impediments | Nil. Publicly available. |

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| General Information |
| ID | 64 |
| Reference | FSANZ, 25th Australian Total Diet Study |
| URL | https://www.foodstandards.gov.au/publications/Pages/25th-Australian-Total-Diet-Study.aspx |
| Other information | The Australian Total Diet Study is Australia’s most comprehensive monitoring survey of chemicals, nutrients and other substances in the Australian diet.Food samples are collected in capital cities and selected regional areas in all Australian states and territories. They are purchased from a range of retail outlets including supermarkets, grocers, butchers, poultry shops, seafood markets, cafes and takeaways.Foods are purchased over two sampling periods (i.e. winter and summer) to account for any seasonal variation in the food supply. |
| Type of monitoring information |
| Compartment | Produce (residues in food) |
| Matrix | Plant and animal food types. |
| Reliability rating |
| Substances ID | Yes (n = 136 in 2013-14). Also includes 12 veterinary medicines (anthelmintics). |
| Analysis/LOD | Partially. Full information would be available from testing laboratories. |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Not applicable for residues monitoring. |
| Dates | Yes |
| Score | 21 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 39 in 2013-14) |
| Produce type | Comprehensive and well characterised.  |
| Number of sites | Not defined |
| Temporal | Can compare summer and winter sampling within the 12 month period |
| Spatial | No. The origin of samples is not defined. |
| Land use link | Not applicable for residues results. |
| Main substances detected | Reported in Appendix to full report1 |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for considering levels of pesticides exceeding MRLs in different produce (plant and animal) for human dietary exposure. |
| Ease of Access |
| Reporting format | Available online as Microsoft word or PDF format. |
| Individual values | No. % detections, mean, minimum, maximum, median reported by commodity. |
| Cost/impediments | Nil. Publicly available. |

Appendix downloadable at: https://www.foodstandards.gov.au/publications/Documents/25th%20Australian%20Total%20Diet%20Study%20appendices.pdf

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| General Information |
| ID | 56 |
| Reference | Targeted AgChem Residue Program (Agriculture Victoria). |
| URL | https://agriculture.vic.gov.au/farm-management/chemicals/managing-chemical-residues/results-of-targeted-agchem-residue-program-tarp-20152019 (summary of results published on internet). |
| Other information | Agriculture Victoria undertakes a Targeted AgChem Residue Program (TARP) on a yearly basis. The testing program measures chemical residues against maximum residue limits (MRL) to assist in verifying if agricultural and veterinary chemical products are being used appropriately. |
| Type of monitoring information |
| Compartment | Produce (residues in food) |
| Matrix | Plant and animal food types |
| Reliability rating |
| Substances ID | Yes (Full list not available). |
| Analysis/LOD | Yes/Yes |
| Matrix ID | Yes |
| Methodology | Yes |
| Locations | Not applicable for residues monitoring. |
| Dates | Yes |
| Score | 20 |
| Relevance and Representativeness |
| Includes listed? | Yes (full list not available) |
| Produce type | 2015-2019 online results available at: https://agriculture.vic.gov.au/farm-management/chemicals/managing-chemical-residues/results-of-targeted-agchem-residue-program-tarp#h2-0. This lists product types with unacceptable residues, identifies the chemical with unacceptable residues and reports the concentration detected. |
| Number of sites | Not defined |
| Temporal | Potentially through comparison of results from different years. |
| Spatial | No. The origin of samples is not defined. |
| Land use link | Not applicable for residues results. |
| Main substances detected | Can be obtained from analysis of monitoring datasets for 2015-19 as reported online. Available at: https://agriculture.vic.gov.au/farm-management/chemicals/managing-chemical-residues/results-of-targeted-agchem-residue-program-tarp#h2-0.  |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for considering levels of pesticides exceeding MRLs in different produce (plant and animal) for human dietary exposure, or detected where no MRL exists. HOWEVER, only results from 2015-2019 appear publicly available. |
| Ease of Access |
| Reporting format | Maintained in SharePoint database. Reports can be exported into excel etc. |
| Individual values | Yes. Limited years available online. |
| Cost/impediments | None identified. |
| Other comments | Victorian privacy and data protection requirements will apply to the data. Main contact: Maresa Heath (maresa.heath@agriculture.vic.gov.au; Tel: 0436 680 395). |

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| General Information |
| ID | 16, 17, 18 |
| Reference | Food monitoring programs (Department of Health, Government of Western Australia) |
| URL | https://ww2.health.wa.gov.au/Articles/F\_I/Food-monitoring-program. (Survey findings for 2009, 2011, 2013, 2018 and 2020). |
| Other information | As part of Government and industry efforts to safeguard agriculture produce within Western Australia, the Department of Health, with support from local governments, monitors chemical residues in fresh fruit and vegetables in addition to various other food surveys conducted under the Western Australian Food Monitoring Program. Local Government environmental health officers collect a wide variety of fruit and vegetables from growers, packers, wholesale and retail markets for this purpose. |
| Type of monitoring information |
| Compartment | Produce (residues in food) |
| Matrix | Plant and animal food types |
| Reliability rating |
| Substances ID | Yes (n = 108 identified over several years) |
| Analysis/LOD | No/Yes |
| Matrix ID | Yes |
| Methodology | Yes  |
| Locations | Not applicable for residues monitoring |
| Dates | Yes |
| Score | 17 |
| Relevance and Representativeness |
| Includes listed? | Yes (n = 52 identified over several years) |
| Produce type | Identified in https://ww2.health.wa.gov.au/~/media/Files/Corporate/general%20documents/food/PDF/Monitoring-agricultural-chemical-residue-levels-updated18Feb.ashx) |
| Number of sites | Not defined |
| Temporal | Potentially through comparison of results from different years. |
| Spatial | No. The origin of samples is not defined. |
| Land use link | Not applicable for residues results. |
| Main substances detected | Can be obtained from analysis of monitoring datasets for 2015-19 as reported online. Available at: https://agriculture.vic.gov.au/farm-management/chemicals/managing-chemical-residues/results-of-targeted-agchem-residue-program-tarp#h2-0. |
| Conclusion |
| The data set is considered **reliable** for the purpose of this project. It is **relevant** in that it describes monitoring results for a number of pesticides regulated by the APVMA, including some identified in the priority list established for this project. It is considered **representative** for considering levels of pesticides exceeding MRLs in different produce (plant and animal) for human dietary exposure, or detected where no MRL exists. |
| Ease of Access |
| Reporting format | Online documents available at https://ww2.health.wa.gov.au/Articles/F\_I/Food-monitoring-program |
| Individual values | Yes. Limited years available online. |
| Cost/ impediments | None identified. |
| Other comments | The identity of the organisation who has control of the data is stated as “The WA Department of Health, Environmental Health Directorate owns the data” (email received 14/7/2022, Kim Unwin). However, the raw data can only be accessed through the ChemCentre WA if these are still maintained in the laboratory. It is unlikely that there would be costs associated with the data although it is stated that all data would need to be de-identified. |

### Human biomonitoring

One study only was identified. Campbell et al, 2022[[90]](#footnote-91) characterised concentrations of glyphosate and its metabolite, AMPA in urine of Australian and New Zealand populations. Pooled urine samples from the Australian general population (n = 125 pools representing >1875 individuals) and individual urine samples (n = 27) from occupationally exposed New Zealand farmers were analysed. Glyphosate was detected above the LOD (0.20–1.25 µg/L) in 8% of the Australian population pooled urine samples with most detections in the 45–60 years age group. Furthermore, glyphosate (0.85 to 153 µg/L) and AMPA (0.50 to 3.35 µg/L) were detected in 96 % and 33 % of farmers, respectively.

In a recent study, monitoring of cholinesterase in red blood cells (AChE) is reported.[[91]](#footnote-92) This was not reviewed as a data source because it did not directly measure for pesticides. However, AChE inhibition may be a symptom of organophosphate (OP) insecticide toxicity. The study explored integration of AChE monitoring into routine health checks for those at risk and also to examine any association between AChE activity and agrichemical use in a Victorian farming community in Australia. This was a prospective cohort study, where farmers and non-famers were compared on the levels of AChE at four time points of baseline, 3–4 weeks, 6-weeks and at 9-weeks. Study participants (N = 55) were residents from South West Victoria, aged between 18 and 75 years. Testing of AChE was repeated for all participants with a maximum of three times over 10 weeks. There was no significant difference in average AChE activity between farming and non-farming participants in the study. There was no significant difference between personal use of agricultural chemicals on farm and the levels of AChE at baseline (measurement 1) or any of the follow up periods. However, the mean activity of AChE was significantly lower within follow up periods. There was a significant reduction of AChE between the follow up at 3-weeks and 6-weeks period.

1. [Health monitoring, Guide for organophosphate pesticides](https://www.safeworkaustralia.gov.au/sites/default/files/2021-10/health_monitoring_guidance_-_ops.pdf) [↑](#footnote-ref-2)
2. [Cotton, J., Edwards, J., Rahman, M.A. et al. Cholinesterase research outreach project (CROP): point of care cholinesterase measurement in an Australian agricultural community. Environ Health 2018. 17, 31](https://doi.org/10.1186/s12940-018-0374-1). [↑](#footnote-ref-3)
3. [National Livestock Identification System](https://www.nlis.com.au/) [↑](#footnote-ref-4)
4. [National Institute for Public Health and the Environment Ministry of Health , Welfare and Sport, monitoring programmes](https://www.rivm.nl/en/chemkap/fruit-and-vegetables/monitoring-programmes) [↑](#footnote-ref-5)
5. [Gov UK Pesticide residues in food: quarterly monitoring results for 2021](https://www.gov.uk/government/publications/pesticide-residues-in-food-quarterly-monitoring-results-for-2021) [↑](#footnote-ref-6)
6. [Department for Environment, Food and Rural Affairs, Report on the pesticide residues monitoring](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1089649/Quarter_4_2021_PRiF_report.pdf) [↑](#footnote-ref-7)
7. [U.S. Food and Drug Administration, Pesticide Residue Monitoring Program Questions and Answers](%20https%3A/www.fda.gov/food/pesticides/pesticide-residue-monitoring-program-questions-and-answers) [↑](#footnote-ref-8)
8. [Government of Canada, National Chemical Residue Monitoring Program and Chemistry Food Safety Oversight Program Annual Report 2018-2019](%20https%3A/inspection.canada.ca/food-safety-for-industry/food-chemistry-and-microbiology/food-safety-testing-bulletin-and-reports/national-chemical-residue-monitoring-program-and-c/eng/1657643289864/1657643290536) [↑](#footnote-ref-9)
9. [The Australian Chamber of Fruit and Vegetable Industries Limited, FreshTest](https://www.freshmarkets.com.au/freshtest/) [↑](#footnote-ref-10)
10. [Woolworths Food Safety](https://www.woolworths.com.au/shop/discover/healthy-eating/food-safety) [↑](#footnote-ref-11)
11. [ctgb, Authorisation of Plant Protection Products and Biocidal Products (Ctgb), Monitoring Compliance and Enforcement](https://english.ctgb.nl/plant-protection-products/assessment-framework/registration-manual/monitoring-compliance-en-enforcement) [↑](#footnote-ref-12)
12. [Authorisation of Plant Protection Products and Biocidal Products (Ctgb)](https://english.ctgb.nl/) [↑](#footnote-ref-13)
13. [The Netherlands publicly publishes environmental survey findings in a Pesticide Atlas](%20https%3A/www.bestrijdingsmiddelenatlas.nl/atlas/1/1) [↑](#footnote-ref-14)
14. [Fairway Farm systems management and governance for producing good water quality for drinking water suppliers - the objective of Fairway](https://www.fairway-project.eu/) [↑](#footnote-ref-15)
15. [Drinking Water Inspectorate, reports](https://www.dwi.gov.uk/what-we-do/annual-report/) [↑](#footnote-ref-16)
16. [Scottish Water, Scotland, Drinking Water Protection Scheme](https://www.scottishwater.co.uk/About-Us/Energy-and-Sustainability/Sustainable-Land-Management/Drinking-Water-Protection-Scheme) [↑](#footnote-ref-17)
17. [United States Environmental Protection Agency, Drinking Water and Pesticides](https://www.epa.gov/safepestcontrol/drinking-water-and-pesticides) [↑](#footnote-ref-18)
18. [United States Environmental Protection Agency, Safe Drinking Water Act: Consumer Confidence Reports (CCR)](https://www.epa.gov/ccr) [↑](#footnote-ref-19)
19. [Government of Canada, Water, Pesticides Indicator](https://agriculture.canada.ca/en/agriculture-and-environment/agriculture-and-water/pesticides-indicator) [↑](#footnote-ref-20)
20. [Government of Canada, Report, Presence and levels of priority pesticides in selected Canadian aquatic ecosystems](https://publications.gc.ca/collections/collection_2011/ec/En14-40-2011-eng.pdf) [↑](#footnote-ref-21)
21. [Government of Canada, pesticides indicator, overall state trend](https://agriculture.canada.ca/en/agriculture-and-environment/agriculture-and-water/pesticides-indicator%23a) [↑](#footnote-ref-22)
22. [Ausveg, piloting digital remote monitoring to improve environmental performance](https://ausveg.com.au/articles/piloting-digital-remote-monitoring-to-improve-environmental-performance/) [↑](#footnote-ref-23)
23. [Business.gov.nl, regulation crop protection products biocides](https://business.gov.nl/regulation/crop-protection-products-biocides/) [↑](#footnote-ref-24)
24. [cbs, use of pesticides in agriculture, survey](https://www.cbs.nl/en-gb/our-services/methods/surveys/brief-survey-description/use-of-pesticides-in-agriculture) [↑](#footnote-ref-25)
25. [cbs, less pesticide used in agriculture, article](https://www.cbs.nl/en-gb/news/2022/02/less-pesticide-used-in-agriculture) [↑](#footnote-ref-26)
26. [fera, Pesticide usage surveys](https://pusstats.fera.co.uk/home) [↑](#footnote-ref-27)
27. [Agri-food and Biosciences Institute, Pesticide usage monitoring reports](https://www.afbini.gov.uk/articles/pesticide-usage-monitoring-reports) [↑](#footnote-ref-28)
28. [Agri-food and Biosciences Institute, Pesticides usage monitoring surveys](https://www.afbini.gov.uk/articles/pesticide-usage-monitoring-surveys) [↑](#footnote-ref-29)
29. [United States Department of Agriculture, National Agricultural Statistics Service, Agricultural Chemical Use Program](https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Chemical_Use/) [↑](#footnote-ref-30)
30. [California Department of Pesticide Regulation, Pesticide Use Reporting](https://www.cdpr.ca.gov/docs/pur/purmain.htm) [↑](#footnote-ref-31)
31. [Statistics Canada, Farm Environmental Management Survey](https://www150.statcan.gc.ca/n1/pub/21-023-x/21-023-x2013001-eng.htm) [↑](#footnote-ref-32)
32. [Farm and Food Care Ontario, Survey of Pesticides use in Ontario](https://www.farmfoodcareon.org/wp-content/uploads/2016/10/ONTARIO-Pesticide-Use-Survey-Final-2013.pdf) [↑](#footnote-ref-33)
33. [Government of Alberta, Pesticide Sales in Alberta](https://open.alberta.ca/dataset/fc2a6bbb-a070-444c-8616-97fad2d08ae4/resource/4a6d2fbb-6904-4b09-a312-81aa810ca25a/download/aep-overview-2018-pesticide-sales-alberta-2020-07.pdf) [↑](#footnote-ref-34)
34. [Australian Pesticides and Veterinary Medicines Authority, Annual Product Sales Data](https://apvma.gov.au/node/10756) [↑](#footnote-ref-35)
35. [Fairway Information System, Treatment frequency indices](https://fairway-is.eu/index.php/adwi/167-treatment-frequency-indices-tfi) [↑](#footnote-ref-36)
36. [Directorate General for the Economic and Environmental Performance of Enterprises, Indicator of frequency of treatment](file:///%5C%5CACT001CL01FS06%5CAPDDATA%24%5CAgVet%5CProjects%5C05%20Policy%5CFirst%20Principles%20Review%5CGovernment%20response%5CSurveillance%20and%20monitoring%20system%5CProcurement%5CWeb%20content%20and%20MO%20briefing%5CAccesibility%5Cprevious%20versions) [↑](#footnote-ref-37)
37. [Fairway Information System, Treatment frequency indices](https://fairway-is.eu/index.php/adwi/167-treatment-frequency-indices-tfi) [↑](#footnote-ref-38)
38. [Graingrowers, Australian grains industry sustainability framework](https://www.graingrowers.com.au/news/australian-grains-industry-sustainability-framework) [↑](#footnote-ref-39)
39. [Australian Grain Industry, Sustainability Framework July 2020](https://cdn.sanity.io/files/1nr0ob5f/production/7e65e9706a43a017525ed19ce7eb87a43b63904b.pdf) [↑](#footnote-ref-40)
40. [Australian Grains Industry, Sustainability Framework January 2021](https://www.behindaustraliangrain.com.au/wordpress/wp-content/uploads/2021/01/Australian-Grains-Industry-Sustainability-Framework-Jan2021.pdf) [↑](#footnote-ref-41)
41. [Department of Agriculture, Fisheries and Forestry, Independent review of the pesticides and veterinary medicines regulatory system in Australia](https://www.agriculture.gov.au/agriculture-land/farm-food-drought/ag-vet-chemicals/better-regulation-of-ag-vet-chemicals/independent-review-agvet-chemical-regulatory-framework) [↑](#footnote-ref-42)
42. [Grain Producers Australia, submission to independent Review Panel - Draft Report of the](https://ehq-production-australia.s3.ap-southeast-2.amazonaws.com/434db9acd52bcb68ed476f1144b828eb81acf43f/original/1616382593/76a4a59ceba5a3e5b7fbf4913fbec33c_Grain_Producers_Australia.pdf) [↑](#footnote-ref-43)
43. [Hort Innovation, Australian Grown, Horticulture Sustainability Framework June 2021](https://www.horticulture.com.au/globalassets/hort-innovation/corporate-documents/hort-innovation-australian-grown-horticulture-sustainability-framework.pdf) [↑](#footnote-ref-44)
44. [Red Mead Advisory Council, Australian Beef Sustainability Framework, 2021](https://www.sustainableaustralianbeef.com.au/globalassets/beef-sustainability/documents/bh02_annual-update_v18.pdf) [↑](#footnote-ref-45)
45. [Red Meat Advisory Council, Australian Beed Sustainability Framework, 2022](https://www.sustainableaustralianbeef.com.au/globalassets/beef-sustainability/documents/absf_update_2022_web.pdf) [↑](#footnote-ref-46)
46. [EY, Doug Fitch, Western Region National Finalist](https://www.ey.com/en_au/entrepreneur-of-the-year/australia/2021-finalists/doug-fitch) [↑](#footnote-ref-47)
47. [AgGateway Europe, ADAPT for agricultural data](https://agn-public.s3.amazonaws.com/videos/iof2020/2018-10-25_IOF2020_AgGateway_1_of_2.pdf) [↑](#footnote-ref-48)
48. [AgGateway Europe, Europe Update, Regional Update](file:///%5C%5CACT001CL01FS06%5CAPDDATA%24%5CAgVet%5CProjects%5C05%20Policy%5CFirst%20Principles%20Review%5CGovernment%20response%5CSurveillance%20and%20monitoring%20system%5CProcurement%5CWeb%20content%20and%20MO%20briefing%5CAccesibility%5Cprevious%20versions) [↑](#footnote-ref-49)
49. [Agricultural Interoperability and Analysis System](https://www.atlas-h2020.eu/) [↑](#footnote-ref-50)
50. [AgGateway, Working Group Priorities for 2022](https://www.aggateway.org/News/2022Newsletters/2022JanuaryFebruaryNewsletter/WorkingGroupPrioritiesfor2022.aspx) [↑](#footnote-ref-51)
51. [Syngenta, Digitization of Label Information](https://www.epa.gov/system/files/documents/2022-05/PPDC-Syngenta-Label%20Digitization-%20May-%2025-2022.pdf) [↑](#footnote-ref-52)
52. [Syngenta, Digitization of Label Information](https://www.epa.gov/system/files/documents/2022-05/PPDC-Syngenta-Label%20Digitization-%20May-%2025-2022.pdf) [↑](#footnote-ref-53)
53. [National Library of Medicines, Data Driven approach to using individual cattle weights to estimate mean default dairy cattle weight, Schubert H, Wood S, Reyher K, Mills H.](https://pubmed.ncbi.nlm.nih.gov/31554711/) [↑](#footnote-ref-54)
54. [Automed, medication delivery system](https://automed.io) [↑](#footnote-ref-55)
55. [Health for Animals Global Animal Health Association, Digital Revolution in Animal Health report](https://www.healthforanimals.org/reports/digital-revolution-in-animal-health/) [↑](#footnote-ref-56)
56. [National Library of Medicine, What are the Main Sensor Methods for Quantifying Pesticides in Agricultural Activities? Zamora-Sequeira R, Starbird-Pérez R, Rojas-Carillo O and Vargas-Villalobos S.](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6680408/) [↑](#footnote-ref-57)
57. [US Department of Energy, Office of Scientific and Technical Information, Micro Gas Analyzer - Sandia](https://www.osti.gov/servlets/purl/1294263) [↑](#footnote-ref-58)
58. [National Library of Medicine, Detection of Nutrient Elements and Contamination by Pesticides in Spinach and Rice Samples Using Laser-Induced Breakdown Spectroscopy (LIBS). Kim G, Kwak J, Choi J and Park K.](https://pubmed.ncbi.nlm.nih.gov/22148630/) [↑](#footnote-ref-59)
59. [ABC Landline 25 September 2022](file:///%5C%5CACT001CL01FS06%5CAPDDATA%24%5CAgVet%5CProjects%5C05%20Policy%5CFirst%20Principles%20Review%5CGovernment%20response%5CSurveillance%20and%20monitoring%20system%5CProcurement%5CWeb%20content%20and%20MO%20briefing%5CAccesibility%5CABC%20Landline%2025%20September%202022%20https%3A%5Ciview.abc.net.au%5Cvideo%5CRF2204Q033S00) [↑](#footnote-ref-60)
60. [Contton Australia, Spray Drift and Satacrop](https://cottonaustralia.com.au/spraydrift-and-satacrop) [↑](#footnote-ref-61)
61. [ABC News, farmer chemical spray-drift multi million dollar payout](https://www.abc.net.au/news/rural/2017-08-11/farmer-chemical-spray-drift-multi-million-dollar-payout/8781102) [↑](#footnote-ref-62)
62. [ABC News, million dollar crop loss warning for herbicide users](https://www.abc.net.au/news/rural/2014-12-10/million-dollar-crop-loss-warning-for-herbicide-users/5956356) [↑](#footnote-ref-63)
63. [MDPI, Monolithically-Integrated μGC Chemical Sensor System Sensors 2011, Manginell RP, Bauer JM, Moorman MW, Sanchez LJ, Anderson JM, Whiting JJ, Porter DA, Copic D and Achyuthan KE. A .](https://www.google.com/search?q=Manginell+RP%2C+Bauer+JM%2C+Moorman+MW%2C+Sanchez+LJ%2C+Anderson+JM%2C+Whiting+JJ%2C+Porter+DA%2C+Copic+D+and+Achyuthan+KE.+A+Monolithically-Integrated+%CE%BCGC+Chemical+Sensor+System.+Sensors+2011%2C+11%2C+6517-6532&oq=Manginell+RP%2C+Bauer+JM%2C+Moorman+MW%2C+Sanchez+LJ%2C+Anderson+JM%2C+Whiting+JJ%2C+Porter+DA%2C+Copic+D+and+Achyuthan+KE.+A+Monolithically-Integrated+%CE%BCGC+Chemical+Sensor+System.+Sensors+2011%2C+11%2C+6517-6532&aqs=edge..69i57.563j0j4&sourceid=chrome&ie=UTF-8) [↑](#footnote-ref-64)
64. [National Library of Medicine, Metal-Organic Framework Stationary Phases for One- and Two-Dimensional Micro-Gas Chromatographic Separations of Light Alkanes and Polar Toxic Industrial Chemicals. J Chromatogr Sci. 2020 Apr 25, DH, Sillerud CH, Whiting JJ and Achyuthan KE.](https://www.google.com/search?q=Read+DH%2C+Sillerud+CH%2C+Whiting+JJ+and+Achyuthan+KE.+Metal-Organic+Framework+Stationary+Phases+for+One-+and+Two-Dimensional+Micro-Gas+Chromatographic+Separations+of+Light+Alkanes+and+Polar+Toxic+Industrial+Chemicals.+J+Chromatogr+Sci.+2020+Apr+25%3B58(5)%3A389-400.+doi%3A+10.1093%2Fchromsci%2Fbmaa005.+PMID%3A+32291439.&oq=Read+DH%2C+Sillerud+CH%2C+Whiting+JJ+and+Achyuthan+KE.+Metal-Organic+Framework+Stationary+Phases+for+One-+and+Two-Dimensional+Micro-Gas+Chromatographic+Separations+of+Light+Alkanes+and+Polar+Toxic+Industrial+Chemicals.+J+Chromatogr+Sci.+2020+Apr+25%3B58(5)%3A389-400.+doi%3A+10.1093%2Fchromsci%2Fbmaa005.+PMID%3A+32291439.&aqs=edge.0.69i59.5034j0j4&sourceid=chrome&ie=UTF-8). [↑](#footnote-ref-65)
65. [ACS Publications, Selectivity enhancement for high-speed GC analysis of volatile organic compounds with portable instruments designed for vacuum-outlet and atmospheric-pressure inlet operation using air as the carrier gas, Whiting J and Sacks R.](https://pubs.acs.org/doi/abs/10.1021/ac010879g) . [↑](#footnote-ref-66)
66. [A high-speed, high-performance, microfabricated comprehensive two-dimensional gas chromatograph. Whiting JJ, Myers E, Manginell RP, Moorman MW, Anderson J, Fix CS, Washburn C, Staton A, Porter D, Graf D, Wheeler DR, Howell S, Richards J, Monteith H, Achyuthan KE, Roukes M and Simonson RJ. Lab Chip. 2019 Apr 23;19(9):1633-1643. doi: 10.1039/c9lc00027e. PMID: 30919866.](https://www.google.com/search?q=Whiting+JJ%2C+Myers+E%2C+Manginell+RP%2C+Moorman+MW%2C+Anderson+J%2C+Fix+CS%2C+Washburn+C%2C+Staton+A%2C+Porter+D%2C+Graf+D%2C+Wheeler+DR%2C+Howell+S%2C+Richards+J%2C+Monteith+H%2C+Achyuthan+KE%2C+Roukes+M+and+Simonson+RJ.+A+high-speed%2C+high-performance%2C+microfabricated+comprehensive+two-dimensional+gas+chromatograph.+Lab+Chip.+2019+Apr+23%3B19(9)%3A1633-1643.+doi%3A+10.1039%2Fc9lc00027e.+PMID%3A+30919866.&oq=Whiting+JJ%2C+Myers+E%2C+Manginell+RP%2C+Moorman+MW%2C+Anderson+J%2C+Fix+CS%2C+Washburn+C%2C+Staton+A%2C+Porter+D%2C+Graf+D%2C+Wheeler+DR%2C+Howell+S%2C+Richards+J%2C+Monteith+H%2C+Achyuthan+KE%2C+Roukes+M+and+Simonson+RJ.+A+high-speed%2C+high-performance%2C+microfabricated+comprehensive+two-dimensional+gas+chromatograph.+Lab+Chip.+2019+Apr+23%3B19(9)%3A1633-1643.+doi%3A+10.1039%2Fc9lc00027e.+PMID%3A+30919866.&aqs=edge..69i57.461j0j4&sourceid=chrome&ie=UTF-8) [↑](#footnote-ref-67)
67. [National Library of Medicine, A sensing approach for automated and real-time pesticide detection in the scope of smart-farming, Computers and Electronics in Agriculture, Volume 178. Skotadis E, Kanaris A, Aslanidis E, Michalis P, Kalatzis N, Chatzipapadopoulos F, Marianos N and Tsoukalas, D, 2020,105759](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7485459/) [↑](#footnote-ref-68)
68. [ScienceDirect, Optical Biosensors (Second Edition), 2008, Elsevier Science, Peter B. Tarsa Ph.D., Kevin K. Lehmann Ph.D.](https://www.google.com/search?q=ScienceDirect%2C+Optical+Biosensors+(Second+Edition)%2C+2008%2C+Elsevier+Science%2C+Peter+B.+Tarsa+Ph.D.%2C+Kevin+K.+Lehmann+Ph.D.&oq=ScienceDirect%2C+Optical+Biosensors+(Second+Edition)%2C+2008%2C+Elsevier+Science%2C+Peter+B.+Tarsa+Ph.D.%2C+Kevin+K.+Lehmann+Ph.D.&aqs=edge..69i57.1798j0j3&sourceid=chrome&ie=UTF-8) [↑](#footnote-ref-69)
69. [doi, Aerosol analysis by cavity-ring-down laser spectroscopy, Analytica Chimica Acta, Volume 466, Issue 1, 2002, Pages 1-9Bulatov V, Fisher M and Israel Schechter I.](https://www.google.com/search?q=doi,+Aerosol+analysis+by+cavity-ring-down+laser+spectroscopy,+Analytica+Chimica+Acta,+Volume+466,+Issue+1,+2002,+Pages+1-9+Bulatov+V,+Fisher+M+and+Israel+Schechter+I.&spell=1&sa=X&ved=2ahUKEwjt_bOrm_X8AhW_tmMGHeBRCecQBSgAegQICBAB&biw=1233&bih=609&dpr=1.5) [↑](#footnote-ref-70)
70. [RingIR, Forensic Identification](https://ring-ir.com/technology/) [↑](#footnote-ref-71)
71. Lvova L, Di Natale C and Paolesse R. Chemical Sensors for Water Potability Assessment. In: Grumezescu A., Holban A.M., editors. Bottled Packaged Water. 2019. Volume 7. Elsevier Science; Amsterdam, The Netherlands, 177–208. [↑](#footnote-ref-72)
72. [National Library of Medicine, Solid-phase micro-extraction-gas chromatography-(tandem) mass spectrometry as a tool for pesticide residue analysis in water samples at high sensitivity and selectivity with confirmation capabilities. Gonçalves C and Alpendurada MF. J Chromatogr A. 2004 Feb 13;1026(1-2):239-50.](https://pubmed.ncbi.nlm.nih.gov/14763751/). [↑](#footnote-ref-73)
73. la Cecilia D, Dax A, Ehmann H, Koster M, Singer H and Stamm C. Continuous high-frequency pesticide monitoring to observe the unexpected and the overlooked, Water Research X, Volume 13, 2021, 100125. [↑](#footnote-ref-74)
74. [ScienceDirect, The monitoring of pesticides in water matrices and the analytical criticalities: A review, TrAC Trends in Analytical Chemistry, Volume 144, 2021, 116423, Campanale C, Massarelli C, Losacco D, Bisaccia D, Triozzi M and Felice Uricchio V.](https://www.sciencedirect.com/science/article/pii/S0165993621002466?via%3Dihub) [↑](#footnote-ref-75)
75. [European Food Safety Authority, Monitoring of pesticide amount in water and drinkable food by a fluorescence-based biosensor. Barbieri MV, Rodrigues ACM and Febbraio, F. EFSA Journal 2022; 20( S1):e200403, 9 pp](https://efsa.onlinelibrary.wiley.com/doi/full/10.2903/j.efsa.2022.e200403)3 [↑](#footnote-ref-76)
76. Dhamu VN, Poudyal DC, Telang CM, Paul A, Muthukumar S and Prasad S. Office Paper-Based Electrochemical Strips for Organophosphorus Pesticide Monitoring in Agricultural Soil. Electrochem Sci Adv. 2021, 00, e2100128. [↑](#footnote-ref-77)
77. Yaroshenko I, Kirsanov D, Marjanovic M, Lieberzeit PA, Korostynska O, Mason A, Frau I and Legin A. Real-Time Water Quality Monitoring with Chemical Sensors. Sensors (Basel). 2020 Jun 17;20(12):3432. doi: 10.3390/s20123432. PMID: 32560552; PMCID: PMC7349867. [↑](#footnote-ref-78)
78. Ispas CR, Crivat G and Andreescu S. Review: Recent Developments in Enzyme-Based Biosensors for Biomedical Analysis. Anal. Lett. 2012, 45 (2−3), 168−186 [↑](#footnote-ref-79)
79. Fan Y, Wang X, Funk T, Rashid I, Herman B, Bompoti N, Mahmud MS, Chrysochoou M, Yang M, Vadas TM, Lei Y and Li B. A Critical Review for Real-Time Continuous Soil Monitoring: Advantages, Challenges, and Perspectives. Environ Sci Technol. 2022 Sep 19. doi: 10.1021/acs.est.2c03562. Epub ahead of print. PMID: 36121207. [↑](#footnote-ref-80)
80. [National Library of Medicine, What Are the Main Sensor Methods for Quantifying Pesticides in Agricultural Activities? A Review. amora-Sequeira R, Starbird-Pérez R, Rojas-Carillo O and Vargas-Villalobos S. Molecules 2019, 24 (14), 2659](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6680408/). [↑](#footnote-ref-81)
81. Das J and Sarkar P. Enzymatic Electrochemical Biosensor for Urea with a Polyaniline Grafted Conducting Hydrogel Composite Modified Electrode. RSC Adv. 2016, 6 (95), 92520−92533 [↑](#footnote-ref-82)
82. Cioffi A, Mancini M, Gioia V and Cinti S. Environmental Science & Technology 2021. 55 (13), 8859-8865 DOI: 10.1021/acs.est.1c01931 [↑](#footnote-ref-83)
83. [MDPI, Soil Nutrient Detection for Precision Agriculture Using Handheld Laser-Induced Breakdown Spectroscopy (LIBS) and Multivariate Regression Methods (PLSR, Lasso and GPR). Erler A, Riebe D, Beitz T, Löhmannsröben H-G and Gebbers R. Sensors; 2020. 20(2):418.](https://doi.org/10.3390/s20020418) [↑](#footnote-ref-84)
84. Yu K, Ren J and Zhao Y. Principles, developments and applications of laser-induced breakdown spectroscopy in agriculture: A review, Artificial Intelligence in Agriculture, 2020. Volume 4, 127-139. [↑](#footnote-ref-85)
85. Martino L, D'Angelo C, Marinelli C and Cepeda R. Identification and detection of pesticide in chard samples by laser-induced breakdown spectroscopy using chemometric methods, Spectrochimica Acta Part B: Atomic Spectroscopy, 2021, Volume 177, 106031. [↑](#footnote-ref-86)
86. [Mid North Mesonet, overview](https://midnorthmesonet.com.au/about/overview) [↑](#footnote-ref-87)
87. [GoannaAg, Spray Inversion Network](https://www.goannaag.com.au/spray-inversion-network) [↑](#footnote-ref-88)
88. [Bureau of Meteorology, Supercomputing Programme](http://www.bom.gov.au/research/workshop/2016/pdf/05-Pugh_Dec2016-V2.pdf) [↑](#footnote-ref-89)
89. [OECD Improving the use of monitoring data in the exposure assessment of industrial chemicals](https://read.oecd-ilibrary.org/environment/report-of-the-oecd-workshop-on-improving-the-use-of-monitoring-data-in-the-exposure-assessment-of-industrial-chemicals_9789264078369-en) [↑](#footnote-ref-90)
90. [National Library of Medicine, Characterisation of glyphosate and AMPA concentrations in the urine of Australian and New Zealand populations. Science of the Total Environment. 15 November 2022. Vol 857, 157585. Campbell G, Mannetje A, Keer S, Eaglesham G, Wang X, Lin C, Hobson P, Toms L-M, Douwes J, Thomas K, Mueller J and Kaserzon S.](https://pubmed.ncbi.nlm.nih.gov/35882334/) [↑](#footnote-ref-91)
91. Cotton, J., Edwards, J., Rahman, M.A. et al. Cholinesterase research outreach project (CROP): point of care cholinesterase measurement in an Australian agricultural community. Environ Health 2018. 17, 31. [↑](#footnote-ref-92)