

Understanding the Data and Interpreting Pesticide Guideline Exceedances

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What is monitored?

Pesticides are routinely used in agricultural and other land management practices. They are typically categorised as insecticides, herbicides or fungicides, although other classes are also relevant (e.g. nematicides, rodenticides). Pesticide run-off potentially impacts the environmental values of our rivers, streams and coastal waters. The Department of the Environment, Tourism, Science and Innovation runs water quality monitoring programs that collect and analyse water samples from coastal river basins for pesticides. The monitoring programs include the [Great Barrier Reef Catchment Loads Monitoring Program](#)¹ and the South East Queensland Catchment Loads Monitoring Program. Water level is also monitored, either directly using height gauges at the site, or by using proxy indicators of water height.

How does the monitoring and testing work?

Water samples are collected at multiple sites across Queensland coastal catchments by over 30 regionally based collaborators, including Queensland traditional owner partners, agricultural industries, natural resource management bodies, landholders and regional councils. These samples are collected either using remotely triggered automatic samplers or collected manually. Water samples are collected, stored and transported in accordance with the Water Quality and Investigations, Quality Management System that aligns with the [Environmental Protection Policy Water, Monitoring and Sampling Manual 2018](#)². Once collected, the samples are sent to the Queensland Health Forensic and Scientific Services Organics Laboratory (Coopers Plains, Queensland) and analysed for the presence and concentration of a range of pesticides. This laboratory is accredited by National Association of Testing Authorities (NATA) against International Organization for Standardization (ISO) standards for water testing and analysis. When a pesticide is detected at concentrations higher than the guideline values, those concentrations are represented here as a coloured point on a graph.

Which pesticides are included in the Pesticide Reporting Portal?

Although the monitoring programs obtain analyses for >90 different pesticides (including break-down products), reporting against pesticide guidelines is currently limited to 30 different pesticides. They include ten photosystem II herbicides (ametryn, atrazine, prometryn, terbuthylazine, tebuthiuron, simazine, diuron, hexazinone, metribuzin, bromacil), eleven other herbicides (haloxyfop, imazapic, metsulfuron-methyl, halosulfuron-methyl, pendimethalin, metolachlor, 2,4-dichlorophenoxyacetic acid (2,4-D), MCPA, fluroxypyr, triclopyr, isoxaflutole), three fungicides (chlorothalonil, 4-hydroxychlorothalonil, carbendazim) and six insecticides (chlorpyrifos, diazinon, dimethoate, fipronil, imidacloprid, methoxyfenozide). These 30 pesticides are currently considered the greatest risk to coastal freshwater and marine aquatic ecosystems in coastal waterways in Queensland.

The decision to add a pesticide will be dependent on the availability of reliable guideline values, inclusion of those pesticides in Queensland Government analysis suites and an assessment of risk. Many pesticides will never be reported because methods are not available to accurately estimate the concentrations, because they are not detected in waterways or because the risk is considered low.

Pesticide exceedances occur when test results show that pesticide concentrations are higher than published pesticide guideline values (previously referred to as trigger values) for the protection of specific environmental values.

What are environmental values?

All tidal and non-tidal waters have environmental values that are defined within Schedule 1 of the Queensland [Environmental Protection Policy \(Water and Wetland Biodiversity\) 2019](#)³. Environmental values are the qualities that make water suitable for supporting aquatic ecosystems and human use. A full list of the environmental values that may be allocated to a waterway can be found in a [fact sheet](#)⁴ on the Department of Environment, Science and Innovation website. These values need to be protected to ensure the health of aquatic ecosystems and safety of waterways for community use. Those environmental values most relevant to the Pesticide Reporting Portal include aquatic ecosystems, irrigation, and drinking water supply.

What is a guideline value?

The guideline values used in the pesticide reporting portal represent the threshold concentrations between low or very low risk (i.e. acceptable) and moderate to high risk (i.e. unacceptable) to an environmental value (Figure 1).

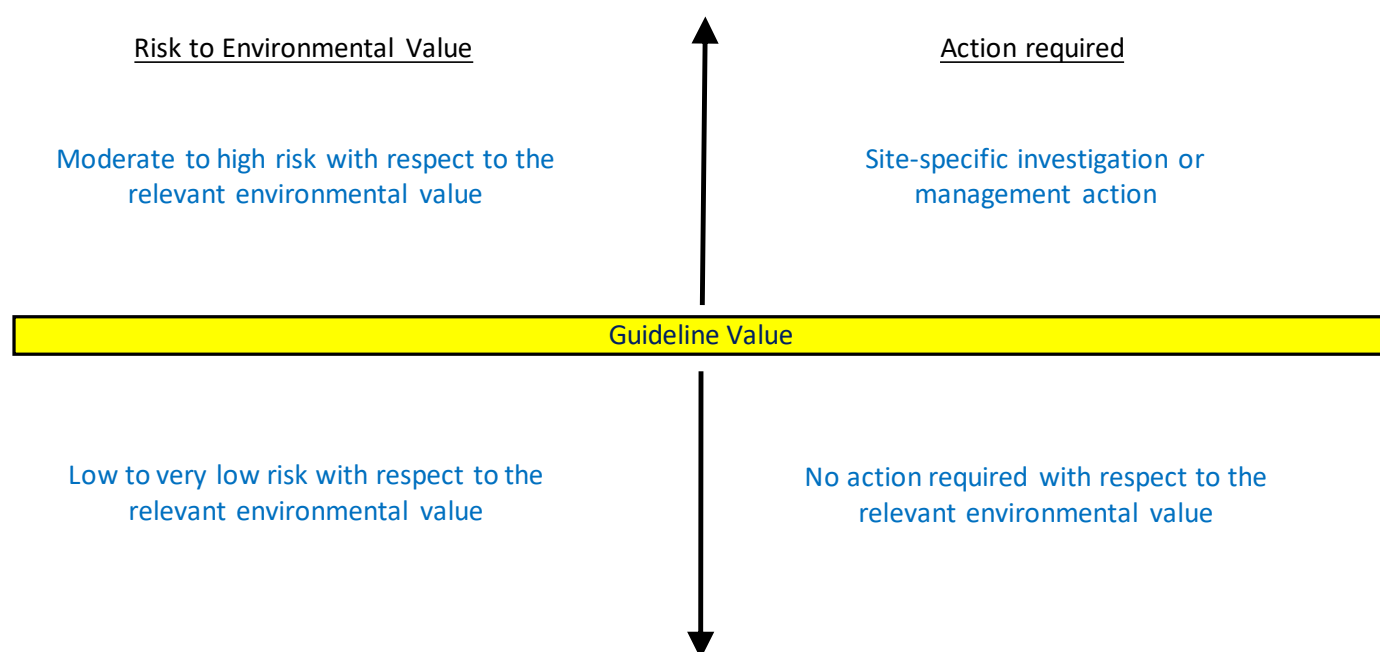


Figure 1. Guidelines as theoretical thresholds between high and low risk for environmental values.

The guideline values (where they exist) for three different environmental values are included in Pesticide Reporting Portal. These are:

1. Aquatic ecosystem protection guidelines

Under the frameworks established in the [Australian and New Zealand Guidelines for Fresh and Marine Water Quality](#)⁵ and the Queensland [Environmental Protection Policy \(Water and Wetland Biodiversity\) 2019](#)³, aquatic ecosystems are categorised as being of either; High Ecological Value (HEV; e.g. National Parks or internationally recognised conservation areas); Slightly Disturbed (SD; same protection status as HEV); Moderately Disturbed (MD; the majority of fresh and marine aquatic ecosystems) or Highly Disturbed (HD; e.g. highly degraded industrial harbours or highly modified urban or rural waterways). Guideline values for aquatic ecosystem protection are numerical values derived using a [statistical method](#)⁶ that provides concentration thresholds for the protection of either, ≥99% of species (for HEV and SD), >95% of species (for MD) or >90% / >80% of species (for HD). Of these ecosystem protection guidelines, the Pesticide Reporting Portal only reports against guideline values for the protection of MD aquatic ecosystems; i.e. 95% species protection guideline (PC95 guideline). Exceedances of the PC95 appear as yellow points on the graphs. Note that for some chemicals not currently reported in the Pesticide Reporting Portal, the 99% species protection guideline would apply to MD aquatic ecosystems. Also, some of the sites are located adjacent to HEV zones. For example, the Murray River site at Bilyana in the Wet Tropics is located immediately upstream of a [HEV zone](#)⁷, where the 99% species protection guideline (PC99) would apply. Therefore, all guideline values (PC99, PC95, PC90, PC80) are provided in tabulated form within the Pesticide Reporting Portal.

2. Irrigation water guidelines

Generally, the Pesticide Reporting Portal provides information about waterways that receive run-off from agriculture. Such waterways do not necessarily constitute an irrigation water supply. However, because irrigation water may be extracted from these waterways further downstream, all exceedances of the irrigation guidelines are reported for all waterways. The [Australian and New Zealand Guidelines for Fresh and Marine Water Quality \(2018\)](#)⁸ provides draft guidelines in the form of pesticide residue limits in irrigation water supplies for the protection of irrigated crops. Atrazine, bromacil and diuron are some one of the few pesticides for which there are irrigation water protection guideline values and the only irrigation guidelines represented in the Pesticide Reporting Portal are for these three pesticides. Exceedances of an irrigation guideline appear as blue points on the graphs.

3. Drinking water guidelines

The [Australian Drinking Water Guidelines](#)⁹ (NHMRC 2011) provides health-based guideline values that are used to determine compliance with drinking water regulations. The drinking water quality guideline values apply only to fully treated drinking water as supplied to consumers. Where treated drinking water complies with the guideline values, the consumer can be confident that long-term consumption will have no negative health effects. As a general rule, the Pesticide Reporting Portal provides information about waterways that do not provide water that will be treated and supplied as drinking water, and they are usually not allocated the environmental value of 'drinking water'. However, because some waterways do provide supply to drinking water treatment plants, and other waterways may be used as a routine or emergency water supply for stock or humans, all exceedances of the drinking water guidelines are reported for all waterways. Exceedances of the drinking water guidelines are

rare, primarily because the concentration thresholds are usually (but not always) substantially higher than those for the protection of aquatic ecosystems or irrigation waters. Exceedances of a drinking water guideline (DW Guideline (Health)) appear as purple dots on the graphs.

How does knowledge about pesticide exceedances help landholders, industry bodies and government agencies?

Water sample test results allow landholders and other relevant agencies to see where and when pesticide concentrations are above guideline values for the protection of three different environmental values. This may occur during ambient conditions (river flow in times of no rainfall) or during rainfall run-off events. Pesticide concentrations above the aquatic ecosystem protection guideline values have been shown to cause harm to marine and freshwater species if the exposure lasts for a significant portion of the organism's life cycle (known as chronic exposure). When pesticides are identified above the irrigation / drinking water guideline value, this is mainly of value to irrigation / drinking water service providers so that they can ensure their treatment processes are sufficient to reduce pesticide concentrations to below guideline levels. By understanding when pesticide guideline values have been exceeded, landholders, industry bodies and government agencies have more information that allows them to:

- manage loss of pesticide residues in run-off waters
- ensure and implement Best Management Practice programs
- create awareness with landholders to promote stewardship of waterway health
- reduce losses of pesticides from land to improve water quality in local waterways, and
- alert drinking / irrigation water service providers that they should consider the need to ensure that their treatment processes reduce pesticides to safe levels. For riparian users of their local waterway, it may indicate that they need to consider an alternative source for drinking, irrigation or stock water.

What information is provided in the graphs?

For each monitoring site, a series of graphs are provided for each of the 30 pesticides. These graphs illustrate water level and the pesticide concentration data (Figure 2). By combining water level and pesticide concentration data on the same graph, the user can see whether exceedances coincide with rainfall events or ambient conditions. Water level is plotted against the axis on the right as a blue line. At tidal sites, the tidal signature will be presented as an oscillating trace.

Pesticide concentrations are plotted against the left (y) axis and are represented as coloured dots. The dots represent the concentration of a specific pesticide at the time when, and at the location where, water samples were collected. The highest concentration detected for the date range will determine the concentration range on the left y-axis. Because the range of concentration data is frequently very large, the y-axis is presented in logarithmic scale, which makes it easier to differentiate between the lower concentrations. The grey dots represent analytical reporting of data that were unquantifiable; specifically, data that fall below the laboratory's limit of reporting (LoR) or

data coded as being at trace concentrations (TR). All these unquantifiable data have been replaced with a fixed value (0.005 µg/L) for graphical convenience and should be interpreted with caution (representative LoRs for individual pesticides are provided along with analytical error in Table 1). Black dots represent pesticide concentrations above laboratory limits of reporting but below any of the guideline values. Note that for some data collected in 2016 and 2017, an ultra-low analytical method was employed such that detections above the LoR for that analysis were still lower than 0.005 µg/L (i.e. black dots at concentrations lower than grey dots). The yellow dots represent a concentration that exceeds the pesticide-specific guideline for the protection of Moderately Disturbed (MD) aquatic ecosystems (PC95 Guideline). Similarly, if the pesticide concentration is found to also exceed the guidelines for irrigation waters or drinking water the corresponding dot will appear – blue dots for exceedances of irrigation guideline, and purple dots for exceedances of drinking water guidelines. Clicking on a concentration data-point will bring up a pop-up that specifies the date the sample was collected, the concentration reported, and a data quality code (Table 2). Data are displayed in the Portal as soon as they are made available by the analytical laboratory and prior to a final validation step. For unverified data, the concentration data (dots) have a quality code indicating unverified status of the datapoint.

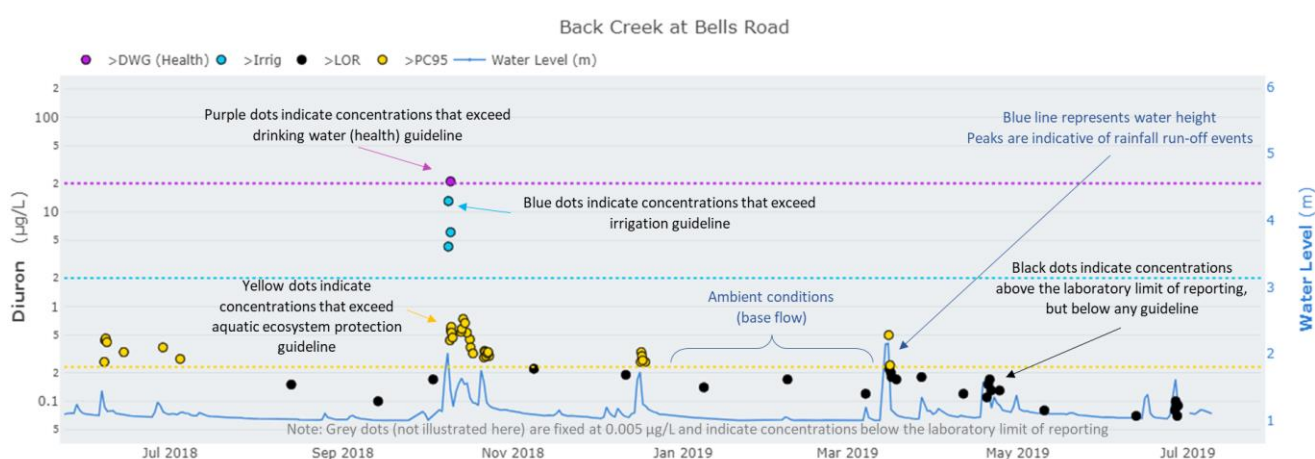


Figure 2. Example of graphical information provided in the Pesticide Reporting Portal

What does an exceedance mean, and should I be concerned?

Please note the following statements:

- exceedance of the aquatic ecosystem protection guideline (PC95 guideline – yellow dots) does not necessarily indicate a hazard to aquatic ecosystems, but is intended to provide the relevant industry, or Queensland or Australian government agency with information that may lead to further exploration of potential water quality issues, and could trigger greater engagement with the local farming community.
- Exceedance of the irrigation guideline (blue dots) does not necessarily indicate a negative impact to irrigated crops, but is intended to provide the relevant industry, or Queensland or

Australian government agency with information that may assist in managing the impacts of pesticide use.

- Exceedance of the drinking water guideline (DW guideline (Health) - purple dots) does not necessarily indicate a hazard to drinking water supplies, but is intended to provide the relevant industry, or Queensland or Australian government agency, with information that may lead to an investigation of the need for further water treatment, or the risks to humans and livestock if the water is found to constitute an unregistered supply.

These statements are provided because a guideline exceedance does not necessarily mean that the environmental value of the waterway has been compromised, but rather, that there is the possibility that harm has occurred or would occur if contamination continued. Whether or not harm has occurred, will depend on several factors, including:

- the time frame over which contamination occurs
- the magnitude of the exceedance
- the presence of other contaminants in the water that may contribute to toxicity or harm, and
- the presence of conditions in the waterway that are likely to reduce toxicity or harm.

Note that a measured concentration represents a single instant in time at a very specific location in the waterway. Pesticide concentrations will vary over time and space, and the concentrations provided in the Pesticide Reporting Portal should be regarded as indicative of water quality only.

An individual exceedance can provide a trigger for further investigation. Where exceedances are commonplace and suspected to have negative effects on aquatic ecosystems or other environmental values, exceedances can be used as triggers for further extension programs or management actions. In some cases, the presence of a chemical may be inconsistent with its registered use profile, and in these instances information provided in the Pesticide Reporting Portal may be used as a trigger for compliance action under the Chemical Usage Control Act 1988.

The Pesticide Reporting Portal is provided in parallel with the efforts of multiple organisations to improve the water quality of Queensland's waterways, including the Great Barrier Reef Marine Park and coastal marine waters in southern Queensland. It is anticipated that improvements in land management practices through programs like the [Queensland Reef Water Quality Program](#)¹⁰, projects funded through the [Reef Trust Partnership](#)¹¹, and increased awareness of the potential risks associated with pesticide contamination, will result in improved water quality that will ultimately benefit both the environment and the communities that utilise Queensland's waterways.

Table 1. The 30 reported pesticides analysed (Liquid Chromatography Mass Spectrometry - Direct Injection or High Resolution Accurate Mass (HRAM)) as part of the Great Barrier Reef and South East Queensland Catchment Loads Monitoring Program analysis suite, their corresponding laboratory reporting limits and analytical error ranges.

Analyte	Reporting Limit (µg/L)	Lower limit error (%)	Upper limit error (%)	Analyte	Reporting Limit (µg/L)	Lower limit error (%)	Upper limit error (%)
2,4-D	0.05	26	50	Hexazinone	0.01	11	50
4-Hydroxychlorothalonil	0.05	7	50	Imazapic	0.01	14	50
Ametryn	0.01	15	50	Imidacloprid	0.02	19	50
Atrazine	0.02	15	50	Isoxaflutole	0.07	32	50
Bromacil	0.02	24	50	MCPA	0.02	14	50
Carbendazim	0.01	13	50	Methoxyfenozide	0.01	18	50
Chlorothalonil	0.3	27	50	Metolachlor	0.01	5	50
Chlorpyrifos	0.02	40	50	Metribuzin	0.02	18	50
Diazinon	0.01	5	50	Metsulfuron-methyl	0.01	14	50
Dimethoate	0.02	21	50	Pendimethalin	0.02	11	50
Diuron	0.02	17	50	Prometryn	0.01	18	50
Fipronil	0.01	22	50	Simazine	0.02	10	50
Fluroxypyr	0.07	22	50	Tebuthiuron	0.02	17	50
Halosulfuron-methyl	0.01	14	50	Terbuthylazine	0.01	12	50
Haloxypop	0.02	19	50	Triclopyr	0.07	24	50

Table 2 Quality codes used in the Pesticide Reporting Portal

Quality Code	Code definition
10	Good data. WQI Quality Assurance and Quality Controls (QA/QC) process has been conducted and results are satisfactory
20	Fair data. WQI Quality Assurance and Quality Controls (QA/QC) process has been conducted, and although the results are outside expected range they have been checked and accepted
40	Unverified data. WQI Quality Assurance and Quality Controls (QA/QC) process has not been conducted
125	Historic data. Data where there can be no confirmation that a formal QA/QC procedure was followed to validate results. There is only confidence placed in the NATA accredited results as output from a laboratory.

FAQs

How do I request data?

All concentration data for the pesticides visualised in the Pesticide Reporting Portal can be obtained from [Tahbil – Water Quality Data Portal](#)¹². For more information about the Great Barrier Reef and South East Queensland Catchment Loads Monitoring Programs, or to request data please contact wqi@qld.gov.au.

Why is water height on the graphs and how accurate is it?

Water height is a proxy for base or event flow discharge and is provided for context only. High pesticide concentrations are usually associated with run-off events and the water height traces allow the user to see those concentrations in the context of the waterway flow profile. Water height data are collected at an hourly time-step; however, in order to reduce the amount of data that needs to be loaded, water height is displayed as the mean value of each four hour window and is therefore only an approximation of height.

Why are there fewer data during the dry season?

As the name suggests, there are fewer rainfall events and therefore less runoff during the dry season. Pesticide concentrations during the dry season are generally of low risk and water samples are collected far less frequently.

Why does the water level look strange at some sites?

At tidal sites, the water level data appear as an oscillating trace. This is because water level sensors measure the vertical movement of water and do not correct for the tide. Large freshwater flow events will still be visible as a rise and fall independent of the tidal signal, as in the figure below.

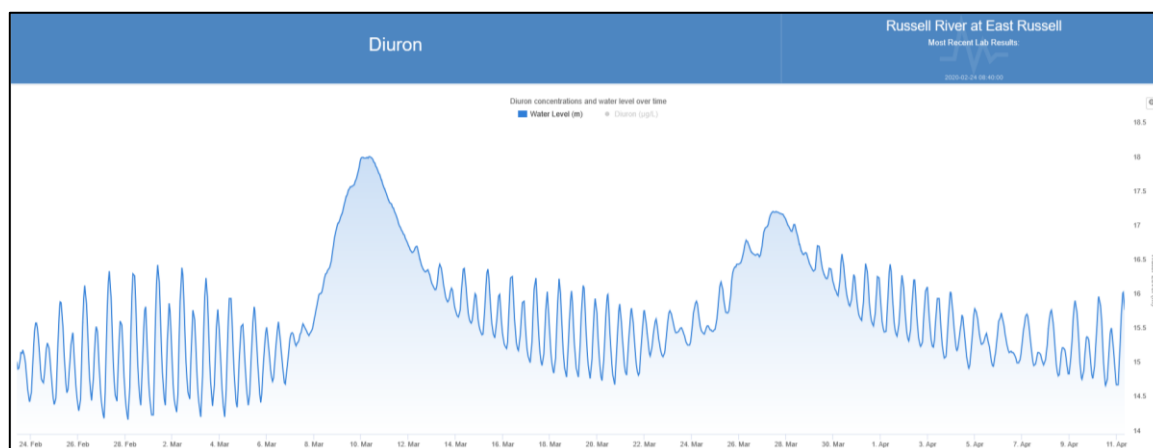


Figure 3. Example of water level at a site that experiences tidal inundation. The large rises in water level are indicative of large freshwater flow events.

What is a log scale?

On the pesticide concentration plots, the highest concentration detected in the viewing window will determine the concentration range on the left (y) axis. Because the range of concentration data is frequently very large, a linear axis can result in the data 'bunching' close together at the bottom of the plot. The y-axis has therefore been presented on a logarithmic scale that helps to decompress the data, making it easier to differentiate between the lower concentrations. The Pesticide Reporting Portal uses a $\log(10)$ scale for concentration data, meaning that values such as 0.02, 0.2 and 2.0 will appear the same distance apart vertically.

What are LoR and TR values?

The limit of reporting (LoR) is the lowest concentration of a specific chemical that the laboratory can accurately measure, within specified limits of precision and accuracy. Trace (TR) means that the compound has been confirmed as present at a level greater than the Limit of Detection but less than the LoR. Assessing the risk of a chemical can be complicated by the presence of concentration measurements below the limit of reporting (LoR), which are often a significant proportion of environmental monitoring data. All that is known about the concentration of such data is that they lie somewhere between zero and the laboratory LoR. Laboratories report any detection of a chemical at a concentration less than the limit of reporting simply by "<LoR" or, for example, "<0.01 µg/L" if the limit of reporting was 0.01 µg/L. For the purpose of the Pesticide Reporting Portal, all concentrations below the limit of reporting (i.e. <LoR) have been fixed at a value of 0.005 ug/L and will appear grey in the plots. Typical LoR values for the analysis used are provided in Table 1.

Why are there black dots (i.e. concentrations above the usual LoR) at concentrations below 0.005 µg/L?

For some data collected in 2016 and 2017, an ultra-low analytical method was employed such that detections above the LoR for that analysis were lower than 0.005 µg/L (i.e. black dots at concentrations lower than grey dots).

Why do concentration data appear to be “missing” when water level is up to date?

Water level data in the Pesticide Reporting Portal are sourced from real-time, remote-telemetered monitoring equipment. These data are ‘pulled’ into the platform every 10 minutes; however, in order to reduce the amount of data that needs to be loaded water height is displayed as the mean value of each four hour window. Water level data will therefore appear up to date in the plots for each site. The pesticide concentration data are sourced from grab samples collected either manually or using automated sampling equipment that are located at numerous sites along the eastern coast of Queensland. Water samples are collected by over 30 regionally based and partner organisations including indigenous partners, agricultural industries, natural resource management bodies, land holders and regional councils. Water samples are collected, stored and transported in accordance with the Water Quality & Investigations Quality Management System, which aligns with the [Environmental Protection Policy Water Monitoring and Sampling Manual](#)¹³. Samples are couriered to the laboratory for analysis and once analysed, results undergo extensive quality control as part of our Quality Management System. Concentration data will appear in the Pesticide Monitoring Portal as soon as they are made available by the analysis laboratory. Consequently, there will be a lag between plotted concentration and water level data.

What is the difference between a region, basin and catchment?

The Great Barrier Reef receives runoff from [six natural resource management \(NRM\) regions](#)¹⁴ that drain 424,000 square kilometres of coastal Queensland to the Great Barrier Reef Lagoon. The regions are Cape York, Wet Tropics, Burdekin, Mackay Whitsunday, Fitzroy and Burnett Mary. South East Queensland comprises a seventh NRM region that drains to Moreton Bay.

Within NRM regions, the term ‘basin’ (synonymous with ‘drainage basin’ as defined by the [Australian Water Resources Management Committee via Geosciences Australia, 1997](#)¹⁵) is used to refer to river basin management areas.

A catchment, or ‘monitoring catchment’, refers to the natural drainage area upstream of a monitoring site, from which all run-off water flows. There may be multiple catchments within a basin.

Why are some basins not monitored?

The Great Barrier Reef and South East Queensland Catchment Loads Monitoring Programs are two long-term, large-scale water quality monitoring programs conducted along the east coast of Queensland. Combined, they monitor the concentrations of pesticides for multiple sites within priority

basins that discharge to the Great Barrier Reef lagoon and Moreton Bay. Monitoring locations are chosen based on a combination of pesticide risk and reporting requirements under the Paddock to Reef Integrated Monitoring, Modelling and Reporting ([Paddock to Reef](#)¹⁶) Program, under the [Reef 2050 Water Quality Improvement Plan](#)¹⁷. Some basins may not be monitored if research and/or monitoring has shown them to be of lower risk for pesticides.

All pesticide samples are analysed by Queensland Health Forensic and Scientific Services - a NATA accredited laboratory.

How does the information presented here relate to the Great Barrier Reef Catchment Loads Monitoring Program?

The pesticide concentration data collected by Water Quality & Investigations is also used to calculate the Pesticide Risk Metric. The Pesticide Risk Metric is a method for expressing the risk associated with mixtures of up to 22 different pesticides that occur frequently in waterways that enter the Great Barrier Reef lagoon. Pesticide Risk Metrics are published in several reporting products, including the [GBRCLMP Condition Report](#)¹⁸, [Reef Water Quality Report Card](#)¹⁹ and the [Regional Report Cards](#)²⁰. Monitoring Site-specific Pesticide Risk Metrics are also published in a stand alone [Pesticide Risk Metric Dashboard](#)²¹.

Resources and References

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21. <https://prmdashboard.des.qld.gov.au/>